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**CONTEXTUALISING STISA-2024<sup>1</sup>  
Africa's STI Implementation Report**

**2014 - 2019**

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<sup>1</sup> Science, Technology and Innovation Strategy for Africa - 2024

Supported by

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## **Acronyms and Abbreviations**

AAIN	African Agribusiness Incubators Network
AAS	African Academy of Sciences
AAU	Association of African Universities
ACBF	Africa Capacity Building Foundation
ACE Impact	Africa Centres of Excellence for Development Impact
ACMMAA	Association of Chambers of Mines and other Mining Associations in Africa
ADEA	Association for Development of Education in Africa
AfDB	African Development Bank
AfCFTA	African Continental Free Trade Agreement
AESA	The Alliance for Accelerating Excellence in Science in Africa
AFAWA	Affirmative Finance Action for Women in Africa
AIDA	Accelerated Industrial Development for Africa
AIMS	African Institute for Mathematical Sciences
ALC	African Laser Centre
AMCOST	African Ministerial Council on Science and Technology
AMCOW	African Ministerial Council on Water
AMDC	African Mineral Development Centre
AMRH	African Medicines Regulatory Harmonisation
AMU	Arab Maghreb Union
ANDI	African Network for Drugs and Diagnostics Innovation
AOSTI	African Observatory of Science Technology and Innovation
APET	African Union High-Level Panel on Emerging Technologies
ARIPO	African Regional Intellectual Property Organization
ASEAN	Association of South-East Asian Nations
ASRIC	African Science Research and Innovation Council
ASTIF	African STI Fund
ASTII	African Science, Technology and Innovation Indicators
ASRIC	African Scientific, Research and Innovation Council
AU	African Union
AUC	African Union Commission
AU-C10	AU Committee of Ten Heads of State and Government (C10), Championing Education, Science and Technology in Africa
AUDA-NEPAD	African Union Development Agency-NEPAD
AUKNASE	African Union Kwame Nkrumah Awards for Scientific Excellence
AU-STRC	The AU Scientific Technical Research Commission
AUC-HRST	The AUC Dept of Human Resources, Science and Technology
AWF	African Water Facility
BecA-ILRI Hub	Biosciences for Eastern and Central Africa-International Livestock Research Institute Hub
CAADP	Comprehensive African Agriculture Development Programme

CAMES	Conseil Africain et Malgache pour l'Enseignement Supérieur
CARI	Coalition for African Research and Innovation
CDC	Centres for Disease Control
CEN-SAD	Community of Sahel-Saharan States
CESA	Continental Education Strategy for Africa
CFTA	Continental Free Trade Area
CIDA	Canadian International Development Agency
COMESA	Common Market for Eastern and Southern Africa,
COP	Conference of Parties
CPA	Africa's Science and Technology Consolidated Plan of Action
EAC	East African Community
EASTECO	East African Science and Technology Commission
ECA	United Nations Economic Commission for Africa
ECCAS	Economic Community of Central African States
ECOPOST	ECOWAS Policy on Science and Technology
ECOWAS	Economic Community of West African States
EGNOS	European Geostationary Navigation Overlay Service
ENQA	European Association for Quality Assurance in Higher Education
EU	European Union
FARA	Forum for Agricultural Research in Africa
GCTCI	Global Cities Talent Competitiveness Index
GDP	Gross Domestic Product
GETFUND	Ghana Education Trust Fund
GERD	Gross Expenditure on Research and Development
GII	Global Innovation Index
GMES	Global Monitoring for Environment and Security
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GTCI	Global Talent Competitiveness Index
HEI	Higher Education Institute
HEST	Higher Education Science and Technology Project
IAU	International Astronomical Union
ICT	Information and Communication Technologies
ICSU-ROA	International Council for Science - Regional Office for Africa
IFPRI	International Food Policy Research Institute
IGAD	Intergovernmental Authority on Development
IPR	Intellectual Property Right
IRENA	International Renewable Energy Agency
IUCEA	Inter-University Council for East Africa
M&E	Monitoring and Evaluation
MDGs	Millennium Development Goals
NAIP	National Agriculture and food security Investment Plan
NEPAD	New Partnership for Africa's Development
NEPAD Agency	NEPAD Planning and Coordinating Agency

NSTIH	NEPAD Science, Technology and Innovation Hub
OAPI	Organisation Africaine de la Propriete Intellectuelle
OAU	Organisation for African Unity
OECD	Organisation for Economic Cooperation and Development
PAFTRAC	Pan-African Private Sector Trade and Investment Committee
PAIPO	Pan African Intellectual Property Organization
PAQAF	Pan-African Quality Assurance and Accreditation Framework
PAU	Pan African University
PCT	Patent Convention treaty
PIDA	Programme for Infrastructure Development for Africa
PMPA	Pharmaceutical Manufacturing Plan for Africa
PPP\$	Purchasing Power Parity dollars
PRIDA	Policy and Regulation Initiative for Digital Africa
R&D	Research and Development
RCM	Regional Coordination Mechanism (of the AU)
REC	Regional Economic Community
RUFORUM	Regional Universities Forum for Capacity Building in Agriculture
SADC	Southern African Development Community
SANBIO	Southern African Network for BioSciences
S&T	Science and Technology
SBAS	Satellite-based Augmentation System
SCIE	Science Citation Index Expanded
SDGs	Sustainable Development Goals
SHAEA	Strengthening Higher Agricultural Education in Africa Programme
SKA	Square Kilometer Array
SMEs	Small and Medium Enterprises
STC	Specialized Technical Committee
STC-EST	Specialized Technical committee on Education Science and Technology
STI	Science, Technology and Innovation
STISA	Science, Technology and Innovation Strategy for Africa
TAAT	Technologies for African Agricultural Transformation
TETFUND	Tertiary Education Trust Fund
TVET	Technical Vocational Education and Training
TFTA	Tripartite Free Trade Area
TRIPS	Trade-Related Aspects of Intellectual Property Rights
TWAS	The World Academy of Sciences
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNCTAD	United Nations Conference on Trade and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCO-SISTER	UNESCO System of Information on Strategies, Tasks and Evaluation of Results
UNIDO	United Nations Industrial Development Organization

UNISA	University of South Africa
WHO	World Health Organization
WHO/TDR	Special Programme for Research and Training in Tropical Diseases
WIPO	World Intellectual Property Organisation
WTO	World Trade Organisation



## **Executive Summary**

1. The launch by the African Union of “Agenda 2063. The Africa We Want”, as a comprehensive long-term vision and 50-year strategy for the development of Africa, and its alignment with the Sustainable Development Goals (Agenda 2030) has provided an impetus for a range of developmental activities across the continent over the last five years. This has included the development of the first of a series of 10-year Science, Technology and Innovation Strategies for Africa (STISA-2024).
2. Economies can be divided into three phases of development: (i) factor (resource) driven; (ii) efficiency driven; and (iii) innovation driven. The mission of STISA-2024 is to “*Accelerate Africa’s transition to an innovation-led, Knowledge-based Economy*”, the third phase of development. If effectively implemented, STISA-2024 could play a substantive role in meeting the aspirations and goals outlined in Agenda 2063.
3. This report seeks to give an overview of STI developments in Africa over the past five years 2014-2019 and to contextualize the developments in terms of STISA-2024, Agenda 2063 and the broader political, social, economic, environmental and business developments on the continent. It is not a review of STISA-2024 *per se*. The report does however attempt to outline the continental developments related to science, technology and innovation in a range of categories and priority areas highlighted by STISA-2024.

## **Status of African Science, Technology, Innovation and Entrepreneurship**

4. The global status of African scientific research, innovation and entrepreneurship was reviewed through several critical reports. These include the UNESCO Institute of Statistics’ review of Global Research Intensity, the Global Innovation Index and the Global Talent Competitiveness Index that assesses entrepreneurial talent.
5. In all three areas, Africa as a region scores poorly compared to other regions. The challenges facing the weakest countries of the region in STI are exemplified by the fact that many countries are unable to even provide adequate data for assessment.
6. However, there are a number of reasons to be hopeful. Firstly, African countries as a whole, whether lower middle-income or low income, perform equally as well as their counterpart countries with similar GDP levels in other regions. Secondly, a number of countries appear as standout performers, with higher scores for innovation and entrepreneurship than would be expected from their GDP levels. These countries are labelled ‘innovation achievers’; in the 2018 Global Innovation Index report, Africa had six ‘innovation achiever’ countries, more than any other region.
7. The foundations appear to be in place for a number of countries to convert their innovation and entrepreneurship potential into economic growth and prosperity. There

is a danger, however, that a number of countries, notably those failing to generate data on STI, get left further behind in terms of education, innovation and development. As we celebrate the successes of certain countries, we must seek to assist those that are in danger of falling further behind.

8. Evidence shows that innovation and entrepreneurial success is clustered around localised geographical regions and cities and is not evenly spread within countries. Such clusters comprise cities or regions where academic centres of excellence, technology hubs and start-up companies can interact with each other. This needs to be taken into account within regional and national planning. Some African cities are starting to be recognised on a Global Cities Talent Competitiveness index.

### **Creating an Enabling Environment**

9. There has been substantial effort and achievement by the African Union and its member states over the past five years in establishing critical institutions that can support an enabling environment for STI on the continent. These include: (i) African Scientific Research and innovation Council; (ii) African Observatory for Science, Technology and Innovation; (iii) Pan African Intellectual Property Organization; (iv) Pan African Quality Assurance and Accreditation Framework; (v) Africa Centres for Disease Control; (vi) Committee of Ten Heads of State and Government (C10) championing Education, Science and Technology; (vii) Africa Virtual and E-Learning University; and (viii) Pan African Private Sector Trade and Investment Committee.
10. Now that they are established, the progress of these institutions must be monitored closely to ensure the future success of STISA-2024 and, by implication, Agenda 2063. One objective lacking in progress is the operationalisation of the Pan-African Intellectual Property Organisation (PAIPO) with a consequent lack of activity in the critical area of intellectual property management and technology transfer.
11. The series of institutional developments have been complemented by the introduction of several important continental strategies and policies. In addition to STISA-2024, the Continental Education Strategy for Africa (CESA16-25) has been developed. There have also been significant advances made towards the establishment of a Continental Free Trade Area with the signing of the African Continental Free Trade Agreement (AfCFTA). Once developed the CFTA will have a profound impact on STI and associated entrepreneurship and industrialisation. The establishment of an African Space Policy is also a particularly noteworthy development as a driver for STI on the continent, particularly in the area of the physical sciences, information technology, engineering and mathematics.
12. There has been a significant attempt over the last several years by many RECs and countries to develop and / or update their STI strategies and many more such strategies are now in place. At least 25 countries were reported to have STI strategies

in 2016, suggesting that many countries still lack substantive strategy development in STI. In addition, many of those countries that have strategies often do not have in place the concrete plans and budgetary allocations necessary to achieve their goals and objectives. Although there may be a gap in STI policies, countries have been very proactive in developing ICT policies. As of 2016, at least 45 African countries have ICT policy frameworks that are in general being effectively implemented.

13. Although national policies need to be aligned to sub-regional and continental policies, they need to address national priorities and respond to national characteristics. There is a need to balance horizontal policy approaches e.g. through science technology and innovation generally, and vertical policy approaches e.g. through agriculture, health, industry, space sectors etc. There is a value in promoting city and local council engagement in STI policy given the potential importance of local geographic clusters in promoting innovation and entrepreneurship.
14. A review undertaken by the African Academies of Science noted that where there are STI policies they often focus solely on business and industrial development and that *“social and environmental goals are not adequately integrated into national STI policy frameworks of African countries.”* There is a danger that by focusing on industry and market-oriented developments alone, the opportunity for STI to positively impact on non-commercial sustainable development is missed. There is a need for STI policy to interface with other policy areas, notably education, including tertiary education; and industry and trade, including agriculture. There is also value in interfacing more broadly with social and environmental development policies.
15. Science, Technology and Innovation can be an important driver of African integration and can in turn benefit from African integration. It is important that national and regional policies incorporate a continental perspective. Some lessons are available from other sub-continental and continental efforts to promote STI. An important lesson from India’s experience may be to focus resources on ‘location-based research’ which may generate context-specific solutions to local, national and continental issues. This approach, allied to ‘frugal innovation’ is credited for India’s Green Revolution in the 1960’s and 1970’s. An important lesson from the broader Asian experience is the positive impact on research and innovation of trade, investment, supply-chain integration and labour mobility, within the context of collective trade agreements.

### **STI and Research – Financial Inputs and Technical Outputs**

16. There has been an increase in continental financing initiatives over the last several years to develop technical competences and promote scientific research, primarily within institutions of higher education. These initiatives result in cross-cutting, generic financing of STI as opposed to regional and more narrowly focused projects or programmes, which are highlighted in section 6 of this document. Substantive continental cross-cutting financing initiatives include: (i) African Development Bank

amounting to UA694 million to promote higher education, science, technology and vocational training; (ii) World Bank amounting to \$845 million to develop African Centres of Excellence (ACE) and \$190 million for Strengthening Higher Agricultural Education in Africa (SHAFA); (iii) Alliance for Accelerating Excellence in Science in Africa of \$200 million for research and training; (iv) Coalition for African Research and Innovation seeking to promote higher levels of financing for innovation; (v) African Union Research Grant Programme amounting to \$35 million; and (vi) African Union High Level Panel on Emerging Technologies to help identify technologies requiring special attention and potential investment within Africa.

17. Africa as a whole increased its number of publications from 15,285 in 2005 to 54,069 in 2016, at a rate well above the global average, and increased its global share of publications from 1.5% to 3.2%. However, 75% of this output came from just five countries: South Africa, Egypt, Tunisia, Morocco and Algeria. Research publications from sub-Saharan Africa, (omitting South Africa and north African countries) have also increased markedly, albeit at lower levels, doubling between 2003 and 2012, and increasing sub-Saharan Africa's percentage of global research output from 0.44% to 0.72% over that period.
18. Africa' relative research strength is strongest in fields such as agriculture, tropical medicine and infectious diseases. There is a predominance of health research over Physical Science and STEM research in sub-Saharan Africa and this needs to be addressed if a broad-based continental STI strategy is to succeed.
19. Patent activity in Africa as a whole increased by 30% between 2006 and 2016, but accounted for only 0.5% of global activity in 2016. Resident patent activity is dominated by South Africa and Egypt, at around 600 to 800 applications per year, followed by much lower levels of activity in Tunisia, Morocco, Kenya and Algeria, who receive around 200 per year or less. Non-resident patent applications i.e. those arising from outside the country to protect external innovations within the market of the target country, is dominated by South Africa, which receives over 6,000 applications per year. Egypt and Morocco receive about 1,000 applications per year, with very limited activity in Tunisia, Algeria and Kenya and other African countries.
20. It is apparent that research and patent activity arises primarily from a few select countries. There is a danger that many low-income countries in Africa will get left further behind unless there is a concerted effort to address this imbalance.
21. There is a high dependence on international collaboration. Research on the continent is fragmented, with intra-African collaboration (i.e. with a partner from another African country and without a non-African partner) standing at only 2% of all published research. The dependence on international collaboration, and international financing, is particularly acute in sub-Saharan African collaboration. This needs to be addressed through scaling up postgraduate education, enhancing regional collaboration and

improving research laboratory facilities, particularly in those countries lagging behind in publication and patent output.

22. Most funds for research still originate from outside Africa. An analysis of the top 19 funding agencies acknowledged in African authored research publications between 2009 and 2014 had representation from only two African countries (South Africa and Tunisia). More funding needs to originate from national budgets and the African private sector. There is a need for national governments and continental and international financing institutions to strategically develop improved options for financing improved research facilities and more research. There is a need for progress with the STISA-2024 call for an African STI Fund (ASTIF).
23. Much of the research on the continent is at an early stage in the innovation pathway. Substantive further investment will be needed to take promising research results through to an innovation that provides a market return or a social return on investment. It should be remembered that many projects will fail for every one that succeeds.

### **Innovation and Entrepreneurship**

24. African entrepreneurship ecosystems are becoming vibrant. They score highly on 'opportunity perception', but low on start-up skills, risk acceptance and capital availability. For sub-Saharan Africa the quickest gains could be achieved by improving start-up skills, with improved access to education and skills that support careers in entrepreneurship.
25. The collective GDP of Africa reached US\$ 2.26 trillion in 2014, larger than Brazil, Russia and India combined. There has been a significant increase in the number of 'large companies' between 2008 and 2014, with over 700 companies now having revenues greater than US\$500 million, illustrating a positive growth across the business sector in Africa.
26. There has been a massive increase in innovation driven entrepreneurship over the past several years as evidenced by the rapid rise of technology hubs in many countries across Africa, with 442 African technology hubs established in early 2018. The most prominent cities involved were Lagos, Cape Town, Nairobi, Cairo and Accra. The rise in entrepreneurship is reflected by an increase in start-up funding of up to US\$ 560 million in 2017, much of it associated with IT-related innovations across multiple sectors.
27. Over 16 foundations award prizes across the continent for entrepreneurship. These serve both to promote the concept of entrepreneurship and encourage the youth specially to participate and invest their time and energy.

## Progress in Priority Areas

28. STISA-2024 derives its strategic orientation from six priority areas. Continental progress in each of these areas is briefly reviewed
29. **Priority Area 1: Eradication of Hunger.** Continental activities occur under the overarching framework of the Comprehensive African Agriculture Development Programme (CAADP). Within this framework the 2014 Malabo declaration on Accelerated Agricultural Growth and Transformation has proved significant and the responsiveness of almost all countries providing data to allow the monitoring of indicators is a very welcome development. The Science Agenda for Agriculture in Africa (S3A) launched in 2014 and coordinated by the Forum for Agricultural Research in Africa (FARA) seeks to serve CAADP and to double current level of Agricultural Total Factor Productivity (ATFP) by 2025. A number of financing, research and innovation initiatives are under way, for example the African Agribusiness Incubators Network (AAIN), the Technologies for African Agricultural Transformation (TAAT) programme and Strengthening Higher Agricultural Education in Africa (SHAEA) with the potential to make an impact on the sector. A 2016 IFPRI report stated that spending on Agricultural Research in Africa, excluding the for-profit sector had increased by around 50% between 2000 and 2014, from \$1.7 billion to \$2.5 billion. The underlying emphasis placed by the African Development Bank on its 'Africa Feeding Africa' strategy gives additional cause for hope that finance will be made available for continued innovation-led agricultural development.
30. **Priority Area 2: Prevention and Control of Disease.** The international response to Africa's 'global' health challenges over the last two decades has been impressive. As well as approximately halving under-5 mortality, maternal mortality and HIV/AIDS, malaria and TB, Africa's share of health research output rose from 0.7% to 1.3%. The transition from the MDGs to the SDGs places a strong emphasis on health systems. Historically, there has been limited coordination from within the continent, with a multitude of actors often operating with diverse objectives. The launch in 2016 of the AU African Health Strategy and the WHO African Research for Health strategy, combined with the establishment in 2017 of the Africa CDC, provide an opportunity for a greater level of ownership on health issues to be developed within Africa.
31. This level of ownership will be reinforced if home-grown innovation can start to play a role in addressing the continent's health challenges, from communicable and non-communicable diseases to resource constrained health systems. The low level of national resources for health research in many countries hinders innovation and the continent will likely remain dependent on international financing of health research and innovation for the foreseeable future, for example through the EU, NIH, Gates Foundation, the Wellcome Trust and several development agencies. The African healthcare sector was valued at US\$35 billion in 2016, providing opportunities home-grown innovation and businesses to develop. There are an increasing number of

examples of home-grown innovation and several funds have been established to support innovation and entrepreneurship in the health sector. These include AESA's 'Grand Challenges Africa' innovation grants and Amref Health Africa's 'Innovate for Life' fund. The continued development of the Pharmaceutical Manufacturing Plan for Africa, for example through a new African Medicines Agency, supported by the domestication of an African Union Model Law on Medical Products Regulation, offers hope for the development of pharmaceutical innovation on the continent,

32. **Priority Area 3: Communication (Physical and Intellectual).** There has been substantive progress towards connecting the continent with transport, energy and digital communications infrastructure through the Programme for Infrastructure Development for Africa (PIDA). Three hundred infrastructure projects now span the continent. The PIDA 2018 report states that since its first financing summit in 2014 there has been an addition of 16,066 km of roads, 4,077 km of railway lines to the African transport infrastructure, plus 3, 506 km transmission lines to the power grid and the connection of 17 countries to fibre-optic cables. This has led to 112,900 direct jobs and 49,000 indirect jobs. There are a number of capacity building programmes associated with PIDA, notably in the areas of TVET and community development. However, this activity seems less than it could be, given the massive scale of PIDA. Apart from a general scaling up of capacity building in the current areas, one option relevant to innovation development could be to extend capacity building to postgraduate training through research to help address the implementation challenges that always arise with such large-scale projects. There could be great value in integrating local problem solving (research and evaluation) expertise into infrastructure projects.
33. Through PIDA and other programmes there has been progress towards the establishment of continental e-networks. These include the Pan African e-Network in partnership with the Government of India and the Africa Connect project supported by the European Union, which works with national research and education networks (NRENs). Both of these networks target educational and research institutions. These are complemented by a European Union supported project to enhance harmonised spectrum utilisation and ITC/Telecommunications policy, legal and regulatory frameworks. These efforts need to be set against the 'digital divide' between African and the rest of the world and within Africa. Thus, based on 2016 data, The Seychelles has 161 mobile phone subscriptions per 100 people, while Eritrea has 7.29. In Morocco 58% people access internet, while in Eritrea it is 1.18%. This digital divide was highlighted in the 2016 World Development Report and the World Bank has initiated a partnership to address digital development globally. More recently, the World Bank has promoted a more coherent and coordinated approach to Africa in response to the African Union's new Digital Transformation Agenda.
34. **Priority Area 4: Protection of Our Space.** Protection of our space incorporates environmental management, including responses to climate change, water

management and the launch of the African Space Strategy, which incorporates satellite-based earth observation technology to assist environmental monitoring, including water detection and management. The main conference of the last several years on climate change, which led to the Paris Agreement of 2015, marked a major success for collective African negotiating, leading to a recognition of the need to establish policies, and resources, to assist continental adaptation to, as well as mitigation of, climate change. A central argument was that Africa collectively produces around 4% of greenhouse gas emissions compared to China and the USA combined producing over 40%, yet climate change adversely affects African agriculture, which accounts for 30 to 40% of Africa's GDP. An African Adaptation Fund has been established and realised US\$564 million against a calculated need of US\$100 billion.

35. It is widely reported that Northern Africa has 92% safe water coverage, but sub-Saharan Africa remains low at 60% of coverage, leaving about 40% of people in that region without access to clean drinking water. This seems to be based on pre-2010 data and is in need of revision. With respect to water management, improved hydrogeological mapping of aquifers on the continent, including through new earth observation technologies provides a useful resource for planning water management in Africa and needs to be better domesticated on the continent. Through the African Ministerial Conference on Water (AMCOW) a new strategic plan aligned to SDG 6 on clean water and sanitation was launched and complemented by the establishment of an African Water Fund to finance projects for water supply, sanitation, irrigation and hydropower. Over US\$1 billion has so far been committed and there are plans to increase this to US\$15 billion by 2025, but this still falls well short of requirements to achieve the African Water Vision 2025.
36. The issues of environmental and water management will be greatly assisted through satellite earth observation, which lies at the heart of the African Space Strategy, an Agenda 2063 flagship project, which was launched in 2016. The statutes of an African Space Agency were developed in 2017 and this will be hosted by Egypt. The Space Strategy is supported and complemented by 15 African countries that either have national space agencies or coordinating bodies, seven of which have launched space satellites. A number of international collaborations have been established, including the 'Copernicus' programme to access Global Monitoring for Environmental Security (GMES) and 'EGNOS' to support air navigation through links to the USA-based GPS and the EU-based Galileo positioning systems. The star scientific development of the last several years has been the further development of the Square Kilometre Array (SKA) project, now established as an intergovernmental organisation since 2019, to develop the most powerful radio telescope in the world over the next two decades by building and connecting an array of radio telescopes across Southern Africa and Western Australia. It will be important for South Africa, in its leadership role in the project, and other participating African states, to maximise their engagement in SKA activities in the coming decade if Africa is to fully reap the potential benefits of this



international collaboration, including over €700 million worth of contracts, which will be issued from early 2020 among partner countries to build the SKA.

37. **Priority Area 5: Live Together - Build the Society.** This priority area links STI to the socio-economic and political issues of how to build a society that can adapt to future changes associated with e.g. urbanisation, pan-Africanism, regional integration, changing demographics, democratisation and cultural development. The need to promote sustainable urban and environmental 'green' development through an African Urban Agenda Programme has been recognised by UN Habitat and this is complemented by approaches to also improve rural living environments. Sustainable progress is dependent on clean energy and innovative approaches to its generation and use, whether through cost-effective trans-boundary 'clean energy corridors' on international grids being advocated by the International Renewable Energy Agency (IRENA) in collaboration with PIDA, or through localised micro-grids. A major challenge facing the continent in this regard is the small number of professional planners, architects and engineers available. compared with the numbers required to meet the scaled-up and timely delivery of these approaches.
38. Much of Africa's future success in achieving well-being as a society will depend on how we organise ourselves to utilise, and benefit from, global and home-grown technology and innovation. The need to incorporate policy-based approaches that value inclusivity and equitable access to technology, as well as rewarding innovators and entrepreneurs through market mechanisms, has been increasingly recognised in the past several years e.g. by the African Academy of Sciences and UNCTAD. This requires an open and international approach to knowledge sharing that is compatible with African integration. There is a need to increase the very low levels of intra-African international STI collaboration (2%) compared to the high level of international collaboration with parties outside Africa.
39. There is an urgent need to enable women and the youth, along with minority groups, to participate in the process and rewards of innovation and entrepreneurship. The proportion of women engaged in STI in Africa must increase from the current level of 30% and they must be better represented at higher levels of authority in public and private sector organisations. An African Development Bank initiative for Affirmative Finance Action for Women in Africa that aims to mobilise US\$ 3 billion is a step in the right direction. Africa has the youngest population in the world, with 2015 data indicating that over 60% were below 25 and 19% were designated as youths, aged 15-24. The African population will continue to grow over the coming decades, with youth numbers likely to increase by 42% by 2030. It is increasingly recognised that in order to realise Africa's demographic dividend, the youth must be linked to STI and entrepreneurship strategies and a number of initiatives in this area have been promoted in recent years at the highest levels by the AfDB, AU, G20, ILO, UNCTAD and the UN as a whole.

40. Societal change to meet the vision of Agenda 2063 requires a change of attitudes as well as the implementation of programmes. This can be nurtured through developing an appropriate science culture across Africa. For a stronger engagement internationally the Africa Academies of Sciences (AAS) and The World Academy of Sciences (TWAS) have started to promote programmes in science diplomacy. Science communication and science journalism is increasingly recognised and this was highlighted in the recent South African White Paper on Science Technology and Innovation. The promotion of citizen science is another area that could radically improve the general public's, and the youth's perception of science.
41. **Priority Area 6: Wealth Creation.** Wealth creation is the crucial outcome of the strategic approach to Science, Technology and Innovation that seeks to deliver on Agenda 2063. Without the generation of wealth, none of the other priority areas can be realised. Education, and the development of human resources, is a prerequisite for a strong STI performance. Economic analyses continue to show the national economic benefit to Africa of every extra year a child spends in education, especially in Higher Education. However, the 2018 World Development Report reflected continued limited completion of primary education and limited access to secondary education and early childhood development. This is combined with many examples of low-quality education, with a 2014 assessment citing low levels of proficiency in reading (42 to 63%) and writing (58-60%) for standard 6 students in West and Central Africa and East and Southern Africa. Efforts are needed to enhance access to, and quality of, education at all levels and to take advantage of innovations such as online education. A 2017 World Bank report on Higher Education noted an average annual increase in enrolment in Africa from 1970 to 2013 of 4.3% against a global average of 2.8%, but that levels of students in Higher Education remained very low compared to other regions of the world. It also noted the high degree of inequity in students from different socio-economic strata being able to access Higher Education. The establishment of the African Virtual and e-Learning University under the auspices of the Pan-African University in 2017 is an important development, with the objective of making open distance and e-learning accessible to students across the 55 countries of Africa.
42. The efficient and effective use of natural resources is critical to sustainable wealth creation. Increased attention must be paid to minerals, forests and the blue economy and to support their ethical and sustainable exploitation to yield both primary products and innovative value-added products and services for continental economic benefit. There is need for an enhanced control of illegal mining and logging on the one hand and enhanced investment on the other hand. The Africa Progress Report of 2013 highlighted the need for increased transparency of financial flows within the mineral resources sector. The establishment and operationalisation of the African Mineral Development Centre (AMDC) in 2016 is an important development in this regard. The Zanzibar declaration of 2015 has exerted pressure to protect and invest in the Forests that cover 22% of the African continent, yet still yielded a forestry products trade deficit of US\$1 billion between 2006 and 2013. The blue economy flagship project offers a

huge potential for the continent in areas of natural resources exploitation, food security and conservation, and other sectors such as tourism and transport. The development of the blue economy is potentially valuable but also complex, given the requirement for appropriate intra-African agreements and adherence to a number of international maritime treaties and frameworks. Developments will take time and large-scale investments. The results from the first international conference on the Blue Economy in November, 2018 resulted in commitments of US\$172 billion and suggest that there is a strong degree of international will to make a success of this endeavour.

43. Last, but not least, wealth creation resulting from innovation and entrepreneurship will require a strong and well-regulated trading environment that promotes free trade and free movement as much as possible. The establishment of the African Continental Free Trade Agreement in 2018 provides an opportunity to create such an environment and increase intra-continental trade from the current low levels of 15% to higher levels in line with more developed regions. The development of continental free trade and industrial development supported by STI go hand in hand, each reinforcing the other. The revival in 2018 of the Pan-African Private Sector Trade and Investment Committee (PAFTRAC) by the African Union, in partnership with Afreximbank provides a potential interface for dialogue between the public and private sectors on this issue. Together, STI, linked to trade and industry, can help drive continental integration and the realisation of the aspirations of Agenda 2063.

### **Concluding Remarks – 10 take home messages**

44. There are ten recurring themes in this report that can help conceptualise STI in general and STISA-2024 in particular within the broader context of Agenda 2063. These are presented in full here as 10 take home messages so that the reader may consider these aspects as (s)he progresses through the report.
  - i. STISA-2024, if fully integrated into the Agenda 2063 planning and implementation process, could represent the equivalent of an R&D arm of a large conglomerate, providing research and technical analysis linked to innovation and entrepreneurship to help deliver on agenda 2063's aspirations and its goals;
  - ii. The STI concept moves beyond promoting academic research alone; it links the generation of knowledge to innovations, in the form of products and services, and entrepreneurship that can create a market and/or social return on investment;
  - iii. STI in this context needs to recognise the importance and significance of engineering as a critical driver of innovation and development and fully incorporate engineering disciplines into STI frameworks;

- iv. STI, through applied and operational research, and through monitoring and evaluation approaches, can contribute to large scale projects, whether in agriculture, health or infrastructure development, and in turn large scale projects can be used as a platform to develop STI, engineering, planning, managerial and entrepreneurial capacity for the future.
- v. STI policy and practice must be aligned broadly to sustainable socio-economic and environmental development and not restricted to market-oriented deliverables;
- vi. STI in practice, with regard to (v) can be a force to respond to, and support, the equitable empowerment of women, youth and children and help realise Africa's demographic dividend;
- vii. STI is heavily dependent on, and contributes to, a strong education system, especially a strong higher education system, that includes technical and vocational education and training;
- viii. STI can only deliver its potential economic return within an open and well-regulated trading environment and through well-designed trade and industry policies;
- ix. Linked to (viii) appropriate policies and management of intellectual property is a critical prerequisite for large scale investment in innovation.
- x. STI can only deliver on its promise if there are well-designed financial vehicles available to support both early stage research, its transition into development and its conversion into products and services that can respond to market and/or developmental needs.

# 1. Introduction

## 1.1. Agenda 2063 and the Origins of STISA-2024

1. The opening pages of the Science Technology and Innovation Strategy for Africa, STISA-2024 (AU, 2014a) which provides the backdrop for this report on Science Technology and Innovation in Africa, contains the following quotation from President Kwame Nkrumah as he gave the first speech at the foundation summit of the Organisation of African Unity (OAU) in Addis Ababa on May 24<sup>th</sup>, 1963.

*“We shall accumulate machinery and establish steel works, iron foundries and factories; we shall link the various states of our continent with communications; we shall astound the world with our hydroelectric power; we shall drain marshes and swamps, clear infested areas, feed the undernourished, and rid our people of parasites and disease. It is within the possibility of science and technology to make even the Sahara bloom into a vast field with verdant vegetation for agricultural and industrial developments”.*

2. STISA-2024 is a product of the broader vision and goals of the African Union as expressed by its overarching strategic document ‘Agenda 2063. The Africa we want’ (AU, 2015a). We must first understand the origins of this strategy before we proceed to explore STISA-2024 and its implications in more detail.

3. Fifty years to the day after the formation of the OAU, the leadership of the African Union (AU), the OAU’s successor organisation, gathered in Addis Ababa for golden jubilee celebrations. At that summit they made a ‘Solemn Declaration’ (AU, 2013) that reaffirmed their commitment to their founding vision to

*“build an integrated, prosperous and peaceful Africa, driven by its own citizens and representing a dynamic force in the global arena.”*

Guided by this vision the leaders committed themselves to a set of high-level goals and ideals to transform the continent over the next 50 years, through the development of an Agenda 2063, that looked ahead to the centenary of the formation of the OAU. Over the next year and a half there were extensive consultations and studies (tralac, 2015a) leading to the adoption of the visionary and aspirational document ‘Agenda 2063. The Africa we want’ (AU, 2015a) that was also backed up by a first 10-year implementation plan (AU, 2015b).

4. Agenda 2063 contains 20 goals associated with seven aspirations, which are illustrated in Figure 1.1. It is important to recognise the scale of vision and transformation that this fifty-year endeavour represents. It has already stimulated a number of important actions over the past several years, some of which will be enunciated in this report. These include a strong push for transformation and reform of the AU itself and how it is structured and governed (Kagame, 2017; TANA Forum

Secretariat, 2018). Some of these reforms have started to be implemented (AU, 2018a) but there are still questions if the political will exists for them to be fully implemented (Nantulya, 2019).



**Figure 1.1. Schematic representation of Agenda 2063 aspirations and goals (AU, 2015c).**

5. Agenda 2063 was developed just as the wider international community, through the United Nations (UN) were transitioning from the Millennium Development Goals and developing the Sustainable Development Goals (UN, 2015a; ECA, 2016a). The SDGs are aligned to Agenda 2063, and indeed the AU contributed significantly to SDG development. Both the UN and the AU have worked to integrate and align the two agendas so that they reinforce each other (ECA, 2017a; ECA, 2018; UN & AU, 2018).
6. The implementation of Agenda 2063 builds upon previous continental initiatives that will be referred to later on in this report, notably the Comprehensive African Agriculture Development Programme (CAADP) and the Programme for Infrastructure Development for Africa (PIDA). It has also been jump-started by a commitment to 12 flagship projects, some of which are particularly relevant to this report on science, technology and innovation, namely: (i) Outer Space; (ii) Pan-African e-Network; (iii) Establishment of the Virtual University; and (iv) Continental Free Trade Area, plus several substantive construction and transport related projects.
7. STISA-2024 is one of several supplementary continental strategies have been initiated at the outset of Agenda 2063. There have been a number of initiatives promoting Science, Technology and Innovation (STI) dating back to the creation of the Organisation for African Unity (OAU) in 1963, as Science Technology and Innovation

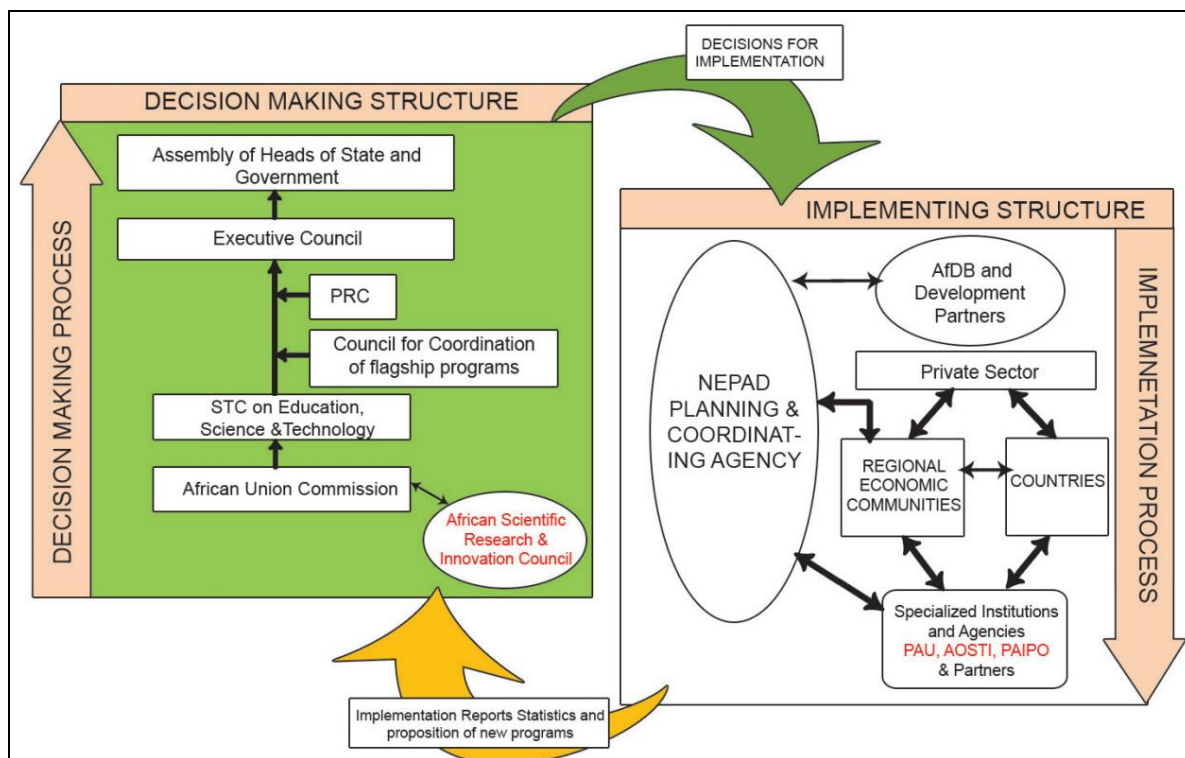
has always been understood to be critical for industrial growth and socio-economic development. The most recent of these, and in many ways the progenitor of STISA-2024 was the Consolidated Plan of Action (CPA), which had operated from 2006. However, STISA-2024 represents the first time that a comprehensive 10-year strategy for Science Technology and Innovation has been developed and there are plans that this will transition into future 10-year strategies.

## 1.2. STISA-2024

8. The World Economic Forum classification of economies by economic development describes three phases of development. The first phase is ‘factor-driven’ dominated by resource availability. The second phase is efficiency-driven based on the development of more-efficient production processes and improved product quality. The third phase is the innovation-driven phase, where businesses are more knowledge-intensive and there is an expansion in particular of the service sector<sup>2</sup> (Global Entrepreneurship Research Association, 2017, p. 13). Most African economies are at stage one of this process, with some moving to stage two. None can yet be classified at stage 3. For example, the 2016/17 Global Entrepreneurship Monitor Report referred to above classifies Egypt, Morocco and South Africa as phase 2 countries.
9. The Mission of STISA-2024 (AU, 2014a) is to boldly “*Accelerate Africa’s transition to an innovation-led, knowledge-based economy*”, the third stage of development outlined above. This will be achieved by:
  - i. Improving STI readiness in Africa in terms of infrastructure, professional and technical competence, and entrepreneurial capacity; and
  - ii. Implementing specific policies and programs in science, technology and innovation that address societal needs in a holistic and sustainable way.This will require concerted and integrated action at national level, at regional level through the Regional Economic Communities, at Continental level, and with partners outside Africa. Science, Technology and Innovation develops best when there is a free and facilitated flow of ideas and people, when collaboration is enabled across national divides and across the divides of public and private sectors. Moves to develop STI in Africa are therefore closely aligned to enhanced African Integration.
10. There is currently no official implementation plan and no official set of indicators established for STISA-2024. These are under development based on the many actions that are called for within the STISA-2024 document, a number of goals that are identified within the first 10-year implementation plan of Agenda 2063 (AU, 2015b) and best practice indicators and objectives derived from other AU documents and international STI-related endeavours. An overview of the STISA-2024 institutional architecture is shown in Figure 1.2.

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<sup>2</sup> <http://weforum.org>



**Figure 1.2. Planned Institutional Architecture of STISA-2024 (AU, 2014a)**

11. The aspects of the Agenda 2063 10-year implementation plan that directly interface with STISA-2024 are shown in Table 1.1. From the 20 goals associated with Agenda 2063’s seven aspirations, there are 6 goals associated with Aspiration 1, a prosperous Africa, and 1 goal associated with Aspiration 2, an integrated continent, that are closely aligned with STI.

**Table 1.1. Goals and Priority Areas from the Agenda-2063 10-year implementation plan that directly connect to STISA-2024.** Adapted from (AU, 2015b, pp. 18-20).

Aspiration	Goal	Priority Area
1) A Prosperous Africa, based on Inclusive Growth and Sustainable Development	2) Well Educated Citizens and Skills revolution underpinned by Science, Technology and Innovation	• Education and STI skills driven revolution
	3) Healthy and well-nourished citizens	• Health and Nutrition



	4) Transformed Economies	<ul style="list-style-type: none"> <li>• STI driven Manufacturing / Industrialization and Value Addition</li> </ul>
	5) Modern Agriculture for increased productivity and production	<ul style="list-style-type: none"> <li>• Agricultural Productivity and Production</li> </ul>
	6) Blue/ ocean economy for accelerated economic growth	<ul style="list-style-type: none"> <li>• Marine resources and Energy</li> <li>• Ports Operations and Marine Transport</li> </ul>
	7) Environmentally sustainable and climate resilient economies and communities	<ul style="list-style-type: none"> <li>• Bio-diversity, conservation and sustainable natural resource management.</li> <li>• Water security</li> <li>• Climate resilience and natural disasters preparedness and prevention</li> <li>• Renewable energy</li> </ul>
2) An Integrated Continent Politically united and based on the ideals of Pan Africanism and the vision of African Renaissance	10) World Class Infrastructure criss-crosses Africa	<ul style="list-style-type: none"> <li>• Communications and Infrastructure Connectivity</li> </ul>

12. STISA-2024 is built upon four cross-cutting pillars:

- i. Infrastructure Development
- ii. Technical Competences
- iii. Innovation and Entrepreneurship; and
- iv. Enabling Environment

13. STISA-2024 gains its strategic orientation from six priority areas:

- i. Eradication of hunger and achieving food security
- ii. Prevention and control of diseases
- iii. Communication (Physical and Intellectual)
- iv. Protection of our space
- v. Live together – build the society

vi. Wealth creation.

14. In order for STISA-2024 to be successful the relevant secretariats must, first and foremost, work through the continental, Regional Economic Community (REC) and national governance structures to help create an appropriate enabling environment that values, recognises and supports STI. Through these governance structures they must reach out to academia, industry and civil society organisations that are central to STI-led development. They must also reach out to the youthful scientists, innovators and entrepreneurs, whose energy will provide the driving force for development. STISA bodies must also help promote and leverage strong communication messages that publicise the wonder of science and the value of science and technology so that society, as a whole, values, appreciates and understands the nature of science and technology.
15. Finally, STISA bodies must work together collectively to promote and respond to opportunities for increased financing of STI across the continent. STISA-2024 recommends the establishment of an African STI Fund (ASTIF) with an emphasis on domestic African mobilisation of resources. A good starting point would be for African countries to realise the goal of 1% GDP to be spent on Research and Development. At the end of the day, resources, financial, in-kind and human, will determine the success of STISA-2024 and of STI and industrial development on the continent. While recognising the value of international support and foreign direct investment, the level of African funds and finance underpinning the financial resources will determine the degree of African ownership of STI developments and, consequently, the directions for future socio-economic and environmental developments on the continent. This requires a strong political will from national governments and a responsiveness from scientists and research institutions to meet the practical needs of development.

### **1.3. Report Structure**

45. This report seeks to give an overview of STI developments in Africa over the past five years 2014-2019 and to contextualize the developments in terms of STISA-2024, Agenda 2063 and the broader political, social, economic, environmental and business developments on the continent. It is not a review of STISA-2024 *per se*. The report does however attempt to outline the continental developments related to science, technology and innovation in a range of categories and priority areas highlighted by STISA-2024.
16. This report is organised into the following sections.
  - i. Section 2 reviews the current status of African research, innovation and entrepreneurship
  - ii. Section 3 reviews progress towards creating an enabling environment for STI through the creation of new continental institutions and through policy

developments at continental, sub-regional and national levels. A sub-section is included that links STI policies to continental integration.

- iii. Section 4 reviews recent cross-cutting continental financing initiatives for Science, Technology and Research, together with trends in research publications and innovation-driven patent activity.
- iv. Section 5 reviews developments relating to innovation and entrepreneurship
- v. Section 6 reviews progress in each of STISA's six priority areas over the past five years. Some of these areas incorporate Agenda 2063 flagship projects and sectoral continental initiatives, complementing the generic initiatives outlined in section 4.

## 2. Current Status of African Research Innovation and Entrepreneurship

17. There are an increasing number of organizations seeking to develop international and global databases on issues relating to innovation and entrepreneurship. A number of significant reports have been issued over the past several years that deserve mention. These include
- i. UNESCO Institute for Statistics Fact Sheets on Global R&D (UNESCO Institute for Statistics, 2017)
  - ii. UNESCO Science Report. Towards 2030 (UNESCO, 2015)
  - iii. The biennial OECD STI Outlook series (OECD, 2018)
  - iv. The four-yearly African Innovation Outlook series (NEPAD, 2014)
  - v. The annual Global Innovation Index Reports (Cornell University, INSEAD, and WIPO, 2018)
  - vi. The annual Global Talent Competitiveness Index Reports (INSEAD, 2019a)

These reports are reviewed in the next three subsections providing overviews on: (i) Research and Science; (ii) Innovation; and (iii) Entrepreneurship.

### 2.1. Research and Science Overview

18. Research Intensity, which is defined as a nation's Global Expenditure on R&D (GERD) as a percentage of its GDP, strongly correlates with national wealth and the national level of development. This is illustrated in Figure 1.2, which outlines the geographic distribution of R&D Intensity. Clearly, African R&D Intensity is low compared to the more developed parts of the world.

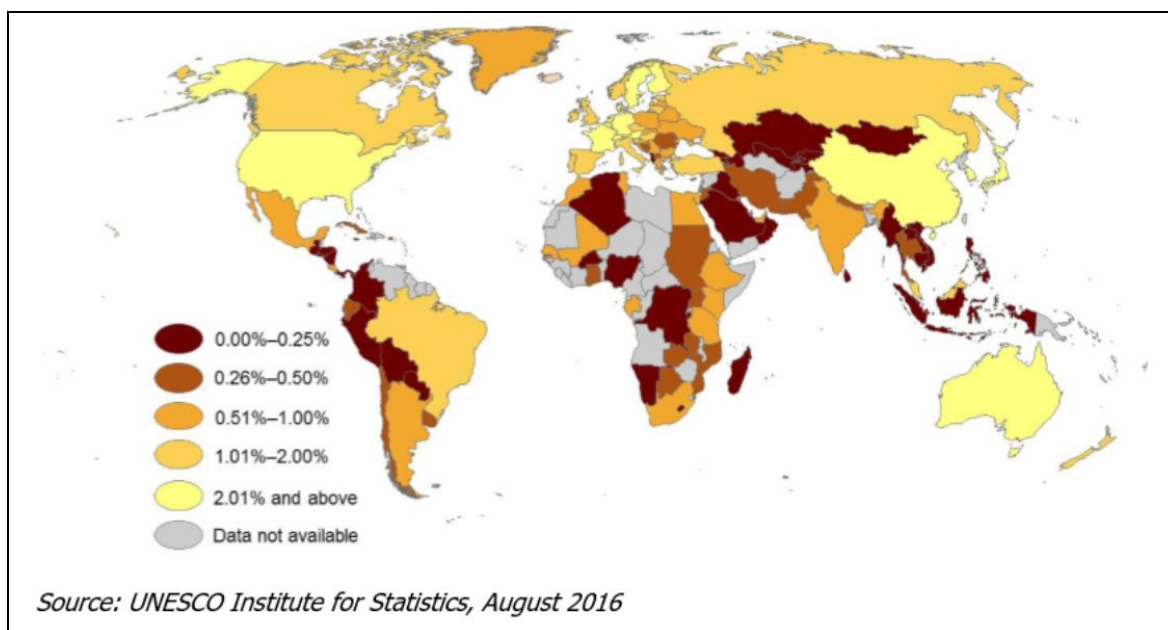


Figure 1.2 Global R&D Intensity (UNESCO Institute for Statistics, 2017)

19. According to the UNESCO Institute of Statistics, however, sub-Saharan Africa is not, as is commonly assumed, the bottom of the global list when it comes to R&D Intensity. The breakdown of Global R&D Intensity, i.e. GERD values as a percentage of GDP is as follows (UNESCO Institute for Statistics, 2017):

- i. 1.7% for World
- ii. 2.4% for North America and Western Europe
- iii. 2.1% for East Asia and the Pacific
- iv. 1.1% for Central and Eastern Europe
- v. 0.7% for Latin America and the Caribbean
- vi. 0.7% for South and West Asia
- vii. 0.4% for Sub-Saharan Africa
- viii. 0.3% for Arab States
- ix. 0.2% for Central Asia

20. The UNESCO Science Report focused on a number of substantive areas of progress over recent years, as well as highlighting challenges. Areas of progress included:

- i. A major increase in the number of countries and Regional Economic Communities (RECs) engaging in the development of, or updating of, STI strategies together with a major effort by a number of RECs to foster scientific integration.
- ii. Several countries making substantive increases in their global expenditure on R&D since 2009, as measured by R&D Intensity, namely Egypt (0.43% to 0.68%) Ethiopia (0.24% to 0.61%) Kenya (0.36% to 0.79%) Mali (0.25% to 0.66%) Senegal (0.37% 0.54%) and Uganda (0.36% to 0.48%).
- iii. Efforts to increase private sector R&D, notably through the successful introduction of innovation hubs in several countries.

Challenges included

- i. Limited diversification due to skills shortages
- ii. Gender inequity, with only 3 in 10 sub-Saharan researchers being a woman
- iii. Lack of adequate investment in Agriculture

21. Although there is a huge task ahead of most sub-Saharan African and North African countries to build their R&D capabilities, it appears that African states may be performing better globally than is commonly thought, when taking into account their GDP levels. African performance in Innovation and Entrepreneurship will be explored in more detail below.

## **2.2. Innovation overview**

22. The OECD Innovation Outlook series, the African Innovation Outlook series and the annual Global Innovation Index reports are each reported on here, but most emphasis

is placed on the Global Innovation Index to provide a comparative assessment of African country performance.

23. The OECD STI Outlook series (OECD, 2018) is a forerunner in global efforts to assess and measure innovation. However, it focuses mainly on OECD countries and on business generated innovation. This has a limited relevance to Africa given the poor data availability on business expenditure in many African countries, and indeed the low levels of business-driven R&D in Africa. The OECD is however seeking to engage more in measurements and studies that are relevant to developing countries and their reports provide excellent articles on the general theory and practice of innovation that are of global relevance to policy makers. Two articles of note in recent OECD reports are:
- i. “The Role of Public Policy” (OECD, 2015, pp. 69-92); and
  - ii. “STI policies for delivering on the SDGs” (Cervantes & Hong, 2018)
24. The African Innovation Outlook series (NEPAD, 2014), organized through AUDA-NEPAD by the African Science Technology and Innovation Indicators (ASTII)<sup>3</sup> initiative is attempting to utilize the approach of the OECD Oslo and Frascati manuals for Africa. In the process, ASTII seeks to build capacity within African countries to measure and document innovation related indicators, which can feed into effective policy making. The first report in 2010 had 19 countries participating and this grew to 35 countries for the second report in 2014, This however dropped to 23 countries in the third report (AUDA-NEPAD, in press) probably owing to the more detailed data requests that were required for this latest edition. As the systems and level of country participation continue to develop, the Africa Innovation Outlook series will likely become the premier source of information on African innovation in future years.
25. The Global Innovation Index (GII) (Cornell University, INSEAD, and WIPO, 2018) produces a global index based on the average of a composite set of Innovation Inputs and a composite set of Innovation Outputs. It includes 28 African countries. It places emphasis on measuring the climate and infrastructure for innovation and on measuring related outcomes. The Index recognises that innovation includes social innovations and business model innovations as well as technical innovation. The manual has the advantage that it gathers its data from existing data sources and does not require extensive additional surveys and sampling. It includes R&D measurement in its assessment of innovation and its approach is relevant for high-income, middle-income and low-income countries. It divides its measurements into seven major composite elements. Each of these has three sub-composite elements and these are fed in turn by a total of 80 indicator measurements. The seven major composite elements are:
- Input Elements**
- i. **Institutions**, composed of: (i) Political Environment; (ii) Regulatory Environment; and (iii) Business Environment.

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<sup>3</sup> <http://www.nepad.org/programme/african-science-technology-and-innovation-indicators-astii>

- ii. **Human capital and research**, composed of: (i) Education; (ii) Tertiary Education; and (iii) Research and development (R&D).
- iii. **Infrastructure**, composed of: (i) Information and communication technologies (ICTs); (ii) General Infrastructure; and (iii) Ecological sustainability.
- iv. **Market sophistication**, composed of: (i) Credit; (ii) Investment; and (iii) Trade, competition and market scale.
- v. **Business sophistication**, composed of: (i) Knowledge workers; (ii) Innovation linkages; and (iii) Knowledge Absorption

**Output Elements**

- vi. **Knowledge and technology outputs**, composed of: (i) Knowledge creation; (ii) Knowledge impact; and (iii) Knowledge diffusion.
- vii. **Creative outputs**, composed of: (i) Intangible assets; (ii) Creative goods and services; and (iii) Online Creativity

26. The GII repeatedly shows sub-Saharan African as the last of the six regions it covers in its overall score for innovation. However, a deeper analysis of the innovation scores against the GDPs of countries allows the index to identify “Innovation Achievers”, i.e. countries that have a score over 10% above what would be expected based on their GDP. Africa contains the greatest number of such achievers of any region, indicating that if the finances and resources were available, African nations could likely compete with their peers in other regions. The 2018 index (Cornell University, INSEAD, and WIPO, 2018), as shown in the Table 2.1 below, identifies the following African countries as “Innovation Achievers”: (i) Kenya; (ii) Malawi; (iii) Mozambique; (iv) Rwanda; (v) Madagascar; (vi) South Africa; and (vii) Tunisia. In 2018 Egypt also performed better than would be expected from its GDP, but failed to make the Achievers List. The other African countries evaluated are largely performing at the level anticipated for their GDP. There are very few African underperformers included within the index, though of course there remain a number of countries that are not yet included due to lack of data.

**Table 2.1. African Innovation Achievers based on a comparison of their Innovation Index with GDP per capita** (Cornell University, INSEAD, and WIPO, 2018)

Country	Income Group	Years as an Innovation Achiever
Kenya	Lower Middle Income	2018, 2017, 2016, 2015, 2014, 2013, 2012, 2011
Malawi	Low Income	2018, 2017, 2016, 2015, 2014, 2012
Mozambique	Low Income	2018, 2017, 2016, 2015, 2014, 2012
Rwanda	Low Income	2018, 2017, 2016, 2015, 2014, 2012
Madagascar	Low Income	2018, 2017, 2016
South Africa	Upper Middle Income	2018
Tunisia	Lower Middle Income	2018

27. The breakdown of the composite global rankings of these countries into the global rankings of their component elements is shown in Table 2.2. It shows that five of the six sub-Saharan African countries, led by Kenya, rank significantly higher than their overall ranking in the elements of business sophistication e.g. through foreign direct investment inflows and high levels of industry-university collaboration, and, in some cases, market sophistication e.g. through ease of access to credit. Rwanda also scores highly in its institutional element, due to its strong regulatory environment. Mozambique appears in the Innovation Achievers list because of its high ranking in knowledge and creative outputs, which is primarily due to high scores in its local generation of utility models and trademarks. Tunisia appear in the list primarily due to its high ranking in Human Capital and Research. This reflects Tunisia's high levels of investment in education in general and in higher education in particular, especially its generation of science and technology graduates.

**Table 2.2. A breakdown of GII global ranking of African 'Innovation Achievers' into their composite elements.** Particularly high-ranking elements compared to the overall ranking are highlighted. Data taken from the country reports in (Cornell University, INSEAD, and WIPO, 2018)

Country	Kenya	Malawi	Mozam -bique	Rwand a	Mada- gascar	S. Africa	Tunisi a
<b>GI Overall Global Ranking</b>	<b>78</b>	<b>114</b>	<b>115</b>	<b>99</b>	<b>106</b>	<b>58</b>	<b>66</b>
Input Elements							
Institutions	84	100	122	<b>60</b>	106	53	77
Human Capital & Research	112	121	104	<b>107</b>	108	64	<b>33</b>
Infra-structure	103	116	107	91	128	84	70
Market Sophistication	<b>61</b>	110	121	<b>34</b>	102	<b>23</b>	111
Business Sophistication	<b>49</b>	<b>94</b>	<b>74</b>	<b>57</b>	112	<b>47</b>	109
Output Elements							
Knowledge & Tech Outputs	70	105	99	124	<b>92</b>	55	63
Creative Outputs	56	110	114	101	<b>80</b>	76	66

28. The potential value of this level of analysis from the Global Innovation Index data to inform policy decisions and planning at country level is self-evident. Combining the individual country analyses also allows some broad statements to be made about the



status of innovation at a continental level. The following statement from the 2017 Global Innovation Index (Cornell University, INSEAD and WIPO, 2017, p. 27) explains some of the factors that underpin the 'relatively' positive performance of sub-Saharan Africa as a whole.

*Noted improvements in the Institutions, Business sophistication, and Knowledge and technology output pillars have allowed the region as a whole to catch up to Central and Southern Asia in these factors, and even to overtake Northern Africa and Western Asia.*

*Led by economies such as Botswana, Mauritius, Rwanda, and South Africa, Sub-Saharan Africa countries this year show their highest scores in Institutions and in Market sophistication. Larger economies, such as Botswana and Namibia, show stronger performances in the General infrastructure and Ecological sustainability sub-pillars. Yet the relatively strong performance in innovation in the region is neither uniform across all economies nor is future success guaranteed. Indeed, economic forecasts predict that Sub-Saharan Africa will face an economic slowdown. As economic slowdown occurs, it will be important for Africa to preserve its current innovation momentum and to continue moving away from relying on ..... commodity revenues*

29. The following statement from the 2018 report (page 38) similarly provides a useful overview of innovation performance in sub-Saharan Africa. Unfortunately, from an African integration perspective, North Africa is paired with West Asia and separated from sub-Saharan Africa for these analyses

*For several editions, the GII has noted that Sub-Saharan Africa performs relatively well on innovation. Since 2012 the region has had more countries among the group of innovation achievers than any other region. It will be important for Africa to preserve its current innovation momentum.*

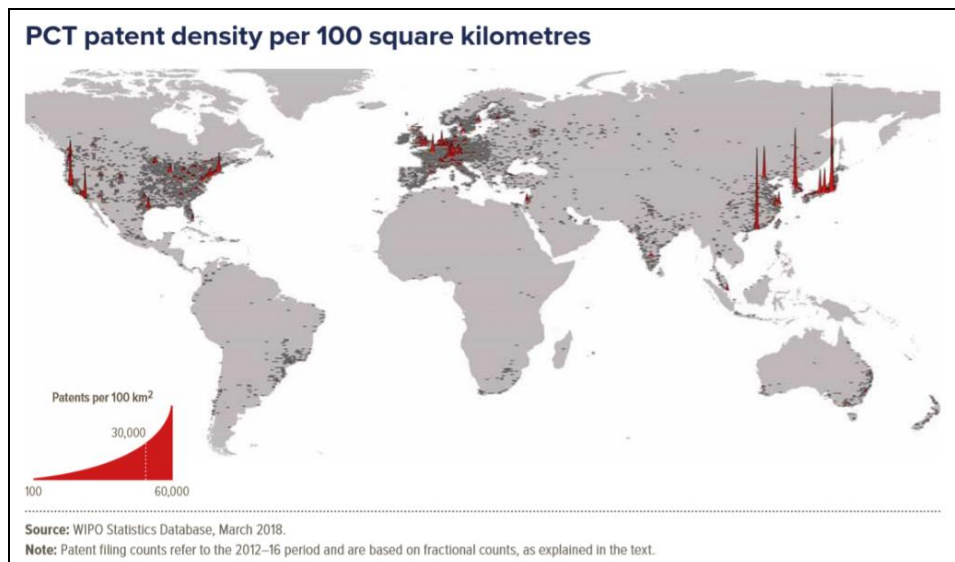
*As last year, this year South Africa takes the top spot among all economies in the region (58th), followed by Mauritius (75th), Kenya (78th), Botswana (91st), the United Republic of Tanzania (92nd), Namibia (93rd), Rwanda (99th), and Senegal (100th). Among these, Kenya, the United Republic of Tanzania, and Namibia improve their GII ranking compared to 2017, while Rwanda and Senegal remain stable and the other three economies (South Africa, Mauritius, and Botswana) lose positions.*

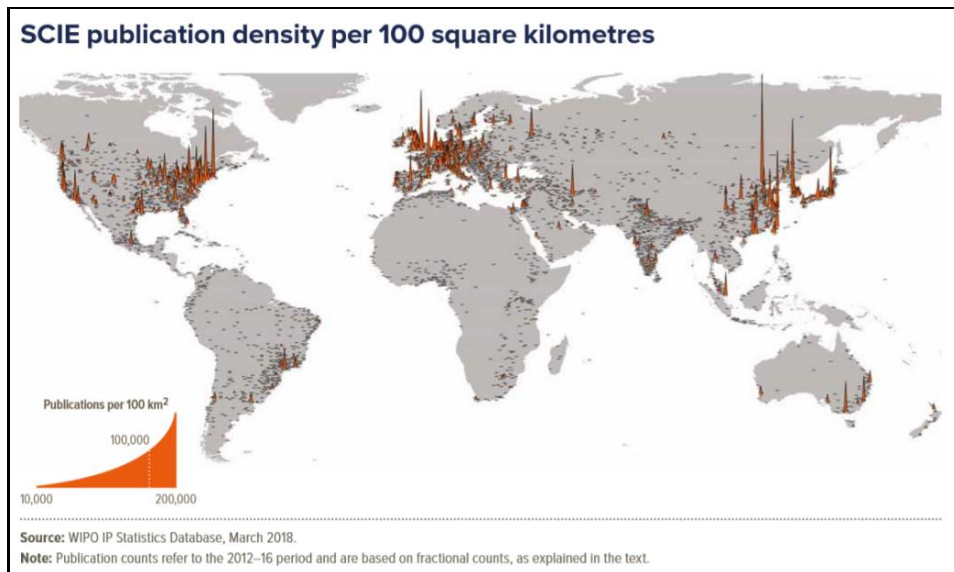
*The remaining 16 economies in this region can be found at ranks lower than 100. Nine of them have improved since 2017: Madagascar (106th), Cameroon (111th), Mali (112th), Zimbabwe (113th) Malawi (114th), Nigeria (118th), Guinea (119th), Zambia (120th), and Niger (122nd).*

*Because of issues with data coverage, Ethiopia and Burundi drop out of the GII this year, while Ghana is added back after having dropped out in 2017.*

### **Importance of Tech and Innovation Clusters**

30. In the last two years the Global Innovation Index has started to collect data on Science and Technology Clusters. Innovation activities are not evenly spread, even within innovative countries and regions. Instead, they tend to concentrate geographically into specific clusters, often around specific areas of expertise. An example of this phenomenon is the famous Silicon Valley in California, which has led to, and attracted, many start-up companies engaged in high technology and social media, including Apple, Facebook and Google, centred around Palo Alto's Stanford University. The power of this academic and business interface is illustrated by the outstanding patent and scientific publishing performance of the Silicon Valley region. If Africa is to promote innovation then it is important to facilitate the development clusters of innovation, linking industry and academia, that have a critical mass of research, innovation and entrepreneurship capacity.
  
31. The 2018 GII globally measures the strength of innovation clusters by taking an average of scores that measure both Patent Convention Treaty (PCT) patent filing and Scientific publications, as measured using the Science Citation Index Expanded (SCIE) database. The global picture that emerges is presented below. As expected, Africa performs poorly from a global perspective, though there is some visible activity. No African centre appears in the top 100 clusters. The top cluster globally is Tokyo-Yokohama.





**Figure 2.1. Geographic density of PCT patent filing and SCIE publications** (Cornell University, INSEAD, and WIPO, 2018)

### 2.3. Entrepreneurship overview

32. This section reviews information provided on entrepreneurship through the Global Talent Competitive Index (INSEAD, 2019a). This index works on the hypothesis that entrepreneurial talent, just as with innovation, closely correlates with economic performance. Most recent studies and recent literature focus on entrepreneurship in small and medium enterprises (SMEs), as an engine of growth. This is particularly relevant to developing countries in Africa, where the number of large, multinational companies is small and where SMEs constitute over 90% of companies (World Bank, 2018). A major challenge in low income countries is to identify entry points for entrepreneurship / talent competitiveness. Once this has been achieved there is a further challenge, especially in Africa, to access credit. Much of the work of the World Bank and other agencies, operating in the area of microfinance and small medium enterprise development, is to develop and test innovative ways of providing access to credit that is sustainable e.g. novel concepts of collateral that can be used as the basis for loans.
33. Much like the Global Innovation Index, the Global Talent Competitiveness Index is based upon several main composite Input and Output Indicators, each composed of several component indicators. These are listed below for reference.

#### Input Elements

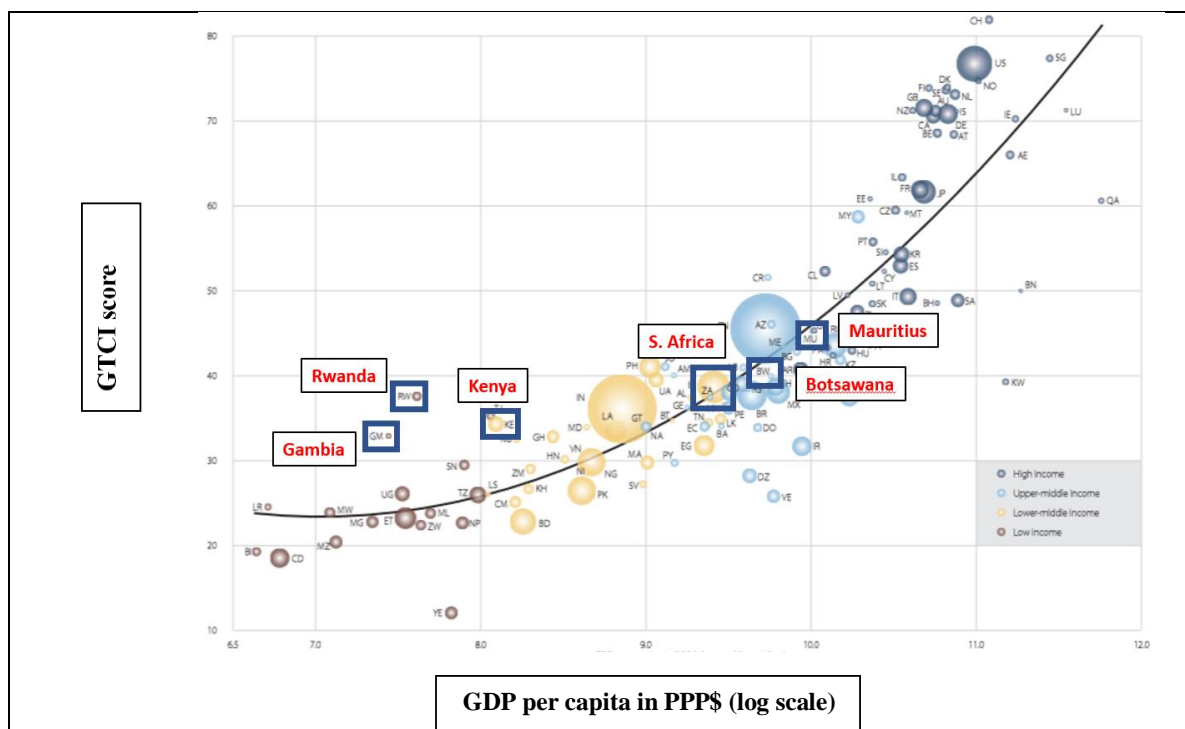
- i. **Enable**, composed of: (i) Regulatory Landscape; (ii) Market Landscape; and (iii) Business and Labour Landscape.
- ii. **Attract**, composed of: (i) External Openness; and (ii) Internal Openness.
- iii. **Grow**, composed of: (i) Formal Education; (ii) Lifelong Learning; and (iii) Access to Growth Opportunities.
- iv. **Retain**, composed of: (i) Sustainability; and (ii) Lifestyle.

#### Output Elements

- v. **Vocational and Technical Skills**, composed of: (i) Mid-level Skills; and (ii) Employability.
- vi. **Global knowledge Skills**, composed of: (i) High-level Skills; and (ii) Talent Impact.

The GTCI index is the average of each of the scores for the six composite indicators above

34. A graphic illustration of the GTCI scores plotted against the log of GDP per capita (measured using Purchasing Power Parity dollars (PPP\$)) is given in Figure 2.2, taken and adapted from the GTCI Index 2019 report. The different coloured circles represent low-income, lower middle income, upper middle income and high-income countries. The African countries fall into the low income and lower middle-income bracket. As such, they have low GTCI scores. Most of them lie on or around the curve, indicating that they are performing as expected for their level of income. There are six countries highlighted; this is for two reasons. First, Mauritius, Botswana and South Africa are highlighted because they lie 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> respectively within sub-Saharan Africa. They perform well, but their performance is essentially aligned to their GDP per capita score. The second group consists of Rwanda, Kenya and Gambia. These are selected as standout performers as they lie above the curve and are performing exceptionally well compared to their GDP per capita.
35. The composite data for the six countries identified is provided in Table 2.3. The table presents the overall GTCI ranking and the global rankings of the component elements of the GTCI. It is notable that all of the selected countries perform best in their 'input elements' rather than their 'output elements'. They are all strong at attracting talent, both at a business and people level. Several have a strong enabling environment, with a good regulatory, market and business and labour landscape. Botswana, South Africa and Kenya also score highly in the growth category, which includes factors such as formal education, lifelong learning and collaborative environment. With these input elements increasingly in place it is hoped that these countries, and others in the region, may start to also enhance their output elements and thus generate wealth and become more competitive in the future.



**Figure 2.2. GTCI score vs Log scale GDP per capita with selected countries highlighted.** GDP per capita in PPP\$ and population data (represented by the size of the bubbles) are for 2017 or the latest year available. The data are drawn from the World Bank’s World Development Indicators database. The trend line is a polynomial of degree two ( $R^2 = 0.77$ ). Taken and adapted from the country reports in (INSEAD, 2019b, p. 14)

**Table 2.3. A breakdown of GTCI global rankings of selected African countries into their composite elements.** Particularly high-ranking elements compared to the overall ranking are highlighted. Data taken from the country reports in (INSEAD, 2019b).

Country	GTI overall ranking	Input Rankings				Output Rankings	
		Enable	Attract	Growth	Retention	Vocational Technical Skills	Global Knowledge Skill
Top three performers in sub-Saharan Africa							
Mauritius	47	32	32	59	50	43	81
Botswana	62	49	35	49	94	85	67
S. Africa	71	71	52	45	102	68	64
Standout performers compared to their GDP per capita							
Rwanda	73	36	36	73	90	98	108
Kenya	85	75	54	70	110	75	91

Gambia	93	63	32	97	101	82	122
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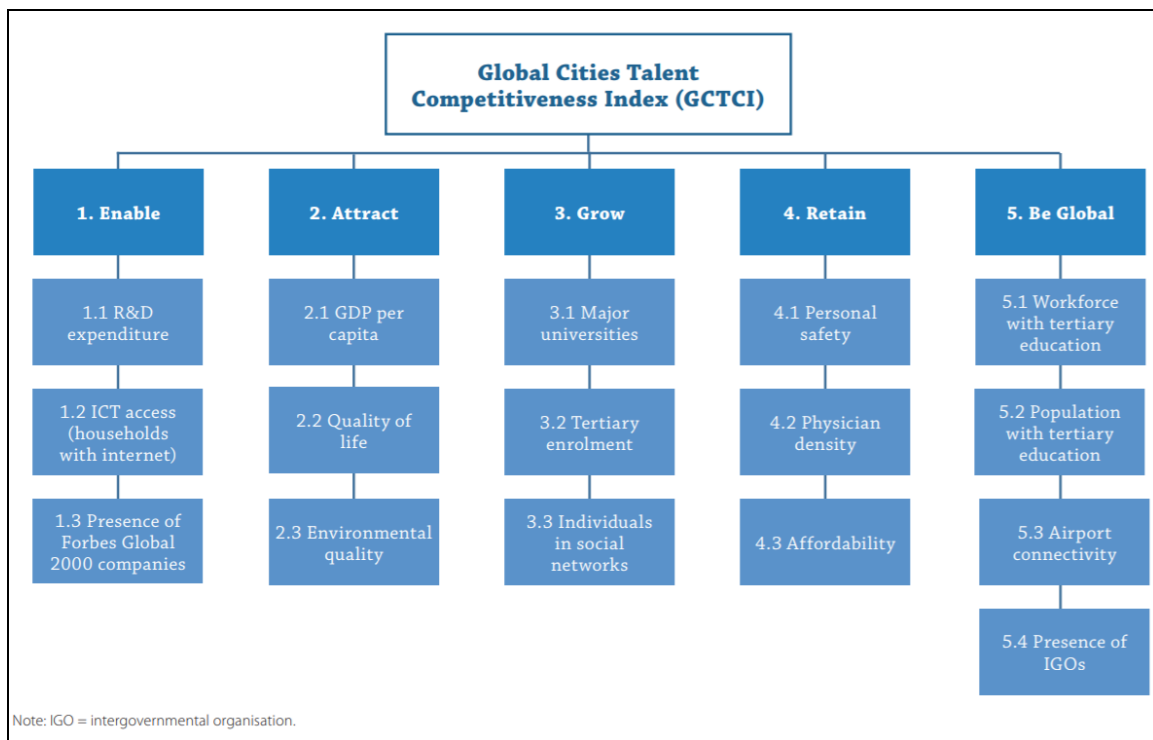
21. The following summary of sub-Saharan talent competitiveness is provided in the GTCI 2019 report (page 35)

*Sub-Saharan Africa (24 countries): It has already been seen that this region has the weakest average performance in the GTCI 2019. .... This is not a surprising result given that 14 of the countries in the region belong to the low-income group, .... The top performer in the region, Mauritius (47th), is one of only two countries with an overall score above the GTCI median. This stems above all from its solid performance in the Enable (32nd) pillar, where it performs relatively well in all three sub-pillars. At the other end of the spectrum, the country faces a challenge to improve its pool of Global Knowledge Skills (86th), particularly with respect to High-Level Skills (89th). The other country with a score above the GTCI median is Botswana (62nd). Its main strength lies in attracting (35th) talent, which is boosted by a high degree of Internal Openness (21st). More discouraging is the country's performance in the Retain (94th) pillar, which is due to weak ranks in both Sustainability (85th) and Lifestyle (94th). South Africa (71st) is the third-best performing country in the region, registering a relatively high score in the Grow (45th) pillar that can be attributed to good Access to Growth Opportunities (33rd). When it comes to retaining (102nd) talent, however, the country's performance is well below par as a result of disappointing levels of Sustainability (103rd) and Lifestyle (99th). A welcome feature of the GTCI 2019 is that the country coverage of Sub-Saharan Africa has expanded by six countries compared with last year. Among the six is the largest economy in the region: Nigeria (99th). Its most encouraging performance is related to attracting (61st) talent, which is chiefly driven by luring foreign resources and talent (it ranks 57th in External Openness). All the same, the country finds itself in the bottom quartile in four of the six pillars (Enable: 95th; Grow: 103rd; Retain: 120th; Global Knowledge Skills: 97th); clearly Nigeria has plenty of scope to strengthen its talent competitiveness.*

### **The importance of City Clusters to Promote Entrepreneurship**

22. Just as the Global Innovation Index (GII) highlighted the significance of 'Innovation Clusters' to promote innovation, a similar phenomenon can be observed when addressing entrepreneurship. The GTCI 2019 Report presents a specific methodology for assessing a city's competitive talent index. A scheme outlining this assessment is provided in Figure 2.3.
23. Table 2.4 compares the top 10 cities from the GTCI with the top 10 clusters from the GII. Although many cities score highly both for innovation and talent competitiveness, there is not a direct correlation between the two. The Global innovation Index only

provides information for the top 100 clusters and no African city or cluster features in the top 100. The GTCI index provides data on 114 cities. Encouragingly, several African cities appear on that list, albeit at the bottom of the list.



**Figure 2.3.** A scheme to illustrate the measurement of a Global Cities Talent Competitiveness Index (INSEAD, 2019b, p. 73)

**Table 2.4.** Comparison of top 10 city/cluster rankings for innovation and talent competitiveness and ranking of African cities. Data taken from (Cornell University, INSEAD and WIPO, 2017; INSEAD, 2019a)

Rank	Innovation Clusters (GII)	City (GTCI)
1	Tokyo-Yokohama	Washington DC
2	Shenzen-Hong Kong	Copenhagen
3	Seoul	Oslo
4	San Jose-San Francisco	Vienna
5	Beijing	Zurich
6	Osaka-Kobe	Boston
7	Boston-Cambridge	Helsinki
8	New York	New York
9	Paris	Paris
10	San Diego	Seoul
African cities		
109		Tunis
111		Casablanca

112		Cape Town
113		Cairo
114		Nairobi

24. One of the main messages from the Global Talent Competitiveness Index for 2019 is that cities, and their strategic management, play an important role in the generation of innovation and entrepreneurship. The competitiveness of individual cities will therefore play a critical role in national and continental competitiveness. Policy makers in Africa therefore need to think beyond national policies and strategies and engage with local government to build a strong innovation and entrepreneurial culture. The concept of building an innovation and entrepreneurial culture is as important as providing the bricks and mortar of buildings for a city's economic success. Local government can assist in the provision of critical services that support innovation, entrepreneurship and business in general. These include such items as transport and waste management, but also an environment and that promotes social inclusion across traditional societal divides of tribe, gender and nationality. Above all there is a need to recognize, nurture and reward the talent that will bring economic growth to society as a whole, regardless of its origins.

## 2.4. Conclusions

25. Africa as a region, primarily because of its low levels of GDP, continues to perform badly in areas of research and science, innovation and entrepreneurship, when compared with other regions globally.
26. However, there are a number of reasons to be hopeful. Firstly, African countries as a whole, whether lower middle-income or low income, perform equally as well as their counterpart countries with similar GDP levels in other regions. Secondly, a number of countries appear as standout performers, with higher scores for innovation and entrepreneurship than would be expected from their GDP levels. The foundations appear to be in place for a number of countries to convert their innovation and entrepreneurship potential into economic growth and prosperity.
27. A major concern is that many countries, primarily those with the lowest GDP per capita, are not in a position to provide data on research, innovation and entrepreneurship. There is a danger that these countries get left further behind in terms of education, innovation and development. As we celebrate the successes of certain countries, we must seek to assist those that are in danger of falling further behind.
28. There is increasing evidence that countries should seek to foster localised 'innovation' and 'entrepreneurship' clusters, if they are to fully realise the economic and developmental benefits of STI. Such clusters would comprise cities or regions where academic centres of excellence, technology hubs and start-up companies can interact with each other.





### 3. Creating and Enabling Environment

29. STISA-2024 included an institutional architecture for its implementation (Figure 1.1). The stated institutional and implementation architecture for STISA 2024 is broadly divided into: (i) decision making structures and processes within the AU structure, supported by the AUC; and (ii) implementing structure and processes involving a variety of institutions, including AUDA-NEPAD; African Development Bank, Regional Economic Communities (RECs); Governments; Private sector; Specialised agencies and Development Partners.
30. The creation of an enabling environment for Science Technology and Innovation through policy and institutional development on the continent of Africa is considered through four sub-sections below: (i) continental level institutional development; (ii) continental level policy development, focusing primarily on the African Union and associated developments; (iii) sub-regional and national policy developments; and (iv) linking STI policies and actions to African integration.

#### 3.1. Continental Institutional Development

31. A substantive number of institutions that relate to STISA-2024, either directly or indirectly, have been formally created by African Union statute since 2014. These are outlined in Table 3.1 and are individually described in this section. For completeness, another group of institutional initiatives are presented Table 3.2 that pre-date 2014 and are related to STISA priority areas. These are referred to in Section 6 on progress in STISA priority areas.

**Table 3.1. Institutional Initiatives Related to STISA and Established by African Union Statute post-2014**

See Section	Name	Acronym	Year Established
<b>Institutions Established Post-2014 Directly Linked to STISA</b>			
3.1	African Scientific, Research and Innovation Council	ASRIC	2016
3.1	African Observatory for Science, Technology and Innovation	AOSTI	2016
3.1	Pan African Intellectual Property Organization	PAIPO	2016
<b>Institutions Established Post-2014 Indirectly Linked to STISA</b>			
3.1	Pan African Quality Assurance and Accreditation Framework	PAQAF	2014
3.1	Africa Centres for Disease Control and Prevention	CDC	2016
3.1	Committee of Ten Heads of State and Government (C10) championing Education, Science and Technology	AU-C10	2015
3.1	Africa Virtual and E-learning University		2017

3.1	Pan-African Private Sector Trade and Investment Committee	PAFTRAC	2018
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**Table 3.2. Institutional Initiatives Related to STISA and Established by African Union Statute pre-2014**

Institutional Programmes Established Pre-2014			
See Section	Name	Acronym	Year Established
6.1	Comprehensive Africa Agriculture Development Programme	CAADP	2013
6.3	Programme for Infrastructure Development in Africa	PIDA	2012
6.2	Pharmaceutical Manufacturing Plan for Africa	PMPA	2007

### **African Scientific, Research and Innovation Council (ASRIC)**

32. The role of ASRIC is determined by its Statute (AU, 2016a). Its stated objective is “to promote scientific research and innovation in order to address the challenges of Africa’s socio-economic development.” ASRIC serves as the interface between the AU decision making processes of STISA and the implementation processes, notably led by AUDA-NEPAD. It is critical to the STISA architecture (see Figure 1.2). It was formally launched in November 2018 in Abuja. If it works well it should provide a voice for the Science and Technology Community to feed into AU policy and into regional and national policy and practice. It will also provide a vehicle for policy makers to clearly express what they expect from the Science and Technology community of Africa. It represents a powerful democratisation of science in Africa. It offers a voice for science and may also offer a strong voice for innovators and industry. It provides a voice for ‘women in science’ and ‘youth in science’. As a science / policy interface it is unique in the world.
33. ASRIC will be overseen by a bureau consisting of Chairs of Academies of Science from each of Africa’s five main regions and will operate through three committees; (i) Science and Innovation; (ii) Communication; and (iii) Resource Mobilization. The AU Scientific Technical Research Commission (AU-STRC) will act as the Secretariat to ASRIC and will also work closely with AUDA-NEPAD. The role of AUDA-NEPAD is to facilitate and coordinate the implementation of regional and continental priority programmes and projects and to push for partnerships and complementary resource mobilization and research and knowledge management.

### **African Observatory for Science, Technology and Innovation (AOSTI)**

34. The African Union formally endorsed the Statute for the establishment of the African Observatory for Science, Technology and Innovation (AOSTI) in January 2016 (AU, 2016b). AOSTI has the mandate, among others, to develop a framework for reviewing national innovation systems. It is anticipated that AOSTI will work with, and build on

the work of, AUDA-NEPAD and the African Science Technology Innovation Indicators (ASTII) initiative that has produced a 4-yearly African Innovation Outlook series for the continent (NEPAD, 2014). With these organisations in place it is anticipated that coherent and relevant continental STI data will soon be available to assist policy makers and help drive STI instigated development across the continent.

### **Pan African Intellectual Property Organization (PAIPO)**

35. The World Intellectual Property Organisation (WIPO) defines Intellectual Property (IP) as “creations of the mind: inventions, literary and artistic works, and symbols, names, images, and designs used in commerce.” Rights over IP are conferred on creators or innovators over their works for a specified period of time through patents, copyrights, trademarks and industrial designs. This provides the owners of intellectual property commercial protection as they develop and benefit from their inventions and innovations. However, it also ensures that the information is in the public domain to allow for further competitive innovation and to be available for generic application after the defined time period. The rights of the owner and those of society are therefore balanced. The application of intellectual property rights has stimulated innovation where it has been applied. The establishment of operational intellectual property systems in countries is a likely prerequisite for the expansion of innovation led growth.
36. The statute of the Pan African Intellectual Property Organization (PAIPO) was adopted in January 2016 (AU, 2016c) and will come into force 30 days after 15 Member States have ratified it. It was originally intended that PAIPO should begin its scheduled activities in 2018 and be fully functional by 2023 (AU, 2017a). However, it is yet to start its scheduled activities. The mandate of PAIPO is that it “shall be responsible for intellectual property and other emerging issues related to intellectual property in Africa and shall promote effective use of the intellectual property system as a tool for economic, cultural, social and technological development of the continent as well as set intellectual property standards that reflect the needs of the African Union, its Member States, RECs, ARIPO and OAPI.”

### **Pan African Quality Assurance and Accreditation Framework**

37. In 2012 the AU Executive Council made a decision to establish a continental Accreditation Agency for Higher Education<sup>4</sup>. In 2014, with support from UNESCO, the African Region agreed the Addis Declaration, a “Revised Convention on the Recognition of Studies, Certificates, Diplomas, Degrees and Other Academic Qualifications in Higher Education in African States.” (UNESCO, 2014). In response to these decisions the African Union Commission (AUC) with support from the European Association for Quality Assurance in Higher Education (ENQA) and in partnership with the Association of African Universities, has initiated the development

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<sup>4</sup> <https://au.int/en/decisions/council>

of a Pan-African Quality Assurance and Accreditation Framework (PAQAF)<sup>5</sup> (Okebukola, & Fonteyne, 2014).

### **Africa Centres for Disease Control (CDC)**

38. The recent Ebola outbreaks, the ongoing challenges of infectious disease killers such as HIV/AIDS, tuberculosis, malaria, childhood pneumonia and diarrhoeal diseases, and the emergence and recognition of non-communicable diseases such as cancer, cardiovascular diseases and diabetes, have focused the attention of health professionals over the last two decades. There is a recognised value in coordinated action and in data acquisition and data sharing across Africa to reduce the continental health burden. This can best be addressed by a continental Centres for Disease Control (CDC). Africa CDC was established and its statute approved by the 26th Assembly of the Heads of State and Government in January 2016 and was officially launched on 31st January 2017. The Africa CDC will assist Member States through supporting the development of public health institutes. These will especially focus in the first instance on prevention of infection and on surveillance and response to emergencies, whether man-made or natural, especially those of regional and international concern. The Africa CDC has developed a five-year strategic plan (2017—2021) built upon the following five pillars (AU, 2017b; AU, 2017c):
- i. Surveillance & Disease Intelligence
  - ii. Information Systems
  - iii. Laboratory Systems and Networks
  - iv. Emergency Preparedness and Response
  - v. Public Health Research

### **Committee of ten Heads of State and Government (AU-C10), Championing Education, Science and Technology in Africa**

39. The African Head of States and Governments during the June 2015 Assembly established the Committee of 10 Heads of State and Government (two from each geographic region of Africa) as African champions of Education, Science and Technology. West Africa is represented by Senegal and Sierra Leone; North Africa, Egypt and Tunisia; Southern Africa, Malawi and Namibia; East African, Kenya and Mauritius, and Central Africa, Chad and Gabon. The Committee supports the implementation of the Science, Technology and Innovation Strategy for Africa so that it may drive economic growth in Africa in line with Agenda 2063. The Committee held its first meeting in Lilongwe, Malawi in November 2018 (AU, 2018b).

### **Africa Virtual and e-Learning university**

40. The decision has been taken to operate an Africa Virtual and E-learning university under the auspices of the Pan African University (AU, 2017d; Waruru, 2017). A previous institution, the African Virtual University will be incorporated into the Pan

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<sup>5</sup> <http://www.universityworldnews.com/article.php?story=20171117090752810>

African University (PAU) moving from Nairobi to Yaoundé, where the rectorate of the PAU is located. As well as providing an opportunity to massively increase the numbers of undergraduate students, it also provides an opportunity to increase the number of postgraduate research programmes and students, stimulating research generally, including research relating to STI.

### **Pan-African Private Sector Trade and Investment Committee (PAFTRAC)**

41. The Pan-African Private Sector Trade and Investment Committee (PAFTRAC) was recently revived by the African Union in partnership with Afreximbank (AU, 2018c; B&FT Online, 2018). This committee provides an opportunity for the strategic review and oversight of integrating Trade and Industry across the continent. It also offers a potential interface for a dialogue to be created between the Trade and Industry sector and the Science Technology and Innovation sector. The secretariat of PAFTRAC will be hosted by Afreximbank. Membership of the Committee is drawn from leading private sector institutions and corporate entities across Africa, as well as from a range of continental and regional institutions. Members include: (i) Business organizations and traders with a significant continental footprint; (ii) Regional and sub-regional business associations and councils; (iii) Chambers of commerce; (iv) Industry associations; (v) Financial institutions; (vi) Professional, and policy research institutions; and (vii) Other relevant entities and strategic partners involved with trade and investment issues. PAFTRAC will therefore provide a framework to facilitate African Private Sector participation and engagement in trade and investment issues in Africa, including trade and investment policy formulation and trade negotiations. It is anticipated that PAFTRAC could serve as a stepping-stone toward the establishment of the African Business Council, which is envisaged under the African Continental Free Trade Area (CFTA) Architecture (UNCTAD, 2016; Afreximbank, 2018a).

## **3.2. Continental Policy Development**

42. There are three sector-wide continental wide policies that have a direct Impact on Science Technology and Innovation, namely the Decision to establish a Continental Education Strategy for Africa 2016-2025 (AU, 2016d) and the Continental Strategy for Technical and Vocational Education and Training (TVET) (AU, 2007). Another major policy decision that will have an impact on Science Technology and innovation is the policy to develop a Continental Free Trade Area (UNCTAD, 2016) and an associated Action Plan on Boosting Intra-Africa Trade (BIAT).<sup>6</sup> There has also been development of an African Space Policy (AU, 2016e). These are listed for ease of reference in Table 3.3.

**Table 3.3. Policy Initiatives Related to STISA Established by the African Union.**

Policy Name	Acronym	Year published
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<sup>6</sup> <https://au.int/en/ti/cfta/about>

Policy Established Pre-2014		
Continental Strategy for Technical and Vocational Education and Training (TVET)	TVET Strategy	2007
Decision to Establish a Continental Free Trade Area	CFTA	2012
Policies Established Post-2014		
Continental Education Strategy for Africa 2016-2025	CESA 16-25	2016
African Space Policy		2016

### Continental Education and TVET Strategies

43. STISA-2024 has a strong interface with both CESA 16-25 and the Continental Strategy for Technical and Vocational Education and Training (TVET). Particularly noteworthy interfaces occur with CESA 16-25 through its strategic objective 8 to  
*“expand TVET opportunities at both secondary and tertiary levels and strengthen linkages between the world of work and education and training systems”*  
and strategic objective 9 to  
*“Revitalize and expand tertiary education, research and innovation to address continental challenges and promote global competitiveness.”*  
A set of indicators has been developed for the implementation of CESA 16-25 (AU, 2016f)
44. A major approach to operationalise the linkages between STISA-2024 with CESA 16-25 and the TVET strategy is to promote common frameworks for qualifications that link the world of TVET and of Higher Education in general, and promote intracontinental recognition of qualifications leading to enhanced intracontinental mobility. Bateman and Coles (2013) review the concept of Qualifications Frameworks, noting the rise of overarching regional frameworks. The most well-established regional framework operates under the European Association for Quality Assurance in Higher Education (ENQA)<sup>7</sup>. The ENQA is partnering with the AUC to develop a Pan-African Quality Assurance and Accreditation Framework (PAQAF)<sup>8</sup> (Okebukola, & Fonteyne, 2014).
45. STISA-2024 has to be viewed as part of a continuum involving all three strategies, namely CESA 16-25, TVET strategy and STISA-2024. It is noteworthy that the recently convened First Extra-Ordinary Summit for The Committee of Ten Heads of State and Government (C10) Championing Education, Science, and Technology, held on 2<sup>nd</sup>–3<sup>rd</sup> November 2018, in Lilongwe, Malawi covered all three of these strategic elements within their meeting remit. This is reflected within the Lilongwe Declaration that

<sup>7</sup> <https://enqa.eu/>

<sup>8</sup> <http://www.universityworldnews.com/article.php?story=20171117090752810>

accompanied the meeting (AU, 2018d) and its accompanying Action Plan (AU, 2018e). The Action Plan called for action in a number of critical areas, notably:

- i. Development of funds to finance STI development and activity
- ii. Member States to meet the target of 1% GDP on Research and Development
- iii. Promoting Early Childhood Development
- iv. Strengthening Teacher Development and Retention
- v. Enhancing TVET and Skill Development for Employment
- vi. Advancing the Implementation of the Pan African Quality Assurance and Accreditation Framework (PAQAF) and its domestication at regional and national levels
- vii. Strengthen Higher Education Science Technology and Innovation
- viii. Promote Engagement of the Private Sector in Education Science Technology and Innovation
- ix. Promote Linkages between Research Institutions and the Private sector
- x. Enhance Knowledge Sharing, Communication and Advocacy
- xi. Creation of a Think Tank of Eminent individuals from across Africa and the Diaspora to assist the 'C10' in their task of taking forward Education, Science and Technology in Africa

### **The Continental Free Trade Area**

46. Continental Free Trade Area (CFTA) negotiations were formally launched in 2015. The African Continental Free Trade Agreement (AfCFTA) (AU, 2018f) was submitted for signature at an Extraordinary Summit of the African Union from 17-21 March, 2018 and as of March, 2019 all but three countries (Benin, Eritrea and Nigeria) had signed (tralac, 2019). The main objectives of the AfCFTA, as stated in the agreement, are:

*to create a single continental market for goods and services, with free movement of business persons and investments, and thus pave the way for accelerating the establishment of the Customs Union. It will also expand intra-African trade through better harmonization and coordination of trade liberalization and facilitation and instruments across the RECs and across Africa in general. The AfCFTA is also expected to enhance competitiveness at the industry and enterprise level through exploitation of opportunities for scale production, continental market access and better reallocation of resources.*

47. The detailed continental negotiations are still in progress. They are made more complicated by a number of ongoing sub-regional free trade area negotiations, notably a tripartite trade agreement between the Common Market for Eastern and Southern Africa (COMESA), the East African Community (EAC) and the Southern African Development Community (SADC) (tralac, 2015b) that will likely be superseded by the CFTA negotiations. The impact of a continental free trade agreement on Science Technology and Innovation will be substantive. It will allow visa-free travel across the



continent, easy exchange of goods and services and the facilitated flow of information that these two features will unleash. The seventh report on African Regional Integration explores the interface of free trade and STI in some detail (ECA, 2016b). The CFTA is further discussed in section 6.6.3.

### **African Space Policy**

48. The African Space Strategy (AU, 2016e) is predicated on the need for African nations to engage nationally and collectively in space exploration and satellite technology and the economic and developmental benefits that arise from such an engagement. The policy goals are for an African space programme are:
- i. To create a well-coordinated and integrated African space programme that is responsive to the social, economic, political and environmental needs of the continent, as well as being globally competitive.
  - ii. To develop a regulatory framework that supports an African space programme and ensures that Africa is a responsible and peaceful user of outer space.

The applications of space technology span communications, global positioning and navigation services, weather forecasting and other earth observational activities, and can contribute massively to future socio-economic development. Several African countries are engaging significantly in space technology and plans are in preparation to establish an African Space Agency (AU, 2017e). Recent developments related to Space policy are covered in more detail in Section 6.4.3.

## **3.3. Sub-regional and National STI Policy Developments**

### **Sub-regional STI policy**

49. Table 3.3 provides information on STI-related objectives, institutions and policies within the eight Regional Economic Communities of the African Union. The East African Community (EAC) and the Economic Community of West African States (ECOWAS) appear to be the most developed in the process of integrating Science Technology and Innovation across their Economic Communities through the establishment of regional STI policies. The other RECs all include STI within their activities. Some further analysis of REC policy can be found in the 7<sup>th</sup> report on Assessing Regional Integration in Africa (ECA, 2016b, pp. 83-97) and an AAS (2018) report.

**Table 3.3. Summary of STI objectives and policy status in Regional Economic Communities.**

REC	Status
SADC <sup>9</sup>	<ul style="list-style-type: none"> <li>• SADC has a Science Technology and Innovation Desk, launched in 2008, through a special protocol, to pursue goals and objectives of the region for STI through the Regional Indicative Strategic Development</li> </ul>

<sup>9</sup> <https://www.sadc.int/themes/social-human-development/science-technology-innovation/>

	<p>Plan (2005-2020). Science and Technology is considered a cross-sectoral priority intervention area within the plan</p> <ul style="list-style-type: none"> <li>• The Protocol outlines the framework of cooperation between Member States regarding science and technology within the region.</li> <li>• The overall aim of the development and application of science and technology in the region is to develop and strengthen national systems of innovation that drive sustained socio-economic development</li> <li>• SADC launched a Pharmaceutical Business Plan in 2017</li> </ul>
IGAD <sup>10</sup>	<ul style="list-style-type: none"> <li>• IGAD was established in 1996.</li> <li>• It has two objectives that are STI-related, namely (i) Promote joint development strategies and gradually harmonise macroeconomic policies and social, technological and science fields; and (ii) Facilitate, promote and strengthen cooperation in research development and application in science and Technology.</li> <li>• STI is specifically included within the IGAD Strategy Implementation Plan (2016-2020).<sup>11</sup></li> </ul>
ECOWAS <sup>12</sup>	<ul style="list-style-type: none"> <li>• ECOWAS adopted a Policy on Science and Technology (ECOPOST) in 2011 as an integral part of its 10-year plan Vision 2020.</li> <li>• An emphasis is being made to improve data collection to inform national and regional policies</li> <li>• Recent meetings<sup>13</sup> have been convened to emphasize STI as a critical component for the Structural Transformation of the Economies of ECOWAS Member States by 2023.</li> </ul>
ECCAS <sup>14</sup>	<ul style="list-style-type: none"> <li>• ECCAS established in 1983. It seeks harmonisation of policies in many sectoral areas, including in science and technology.</li> <li>• ECCAS plans to implement a regional private sector development programme in Central Africa with support from the European Union</li> </ul>
COMESA <sup>15</sup>	<ul style="list-style-type: none"> <li>• The Common Market for Eastern and Southern Africa (COMESA) was formed in December 1994</li> <li>• COMESA established an Innovation Council in 2012 to support mobilisation and organisation of scientists and engineers, and encourage innovation by individuals and small and medium enterprises (SMEs).<sup>16</sup></li> </ul>
EAC <sup>17,18</sup>	<ul style="list-style-type: none"> <li>• The East African Community (EAC) was originally founded in 1967, dissolved in 1977, and revived in 1999.</li> </ul>

<sup>10</sup> <https://www.uneca.org/oria/pages/igad-intergovernmental-authority-development>

<sup>11</sup> <https://igad.int/documents/6-igad-rs-implementationplan-final-v6/file>

<sup>12</sup> [https://en.wikipedia.org/wiki/ECOWAS\\_Policy\\_on\\_Science\\_and\\_Technology\\_\(ECOPOST\)](https://en.wikipedia.org/wiki/ECOWAS_Policy_on_Science_and_Technology_(ECOPOST))

<sup>13</sup> <http://www.ecowas.int/science-technology-and-innovation-experts-meet-on-way-forward-for-ecowas-regional-development/>

<sup>14</sup> <https://www.uneca.org/oria/pages/eccas-economic-community-central-african-states>

<sup>15</sup> <https://www.uneca.org/oria/pages/comesa-common-market-eastern-and-southern-africa>

<sup>16</sup> <https://www.theeastafrican.co.ke/news/Comesa-council-set-up-to-promote-science-and-technology/2558-1639716-view-printVersion-nhpff1/index.html>

<sup>17</sup> <https://www.uneca.org/oria/pages/eac-%E2%80%93-east-african-community>

<sup>18</sup> <https://easteco.org/>

	<ul style="list-style-type: none"> <li>• It has two subsidiary institutions relevant to STI, namely: (i) East African Science and Technology Commission (EASTECO); and (ii) Inter-University Council for East Africa</li> <li>• EASTECO has a Strategic Plan (2017-2022)<sup>19</sup></li> <li>• EASTECO is in process of establishing and East African STI Policy</li> </ul>
AMU <sup>20</sup>	<ul style="list-style-type: none"> <li>• The AMU was founded in 1989.</li> <li>• There are two STI associated institutions, namely (i) The University of Maghreb; and (ii) The Maghreb Bank for Investment and Foreign Trade</li> </ul>
CEN-SAD <sup>21</sup>	<ul style="list-style-type: none"> <li>• CEN-SAD was established in 1998</li> <li>• One of CEN-SAD's founding objectives is Coordination of pedagogical and educational systems at the various educational levels, and in the cultural, scientific and technical fields.</li> <li>• CEN-SAD has established the Sahel-Saharan Bank for Investment and Trade</li> </ul>

50. The sub-regional policy and strategic approaches undertaken by the RECs may also be complemented by other regional initiatives designed to promote innovation and entrepreneurship. Two initiatives worth noting are the Southern Africa Network for Biosciences (SANBio),<sup>22</sup> based around the Council for Scientific and Industrial Research as a hub in South Africa, and the Biosciences for Eastern and Central Africa-International Livestock Research Institute (BecA-ILRI) Hub.<sup>23</sup> Both networks are based around the concept of a hub with strong central research capabilities and node research institutions and universities in partner countries that each have expertise in a relevant bioscience area. In the past five years SANBio has benefited from its association with programme funding of €7.82 million from the Government of Finland in partnership with South Africa (BioFISA II) that has led to a number of innovations that have market potential. The BECA-ILRI hub has benefited from substantive infrastructure development at ILRI through the Canadian International Development Agency (CIDA) and assistance from a number of other partners.

### National STI Policy

51. Specific policy developments at national level are critical. The 7<sup>th</sup> report on Assessing Regional Integration in Africa (ECA, 2016b, pp. 83-97) contains a chapter on national, regional and continental policies. It reviews a subset of 15 national policies and the STI financing mechanisms for a subset of 13 countries. It also highlights a number of issues and considerations that should be taken into account when developing and reviewing national STI policy. One such consideration is to clarify policy approaches in terms of its coverage as 'vertical', 'horizontal' or 'mixed'. A second is to define the

<sup>19</sup> [https://easteco.org/wp-content/uploads/2017/06/EASTECO-Strategic-Plan-Jan-130427-Approved-by-35th-Council\\_4th-April-2017.pdf](https://easteco.org/wp-content/uploads/2017/06/EASTECO-Strategic-Plan-Jan-130427-Approved-by-35th-Council_4th-April-2017.pdf)

<sup>20</sup> <https://www.uneca.org/oria/pages/amu-arab-maghreb-union>

<sup>21</sup> <https://www.uneca.org/oria/pages/cen-sad-community-sahel-saharan-states>

<sup>22</sup> <https://nepadsanbio.org/>

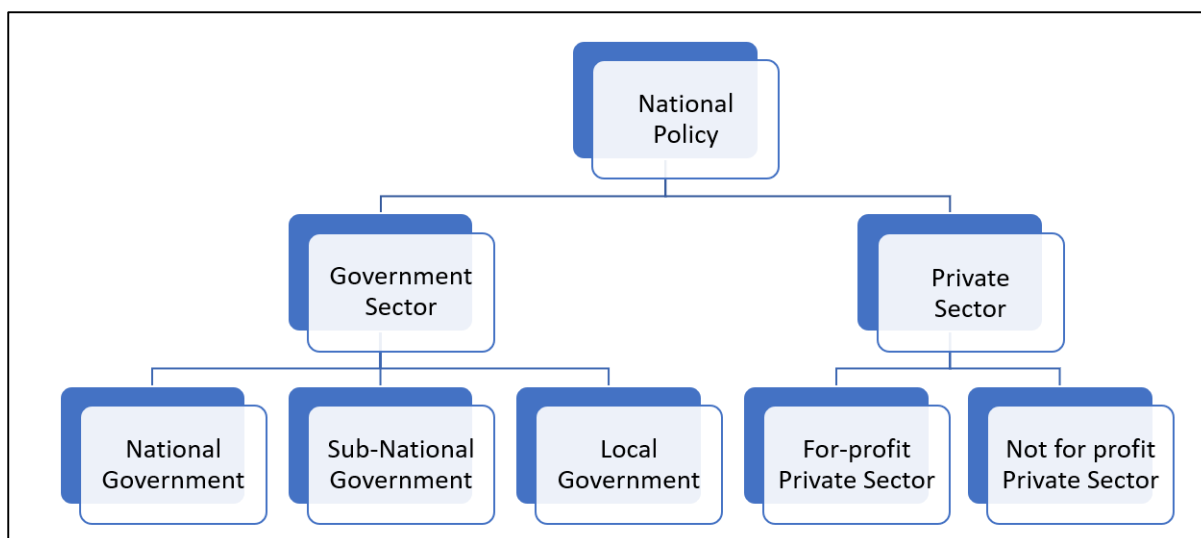
<sup>23</sup> <http://hub.africabiosciences.org/>

sectoral areas of jurisdiction being covered by the policies, for example public and/or private sectors.

52. The vertical, horizontal and mixed categorisations of policy are described briefly below:
- i. Vertical policies are directed towards planned outcomes and investments in particular business sectors. Examples are provided of the promotion of chemicals and pharmaceuticals in Ethiopia, a space sector in Nigeria and green technology in South Africa. Although the investments are sector-specific, such investments can lead to the establishment of global leadership and recognition in these areas and this can have knock-on effects for STI more generally. They represent a more high-risk investment.
  - ii. Horizontal policies promote generalised support, for example through promoting education and human resource development, or providing tax relief for investment in research and innovation. Such approaches allow the organic development of 'market-driven' industries. They are perhaps lower-risk, but there is a danger that they lack the impetus for rapid development and growth.
  - iii. Mixed policies combine elements of vertical and horizontal. They may for example promote generalised areas of innovation in broad thematic areas such as 'biotechnology', 'energy' or 'communications'. This may lead to investment in public sector institutions such as national research centres or centres for industrial research that generically support certain sectors, but do not drive sectoral investment and development. This approach may also lead to these initiatives being included in broader policy frameworks such as education or trade policy.

A policy may ultimately consist of a combination of such approaches.

53. The jurisdictions covered by a policy is crucially important. This is highlighted in Figure 3.1. Different approaches are required to effect change in the government and private sectors. Within the government sector, attention needs to be paid to national approaches, sub-regional approaches and local government approaches. The significance of promoting local clusters of innovation and entrepreneurship outlined in sections 2.2 and 2.3 suggest that an increased level of attention needs to be paid to local government support of STI. Within the private, non-government sector different approaches are needed to support not-for-profit and private sector activity. Within Africa special attention needs to be paid to the not-for-profit sector, based on substantial NGO-based activity driven by international aid. However, this must not be at the expense of generating home-grown businesses built upon STI.



**Figure 3.1. STI policies based on jurisdiction.** Adapted from (ECA, 2016b, p. 85)

54. A report on leveraging knowledge and innovation to secure sustainable development goals by the African Academies of Science (AAS, 2018; Kigotho, 2018) provides a useful update on the status of national STI policies. One of the key findings of the report is that, although the number of countries with such policies is increasing, in 2016, less than half of African countries had adopted STI policies. The countries that had adopted STI policies are listed in Table 3.4.

**Table 3.4 Countries that had adopted STI Policies in 2016 (AAS, 2018)**

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

55. The AAS study highlighted a number of issues arising from its analysis of national STI policies. The first was that such policies are predicated primarily on “*economic growth and competitiveness rationales*” rather than on sustainable development. Related to this they make the statement that

*“Social and environmental goals are not adequately integrated into national STI policy frameworks of African countries.”*

The need to ensure inclusivity within national STI frameworks is highlighted further in section 6.5.2 under the STISA priority area of ‘Live together. Build the society’.

56. Furthermore, the AAS study highlighted that although many of the goals and objectives of national STI policies were laudable, very few of them included distinct mechanisms that could lead to enhanced innovation.

*“A review of frameworks shows that in many instances, while the word ‘innovation’ is in the title, they lack policies for promoting innovation.”*

This view is further supported by the lack of specific mechanisms and plans for delivering on objectives, the lack monitoring and evaluation frameworks and the lack of budgets associated with the STI policies. A lack of capacity in policy development and a lack of understanding of STI also underpins many of the deficiencies observed in national policies. This is emphasised by the observation that many STI policies do not make the connection of the power of science to inform policy, as well as to benefit from policies.

57. This having been said, the ICT sector is one sector where most African countries have effectively established 'vertical' policies. As of 2016, at least 45 African countries have ICT policy frameworks that are in general being effectively implemented (AAS, 2018, p. 31). The take home lesson here may be that where the need and potential gains are immediately obvious, with an immediate personal benefit to the population at large, the political will to effect change and manage it well is easily generated. The challenge for those promoting STI at a national level is that they need to formulate the message in terms that are readily understood at the political level. They also need to provide assistance and help formulate mechanisms and plans on how, practically, STI can sustainably contribute to national development in the short, medium and long term.
58. While promoting 'horizontal' policies that create a pool of well-educated scientists, technologists and engineers that are required to realise the benefits of STI, this must be complemented with more specific, vertical policy decisions to promote specific sectors that are more likely to lead to a more immediate economic (and political) return on investment.
59. Many of these lessons are being responded to at REC and national level. The recent adoption of a white paper on STI by the Government of Republic of South Africa (2019) highlights the growing importance attached to STI as a driver of sustainable growth across Africa.

### **3.4. Linking STI Policies and Actions to African Integration and Development**

60. The 2016 report on African integration (ECA, 2016b) noted that Africa's recent high rates of growth are not based on gains linked to innovation, but on factor accumulation, for example capital accumulation (Limam & Miller, 2004). This result is unsurprising. The World Economic Forum classification of economies by economic development describes three phases of development. The first stage is 'factor-driven' dominated by resource availability. The second stage is efficiency-driven based on the development of more-efficient production processes and improved product quality. The third stage is the innovation-driven phase, where businesses are more knowledge-intensive and

there is an expansion in particular of the service sector<sup>24</sup> (Global Entrepreneurship Research Association, 2017, p. 13).

61. The 2016 report on African integration focused on how regional integration, innovation and competitiveness are interlinked with the end objective of enhancing innovation led growth on the continent i.e. moving African economies to the innovation-driven stage of development. The analysis led to a number of conclusions about how the promotion of innovation, feeding into integration, is critical for competitive growth across Africa. It also led to a number of proposed actions and policy approaches to promote innovation and competitiveness across the continent, citing lessons learned from India and the Association of South-East Asian Nations (ASEAN). Some key recommendations are summarised below:

### **General Policy Approaches**

62. Prioritise reform and financing of quality tertiary education and research. This is a critical element common to the Indian and ASEAN experience. There is an urgent need to invest in human capital for science, technology and innovation. This requires steps to expand tertiary education, including postgraduate training and research, and to raise the international ranking of African universities.
63. Recognise that national policies, though they need to be aligned to sub-regional and continental policies, need to address national priorities and respond to national characteristics. This was an issue that was clearly considered important by ASEAN countries. Within the Indian experience this 'national' focus led to a concentration on vocational training that links to industry and generates location-specific research.
64. Ensure greater alignment between policies for education, industry and science, technology and innovation to enable joined up thinking and an integrated approach to development. This alignment will benefit from private, regional and international partnerships.
65. Balance horizontal policy approaches e.g. through science technology and innovation generally and vertical policy approaches e.g. through agriculture, health, industry, space sectors etc. These two types of approaches must be aligned and be included within national, regional and continental policies. In STISA-2024 vertical approaches are addressed through the concept of priority areas.
66. Cost all policies and resultant actions and identify funds to enable implementation. Many strategies and policies are developed on the continent that are not costed and hence are not included in relevant budgets and are not implemented. Linked to this, it is important that an increased share of financing for science technology and innovation

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<sup>24</sup> <http://weforum.org>

comes from continental, sub-regional and national resources and that there is a corresponding decrease in dependence on aid for STI activities.

### **Approaches to research**

67. Focus on location-based research. In India, this led to a 'bottom-up' approach and India becoming renowned for the concept of 'frugal innovation' (Bhatti & Ventresca, 2012). This concept arose from precursor concepts such as appropriate technology and reverse engineering. Essentially this encompasses a desire for low-cost, sustainable technical solutions that can succeed in the market.
68. Provide more autonomy to public higher education institutions so that these institutions, and individuals within them, are enabled to take forward new ideas and promote innovations. This was identified as a success factor for Indian innovation. Combined with the 'bottom-up' approach mentioned above, this approach gave rise, for example, to the Green Revolution in India in the 1960s and 1970s that massively impacted upon food sustainability and hunger reduction on the sub-continent (Swaminathan, 2017).
69. Regional Economic Communities should: (i) explore sharing research infrastructure; (ii) establish sub-regional research areas to facilitate joint learning and local transfer of technology; (iii) cost and fund joint pan-regional research programmes; (iv) establish sub-regional anchor institutions as centres of excellence; and (v) improve level and mechanisms of financing STI development. The report recommended that similar approaches also be undertaken at the continental level

### **Diaspora**

70. Put in place frameworks that leverage the diaspora. This was a critical component of the Indian success story. In this regard it should be noted that the African Union has designated the African diaspora as the continent's sixth region.

### **Intellectual Property and Trade**

71. Maximise the flexibilities allowed by the international intellectual property treaties such as Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement (WTO, 2017; WTO, n.d.; Kingston, 2011). This will allow countries to operate and utilise technologies and products more freely in areas such as agriculture, manufacturing and public health. It was noted that strong intellectual property legislation underpinned and protected the early development of the Indian industry, notably their generic pharmaceutical industry. Although such levels of protection are no longer possible under current treaties, a strong, coordinated approach at continental, sub-regional and national level, could benefit nascent African industries. The continental free trade area negotiations provide an opportunity to incorporate a collective continental approach to intellectual property management and this may be an early objective of PAIPO, once it is operationally established.



72. Emphasise trade, investment, supply-chain integration and labour mobility. This approach, combined with collective trade agreements have reinforced ASEAN as an economic community and facilitated the development of innovation driven businesses.

### **3.5. Conclusions**

73. There has been a substantive amount of activity and progress by the African Union in establishing key institutions that are required to meet the objectives of STISA-2024 and to develop and promote innovation and entrepreneurship across Africa. Now that they are established, their progress must be monitored closely to ensure the future success of STISA-2024 and, by implication, Agenda 2063.
74. One objective lacking in progress is the operationalisation of the Pan-African Intellectual Property Organisation (PAIPO) and a consequent lack of activity in the critical area of intellectual property management and technology transfer. This needs to be addressed.
75. These institutional developments have been complemented by the introduction of several important continental strategies. In addition to STISA-2024 the Continental Education Strategy for Africa (CESA16-25) has been developed. There have also been significant advances made towards the establishment of a Continental Free Trade Area with the signing of the African Continental Free Trade Agreement (AfCFTA). Once developed the CFTA will have a profound impact on STI and associated entrepreneurship and industrialisation.
76. The establishment of an African Space Policy is also a particularly noteworthy development as a driver for STI on the continent, particularly in the area of the physical sciences, information technology, engineering and mathematics.
77. There has been a significant attempt over the last several years by many RECs and countries to develop and / or update their STI strategies and many more such strategies are now in place. However, many countries still lack substantive strategy development in STI and many of those countries that have strategies do not have in place the concrete plans and budgetary allocations necessary to achieve their goals and objectives. Although there may be a gap in STI policies, almost all countries have been very proactive in developing ICT policies that are in general being effectively implemented.
78. Although national policies need to be aligned to sub-regional and continental policies, they need to address national priorities and respond to national characteristics. There is a need to balance horizontal policy approaches e.g. through science technology and innovation generally, and vertical policy approaches e.g. through agriculture, health, industry, space sectors etc. City and local council engagement in STI policy should be

encouraged given the potential importance of local geographic clusters in promoting innovation and entrepreneurship.

79. A review undertaken by the African Academies of Science noted that where there are STI policies they often focus solely on business and industrial development and that *“social and environmental goals are not adequately integrated into national STI policy frameworks of African countries.”* There is a danger that by focusing on industry and market-oriented developments alone, the opportunity for STI to positively impact on non-commercial sustainable development is missed. There is a need for STI policy to interface with other policy areas, notably education, including tertiary education; and industry and trade, including agriculture. There is also value in interfacing more broadly with social and environmental development policies.
80. Science, Technology and Innovation can be an important driver of African integration and can in turn benefit from African integration. It is important that national and regional policies incorporate a continental perspective. Some lessons are available from other sub-continental and continental efforts to promote STI. An important lesson from India’s experience may be to focus resources on ‘location-based research’ which may generate context-specific solutions to local, national and continental issues. This approach, allied to ‘frugal innovation’ is credited for India’s Green Revolution in the 1960’s and 1970’s. An important lesson from the broader Asian experience is the positive impact on research and innovation of trade, investment, supply-chain integration and labour mobility, within the context of collective trade agreements.

## 4. STI and Research – Financial Inputs and Technical Outputs

81. The lack of resources available in Africa for research and development, and subsequent innovation and entrepreneurship, has already been highlighted in Section 2. The issue permeates all discussions linked to STI in Africa. Without adequate resources the physical infrastructure required for research, such as laboratories and equipment, is lacking, and the critical mass of African scientists, technologists and engineers with the required technical competences for innovation cannot develop. This has an adverse effect on institutional development and the development of national and regional STI systems. This in turn is reflected in reduced research and innovation output, most readily measured by publications and patents. The cry for addressing this state of affairs is growing.
82. There have been several notable developments in Higher Education and sectoral research funding, especially for health, agriculture and the environment, since the turn of the century. These include:
- i. The massification and expansion of Higher Education across Africa, substantially financed through the African public sector, with private sector investment and supplemented by student fees. This has provided an increased population (though still low by global standards) educated to degree level. This has also, however, created challenges for universities as they seek to maintain the quality of education, while expanding access.
  - ii. An increased inflow of development assistance, especially in the fields of health, agriculture and the environment, in response to the Millennium Development Goals and the broader development agenda.
  - iii. An increased level of competitive research funding and research partnership development from the US Government, European Governments and European Union sources, that have increasingly placed some funds at the disposal of African researchers.
  - iv. An increased number of 'out of Africa' postgraduate training opportunities from China and India in addition to the traditional partners such as North America, Europe
  - v. The substantive injection of funds from the Bill and Melinda Gates Foundation, supplemented by other Foundations such as the Wellcome Trust, which have focused on technology driven solutions, especially for health.
  - vi. The development of national research agencies providing limited national resources for research, and taking note in particular of the growing success and impact of South African and Egyptian Higher Education and research.
  - vii. An increased commitment to, and financing of, Higher Education development by the African Development Bank and World Bank. The Development Banks primarily finance their initiatives through loans to

national Governments. These funds therefore represent African Government funding and ownership of the investment, in the same way as an individual taking a personal loan to buy a car or a house, represents a resource commitment by that individual.

83. Adding to this complexity there are numerous independent initiatives in place, some operating in partnership with the AU and its specialised agencies, and many operating independently of them. For example, a study to map and assess innovative initiatives in Higher Education in Africa (Kiamba, 2016) identified thirty continental initiatives, three regional initiatives and sixteen national initiatives.
84. In this section we review some recent developments in the provision of financial inputs to generically support science, technology and research at the continental level in Section 4.1. We then review regional and some national trends in research and innovation output across the continent, as determined by research publications and patents.

#### **4.1. Financing Technical Competences**

85. Many funding initiatives for science and technology research in Africa may be nationally or regionally focused. They may in addition focus on projects and programmes within specific sectors, for example specific areas of health research, agricultural research, environmental research or space research. Examples of some of these initiatives will be provided in section 6 as they apply to the priority areas of STISA. This section focuses on a selection of the most significant continental initiatives operating at a cross-cutting generic level beyond sub-regional and sector-specific projects and programmes.

##### **African Development Bank Initiatives**

86. The African Development Bank (AfDB) approved a total of 70 education/training projects valued at US\$ 2 billion over the period 2005-2017. The AfDB recognised that most development agencies were focused on basic education. It has therefore prioritised and provided finance to a number of Governments for Post-basic Education, Higher Education and Vocational Training through both grants and loans, first for a Higher Education Science and Technology (HEST) Strategy (AfDB, 2008) and then for a Human Capital Strategy in 2014 (AfDB, 2014). Total funds for TVET related activities total over UA<sup>25</sup> 675 million. Table 4.1 indicates recent African Development Bank Financing of TVET related projects.

**Table 4.1. An Overview of African Development Bank Country Financing Agreements with TVET components operational between 2014 and 2018** (Source: AfDB)

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<sup>25</sup> UA is the official currency for the AfDB projects. 1 UA=1 SDR (International Monetary Fund Special Drawing Rights).

Country	Loan Type	Amount in UA
Benin	Loan	16,000,000
Botswana	Grant	600,000
Cape Verde	Grant	800,000
Congo CG	Loan	7,300,000
Côte D'Ivoire	Grant and Loan	18,833,000
Eq Guinea	Loan	34,617,886
Eritrea	Grant	12,020,000
Ghana	Grant and Loan	69,000,000
Guinea	Loan	15,000,000
Guinea-Bissau	Loan	3,510,000
Kenya	Loan	66,000,000
Malawi	Grant and Loan	33,500,000
Mauritania	Grant	2,000,000
Morocco	Grant and Loan	97,187,040
Namibia	Loan	53,077,711
Niger	Grant and Loan	25,500,000
Rwanda	Loan	20,750,000
Sudan	Loan	24,950,000
Tanzania	Loan	49,000,000
Togo	Loan	20,340,000
Uganda	Loan	52,000,000
Zambia	Loan	42,770,000
Zimbabwe	Loan	30,000,000
<b>TOTAL</b>		<b>694,755,637</b>

### World Bank Initiatives

87. The World Bank initiated its re-engagement with the Higher Education sector through a Task Force on Higher Education and Society in 2000. A seminal study (World Bank, 2008) strongly justified investing in Higher Education. Among other data and analysis, the study demonstrated that a one-year increase in average tertiary education levels would raise annual GDP growth in Sub-Saharan Africa by 0.39 percentage points and increase the long-term steady state level of African GDP per capita by 12 percent. This in turn led to policy recommendations for World Bank financing of Higher Education (Experton & Fevre, 2010). The World Bank invested US\$ 1.9 billion in core and non-core projects in higher education in Africa between 2003 and 2014 (Independent Evaluation Group, 2015) and this had risen to US\$ 2.1 billion by 2016 (Independent Evaluation Group, 2017). Of these funds US\$845 million have been designated for core projects in the following countries (Table 4.2)

**Table 4.2. Spread of World Bank Funding for Core Projects in Higher Education in Africa between 2003 and 2016** (Independent Evaluation Group, 2017)

<b>Country</b>	<b>Investment Loan US\$ million</b>
Pan-African	150
Burkina Faso	15
Ethiopia	40
Malawi	51
Mali	33
Mauritania	15
Mozambique	100
Nigeria	180
Senegal	101
Tanzania	115
Uganda	30
<u>Western Africa</u>	<u>15</u>
<b><u>TOTAL</u></b>	<b><u>845</u></b>

88. A recent continental example of World Bank financing is the African Centres of Excellence (ACE) programme (World Bank, 2017; Nordling, 2018) with support and coordination from within Africa by the Association of African Universities and the Inter-University Council for East Africa (IUCEA). A total of over US\$ 500 million has been committed so far for two calls for proposals in West African and one call in East and Southern Africa. This has led to the establishment of 46 centres of excellence in 17 African countries, with a concomitant development of research hubs and postgraduate training. A further example for which calls have been issued, but no awards yet made is the World Bank financed Strengthening Higher Agricultural Education in Africa (SHA EA) programme<sup>26</sup>, with oversight provide by RUFORUM. A total of US\$190 million in financing from the International Development Association (IDA) is envisaged for this programme targeting six countries.<sup>27</sup>

#### **Alliance of Accelerating Excellence in Science in Africa (AES A)**

89. An initiative that deserves a special mention is the recently created Alliance for Accelerating Excellence in Science in Africa (AES A),<sup>28</sup> an initiative of the African Academy of Sciences and AUDA-NEPAD based in Nairobi, which was launched in 2015. The initiative is supported financially by the Wellcome Trust, the Gates Foundation and other development partners, notably UK DfID. AES A provides an

<sup>26</sup> <http://www.ruforum.org/SHA EA/>

<sup>27</sup> <https://www.worldbank.org/en/events/2018/09/06/call-for-proposals-strengthening-higher-agricultural-education-in-africa-shaea>

<sup>28</sup> <https://aes a.ac.ke/>

avenue for competitive grant and capacity building support for research from across the continent. This includes the following programmes:

- i. Climate Impact Research Capacity and Leadership Enhancement
- ii. Grand Challenges Africa
- iii. Developing Excellence in Leadership, Training and Science
- iv. Good Financial Grant Practice
- v. Human Heredity and Health in Africa
- vi. Stem Cell Science and Applications
- vii. Post-doctoral Fellowship schemes
- viii. Building the capacity of science journalists in Africa
- ix. Mobility programmes

The main thrust of the research programmes at the moment is in the area of health research, with one programme also on climate research. It has recently however initiated a US\$2 million postdoctoral; fellowship programme in partnership with the Carnegie Corporation of New York in the general area of science, mathematics and engineering.

90. The funds available through AESA are substantially higher than from most national research agencies in Africa. AESA explicitly states that it has been established in support of STISA-2024. It is developing a strong focus on innovation and is becoming more transdisciplinary in its approach. When it was established in 2015, AESA developed a business plan that set a target of increasing its initial investment of \$65 million to a total of \$241 million by 2021 (AAS, 2017). To date AESA is on track to meet this ambitious target and has raised over US\$ 200 million to finance its activities (AESA, personal communication).

### **Coalition for African research and Innovation (CARI)**

91. The Coalition for African Research and Innovation (CARI)<sup>29</sup> is an initiative arising from AESA that seeks to develop a highly coordinated, well-funded, and African-led African innovation enterprise. It has a high-level leadership group and steering group. It is stated on its web page that\;

*We expect CARI will align stakeholders to issue calls for collaborative investment across sectors in specific R&D challenges for Africa, which would serve the purpose of de-risking investment by any individual stakeholder or sector. An African government is more likely to reach its stated target for R&D investment (1 percent of GDP) if it knows that private sector partners are on board to help usher discoveries through the development and delivery stages. Likewise, private sector companies are more likely to invest resources in Africa if they know governments and other funders are committed to building a sturdy R&D infrastructure on the continent.*

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<sup>29</sup> <https://aesa.ac.ke/cari/coalition-for-african-research-and-innovation/>

92. The web page further states that CARI's will initiate a study on the long-term benefits of investments in R&D to African economies as a way of promoting funds for research in Africa. CARI argues that science and technology is a growth strategy. Research funding should be considered as an investment and not an expense, as is already recognised by the UN National System of National Accounts (United Nations, 2009). It will be interesting to see how this initiative develops. There may well be value in developing an interface between CARI and ASRIC's resource mobilisation efforts.

#### **African Union Research Grant Programme**

93. The African Union Research Grant Programme,<sup>30</sup> supported in large part by the European Union, has been in operation since 2010, and provides a continent-wide opportunity for substantial research funding. There have been four calls and US\$ 35 million has been disbursed to collaborative projects involving 36 African countries and 9 European countries. This has resulted in 218 Masters graduates, 35 PhD graduates and 111 peer reviewed scientific publications.

#### **African Union High Level Panel on Emerging Technologies (APET)**

94. In 2016, the AU initiated a series of steps to harness and adapt 'emerging technologies' for Africa's development. A 10-member African high-level Panel on Emerging Technologies (APET) was established to advise AUDA-NEPAD and the AUC. The panel recommended 10 emerging technologies for review, namely: (i) gene drive/gene editing; (ii) drones; (iii) micro-grids; (iv) precision agriculture; (v) water purification; (vi) 3-D printing; (vii) next-generation medicines; (viii) next-generation batteries; (ix) synthetic biology; and (x) artificial intelligence.
95. Reports of the first three of these areas were launched in June 2018, namely: (i) Gene Drives for Malaria Control and Elimination in Africa (NEPAD, 2018a); (ii) Drones on the Horizon: Transforming Africa's Agriculture (NEPAD, 2018b); and (iii) Micro-grids: Empowering Communities and Enabling Transformation in Africa (NEPAD, 2018c). A further three studies have been initiated on: Artificial Intelligence (AI); Block Chain Technology; and Next Generation Batteries.
96. In honour of the late Chair of APET, the Calestous Juma Executive Dialogue on Innovation and Emerging Technologies was launched in December 2018, to organise platforms and programmes that would stimulate discourse on the role of emerging technologies in Africa's development.

## **4.2. Trends in Regional and National Research Output**

97. Current and regularly updated data on research, science, technology and innovation in many countries in Africa is not readily available. The ASTII initiative and the four-yearly publication of the African Innovation Outlook (NEPAD, 2014; AUDA-NEPAD, in press) combined with the future work of AOSTI offer hope that this will improve in

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<sup>30</sup> <https://au.int/en/aurg>

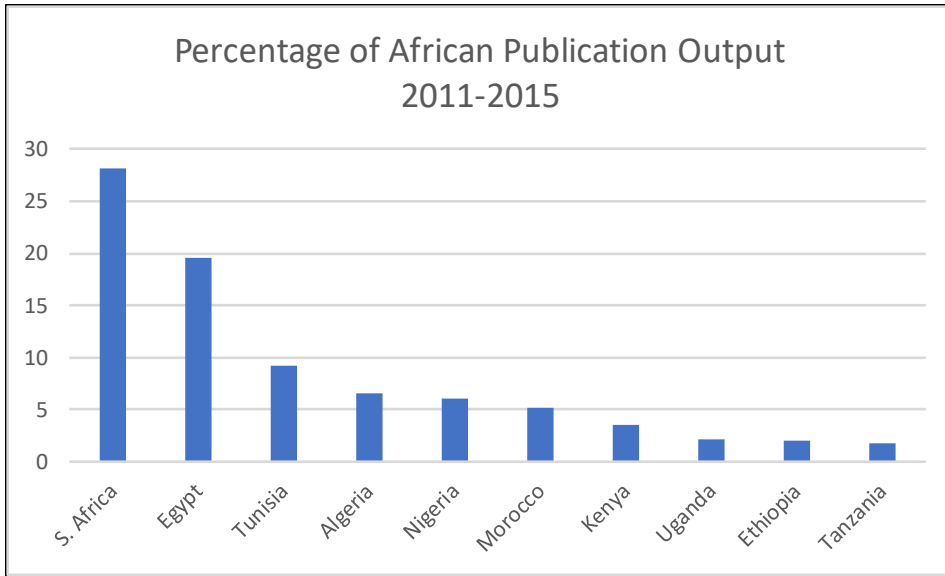


future years. It is important that as well as generating snapshots of research activity, for example in the African Innovation Outlook series and publications such as the Global Innovation Index, that trends can be tracked over time. This section provides a brief overview of global data and then looks at trends in scientific publications and patent applications for a selected number of countries. The section also reviews a report on the main funders of African research based on a bibliometric analysis.

### **Trends in scientific publications**

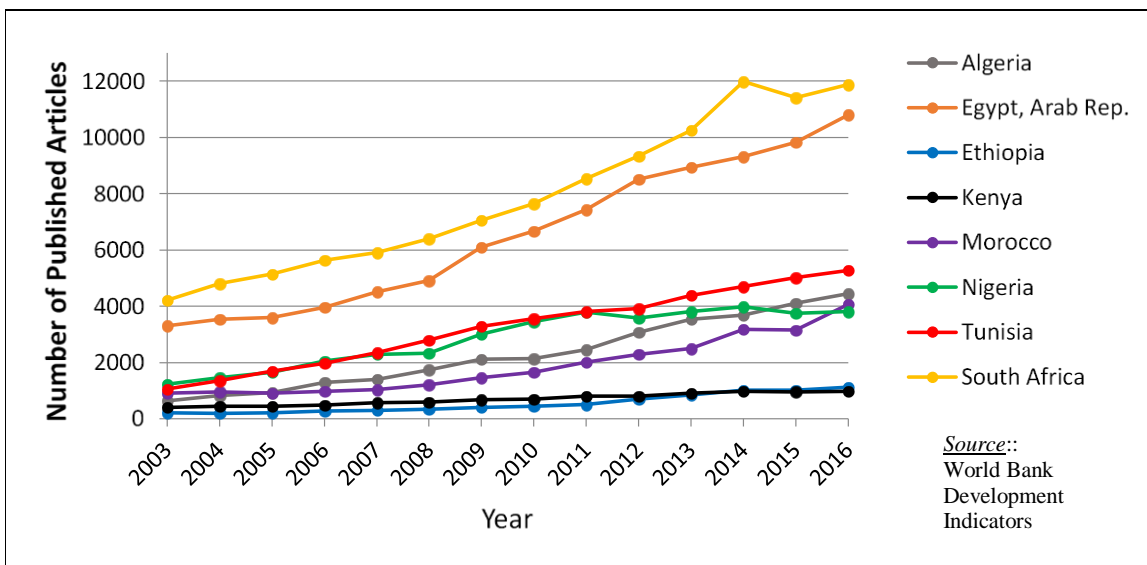
98. The SCIE publication density was shown in Figure 2.1. Two reports will be briefly reviewed in this section. The first is a bibliometric analysis that covers the whole of Africa, including North Africa and the Republic of South Africa, from 2005 to 2016 (Mouton & Blanckenburg, 2018). The second is a World Bank report on sub-Saharan African Science, Technology, Engineering, and Mathematics Research from 2003-2012 that removes that does not include the Republic of South Africa within its analysis (Blom, Lan, & Adil, 2016).
99. Mouton and Brackenbury, basing their analysis on Web of Science data, report that:
  - i. African-authored papers increased from 15,285 in 2005 to 54,069 in 2016, an increase of over 350%;
  - ii. Africa's share of global publication output increased from 1.5% in 2005 to 3.2% in 2016;
  - iii. The top producers as a proportion of total African output were S. Africa (28.2%) followed by Egypt (19.6%), Tunisia (9.2%), Algeria (6.6%) and Nigeria (6.1%) as outlined in Figure 4.1;
  - iv. The top producers per head of population were Tunisia followed by South Africa and then Egypt and Botswana;
  - v. Africa's relative strength is strongest in fields such as agriculture, tropical medicine and infectious diseases. It is weakest in the broad domain of the humanities.

They also report that publications primarily consist of co-publication with institutions in the same country (40%, national collaboration) and papers involving collaboration between Africa and the rest of the world (international collaboration, 50%). The majority of other publications are single-author. Collaboration solely between African countries is negligible and has been recorded at 2% (Kozma, Medina, & Costas, 2018; Beaudry & Mouton, 2017).



**Figure 4.1. Percentage of African scientific publication output from 2011-2015 for top 10 countries in Africa.** Adapted from (Mouton & Blanckenburg, 2018)

100. A more detailed analysis of the increase of publications for some selected countries using a World Bank database is provided in Figure 4.2. South Africa and Egypt were by far the largest generators of scientific and technical publications, achieving around 12,000 and 11,000 respectively in 2016. The north African countries of Tunisia, Algeria and Morocco also demonstrated strong growth, reaching numbers of 4,000 to 6,000. Of the three selected sub-Saharan African countries, Nigeria showed significant but irregular growth and Kenya and Ethiopia, although registering growth, remained with less than 2,000 publications per year.



Source: World Bank Development Indicators

**Figure 4.2: Published Articles for selected African countries**<sup>31,32,33,34</sup>

101. The high figures from South Africa would obviously distort any sub-Saharan African analysis. Blom, Lan, & Adil, in reviewing sub-Saharan African publications therefore divided sub-Saharan Africa into three regions: West and Central; East; and Southern (excluding South Africa). The study showed that:
- i. all three sub-regions more than doubled their research output between 2003 and 2012
  - ii. Sub-Saharan Africa's share of global research increased from 0.44% to 0.72%;
  - iii. Citations increased for the three regions from a range of 0.06-0.16% to 0.12-0.28%
102. The report further noted however that the vast majority of this increase in sub-Saharan Africa was due to increases in health research, presumably due to the vast increase in resources allocated to health arising from the HIV/AIDS pandemic and the drive generated by the health-related MDGs. The share of African research in the Physical Sciences and STEM had declined by 2% annually since 2002. Physical Sciences and STEM research accounted for 29% of total research output compared to well over 40% for health research. This contrasted with a figure of 68% for Physical Science and STEM research Malaysia and Vietnam.
103. The report highlighted two further aspects of scientific research in sub-Saharan Africa. First, there is a high dependence on international collaboration and that, as a result, a large proportion of researchers in Africa are 'non-local and transitory'. Secondly, sub-Saharan African research is fragmented. There is very limited intra-African collaboration (i.e. without any South-African or international collaborator). Such research comprises only 2 percent of all East African research, 0.9 percent of West and Central Africa, and 2.9 percent of Southern Africa. This is similar to the 2% figure obtained for the continent as a whole (Kozma, Medina, & Costas, 2018; Beaudry & Mouton, 2017). This latter issue is further explored in section 6.5. The report contains the following statement.
- Sub-Saharan Africa's high reliance on international collaboration for research is a concern for the World Bank; it signals a lack of internal research capacity and the critical mass to produce international quality research on its own; particularly within STEM. Furthermore, the transitory nature of many researchers may prevent researchers from building*

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<sup>31</sup> Scientific and technical journal articles refer to the number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.

<sup>32</sup> <https://databank.worldbank.org/data/reports.aspx?source=2&series=IP.JRN.ARTC.SC&country=>

<sup>33</sup> <http://api.worldbank.org/v2/en/indicator/IP.JRN.ARTC.SC?downloadformat=excel>

<sup>34</sup> <https://www.indexmundi.com/facts/indicators/IP.JRN.ARTC.SC/compare>

*relationships with African firms and governments, reducing the economic impact and relevance of research.*

104. The report made several recommendations. These included:
- i. Continued international collaboration, and scale-up collaboration within STEM
  - ii. Scaled up postgraduate education in Africa—possibly through regional collaboration
  - iii. Continued scholarship funding for studies in Africa, possibly through “sandwich-programs” to ensure international exposure and included funding support to raise the quality of the postgraduate program.

### **Trends in Patent Applications**

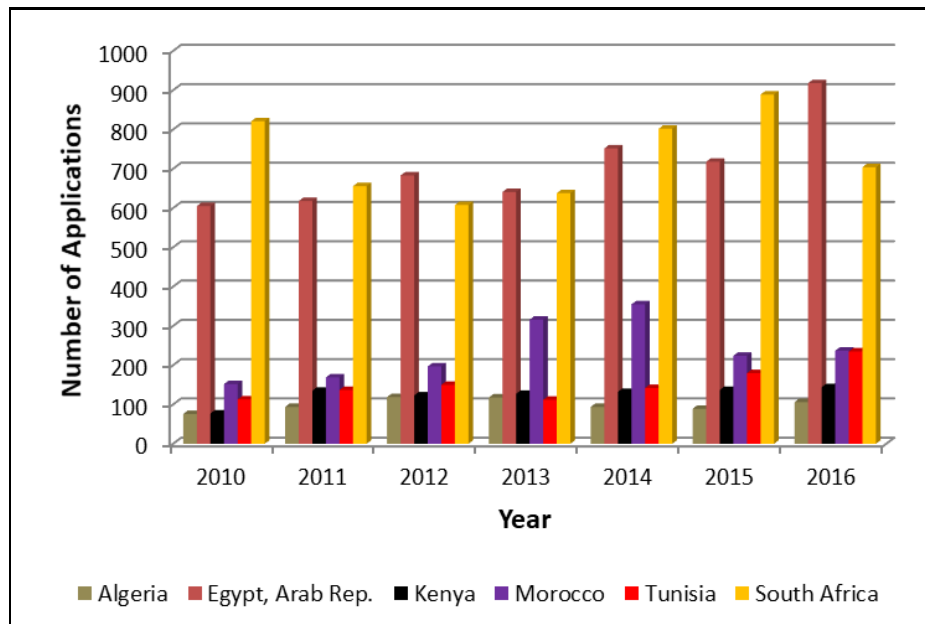
105. The PCT patent density was shown in Figure 2.1. The global patent figures for 2016 (WIPO, 2017) show that there were over 3.1 million patent applications made in 2016, compared to 1,76 million in 2006. This represents an increase of over 78%. The increase of patent applications in China, predominantly resident applications accounts for 1.13 million, or 82% of this increase. A regional distribution of patent applications comparing 2006 and 2016 is shown in Table 4.1. There was a 30% increase in patent activity in Africa over the ten years period, but Africa’s overall percentage of global activity fell due to the increased output in Asia.
106. The major fields of technology into which patents are sub-divided are: (i) Electrical Engineering, including computer technology; (ii) Instruments, including medical technology; (iii) Chemistry, including pharmaceuticals; (iv) mechanical engineering, including transport; and (v) miscellaneous, including games, consumer goods and civil engineering.

**Table 4.1. Comparison of total numbers of patent applications, both resident and non-resident, by region for 2006 and 2016.** Data taken from (WIPO, 2017)

Region	2006		2016	
	Number	Percentage	Number	Percentage
Asia	875,000	49.7	2,020,000	64.6
North America	460,000	26.1	640,000	20.5
Europe	330,000	18.8	350,000	11.3
Latin American Countries	53,000	3.0	63,000	2.0
Oceania	33,000	1.9	34,000	1.1
Africa	12,000	0.7	15,640	0.5

107. The patent counts<sup>35</sup> for six African countries responsible for the vast majority of patent activity on the continent from 2010 to 2016 are presented in figures 4.2 and 4.3. Resident<sup>36</sup> applications from within the country are shown in figure 4.3. Non-resident<sup>37</sup> applications from outside the country are shown in figure 4.4.

108. Resident patent activity is dominated by South Africa and Egypt, at around 600 to 800 applications per year, followed by much lower levels of activity in Tunisia, Morocco, Kenya and Algeria, who receive around 200 per year or less. Non-resident patent applications i.e. those arising from outside the country to protect external innovations within the market of the target country, is dominated by South Africa, which receives over 6,000 applications per year. Egypt and Morocco receive about 1,000 applications per year, with very limited activity in Tunisia, Algeria and Kenya and other African countries. This suggests that South Africa is seen as the most important market by outside innovators. Non-resident filings overall over the period have remained fairly static.



**Figure 4.3. Resident patent applications for selected African countries from 2010 to 2016.** Data obtained from World Bank<sup>38</sup> and Index Mundi<sup>39</sup>

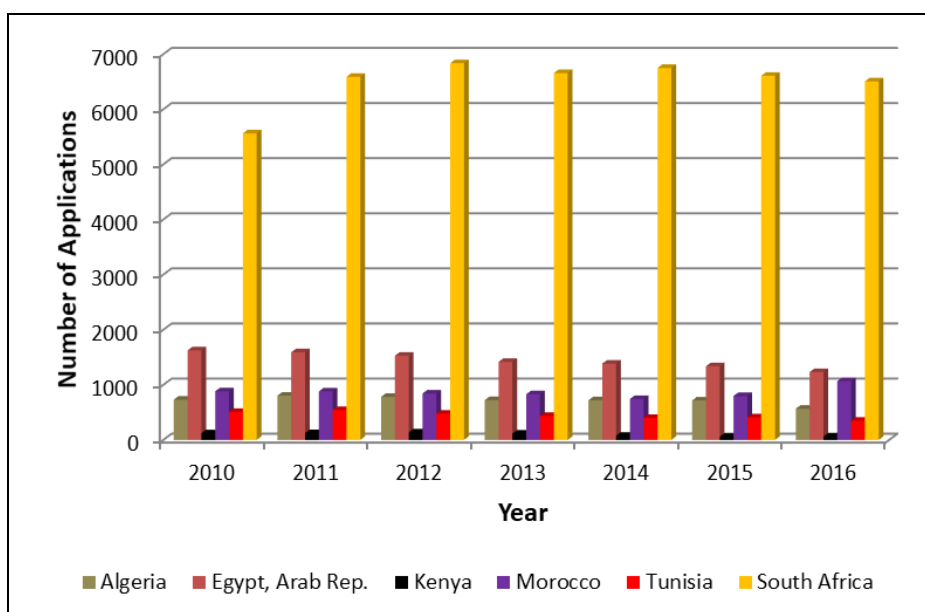
<sup>35</sup> Patent applications are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office for exclusive rights for an invention--a product or process that provides a new way of doing something or offers a new technical solution to a problem. A patent provides protection for the invention to the owner of the patent for a limited period, generally 20 years.

<sup>36</sup> Resident applications refer to domestic filings from within a country.

<sup>37</sup> Non-resident applications refer to filings coming in from other countries.

<sup>38</sup> <http://api.worldbank.org/v2/en/indicator/IP.PAT.RESD?downloadformat=excel>

<sup>39</sup> <https://www.indexmundi.com/facts/indicators/IP.PAT.RESD/compare>



**Figure 4.4. Non-resident patent applications for selected African countries from 2010 to 2016.** Data obtained from World Bank<sup>40</sup> and Index Mundi<sup>41</sup>

### **Bibliometric analysis of Prominent Funding Organisations in Africa**

109. A bibliometric analysis of the funding of science in Africa has been undertaken (Kozma, Medina, & Costas, 2018). The study reviewed web of science data on publications from different African countries and noted if acknowledgements of funding were provided and, if so to whom the acknowledgements were made. Several significant factors emerged.

- i. Overall, approximately 51% of African publications acknowledge funding
- ii. This rate of acknowledgement falls to 32% for national (non-international) collaborations
- iii. Publications where funding is acknowledged are, in general, more highly cited and are in higher impact journals.
- iv. Of the top 10 publishing countries, one group (S. Africa, Kenya, Ethiopia, Uganda and Tanzania) have funding acknowledgements of >70% and another group (Egypt, Tunisia, Nigeria, Algeria and Morocco) have funding acknowledgements of <50%. This may relate to the nature of the national funding agencies and of international collaborations.

110. The top funding organisations of African Science based on publication output are shown in Table 4.2. The main funder by far is the National Research Foundation of South Africa, with the Medical Research Council also prominent, reinforcing South Africa's dominant position on the continent. Only one other national agency is in the table, namely the Ministry of Higher Education and Scientific Research of Tunisia. Among the international funders the most prominently cited is the European Union and

<sup>40</sup> <http://api.worldbank.org/v2/en/indicator/IP.PAT.RESD?downloadformat=excel>

<sup>41</sup> <https://www.indexmundi.com/facts/indicators/IP.PAT.RESD/compare>

European Commission and it is perhaps more appropriate to consider those two agencies as one and the same. Following that come US agencies, the most prominent being the NIH, which incorporates NIAID, plus the US National Science Foundation and USAID, which is also mentioned. The Wellcome Trust and Bill and Melinda Gates Foundation. Three German agencies are also prominent, with additional support being provided by the Government of Spain, the National Natural Science Foundation of China, King Saud University and the National Sciences and Engineering Council of Canada. Interestingly, private companies, collectively, also contribute significantly to research publications

**Table 4.2. Prominent Funding Organisations in Africa based on publication output between 2009 and 2014.** Taken from (Kozma, Medina, & Costas, 2018)

<b>Funding organisation</b>	<b>Country of Funding Organisation</b>	<b>Number of publications 2009-2014</b>
National Research Foundation	South Africa	11,726
European Union	Europe	3,734
National Institutes of Health	USA	3,072
Wellcome Trust	UK	2,663
Deutsche Forschungsgemeinschaft	Germany	2,154
Companies		2,045
Bill and Melinda Gates Foundation	USA	1,963
Government of Spain	Spain	1,950
National Natural Science Foundation	China	1,887
Ministry of Higher Education and Scientific Research	Tunisia	1,729
National Institute of Allergy and Infectious Diseases	USA	1,580
Federal Ministry of Education and Research	Germany	1,357
National Science Foundation	USA	1,318
King Saud University	Saudi Arabia	1,316
Medical Research Council	South Africa	1,298
European Commission	Europe	1,290
German Academic Exchange Service	Germany	1,278
Natural Sciences and Engineering Research Council of Canada	Canada	1,259
United States Agency for International Development	USA	1,225

### 4.3. Conclusions

111. There has been a notable increase in financial support provided to Higher Education and research in recent years, notably through the World Bank and African Development Bank as they have re-assessed the value to a national economy of investment in tertiary education. This, along with other initiatives, such as AESA, is complementing and enhancing traditional scientific research funding mechanisms.
112. Africa as a region is increasing its publication and patent rate at a well above level above the global average, reaching 3.5% of global publications for Africa as a whole and 0.7% for sub-Saharan Africa (omitting South Africa). However, 75% of this output came from just five countries: South Africa, Egypt, Tunisia, Morocco and Algeria. Patent activity in Africa as a whole increased by 30% between 2006 and 2016, but accounted for only 0.5% of global activity in 2016. South Africa, and to a lesser extent, Egypt, dominate the patenting figures.
113. It is apparent that research and patent activity arises primarily from a few select countries. There is a danger, as mentioned in section 2.4 that many low-income countries in Africa will get left further behind unless there is a concerted effort to address this imbalance
114. Africa' relative research strength is strongest in fields such as agriculture, tropical medicine and infectious diseases. There is a predominance of health research over Physical Science and STEM research in sub-Saharan Africa that needs to be addressed if a broad-based continental STI strategy is to succeed.
115. There is a high dependence on international collaboration and research on the continent is fragmented, with intra-African collaboration (i.e. with a partner from another African country and without a non-African partner) standing at only 2% of all published research. The dependence on international collaboration, and international financing, is particularly acute in sub-Saharan Africa. This needs to be addressed through scaling up postgraduate education, enhancing regional collaboration and improving research laboratory facilities, particularly in those countries lagging behind in publication and patent output.
116. Most funds for research still originate from outside Africa. More funding needs to originate from national budgets and the African private sector. There is a need for national governments and continental and international financing institutions to strategically develop improved options for financing improved research facilities and funding for research. There is a need for progress with the STISA-2024 call for an African STI Fund (ASTIF).
117. Much of the research on the continent is at an early stage in the innovation pathway. Substantive further investment will be needed to take promising research results



through to an innovation that provides a market return or a social return on investment. It should be remembered that many projects will fail for every one that succeeds.

## 5. Innovation and Entrepreneurship

118. An overview of the status of Innovation and Entrepreneurship in Africa from a global perspective was provided in Section 2. In this section we seek to provide some more detail on the capacity and ability to develop and take innovative products to market. This will include a review of: (i) the entrepreneurship ecosystems operating in Africa; (ii) growth of established companies; (iii) technology hubs and start-ups; and (iv) prizes for entrepreneurship.

### 5.1. The entrepreneurship ecosystem

119. In section 2, we reviewed the competitiveness of entrepreneurial talent in Africa through the Global Talent Competitiveness Index. Another index, the Global Entrepreneurship Index focuses more on the entrepreneurship ecosystem operating in countries (Ács, Szerb, & Lloyd, 2018). It focuses on three sub-indices consisting of 14 pillars of the entrepreneurship ecosystem to provide a composite score. The sub-indices and pillars are shown below:

Sub-index	Sub-index	Sub-index
“entrepreneurial attitude”	“entrepreneurial abilities	“entrepreneurial aspiration”
i. Opportunity Perception	i. Opportunity Perception	i. Product Innovation
ii. Start-up skills	ii. Technology Absorption	ii. Process Innovation
iii. Risk Acceptance	iii. Human Capital	iii. High Growth
iv. Networking	iv. Competition	iv. Internationalization
v. Cultural Support		v. Risk Capital

120. As in most global analyses of this kind the sub-Saharan African region scored low compared to other regions. North African data was combined with the Middle East for analysis. Tunisia was the top-ranked African country, followed by Botswana, South Africa, Namibia and Morocco. The analysis of the North African and Middle East nations indicated that the quickest gains could be attained by improving competition and reducing barriers to entry for new firms. For sub-Saharan Africa the quickest gains could be achieved by improving start-up skills, with improved access to education and skills that support careers in entrepreneurship. The greatest strength seen in sub-Saharan Africa’s is in the area of Opportunity Perception, where entrepreneurs are able to spot opportunities around them for starting businesses. In addition to a lack of start-up skills, the region scored low on areas of risk acceptance and risk capital availability.

121. A series of three special issues of the Journal of Small Business and Enterprise Development in 2018 explored entrepreneurship in Africa.<sup>42</sup> One of the studies reported in this series (Atiase, Mahmood, Wang, & Botchie, 2018) identified a positive correlation between the national entrepreneurship indices for 35 African countries covered by the Global Entrepreneurship Index with independently determined indices for: (i) access to electricity; (ii) good governance; and (iii) contract enforcement. Interestingly there was no correlation between the entrepreneurship index and access to credit. This was interpreted to mean that electricity provision, good governance and contract enforcement are operating across Africa to the extent that continued improvements in these areas will have a beneficial effect on the entrepreneurship ecosystems of countries. However, entrepreneurs are bypassing financial institutions for credit, presumably because most financial institutions do not have adequate mechanisms to lend to entrepreneurs who may have limited collateral.

## **5.2. Growth of established companies**

122. Large companies are important for innovation. They support and fund innovation to enhance their own competitiveness and they also do deals with smaller companies to implement the innovations of others, as they can take innovations to scale. They are similarly important for assisting in the diffusion of innovation. Small companies see what large companies are doing and try to imitate them. Large companies also tend to be important sources of tax revenue for countries. It is estimated that the top 100 companies in Africa account for over 50% of corporate taxes in Africa. For these and other reasons, more and larger companies are needed.

123. Business for large companies in Africa is generally proceeding well. A report by McKinsey in 2010 entitled 'Lions on the Move' (McKinsey and Company, 2010) predicted continued growth for Africa, noting that Africa's collective GDP in 2008, at US\$1.6 trillion, was equal to that of Brazil or Russia. It also noted that there were 20 companies with revenues of at least US\$3 billion, that foreign direct investment had risen from US\$9 billion in 2000 to US\$62 billion in 2008, and that the rate of return on foreign investment in Africa was higher than in any other region.

124. In 2016 McKinsey issued a follow up report 'Lions on the Move II' (McKinsey and Company, 2016; Dahir, 2016). It noted that by 2014 Africa's collective GDP at US\$2.26 trillion had overtaken that of Russia, Brazil and India combined. There were now over 400 companies with annual revenues exceeding US\$ 1 billion, including 42 with annual revenues of over US\$ 5 billion, more than double the number that existed in 2008. Over 700 companies have revenue of over US\$ 500 million and are officially defined as large companies.

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<sup>42</sup> <https://www.emeraldinsight.com/loi/jsbed>

125. The McKinsey 2016 report noted that large African companies were on the whole growing faster and were more profitable than 'global peers.' However, no African companies are in the Fortune 500 of the top companies in the world. Although not highlighted in the McKinsey report, it should perhaps be noted that the high rates of growth and profitability of African companies may in part be due to lower levels of regulation in Africa compared to other regions.

126. With respect to the ownership of large companies.:

- i. 56% are Africa-owned private firms, 27% are foreign based multinationals and 17% are state owned enterprises.
- ii. The multinationals dominate the food and agricultural sector, while state-owned enterprises play a major role in resources, utilities and transportation
- iii. Less than 20% of these companies are family businesses, a lower figure than is found in other global regions

127. Table 5.1 below shows the spread of which sectors the large companies occupy by share of revenue. Interestingly a substantive number are categorised as R&D intensive manufacturing companies, with an obvious potential to promote innovation.

**Table 5.1. Corporate sector investment in Africa by large companies in 2014** (McKinsey and Company, 2016)

Corporate Sector	Share of Revenue (%)
Resources	28
Wholesale and Retail	13
Financial Services	12
Utilities and Transportation	9
Food and agri-processing	8
R&D intensive manufacturing	7
Telecommunications	6
IT, media and marketing	6
Light manufacturing	4
Resource processing	2
Construction	2
Healthcare	2
Others	1

128. South African companies dominate the corporate sector in Africa, accounting for over 45% of large firms, with North Africa accounting for about 20%. This is illustrated in Table 5.2.

**Table 5.2. Location of large companies in Africa in 2014**  
(McKinsey and Company, 2016)

<b>Location of Large Companies</b>	<b>Number</b>
South Africa	300
North Africa	133
Nigeria	56
Southern Africa	43
West Africa	40
East Africa	25
Central Africa	19

129. More large companies are needed in Africa if Africa is to develop. At the moment, Africa is under-represented globally with respect to large companies. More large companies will drive growth and increase investment, corporate tax contributions, exports, and productivity. New large companies will of course largely arise from smaller companies and will be driven by certain developing trends in Africa's business growth (Gutmann, 2018). Small and medium enterprises account for 90% all businesses in Africa and will be responding to some anticipated growth areas, driven in large part by the rise of an urban middle class. These areas may include: education, healthcare, telecommunications, retail, manufacturing, technology and renewable energies. Power generation will become a particularly important growth area. The next stream of large companies may also include some from the growing number of Chinese companies operating in Africa (McKinsey and Company, 2017; Jayaram, Kassiri, & Sun, 2017). China is by far Africa's largest economic partner, with trade of US\$ 188 billion per year in 2015, greater than the next three largest, India, France and the US, combined. It is estimated that there are over 10,000 Chinese firms operating in Africa, representing a huge investment of resources and a significant transfer and diffusion of technology and innovation across the continent.

### **5.3. Technology hubs and start ups**

#### **The drive behind entrepreneurship**

130. The African region is experiencing an unparalleled population growth and the growth of an extremely young (working) population. Coupled with fast growing urbanisation, Africa is expected to have a larger workforce than either India or China by 2034 (McKinsey and Company, 2017). This upcoming generation of youth is well acquainted with the new technologies and hungry to succeed. This section explores the potential origins of new, innovation-driven companies across the continent through the development of technology hubs.

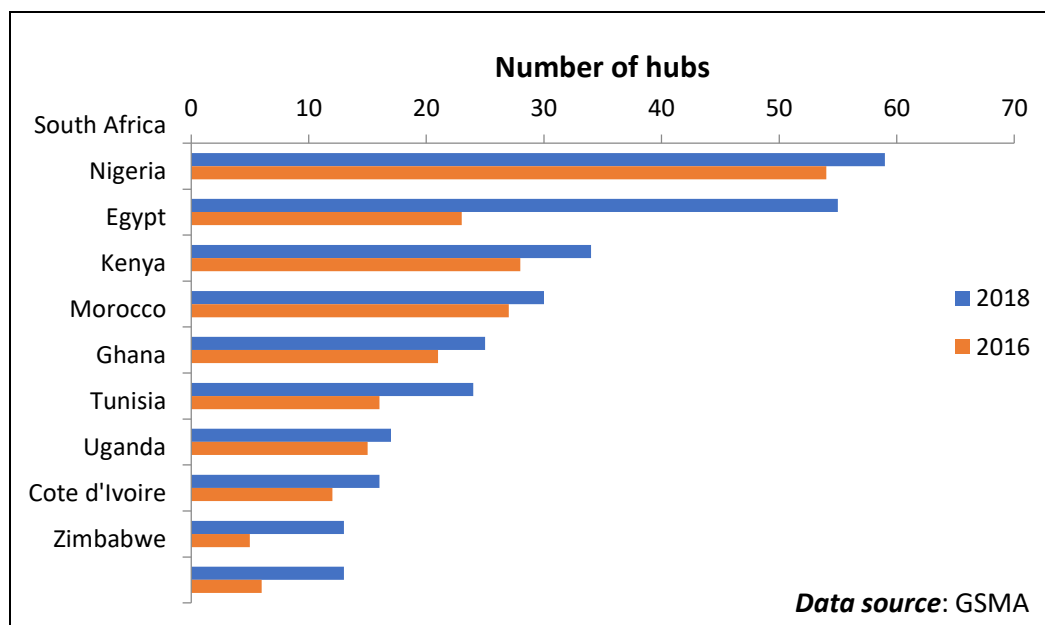
131. There is a burning energy among the youth of Africa. Many young people, unable to get a job after they have completed secondary school or university, are seeking to establish social enterprises and businesses. There is a fearlessness among them. They have nothing to lose by failure as they cannot be worse off than they already are, without a job and without any social welfare to support them. There is also an idealism and optimism borne from youth that drives them. They yearn for success and the rewards that success will bring to them personally, for their families, for their countries and for Africa.
132. A recent survey of eight sub-Saharan African countries addressed six indicators of entrepreneurship (Amorós & Bosma, 2014). It was found that:
- i. 67% of Malawians aged 18-64 expect to start a new business within the next three years.
  - ii. 40% of Nigerians and Zambians aged 18-64 are either a nascent entrepreneur or owner-manager of a new business.
  - iii. 85% of Nigerians aged 18-64 population (individuals involved in any stage of entrepreneurial activity excluded) see good opportunities to start a firm in the area where they live.
  - iv. 90% of Malawians aged 18-64 (individuals involved in any stage of entrepreneurial activity excluded) believe they have the required skills and knowledge to start a business.
  - v. 15% of Ugandans aged 18-64 (individuals involved in any stage of entrepreneurial activity excluded) indicate that fear of failure would prevent them from setting up a business.
  - vi. 23% of Zambians aged 18-64 are currently a nascent entrepreneur i.e. actively involved in setting up a business they will own or co-own; this business has not paid salaries, wages, or any other payments to the owners for more than three months.
133. Although it is valuable to identify trends that operate in support of innovation and entrepreneurship, it is important not to over-simplify issues as applying equally to all countries in Africa. There are many developmental and cultural differences that impact on national and even intra-national approaches to innovation. This is illustrated by data that recently showed Africa to have countries that both demonstrated the lowest level of fear of failure in establishing an enterprise in a global sample, namely 17% in Angola, and the highest, 64% in Morocco (Bosma & Kelley, 2019, p. 13).

### **Technology Hub development on the continent**

134. Linked to the drive for entrepreneurship there is a massive expansion of technological innovation hubs on the continent (Bayen and Giuliani, 2018). Tech hubs are particularly useful to entrepreneurs in Africa, where securing a space, not only to develop ideas, but where power, internet access and other utilities are secured, enables entrepreneurs to focus on developing their ideas and establishing their businesses. Research in early 2018 showed that since 2016, the number of active

tech hubs across Africa has grown by over 50% from a total of 314 in 2016 to a total of 442 in early 2018, with more in development. Many of the hubs are clustered in particular cities. The strongest five cities, at the time of the report, were: Lagos (31 hubs); Cape Town (26 hubs); Nairobi (25 hubs); Cairo (23 hubs) and Accra (16 hubs). Interestingly substantial growth in tech hubs is being seen across the continent, albeit sometimes from a low level, such as in DRC, Zambia, Cote d'Ivoire and Togo.

135. The growth of technology hubs in the top ten countries hosting hubs between 2016 and 2018 is shown in Figure 5.1. A number of foreign companies have begun to actively support start-up companies around the continent. For example. Google has started a Launchpad Accelerator Programme that is active in many countries (Olingo, 2018) The increase in tech hubs in Nigeria in the last two years included the first technology hub, NG\_Hub, established in Africa by Facebook (Adepetun, 2018). Technology hubs are increasingly working together and 75 Nigerian hubs launched a unifying body in March 2019 in a bid to support one another (Ndiomewese, 2019).
136. Following on from experiences elsewhere in the world, one would expect African universities to engage with, and initiate, the establishment of tech hubs. This is beginning to happen,<sup>43</sup> for example at the University of Nairobi, the American University in Cairo, Stellenbosch and Cape Town.<sup>44</sup> Nigeria has recently announced plans to build technology hubs at its universities.<sup>45</sup> An increasing number of African universities, following the lead of universities globally, are also now starting to develop academic degree programmes in innovation and entrepreneurship.



<sup>43</sup> <https://scitechafrica.com/2018/08/01/why-african-universities-must-have-innovation-hub-on-campus/>

<sup>44</sup> <https://www.forbesafrica.com/technology/2018/07/30/africas-new-silicon-valleys/>

<sup>45</sup> <http://dailypost.ng/2018/03/06/nigerian-govt-build-technology-hubs-universities/>

**Figure 5.1. Growth of Technology Hubs in selected African countries between 2016 and 2018<sup>46,47</sup>**

137. An example of how university incubators may operate is provided by the World Bank funded Centre of Excellence in Software Engineering project in the Obafemi Awolowo University (OAU), Ile-Ife, Nigeria. The University, in collaboration with a private company in Lagos, provided a co-location space, named ‘Software Studio’ for students. Third-year university students can take up internship positions in the studio, working with software developers from the industry. Under the supervision of senior University faculty members, they jointly work on industrial problems, leveraging research outputs from the University. One of the earliest beneficiaries of the initiative invented an android watch face that tells time in the local Yoruba language. The success of the Centre of Excellence project has attracted a new round of funding under the World Bank Africa Center of Excellence (ACE).

**Start-up company growth and venture capital**

138. A consequence of the growth of technology hubs is that there has been a rapid increase in start-up ventures. Partech Ventures’ 2018 analysis of start-up funding in Africa in 2017 (Kazeem, 2018; Collon, 2018) showed that venture capital funding in 2017 was US\$ 560 million, recording a 53% year on year growth. The spread of start-up funding per country is shown in Table 5.3. South Africa, Kenya and Nigeria each attracted over USD100 million venture investment for start-ups and are the leading investment destinations. It should be noted that another study by Disrupt Africa came up with a lower total investment figure of US\$ 195 million investment for 2017, rising to US\$ 334.5 million for 2018 (Disrupt Africa, 2019).

**Table 5.3. Start-up funding raised per country in 2017**  
(Collon, 2018)

Country	Start-up Funding (million US\$)
South Africa	167.9
Kenya	147.0
Nigeria	114.6
Egypt	36.9
Rwanda	36.7
Ghana	20.4
Uganda	16.0
Senegal	10.7

<sup>46</sup> <https://qz.com/africa/759666/the-number-of-tech-hubs-across-africa-has-more-than-doubled-in-less-than-a-year/> [2016 data]

<sup>47</sup> <https://www.gsma.com/mobilefordevelopment/programme/ecosystem-accelerator/africa-a-look-at-the-442-active-tech-hubs-of-the-continent/> [2018 data]



Morocco	3.9
Cameroon	2.7

139. The investment alluded to above is increasingly coming from Venture Capital funds, which are becoming more Africa-based, with headquarters on the continent (Bright, 2018). A Techcrunch study identified 51 Africa-focused VC funds globally with seven to ten investments or more. Twenty-two of these funds (43%) were headquartered in Africa and managed by Africans. Nine of the twenty-two funds had been formed since 2016. Nine of the twenty-two funds are Nigerian and four of these were formed within the previous year. Investments ranged from seed investments of tens of thousands of dollars to multi-million-dollar rounds of investment. The largest investment made in 2018 was TPG's Growth Fund investment in the Kenyan Financial technology company Cellulant. Several corporate venture arms are starting to invest in start-ups and there has been a rise in corporate venture funding and acquisition activity.

#### **Prizes for entrepreneurship**

140. Over 16 Foundations, forums and prizes for entrepreneurship have been established in recent years to promote entrepreneurship and associated innovation. Among the most significant are: (i) the Tony Elumelu Foundation,<sup>48</sup> promoting a philosophy of 'Africapitalism' through grants and mentorship support, which positions Africa's private sector and most importantly entrepreneurs, as the catalyst for the social and economic development of the continent; (ii) The Next Einstein Forum,<sup>49</sup> which hosts a major high-profile meeting every two years, with many interim activities, to promote and explore African Science, Technology and Innovation, including through a 'Challenge of Invention to Innovation (Ci2i)' competition. The Next Einstein Forum is an initiative of the African Institute for Mathematical Sciences (AIMS) in partnership with the Robert Bosch Stiftung; (iii) Global innovation Exchange,<sup>50</sup> a tech platform, whose mission is 'to accelerate innovation in developing countries, using a database of innovations and funding opportunities to reveal curated content and industry insights for social entrepreneurs, for the funders who fund them, and for other development professionals'; and (iv) the Africa Innovation Summit,<sup>51</sup> which brings together heads of state, ministers and policy makers, CEOs and leaders of industry, capital market

<sup>48</sup> <http://tonyelumelufoundation.org/>

<sup>49</sup> <https://nef.org/>

<sup>50</sup> <https://www.globalinnovationexchange.org/>

<sup>51</sup> <https://www.africainnovationsummit.com/>

operators, investors and academics to promote and build an enabling environment for innovation in Africa.

#### **5.4. Conclusions**

141. African entrepreneurship ecosystems score highly on 'opportunity perception', but low on start-up skills, risk acceptance and capital availability. For sub-Saharan Africa the quickest gains could be achieved by improving start-up skills, with improved access to education and skills that support careers in entrepreneurship.
142. The collective GDP of Africa is now greater than Brazil, India and Russia combined. The significant increase in the number of 'large companies' between 2008 and 2014, with over 700 companies now having revenues of greater than US\$500 million, illustrates a positive growth across the business sector in Africa
143. There has been a massive increase in innovation driven entrepreneurship over the past several years as evidenced by the rapid rise of technology hubs in many countries, much of it associated with IT-related innovations across multiple sectors, and there is every evidence that this increase will continue.
144. The large number of continental prizes rewarding entrepreneurs serves both to promote the concept of entrepreneurship and encourage the youth specially to participate and invest their time and energy.

## 6. Progress in STISA-2024 Priority Areas

145. Much of the analysis in the preceding sections of this report have dealt with broad ‘horizontal’ issues associated with STI. In this section we deal with vertical, sectoral developments over the past five years. STISA-2024, the first of several planned 10-year strategies for Africa, is built upon a strategic orientation based upon six priority areas, namely:

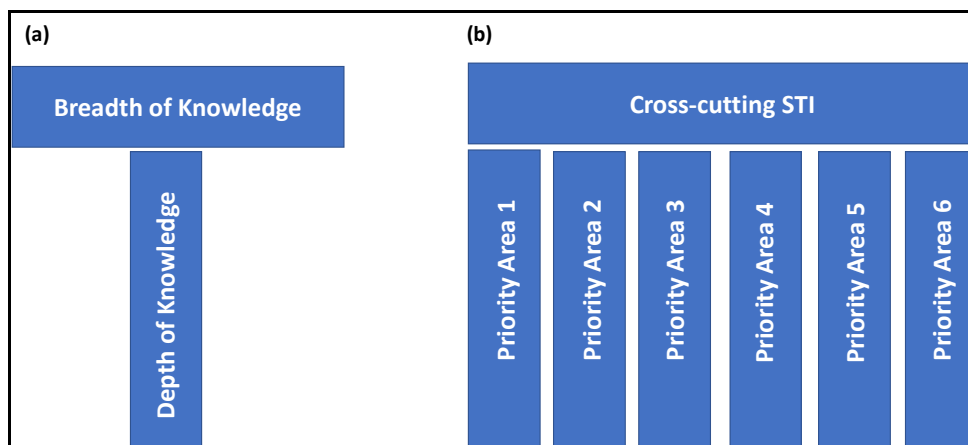
- i. eradication of hunger and achieving food security;
- ii. prevention and control of diseases;
- iii. communication (physical and intellectual mobility);
- iv. protection of our space;
- v. live together–build the society; and
- vi. wealth creation.

Some examples of the types of research and innovation associated with these areas is provided in Table 6.1, taken from STISA-2024.

**Table 6.1. Summary of STISA-2024 Priority Areas (AU, 2014a)**

	Priorities	Research and/or innovation areas
1	Eradicate Hunger and ensure Food and Nutrition Security	- Agriculture/Agronomy in terms of cultivation technique, seeds, soil and climate - Industrial chain in terms of conservation and/or transformation and distribution infrastructure and techniques
2	Prevent and Control Diseases and ensure Well-being	- Better understanding of endemic diseases - HIV/AIDS, Malaria Hemoglobinopathie - Maternal and Child Health - Traditional Medicine
3	Communication (Physical & Intellectual Mobility)	- Physical communication in terms of land, air, river and maritime routes equipment and infrastructure and energy - Promoting local materials - Intellectual communications in terms of ICT
4	Protect our Space	- Environmental Protection including climate change studies - Biodiversity and Atmospheric Physics - Space technologies, maritime and sub-maritime exploration - Knowledge of the water cycle and river systems as well as river basin management
5	Live Together – Build the Society	- Citizenship, History and Shared values - Pan Africanism and Regional integration - Governance and Democracy, City Management, Mobility - Urban Hydrology and Hydraulics - Urban waste management
6	Create Wealth	- Education and Human Resource Development - Exploitation and management of mineral resources, forests, aquatics, marines etc - Management of water resources

146. The combination of both cross-cutting horizontal issues with vertical and sectorial depth may be described as a T-shaped knowledge management structure (Barile, Franco, Nota, & Saviano, 2012) where the cross at the top of the T represents ‘horizontal breadth’ of knowledge and the down stroke represents ‘vertical depth’ of knowledge. The application of this concept to STISA illustrated in Figure 6.1. Developments within the vertical priority areas within the last five years are highlighted in the remainder of Section 6



**Figure 6.1. Adaptation of T-shaped knowledge management model for STISA. (a) T-shape illustrating concept combining cross-cutting breadth of knowledge with depth of a particular area of knowledge. (b) Application of this concept for the interface between STI broadly and the six priority areas of STISA**

## 6.1. Priority Area 1: Eradication of Hunger

### CAADP and Malabo Declaration

147. Agricultural issues and the extreme importance of eradicating hunger on the continent has led to a well-designed and well-coordinated AU-led set of policies and activities that have had a major impact. The ground work has been laid with the adoption of Comprehensive Africa Agricultural Development Programme (CAADP) in 2003, as the Flagship Programme of the African Union for agriculture and food security. The adoption included the establishment of broad targets of 6 percent annual growth in agricultural GDP, and allocation of at least 10 percent of public expenditures to the agricultural sector. These resources are managed through the establishment of national agriculture and food security investment plans (NAIPs) which lie at the heart of CAADP.
148. In June 2014, the AU Heads of State took stock of CAADP and recognised the need to put more effort into ensuring the implementation of NAIPs for impact. This led to the Malabo declaration on Accelerated Agricultural Growth and Transformation (AU, 2014b). This declaration established the Africa 2025 Vision for Agriculture to be implemented within the Framework of CAADP and was aligned to the First Ten Year Implementation Plan of Africa's Agenda 2063. There was an agreement that there should be a biennial review to track, monitor and report on progress. The first of these reports was issued in 2017 (AU, 2018g). This included the development of Country Scorecards (AU, 2018h).

149. An IFPRI analysis (Badiane, 2018) stated that 47 out of 55 AU member states submitted reports and data. Interestingly, Central Africa, which normally is the most capacity-challenged sub-region recorded a 100% return of reports, highlighting the relevance of the process for poverty reduction. Reporting by other regions was also good: Eastern Africa (67 percent), Northern Africa (57 percent), Southern Africa (100 percent), and Western Africa (93 percent). Out of the 47 reporting countries, 20 obtained an overall agricultural transformation score of at least 3.9 out of 10 indicating that they are on track to achieving Malabo commitments by 2025. Regionally, only Eastern and Southern Africa are on track to achieving the Malabo commitments with scores of 4.2 and 4.0, respectively. A major message from the report was that countries should seek to ensure they reach their targets of tripling intra-African trade in agricultural commodities and services by 2025. At the moment this is not on track, with a continental composite score of 14.9% for this indicator against a target of 20% for the period under review. A summary of the scorecard is reproduced in Figure 6.2.

Country overall progress for implementing the Malabo Declaration for Agriculture transformation in Africa							
<p>Against the 2017 Benchmark of <b>3.9 out of 10</b> which is the minimum score for a country to be on track for implementing the Malabo Declaration, countries which score (out of 10) appears in "green" are <b>ON TRACK</b>, and countries which score appears in "red" are <b>NOT ON TRACK</b> for the 2017 reporting exercise to the January 2018 AU Assembly.</p>				Algeria	Angola	Benin	Botswana
				n.a	2.1	4.3	4.4
				Burundi	Burkina Faso	Cameroon	Cabo Verde
				4.7	4.2	2.1	4.6
Central African Rep.	Chad	Comoros	Congo	Côte d'Ivoire	DR Congo	Djibouti	Egypt
2.4	2.2	n.a	2.8	3.5	1.4	3.2	3.4
Equatorial Guinea	Eritrea	Ethiopia	Gabon	Gambia	Ghana	Guinea	Guinea-Bissau
3.6	n.a	5.3	2.9	3.1	3.9	3.3	n.a
Kenya	Lesotho	Liberia	Libya	Madagascar	Malawi	Mali	Mauritania
4.8	3.7	0.9	n.a	3.1	4.9	5.6	4.8
Mauritius	Morocco	Mozambique	Namibia	Niger	Nigeria	Rwanda	Rep. A. Saharawi
5.0	5.5	4.1	4.1	3.5	3.4	6.1	n.a
São Tomé & Príncipe	Senegal	Seychelles	Sierra Leone	Somalia	South Africa	South Sudan	Sudan
1.5	3.8	4.0	1.5	n.a	4.1	n.a	1.9
Swaziland	Tanzania	Togo	Tunisia	Uganda	Zambia	Zimbabwe	2017 Benchmark
4.0	3.1	4.9	1.7	4.5	3.6	3.2	3.9

Figure 6.2 National scores on progress towards the Malabo Declaration (AU, 2018h).

150. Several elements of the scorecard relate directly to innovation and entrepreneurship, namely 'enhancing investment finance in agriculture' and 'boosting intra-African trade in agricultural commodities' though there is no direct reference indicator for research per se. A white paper by Her Excellency Professor Ameenah Gurib-Fakim, President of Mauritius on innovation, entrepreneurship and governance for sustainable development of Africa's agri-food system (Gurib-Fakim, 2015) contained the following key messages:

- i. Africa has the human capital to transform its agricultural sector

- ii. Growth in urban markets provides new opportunities for enterprise development
- iii. Investments in science, technology, engineering and math must be increased
- iv. Bold leadership as well as policies that promote R&D collaboration and provide incentives for partnering with the private sector should be implemented.

### **Research, Technology Development and Implementation**

151. The organisation entrusted with coordinating the research component of CAADP on behalf of the African Union is the Forum for Agricultural Research in Africa (FARA). Together with constituent partners, FARA is leading the development and operationalisation of the Science Agenda for Agriculture in Africa (S3A) (FARA, 2014). The FARA web site states that:

*The strategic thrusts of S3A in the short to medium term are; the implementation of CAADP; increase domestic public and private sector investment; creating the enabling environment for sustainable application of science for agriculture; and to double current level of Agricultural Total Factor Productivity (ATFP) by 2025 through application of science for agriculture. In the medium to long-term the science agenda is to build systemic science capacity at national and regional levels, capable of addressing evolving needs for farmers, producers, entrepreneurs and consumers, especially given strategic and foresight issues such as climate change and urbanisation.*

152. In moving ahead with the S3A strategy FARA seeks to incubate and test new concepts. FARA have collaborated with, and helped establish the African Agribusiness Incubators Network (AAIN) through a UniBRAIN programme supported by DANIDA. Six pilot consortia of universities, businesses and agricultural research institutions are located in five countries (Kenya, Ghana, Mali, Uganda and Zambia) and deal in various value chains; namely coffee, banana, sorghum, non-timber forest products, cereals, fruits and vegetables. (FARA, 2015). In 2016 FARA stated that the AAIN currently hosts over 100 incubators, members and partners in 54 African countries. Under UniBRAIN, the incubators collectively commercialized over 75 Agribusiness technologies and created thousands of jobs. The research networks have supported over 137 SMEs to start up and expand businesses along selected commodity value chains, while creating business networks of about 24,000 value chain actors engaged in agribusiness (FARA, 2016).

153. A range of entrepreneurial activities are active on the continent. A collection of success stories of ICT entrepreneurs contributing to transforming agriculture in African and Caribbean countries is available (CTA, 2016).

154. A major requirement for agricultural development is to bridge the innovation gap from early research and development to the market stage through the identification,

validation and scale-up of technologies. A programme entitled Technologies for African Agricultural Transformation (TAAT)<sup>52</sup> (AfDB, 2016a; International Institute for Tropical Africa, 2018) was initiated in February 2018 to rapidly expand access of high yielding agricultural technologies to smallholder farmers and to guide the deployment of proven agricultural technologies to scale in a developmentally- and commercially sustainable fashion. It is now established (TAAT, 2019) and supported by FARA and its constituent organisations, plus the International Institute for Tropical Agriculture and the African Development Bank, as part of its Africa Feeding Africa strategy (AfDB, 2016b). As the portfolio of new (existing) technologies are assessed as to whether they can be scaled up for inclusion in Africa's agricultural development, more attention will have to be paid to the discovery and development of new technologies. This will require continued and extended support of African Universities and research institutions.

155. A collection of articles providing an overview of agricultural research in Africa was published by the International Food Policy Research Institute (IFPRI) (Lynam, Beintema, Roseboom, & Badiane, 2016). Furthermore, a Comprehensive Overview of Investments in African Agricultural Research has been undertaken under the auspices of IFPRI (Beintema & Stads, 2017). It reports an increase in sub-Saharan African agricultural research spending between 2000 and 2014 from \$1.7 to \$2.5 billion in 2011 PPP prices, excluding the for-profit sector. It noted that three countries accounted for over 50% of all spending in 2014, namely Nigeria (\$434 million), South Africa (\$417 million) and Kenya (\$274 million). Ethiopia, Tanzania, Ghana and Uganda each spent over \$100 million, but twelve of the forty countries providing data spend less than \$10 million. Given the expansion of activities within the last four years, for example through the AfDB Africa Feeding Africa strategy and the planned activities of the World Bank's SHAEA initiative (see below), it is anticipated that we will see a continued increase in research spending levels when they are next comprehensively reported.
156. RUFORUM, The Regional Universities Forum for Capacity Building in Agriculture<sup>53</sup> is a major African-led organisation seeking to enhance capabilities and resources for agricultural research through working with African universities. Established by ten Vice Chancellors in 2004, RUFORUM now constitutes a consortium of 106 African universities operating within 36 countries spanning the African continent. In July, 2014, RUFORUM signed a cooperation agreement with the African Union to support the implementation of priority Area 1 within STISA-2024. RUFORUM takes a partnership approach to support universities development and research through a range of grants and other activities. Recently RUFORUM was instrumental in negotiating with the World Bank to establish the \$190 million Strengthening Higher Agricultural Education in

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<sup>52</sup> <http://taat-africa.org/>

<sup>53</sup> <https://www.ruforum.org/>



Africa (SHAEA) Initiative.<sup>54</sup> RUFORUM's partnership approach to agribusiness innovation is highlighted as a case study in a desk review of this topic (Payumo, Lemgo, & Maredia, 2017). One of the conclusions of the study is that Universities, in partnership with critical sectors in the value chain, including communities and the private sector, will be the key institutions for intellectual capital development and knowledge creation to address agricultural, business and societal needs.

157. One of the main challenges facing Africa is the low land and labour productivity of African Agriculture (Badiane & Collins, 2016). This has led many to call for a green revolution in Africa, similar to what happened in India in the 60s and 70s (Swaminathan, 2017). Over the last four years there has been a demonstrable increase in political support to address the continental crisis of hunger and food security and momentum is building. More and more Africa-led policies and implementation activities, are taking place that are increasingly linked to innovation, entrepreneurship and R&D. This section has summarised some of the recent developments and key actors. Although not highlighted in this report, many of the activities undertaken are linked to resilience and adaptation to climate change, a key indicator on the Malabo declaration scorecards (AU, 2018h).

### **Conclusions**

158. Progress on the 2014 Malabo declaration on 'Accelerated Agricultural Growth and Transformation' and the responsiveness of almost all countries in providing data to allow the monitoring of indicators, is a very welcome development. The degree of coordination across the agricultural and agricultural research sector on the continent through CAADP and FARA is noteworthy, as are the objectives of the new Science Agenda for Agriculture in Africa (S3A) and its objectives to serve CAADP and to double current level of Agricultural Total Factor Productivity (ATFP) by 2025. Initiatives such as the African Agribusiness Incubators Network (AAIN), the Technologies for African Agricultural Transformation (TAAT) programme and Strengthening Agricultural Education in Africa (SHAEA) could have a major impact on the sector. The underlying emphasis placed by the African Development Bank on its 'Africa Feeding Africa' strategy gives additional cause for hope that finance will be made available for innovation-led agricultural development.
159. While acknowledging progress, the underlying challenges of low land and labour productivity remain and need to be addressed in a way that sustains livelihoods and retains social cohesion.

## **6.2. Priority Area 2: Prevention and Control of Diseases**

160. Although health and research for health on the continent have been quite heavily supported over the years by a variety of international partners, its many actors often operate with quite dispersed aims and objectives. This collective, albeit often

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<sup>54</sup> <http://www.ruforum.org/SHAEA/>



dispersed, activity has yielded some significant health gains, but the approach to health on the continent has lacked the coherence of the approach to Agriculture described in the previous section. This section provides some recent historical context to help address health, research and innovation on the continent. It describes how over the past few years there has been a move towards a more coherent continental approach, with a growing interest to support African led health research and innovation.

### **Critical developments from 2000 to 2015**

161. Three of the eight Millennium Development Goals focused on health. MDG 4 aimed to reduce child mortality, MDG 5 aimed to improve maternal health and MDG 6 aimed to combat HIV/AIDS, malaria and other diseases. As the most severe challenges for these three goals were on the African continent, these African issues received a huge global attention at the turn of the century. The Global Fund for AIDS, TB and Malaria was established. The then recently created Bill and Melinda Gates Foundation started to provide resources to address these problems, initially focusing on science and technology-based solutions such as drugs and vaccines. A range of public private partnerships, supported by philanthropic foundations and aid agencies, were established to address the need for drugs and vaccines to combat HIV/AIDS, malaria, tuberculosis and neglected diseases (Ridley, 2001) (Widdus, 2001). At the same time resources from research funding agencies such as the NIH, the European Union and the Wellcome Trust, and also the Gates Foundation, were scaled up to complement these initiatives. Some of these research activities were funded at a scale way beyond what had been imaginable previously, for example through the Gates Grand Challenges (Bill and Melinda Gates Foundation, 2014) and, later, other Grand Challenges Canada (Grand Challenges Canada, 2018). This led to an influx of resources that has helped develop global African partnerships and build substantive health research capability on the continent, complementing more long standing, lower level research funding, such as that from WHO/TDR.<sup>55</sup>
162. These activities were largely successful in that: (i) Under-5 mortality rate declined from 90 to 43 deaths per 1,000 live births; (ii) Maternal mortality ratio declined from 380 to 210 per 100,000 live births; (iii) New annual HIV cases reduced from 3.5 million to 2.1 million; (iv) Malaria annual deaths reduced from 839,000 to 438,000; and non-HIV TB annual deaths reduced from 2.4 to 1.1 million. During this time Africa's percentage share of global health research output was 0.7% in 2000 and increased to 1.3% in 2014.
163. As these activities progressed, a greater awareness developed about: (i) the need to view health research more holistically as operating within a health system; (ii) the growing disease burden in Africa associated with non-communicable diseases; and (iii) the potential value of applying new information technologies to develop e-health

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<sup>55</sup> <https://www.who.int/tdr/en/>

and m-health in support of health systems. Attempts were also made to domesticate the health and health research agendas through the concept of national health research systems (Kennedy & IJsselmuiden, 2006) and the development of intra-African activities. Amref Health Africa continued to mature as an African based and African-led organization<sup>56</sup>. AUDA-NEPAD supported science and research activities, including in health research, for example the Southern African Network for Biosciences (SANBio).<sup>57</sup> The Wellcome Trust and NIH supported the establishment of The Human Heredity and Health in Africa (H3Africa) consortium.<sup>58</sup> The Global Emerging Pathogens Treatment Consortium (GET) was established with support from a number of international donors in response to the Ebola outbreaks of 2013.<sup>59</sup> An African Network for Drugs and Diagnostics Innovation (ANDI) was also established (Nwaka, et al., 2010).

164. These activities laid the groundwork for developments post-2015 associated with the Sustainable Development Goals (Agenda 2030) and Agenda 2063.

#### **African Health and Research for Health Strategies established in 2016**

165. A revised African Health Strategy has been developed covering 2016-2030 (AU, 2016g). It is aligned to Agenda 2063 and the SDGs and seeks to enhance other commitments already made in the field of health. The situation analysis that accompanies the strategy refers to the triple burden of communicable and non-communicable diseases and injury and trauma. It also recognises the need to cover a broad thematic spectrum of health issues, the central importance of strengthening health systems and the threat of disease outbreaks such as Ebola and other disasters that can impact on sustainable development. It recognises the untapped potential of the private sector to support the health sector. The strategy has two main objectives. The first is, by 2030, to achieve universal health coverage and the second is to reduce morbidity and end preventable mortality. A strategic priority within the first objective focuses on innovation:

*Strengthen health research, innovation, ICTs for health, technological capabilities and developing sustainable evidence informed solutions for Africa's health challenges;*

166. The AU health strategy has been complemented by a WHO 'Research for Health Strategy' for the African Region 2016-2025 (WHO-AFRO, 2015). The African Union and the World Health Organization have highlighted their cooperation to advance the health agenda in Africa (AU, 2017f). The situation analysis accompanying the Research for Health Strategy notes that:

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<sup>56</sup> <https://amref.org>

<sup>57</sup> [https://nepadsanbio.org/docs/SANBio\\_BROCHURE.pdf](https://nepadsanbio.org/docs/SANBio_BROCHURE.pdf)

<sup>58</sup> <https://h3africa.org/>

<sup>59</sup> <https://www.getafrica.org/>

*Africa's percentage share of global health research output was 0.7% in 2000 and increased to 1.3% in 2014. The research arena in the African Region is characterized by a multiplicity of actors, dispersed efforts and unclear results in relation to impact on priority health problems.*

The strategy highlights the importance of national health research systems and notes the endorsement by the World Health Assembly to invest at least 2% of national health expenditures and at least 5% of health sector project/ programme aid in strengthening of national health research systems. It also references the *Global strategy and plan of action on public health, innovation and intellectual property* (WHO, 2011) urging Member States to implement the specific actions recommended, including:

*prioritization of research and development needs; promotion of research and development; development and improvement of innovative capacity; transfer of technology; application and management of intellectual property to contribute to innovation with a view to promoting public health, improving delivery and access, promoting sustainable financing mechanisms, and establishing monitoring and reporting systems.*

The strategy defines an internally coherent set of objectives, targets, guiding principles and priority interventions.

#### **Continental initiatives: CDC, PMPA and Networks**

167. Probably the most significant development in African health, with implications for health research and innovation, has been the establishment of the Africa Centres for Disease Control already outlined in section 3.1.5 (AU, 2017c). This organisation can assist in bringing a greater level of coherence in the approach to health across the continent as well as helping address the immediate health needs of the continent and provide support at country level.
168. A second strategically significant continent-wide programme that has seen some development in the last four years has been the Pharmaceutical Manufacturing Plan for Africa (PMPA) (AU and UNIDO, 2012). This plan recognises the variation in disease profiles across the continent and the variations in capabilities that exist between nations on the continent for both pharmaceutical manufacture and for pharmaceutical regulation. The plan also recognises the importance of intra-continental trade systems to allow the development of the industry on the continent and, linked to that, the TRIPS flexibilities referred to in Section 3.4.4 that have a particular relevance for health products (Nicol & Owoeye, 2013). The plan further recognises the need for incorporating the views of a wide range of stakeholders, including the private sector, to move forward effectively. The plan was adopted with the explicit aim of contributing to a sustainable supply of quality essential medicines to improve public health and promote industrial and economic development on the continent. There are two main thrusts to achieving this aim.
  - i. The first is to improve the quality of regulation of pharmaceutical products and their manufacture, both produced within, and imported into, the continent. This work is carried out with the assistance of the African

Medicines Regulatory Harmonisation (AMRH) Initiative, which has led to the domestication of an African Union Model Law on Medical Products Regulation by twelve countries (Ndomondo-Sigonda, et al., 2018). A major advance towards improved regulatory harmonisation has also come about through the adoption of a Treaty for establishment of African Medicines Agency by Ministers of Health in May 2018 (Zarocostas, 2018; AU, 2018i).

- ii. The second is to upgrade the level and quality of manufacture. Most pharmaceutical companies in Africa import the active pharmaceutical ingredients and just package and, sometimes, formulate their products. Only South Africa, Egypt and Ghana have companies that manufacture the active pharmaceutical ingredients that constitutes the medicines. The plan seeks to assist the development of more companies in more countries to develop the capacity for manufacturing the active pharmaceutical ingredients. In the long term the goal is to facilitate the development of R&D based pharmaceutical companies to discover and develop drugs, vaccines and diagnostics on the continent. It may be that the road to R&D based pharmaceutical companies can be facilitated by increased funding for health research e.g. through The Alliance for Accelerating Excellence in Science in Africa (AESAs) and approaches to network academics with the private sector, such as promoted by the African Network for Drugs and Diagnostics Innovation (ANDI) (Nwaka, 2017). Some African academics are developing programmes that are receiving internationally competitive funding for pharmaceutical drug R&D (MMV, 2018).

### **Innovation and Entrepreneurship**

169. Goldstein estimated that the African healthcare sector, covering pharmaceuticals, services, devices and miscellaneous was valued at \$35 billion in 2016 and is expected to grow at a rate of around 6% a year 2024 (Africa Business Communities, 2018). McKinsey estimated that the African pharmaceutical market had increased from \$4.7 billion in 2004 to \$20.8 billion in 2013 and that it can realistically expect to rise to at least \$41.8 billion by 2020 (Holt, Lahrichi, & Santos da Silva, 2015). There is obviously plenty of opportunity for innovation, both to meet unmet needs and to take advantage of a growing market.
170. In 2014 a new international journal was initiated called 'Innovation and Entrepreneurship in Health' (Dove Press, n.d.) reflecting the growing interest in this field. Concomitant with this interest, several agencies have particularly targeted the African health sector for the provision of funds to support innovation and entrepreneurship in recent years. These include:
  - i. AESA, supported by the Bill & Melinda Gates Foundation have committed \$7 million for Grand Challenges Africa Innovation Grants for health and developmental outcomes (Ayemoba, 2016; Grand Challenges Innovation Network, n.d.)

- ii. Amref Health Africa, who have launched a fund called Innovate for Life with several other sponsors (Innovate for Life, n.d.; Amref Health Africa, 2018) and have issued two reports so far on the recipients of their funds (Innovate for Life, 2017; Innovate for Life, 2018)
- iii. Johnson and Johnson who sponsor Africa Innovation Challenge 2.0 (Johnson and Johnson, n.d.)
- iv. Duke University who are sponsoring healthcare innovation in East Africa (Odero, Sable, & Udayakumar, 2016)

## **Conclusions**

171. The international response to Africa's 'global' health challenges over the last two decades has been impressive and has taken on a new direction with the SDGs, with a strong emphasis on health systems. Historically, there has been limited coordination from within the continent, with a multitude of actors have often operated with diverse objectives. The launch in 2016 of the AU African Health Strategy and the WHO African Research for Health strategy, combined with the establishment in 2017 of the Africa CDC, provide an opportunity for a greater level of ownership on health issues to be developed within Africa.
172. This level of ownership will be reinforced if home-grown innovation can start to play a role in addressing the continent's health challenges, from communicable and non-communicable diseases to resource constrained health systems. The low level of national resources for health research in many countries hinders innovation and the continent will likely remain dependent on international financing of health research and innovation for the foreseeable future. However, the recent examples of home-grown innovation and the establishment of funds to support innovation and entrepreneurship in a health sector valued at US\$ 35 billion provide a useful starting point for innovation and entrepreneurial growth. The continued development of the Pharmaceutical Manufacturing Plan for Africa, for example through a new African Medicines Agency, supported by the domestication of an African Union Model Law on Medical Products Regulation, offers hope for the development of pharmaceutical innovation on the continent.

### **6.3. Priority Area 3: Communication (Physical and Intellectual)**

173. This priority area, as indicated in the title, covers both physical communication, such as transportation via roads, rail and air, and intellectual communication based on information and communication technologies. The main continental programme addressing transport related communication is the Programme for Infrastructure Development for Africa (PIDA), which also has energy projects and ICT infrastructure projects. Intellectual communication driven by ICT has a special significance within Agenda 2063. The growth of ICT powered communication has stimulated local research, innovation and entrepreneurship. A number of continental e-networks are being supported to facilitate academic engagement. These include the pan-African e-

network with the Government of India, and Africa Connect and the Policy and Regulation Initiative for Digital Africa (PRIDA) with the European Union.

### Programme for Infrastructure Development for Africa (PIDA)

174. The Programme for Infrastructure Development in Africa (PIDA) was endorsed by the African Union Assembly in January 2012. A Financing Summit was held in June 2014 where AUDA-NEPAD and its partners showcased 16 potential projects (ECA, 2016c) for funding in the areas of regional and trans boundary energy, transport and ICT (NEPAD, AU and AfDB, 2017). As well as receiving funds from traditional sources such as development banks and development partners, funds are also being solicited from the African business sector, for example from regional pension funds. The most recent PIDA annual report (NEPAD, AU and AfDB, 2018), just four years after the financing summit, describes 300 projects in development or under way, as shown in Table 6.2.

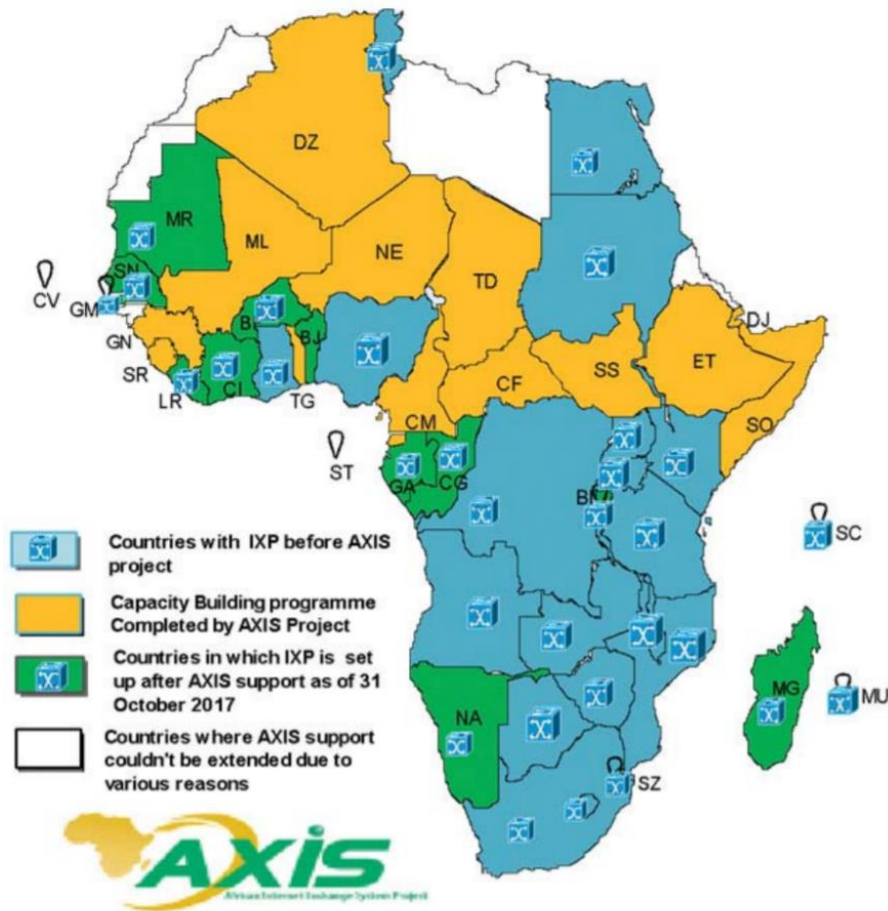
**Table 6.2. PIDA projects in development or under way across the continent (NEPAD, AU and AfDB, 2018).**

Project Stage	Continental	AMU	COMESA	EAC	ECCAS	ECOWAS	IGAD	SADC	Total
S1: Project Definition		2	2	13	3	9	4	13	46
S2A: Pre-Feasibility		4	5	6	12	1	2	8	38
S2B: Feasibility			4	5	4	7		7	27
S3A: Project Structuring		1	2	11	2	5	2	8	31
S3B: Transaction Support & Financial Close		1		9	2	1		4	17
S4A: Tendering			9	5	1	4	1		20
S4B: Constructure	1	1	4	19	19	22	2	12	80
S4C: Operation	1	4	7	19	2	15	1	8	57
<b>Total</b>	<b>2</b>	<b>13</b>	<b>33</b>	<b>87</b>	<b>45</b>	<b>64</b>	<b>12</b>	<b>60</b>	<b>316</b>

175. The scale of the projects being contemplated is immense and is well illustrated by the continental spread of transport projects shown in Figure 6.2 (NEPAD, AU and AfDB, 2017). A similar map is available for energy projects. These projects will obviously go a long way to facilitate African integration and to facilitate intra-continental movement. In this way they will have a significant impact on the ability of academics, innovators, entrepreneurs and established businessmen to interact across the continent and thus enhance science, technology, innovation and entrepreneurship.
176. As part of the process of laying intracontinental infrastructure, a variety of legal requirements need to be established to facilitate cross-border interaction. For example, the ECA has developed a model law to harmonize cross-border rules, regulations, laws and policies governing transboundary infrastructure projects in Africa, which was recently adopted (ECA, 2017b). Another development is the creation of a single African Air Transport Market (SAATM).







**Figure 6.3 Distribution of national capacity building programmes (orange) and implementation (green) of the African Internet Exchange System (AXIS) project (NEPAD, AU and AfDB, 2017)**

178. Several legal issues and requirements are emerging as part of the enhancement of intra-African trafficking of information. A cybersecurity convention was established in 2014 (AU, 2014c). Ratification of the convention will greatly facilitate the governance and management of cybersecurity issues and personal data on the continent. This will help regulate data acquisition and its management in research and will regulate how data is managed and handled by businesses acquiring information and data through ICT.

179. The PIDA initiative has already achieved laudable results. The 2018 report stated that this includes the addition of 16,066 km of roads and 4,077 km of railway lines to the African transport infrastructure network; 3,506 km of transmission lines to the power grid; and the connection of 17 countries with regional fibre-optic cables. The construction and operation phases of its projects have created 112,900 direct and 49,400 indirect jobs. This will provide valuable engineering and management skill development and experience for both technical and professional level workers.



180. There is a specific component for capacity building within PIDA comprising 51 programmes with more than 400 projects to accelerate implementation of infrastructure programmes. Additional opportunities are available through partnerships e.g. GIZ is supporting training in the development and management of public private partnerships. A flavour of the spread of training is found in the 2018 report, which mentioned the specific training schemes of: 24 journalists; 77 PIDA project implementers; and 400 members of cooperatives from Zambia and Angola to facilitate trade along the Lobito Corridor. Much more training is anticipated in the coming years. The PIDA project could become a strong platform for building expertise in Science, Technology, Engineering and Innovation more generally.
181. At a deeper level the PIDA projects also provide an opportunity for innovation. Any large project of the type being undertaken through PIDA has implementation challenges. Some of these are technical while others may be societal or managerial. If funds are set aside within the projects for academic scientists, social scientists and engineers to work alongside the project implementers to identify and address some of these challenges then there could be two major benefits. First, the quality and sustainability of the project may be improved through academic partnership and research. Secondly, the academic partnership could lead to many scientists, technologists and engineers being trained to postgraduate level, with potential for innovative spin-offs from their work.

### **Continental e-networks**

182. A number of continental e-networks are being established to facilitate interconnectivity between academic centres within Africa and with external partners. These include the Pan-African e-Network in collaboration with the Indian Government and Africa Connect 2 and the Policy and Regulation initiative for Digital Africa (PRIDA), which operate with the European Union.
183. **Pan-African e-Network.** This is a flagship programme of Agenda 2063, jointly undertaken with the Government of India, with Indian support of around \$125 million. It started in 2009. The main objective is to help build academic and medical capacity by linking African academic and medical institutions with leading Indian academic and medical institutions. The medical link-up would promote the use of tele-medicine. The project has involved 43 member states and the initial phase was completed in 2011. The project was formally handed over from the Government of India to the AU Commission in July 2017. An Assembly of Parties meeting was held in December 2018 to explore options of using the Pan African e-Network infrastructure for add-on services, potentially including Pan African Mass Education TV (Wikipedia, a; (AU, 2018j)).
184. **Africa Connect** (Africa Connect 2, n.d.). This project aims to enhance e-connectivity between academic institutions within Africa and with the global research and education

community. It works through National Research and Education Networks (NRENs), working with the Ubuntu Alliance in Eastern and Southern Africa, WACREN in Western and Central Africa and ASREN in North Africa. The European Union is providing €20 million and African national partners contribute an additional amount, 20% for East and Southern Africa, where the system is already operational in many countries, 25% for West and Central Africa and 40% for North Africa. Apart from the increased connectivity, a major benefit for African academic institutions is a marked reduction in the cost of bandwidth through the network.

- 185. Policy and Regulation Initiative for Digital Africa (PRIDA)** (The Africa-EU Partnership, n.d.). This is an €8 million project in partnership with the International Telecommunications Union (ITU) to foster universally accessible and affordable broadband across the continent by facilitating efficient and harmonised spectrum utilisation and harmonising measurable ICT/ Telecommunication policy, legal and regulatory frameworks.

### Digital Development Divide - Information Technology Access

186. Much of the innovations taking place on the continent and leading to entrepreneurial and business activity are based on, or utilise ICT. The two tables below demonstrate the spread of IT access between countries on the continent, with obvious implications for the ease of developing ICT expertise and ICT related innovations and businesses in different countries. Table 6.3 shows the number of mobile subscriptions per 100 people for the top 10 African countries and the bottom 10 countries. The global ranking of the country is provided on the side. The highest ranked country is the Seychelles with 161 subscriptions per 100 users and the lowest is Eritrea with 7 subscriptions per 100 users. Table 6.4 provides similar country data for the percentage of people using the internet. For this indicator Morocco is the highest with 58% of people accessing the internet, while once again Eritrea is the lowest with only 1% of people accessing the internet.

**Table 6.3. Number of mobile phone subscriptions per 100 people for the top10 African countries and the bottom 10 African countries**

(2016 data source: <https://www.indexmundi.com/facts/indicators/IT.CEL.SETS.P2/rankings>)

Global Rank	Top 10 African Countries	Value	Global Rank	Bottom 10 African Countries	Value
12	Seychelles	161.23	184	Niger	48.87
16	Botswana	158.53	185	Papua New Guinea	48.56
31	Mauritius	144.24	186	Burundi	48.04
32	Gabon	144.17	187	Chad	44.48
33	South Africa	142.38	188	Madagascar	41.79
38	The Gambia	139.63	189	Malawi	40.32

39	Ghana	139.13	190	Dem. Rep. Congo	39.48
57	Cote d'Ivoire	126.01	191	Djibouti	37.82
58	Tunisia	125.82	193	Central African Republic	25.49
68	Cape Verde	122.02	195	Eritrea	7.29

**Table 6.4. Percentage of people using the internet for the top10 African countries and the bottom 10 African countries**

(2016 data source

<https://www.indexmundi.com/facts/indicators/IT.NET.USER.ZS/rankings>)

Global Rank	Top 10 Countries	Percentage	Global Rank	Bottom 10 Countries	Percentage
85	Morocco	58.27	185	Liberia	7.32
87	Seychelles	56.51	186	Dem. Rep. Congo	6.21
92	South Africa	54.00	187	Burundi	5.17
96	Mauritius	53.23	188	Chad	5.00
100	Tunisia	50.88	189	Madagascar	4.71
103	Cape Verde	48.17	190	Niger	4.32
104	Gabon	48.05	191	Central African Republic	4.00
115	Algeria	42.95	192	Guinea-Bissau	3.76
119	Botswana	39.36	193	Somalia	1.88
120	Egypt	39.21	194	Eritrea	1.18

187. As we move to develop STI capacities across the continent, these figures are a salient reminder of the Agenda 2030 by-line that we should 'leave no one behind'. Termed the 'digital divide' this issue was the subject of the 2016 World Development Report (World Bank Group, 2016). This has led to a World Bank initiated partnership programme on Digital Development (World Bank Group, 2019). This programme to date has led to analysis and strategically developed activities in a number of African countries, including such areas as digital government and cybersecurity. There are now moves to develop a more coherent approach to support African digital development (World Bank, 2019) in response to the African Union's new Digital Transformation Agenda (AU, 2019).

### Conclusions

188. The Programme for Infrastructural Development for Africa is having a profound effect on the infrastructure of the continent. The resulting infrastructure, through facilitating labour and business mobility and intra-continental communication, will also drive information and knowledge exchange, which is a critical element of innovation. As well as delivering on improved mobility and communication, these infrastructure projects offer a range of scientific, technical, engineering and social scientific opportunities for

human and institutional capacity development across the energy, transport, water and ICT sectors. There are already capacity development programmes that are facilitating TVET and community training. However, this activity seems less than it could be, given the massive scale of PIDA. Apart from a general scaling up of capacity building, one option relevant to innovation development could be to extend capacity building to postgraduate training through research to help address implementation challenges that always arise with such large-scale projects. There could be great value in integrating local problem solving (research and evaluation) expertise into infrastructure projects.

189. The IT infrastructure and networks will greatly facilitate academic and research communication within African and internationally, which in turn will stimulate innovation. An analysis of access to mobile phones and internet across Africa shows there is a huge gulf between the richer and poorer countries in Africa. As well as providing IT infrastructure, major emphasis must be placed on enhancing access to internet and mobile communications once it is available. Increased access by all to these technologies will massively improve communication, education and trade and will also serve to reduce socio-economic inequities. It is anticipated that major advances may occur in the coming years given a variety of initiatives, for example through the World Bank initiated Digital Development Partnership.

#### **6.4. Priority Area 4: Protection of our Space**

190. The activities of priority area 4, protection of our space, focus on the technology of space and satellite technology, but have applications directed towards the protection of our terrestrial space and its conservation and management. In the STISA-2024 strategy (AU, 2014a, p. 24) and as outlined in Table 6.1, potential areas of research and innovation linked to this priority area include:

- (i) environmental protection;
- (ii) climate change
- (iii) biodiversity
- (iv) atmospheric physics
- (v) space technologies
- (vi) maritime and sub-maritime exploration
- (vii) water cycle, river systems and river basin management

This activity notably interfaces with priority area 1 on eradication of hunger, which is reliant on the sustainability of agriculture; priority area 5 on living together and building society, which is reliant on managing our environment; and priority area 6 on wealth creation, wherein much of the continent's wealth arises from appropriate exploitation of the continent's natural resources.

191. As indicated in section 3.2.3 a major strategic and policy emphasis related to innovation in this priority area is the establishment and development of a space policy and the associated development of space and satellite technology. This makes a lot

of sense as space and satellite technology are critical to an understanding of the environmental changes affecting our planet and continent, as well as linking to improved communications and enhancing the scientific understandings of our physical origins. Activity related to space science and technology over the last four years will be reviewed within this section along with key continental activities linked to the environment.

192. This short review of priority area 4 activities will cover: (i) environmental management and climate change; (ii) water management; and (iii) the Agenda 2063 flagship project – the African space strategy.

### **Environmental Management and Climate Change**

193. The most significant development relating to climate change and global environmental management over the last several years was undoubtedly the Paris Agreement agreed at the 21<sup>st</sup> Conference of Parties (COP 21) of the UN Framework Convention on Climate Change in December 2015 (UN, 2015b). This agreement's primary decision was to hold temperature rises to 1.5°C above pre-industrial levels. A summary of the what the Paris Agreement means more broadly can be found on the UN climate change website<sup>60</sup> and the implications for Africa are covered concisely in a tralac trade brief (van der Nest, 2016).
194. The Paris agreement represented a success for the African continent as negotiators went into the meeting with a common African position to ensure an inclusive, ambitious and equitable agreement (AU, 2015d). An equitable agreement was important given that Africa collectively produces around 4% of greenhouse gas emissions compared to China and the USA combined producing over 40%, yet climate change adversely affects African agriculture, which accounts for 30 to 40% of Africa's GDP. It also has a major impact on Africa's small island states due to the rise of sea levels and the challenges of potential increases in cyclones and other weather-induced disasters, such as flooding or drought. The negotiating team managed to ensure that attention should be paid equally to both adaptation measures and mitigation measures.
195. The Africa Adaptation Initiative, enhancing action on adaptation and addressing loss and damage in Africa (Africa Adaptation Initiative, 2015) was launched at COP 21. This had been informed by a ECA/ACPC Loss and Damage report (Schaeffer, et al., 2014) which had demonstrated that a 4°C rise could lead to costs of up to 6% of Africa's GDP unless appropriate mitigation and adaptation measures are taken. Adaptation and issues associated with loss and damage had an impact on later COP discussions (Chan & Mogelgaard, 2017) and led to the creation of an Adaptation Fund that has provided US\$ 564 million to 84 projects,<sup>61</sup> though this needs to be set against

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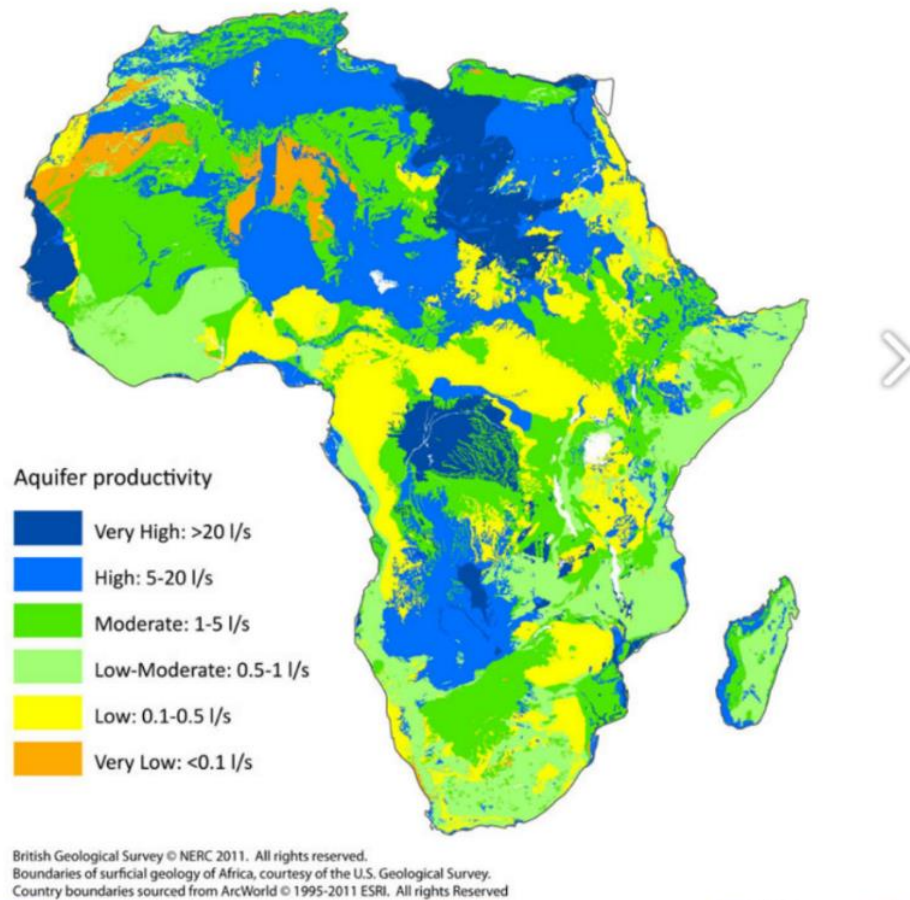
<sup>60</sup> <https://unfccc.int/process-and-meetings/the-paris-agreement/what-is-the-paris-agreement>

<sup>61</sup> <https://www.adaptation-fund.org/cop24/>

calculated requirements of US\$100 billion for adaptation in Africa (van der Nest, 2016, p. 12).

### **Water Management in Africa**

196. It is widely reported that Northern Africa has 92% safe water coverage, but sub-Saharan Africa remains low at 60% of coverage, leaving about 40% of people in that region without access to clean drinking water (Wikipedia, b; Greentumble, n.d.). It should be noted though that this appears to be based on pre-2010 data. As sub-Saharan population growth continues to increase rapidly to an estimated 1.4 billion in 2030 from 970 million in 2015 (UN Population Division, 2017) issues of access to water may become more acute. The potential for this issue to affect even the most developed parts of the continent have recently been highlighted by water shortages in Cape Town (Ziervogel, 2019).
  
197. Improved hydrogeological aquifer mapping techniques have suggested that there is a large supply of groundwater that could support improved access to water on the continent (MacDonald, Bonsor, Dochartaigh, & Taylor, 2012), though the constraints on its access and sustainability need to be recognised (Edmunds, 2012). This is illustrated in Figure 6.4, obtained from an Africa Groundwater Atlas that has now been established online (British Geological Survey, n.d.). It has been argued that, with respect to agricultural development, the issue is not necessarily physical scarcity of water, but economic scarcity of water and that there is significant potential for irrigation fed agriculture if appropriate investments are made (Xie, You, Weilgosz, & Ringler, 2014).



**Figure 6.4. Groundwater Productivity Map of Africa** (British Geological Survey, n.d.)

198. Continental oversight and strategy development for water is undertaken by the African Ministerial Council on Water (AMCOW). Created in 2002, following the development of The Africa Water Vision for 2025 (ECA, AU and AfDB, 2000) AMCOW released a new Strategic Plan 2018-2030 (AMCOW, 2018) aligned to the Strategic Development Goals, notably SDG 6 on clean water and sanitation. The Strategic Plan outlines four strategic priorities, working at national and regional levels:

- (i) Ensure Water Security
- (ii) Ensure Safely Managed Sanitation and Hygiene
- (iii) Good Water Governance and Transboundary Water Cooperation
- (iv) Strengthen AMCOW's Governance and Operational Effectiveness

and four cross-cutting priorities

- (v) Enhance Water and Sanitation Resilience to Climate Change
- (vi) Contribute to Adequate and Sustainable Financing of Water and Sanitation Agendas
- (vii) Improve Monitoring, Evaluation and Knowledge Management Systems
- (viii) Strengthen Gender quality and Youth Empowerment in Water and Sanitation.



199. The African Water Facility (AWF) is an initiative led by AMCOW to mobilise resources to finance water resources development activities in Africa. It is hosted and managed by the African Development Bank and has so far mobilised over €1 billion in committed financing to follow-on investment projects for water supply, sanitation, irrigation and hydropower (African Water Facility, 2016). This has enabled over 100 projects in 52 countries and it aims to leverage an additional €15 billion to further finance infrastructure and service provision by 2025. This will be targeted at:

- (i) Increased access to safely managed water
- (ii) Increased access to safely managed sanitation.
- (iii) Increasing the area of irrigable land area
- (iv) Increasing hydropower capacity
- (v) Increasing volume of multipurpose water storage

Although this finance is significant, it still only achieves 3% of what is required to achieve the Africa Water Vision for 2025, indicating much more needs to be done.

200. There is substantive activity happening at local smallholder level and at national and continental level to address water and sanitation. The Programme for Infrastructure Development in Africa (PIDA) also has water infrastructure projects within its portfolio. This is predicated on a foresight analysis of the Africa Transboundary Water Resources Sector, carried out in 2010 and looking ahead to 2040 (PIDA, 2010) which assessed 10 major transboundary river and lake basins from the 80 international river and lake basins in Africa. PIDA Water currently runs 9 transboundary water projects,<sup>62</sup> each initiated in 2017. PIDA has recently partnered with the Global Water Project and AMCOW to launch a five-year project from 2019-2024 that seeks to raise US\$ 10 billion for improved water security.<sup>63,64</sup>

201. A variety of technologies are utilised to map water on the continent. These range from the more classical approaches<sup>65</sup> to the use of new technologies, such as measuring variations in electrical resistivity by air to map the Earth's subsurface (International Water Management Institute, 2016) or using remote sensing of variations in the earth's magnetic field from space (Otto & Maddocks, 2015) (Space Foundation, 2016). This application of space science feeds into the next section.

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<sup>62</sup> <http://www.au-pida.org/pida-projects/>

<sup>63</sup> <https://www.gwp.org/en/GWP-SouthernAfrica/AIP/programme-components/project-preparation-and--bankability-of--projects-for-water-food-energy-security-in-africa/pida-water/>

<sup>64</sup> <https://www.gwp.org/en/GWP-SouthernAfrica/AIP/programme-components/project-preparation-and--bankability-of--projects-for-water-food-energy-security-in-africa/pida-water/MOU/>

<sup>65</sup> [https://www.usgs.gov/special-topic/water-science-school/science/how-do-hydrologists-locate-groundwater?qt-science\\_center\\_objects=0#qt-science\\_center\\_objects](https://www.usgs.gov/special-topic/water-science-school/science/how-do-hydrologists-locate-groundwater?qt-science_center_objects=0#qt-science_center_objects)



### **Agenda 2063 Flagship Project: African Space Strategy**

202. The African Space Strategy<sup>66</sup> (AU, 2016e) and associated developments such as the establishment of the African Space Agency<sup>67</sup> (AU, 2017e) which will be hosted by Egypt (Kazeem, 2019) is identified as a flagship project for Agenda 2063. The African Space Strategy focuses on four thematic areas namely:
- i. Earth observation;
  - ii. Satellite communication
  - iii. Navigation and positioning; and
  - iv. Space Sciences and Astronomy.

Within each of these thematic areas, there are major continental projects ongoing.

203. A good overview of African Space Science is available (Povic, et al., 2018) which was part of a selection of articles by Nature Astronomy, focusing on Astronomy and space science in Africa (IAU Office of Astronomy for Development, 2018). Povic *et al.* highlight that until recently South Africa, Namibia, Morocco, Algeria and Egypt were the only sources of Astronomy references in Africa and only South Africa, Egypt, Nigeria and Algeria had established satellite programmes. Since 2010, a number of other countries have initiated space programmes. Table 6.5 provides a list of countries that either have a national space agency defined by statute or have another form of coordinating body (Space in Africa, 2018a) and have launched satellites (Space in Africa, 2018b). It should be noted that Namibia is engaged in Astronomy through the University of Namibia and the Namibia University of Science and Technology (Povic, et al., 2018).

# International

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<sup>66</sup> [https://au.int/sites/default/files/newsevents/workingdocuments/33178-wd-african\\_space\\_strategy\\_-\\_st20445\\_e\\_original.pdf](https://au.int/sites/default/files/newsevents/workingdocuments/33178-wd-african_space_strategy_-_st20445_e_original.pdf)

<sup>67</sup> [https://au.int/sites/default/files/newsevents/workingdocuments/33178-wd-st20676\\_e\\_original.pdf](https://au.int/sites/default/files/newsevents/workingdocuments/33178-wd-st20676_e_original.pdf)

# Astronomical Union's Office of Astronom

**Table 6.5. List of National Space Agencies and Coordinating Bodies**  
(Space in Africa, 2018a) (Space in Africa, 2018b).

<b>Country and Name of National Agency as of December, 2018</b>	<b>Date Established</b>	<b>Satellites Launched as of March, 2019</b>
Algerian Space Agency	2002	6
South African National Space Agency	2010	7
Nigerian Space Research and Development Agency	2006	6
Egyptian Space Agency	2018	5
Kenya Space Agency	2017	1
Zimbabwe National Geospatial and Space Agency	2018	
<b>Country and Name of Coordinating Body</b>	<b>Date Established</b>	<b>Satellites Launched</b>
Angola National Space Program Management Office	2013	
Morocco Royal Center for Remote Sensing Space	1989	3
Ghana Space Science and Technology Centre	2012	1
Libya Center for Remote Sensing and Space Science	1989	
Sudan National Remote Sensing Centre	1996	
Tunisia National Mapping and Remote Sensing Center	1988	
Gabon Agence Gabonaise d'Etudes et d'Observation Spatiale	2010	
Ethiopian Space Science and Technology Institute	2016	
Zimbabwe National Geospatial and Space Agency	2018	

204. International partners have also contributed to space development in Africa. For example, at a national level, the Kyushu Institute of Technology, Japan, through their BIRDS project enabled Ghana to launch its first satellite called GhanaSat-1 (JAXA, 2017); Kenya has benefited from a partnership with the Italian space agency; France gave technical and financial support for the establishment of Gabon's space agency; Russia has assisted Angola in the development of its satellite technology; and the Netherlands are collaborating with Namibia to build the first millimetre radio wave telescope in Africa. The EU has also been supporting the use of space applications in Africa through a number of projects that are outlined in more detail below. Furthermore, the engagement of eight African countries, led by South Africa in the Square Kilometre Array project, is also outlined below. A number of international academic partnership and networking projects, including a number supported by the International Astronomical Union's Office of Astronomy for Development, have contributed to build human capacity in space science in Africa.

205. **European Union collaboration with Africa.** The European Union and the African Union operate under the Africa-EU Strategic Partnership, a joint Africa-EU strategy (Council of the European Union, 2007). The Joint Strategy is implemented through multi-year Action Plans that define priority areas of cooperation. The first and second action plans (2008-2013) included 'Science, information society and space.' And this work continues under the latest plan from 2018 onwards under a renewed set of four strategic areas (European Commission, n.d.). There are two main areas of collaboration linked to the African Space Strategy, namely:

- i. The Copernicus Programme<sup>68</sup> which is the EU's major earth observation programme combining sentinel satellite observations with ground-based, sea based and air-based monitoring systems to provide services on land monitoring; environment monitoring; atmosphere monitoring; emergency management; and services for security management and climate change.
- ii. The European Geostationary Navigation Overlay Service (EGNOS),<sup>69,70</sup> which is the European Satellite Based Augmentation System (SBAS) that is used to improve the performance of Global Navigation Satellite Systems (GNSSs), such as GPS and Galileo.

206. **The Copernicus collaboration**, signed in June, 2018 (UN-Spider, 2018) brings the African Union into a global partnership with the US, Australia, Brazil, Colombia, Chile, India, Ukraine and Serbia, with privileged access to Copernicus open data. It builds on an earlier partnership from 2007 with the precursor of Copernicus, namely the Global Monitoring for Environment and Security (GMES). The GMES & Africa programme established services for continent-wide monitoring of: (i) natural

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<sup>68</sup> <https://insitu.copernicus.eu/about>

<sup>69</sup> <https://www.egnos-africa.com/programme-background>

<sup>70</sup> <http://www.gnss-africa.org/>

and water resources; and (ii) marine and coastal resources. The €30 million programmes served to build African capacity to support the African Space Strategy and to access and utilise the earth observation data. It financed 13 consortia, creating 13 regional implementation centres across the five regions of the continent (Space in Africa, 2018).

207. **The EGNOS-Africa collaboration** has primarily focused on supporting air navigation and through that air safety and aviation effectiveness, but also has application for rail transport, maritime transport, agriculture and land management. It feeds into the Global Positioning System (GPS) owned by the USA, as well as the Galileo navigation system owned by the EU. A Joint Programme Office was set up in Dakar, Senegal, to serve as the secretariat of the project, which organises capacity building and outreach programmes for participating Member States. A good overview of the ways in which the EGNOS satellite-based augmentation system can assist Africa can be found at the GNSS web site.<sup>71</sup> Over a 30-year period it is estimated that satellite-based augmentation systems will benefit the continent by many hundreds of millions of Euros.
208. **The Square Kilometre Array Project** seeks to establish an array of thousands of coordinated radio telescopes across Western Australia and Southern Africa that will collectively have an immense power. It will be built in two phases, beginning in 2021, with phase 1 verification planned for the mid-2020s and phase 2 construction likely to be completed in the 2030s. The SKA will create the world's largest radio telescope, which is tens of times more sensitive and hundreds of times faster than today's best radio astronomy facilities, generating data at a rate more than 10 times today's global Internet traffic (Square Kilometer Array, n.d.; Dewdney, Hall, Schilizzi, & Lazio, 2009). Even the phase 1 project (SKA 1) will deliver substantively improved capabilities over the current best telescopes. The elevated, dry and secluded desert areas of Southern Africa and Western Australia form the perfect backdrop for this exercise. Led by South Africa on the continent there are eight additional partner African Countries, Botswana, Ghana, Kenya, Madagascar, Mauritius, Mozambique, Namibia and Zambia which will provide locations for the second phase of the project (SKA 2). SKA offers huge potential for space science globally (Bull, et al., 2018) and for associated development in South Africa (Bhagal, 2018) and Africa as a whole.
209. The SKA project has its origins in 1993 when the International Union of Radio Science (URSI) established the Large Telescope Working Group to begin work on the requirements of the next generation radio observatory. In 2011 the SKA organisation was established as a UK based not for profit company to formalise the relationship between the international partners and centralise the leadership, with a base at the Jodrell bank observatory. In March 2019 the lead partners signed an international treaty establishing the SKA observatory (SKAO) as an intergovernmental organisation

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<sup>71</sup> [http://www.gnss-africa.org/?page\\_id=23](http://www.gnss-africa.org/?page_id=23)

(SKA, 2019). Signatory countries included: Australia, China, Italy, The Netherlands, Portugal, South Africa and the United Kingdom. India and Sweden expect to sign soon after completing internal processes. Canada, France, Malta, New Zealand, the Republic of Korea, Spain and Switzerland have expressed an interest in the project. Over €700 million worth of contracts will be issued from early 2020 among partner countries to build the SKA, which is based on a design that has involved over 1,000 engineers and scientists in over 20 countries. It is important that Africa, the location of this highly significant scientific and technical gains as much benefit from the project as possible.

## **Conclusions**

210. The Paris agreement on climate change has set the global framework for our approach to environmental protection through both mitigation and adaptation processes. Continental funds to support adaptation will continue to be needed to address environmental security. Access to water and water management will prove to be crucial to the continent and new technologies that can assist with underground aquifer detection through terrestrial and space-based observation need to be domesticated within Africa. Earth observation through satellites will be crucial to continental efforts to address, adapt to, and mitigate against, climate change. A substantial increase in resources will be required to meet the essential objectives associated with adaptation to climate change and access to water.
211. The adoption of an African Space Strategy and the establishment of an African Space Agency, to be hosted by Egypt, are significant achievements for the continent. This has occurred on the back of 15 countries actively engaging in space exploration and seven countries successfully launching satellites. A number of centres, supported with international partners, are leading the continental effort and developing expertise that will be invaluable to the continent in future. Space exploration and indeed satellite delivery is an international endeavour. Through partnership, notably with the European Union, Africa will be party to a range of earth observation technologies. However, the continental highlight scientifically is undoubtedly the Square Kilometre Array (SKA) project, in which Southern Africa, together with Western Australia, will host the largest radio telescope in the world. It will be important for South Africa in its leadership role in the project, and African states, to maximise their engagement in SKA activities in the coming decade if Africa is to fully reap the potential benefits of this international collaboration.

## **6.5. Priority Area 5: Live together – build the society**

212. This priority area links to the socio-economic and political issues of how to build a society that can adapt to future changes associated with e.g. urbanisation, Pan-Africanism, regional integration, changing demographics, democratisation and cultural development. How does a report on Science, Technology, Innovation and Entrepreneurship feed into this overarching imperative in a way that differentiates the approach taken in other priority areas?

213. A useful starting point for this question is to re-visit the first Agenda 2063 10-year implementation plan (AU, 2015b) which highlighted five desired key transformational outcomes:
- i. Improvements in Living Standards
  - ii. Transformed, Inclusive and Sustainable Economies
  - iii. Integrated Africa
  - iv. Empowered Women, Youth and Children
  - v. Well-governed, peaceful and cultural centric Africa in a Global Context
214. It is possible for STI and entrepreneurship to influence the socio-political elements as well as the technical elements associated with 'live together–build the society'. This may be achieved by dividing activities into the following sub-categories that respond to the above five desired outcomes:
- i. Sustainable urban and environmental 'green' development.
  - ii. Inclusive STI policy and regulatory frameworks.
  - iii. Pan-African and international collaboration to strengthen integration.
  - iv. Empowering Women and Youth through STI.
  - v. Science, Culture and Diplomacy.

#### **Sustainable urban and environmental 'green' development**

215. Sustainable urban and environmental green development can improve people's quality of life through their living space and work space. The report of the Africa Urban Agenda Programme (UN Habitat and ECA, 2015) and the New Urban Agenda. Habitat III (UN, 2017) both highlight the STI – related principles of
- i. "providing equal access for all to physical and social infrastructure and basic services, as well as adequate and affordable housing."
  - ii. "leveraging the agglomeration benefits of well-planned urbanization, including high productivity, competitiveness and innovation ..... promoting secure land tenure ..."
  - iii. "promoting clean energy and sustainable use of land and resources in urban development, by protecting ecosystems and biodiversity"
216. The promotion of built environment related studies and research (Aber Foundation) geared towards resource efficiency (Nass & Xing, 2017) and green growth is critical. It has been suggested that there is a need to review approaches to city and town planning, recognising that the theories of the north may not apply to Africa and that a shift to 'southern theorising' is under way (Watson, 2016a). These new planning theories need to take advantage of the opportunities provided by sustainable green and smart buildings (Darwish, 2016; Vattano, 2014) while recognising that basic social needs such as inclusive sanitation are met (AfDB, 2018a) and that inequality through the spatial and functional marginalisation of the poor should be avoided (Watson, 2016b). The challenge of managing this within a competitive economic environment that is heavily dependent on foreign direct investment is covered in a UN Habitat report

on *The State of African Cities* (UN Habitat and IHS-Erasmus University of Rotterdam, 2018). These desired objectives will be difficult to achieve given the low-level of capacity and limited resources available to the planning profession, an issue that requires urgent attention (UN Habitat and African Planning Association, 2014). As well as improved planning expertise, there is a need to promote, support and develop cadres of architects and engineers to provide input into, and help realise, improved, sustainable and inclusive urban plans.

217. With one in three people in Africa lacking access to electricity, with deforestation rampant and with a chronic under supply of power adversely affecting industrial productivity, there is an urgent need to build inclusive green economies across Africa linking technical innovation and entrepreneurship with inclusive economic transformation and green growth (UNEP, 2015; Brahmbhatt, Haddaoui, & Page, 2017; AfDB, OECD and UNDP, 2017; NCE, 2018; UNDP, 2018). The three-year annual average of official development finance to the electricity sector in Africa between 2014–2016 was over US\$ 5.5, billion (Corfee-Morlot, Parks, Ogunleye, & Ayeni, 2019), with a marked increase over the past decade in finance for renewables generation (AfDB, DANIDA, USAID and UKaid, 2015; World Bank, 2019). The urgent need to address climate change and meet inclusive developmental goals has caused a re-think about how to best align financial flows and investments with the new realities brought about by these priorities (OECD, World Bank and UN Environment, 2018).
218. Recent progress in solar and wind technologies means that small and medium scale off-grid and mini-grid approaches can now compete with traditional centralised power delivery, especially if supported by appropriate policy and financial systems (Corfee-Morlot, Parks, Ogunleye, & Ayeni, 2019). However, large scale renewable energy infrastructure projects that can replace and supplement fossil fuel power generation within a centralised grid are also needed for sustainable green growth. The international renewable energy agency (IRENA) is looking to scale up renewable energy deployment in Africa for this purpose (IRENA, 2019a). One of its approaches, among others, is to develop sub-regional clean energy corridors of renewable wind and solar energy feeding into a coordinated cross-border grid. A major study has validated this approach by identifying zones for the substantive production of cost-effective wind, solar photovoltaic, and concentrating solar power in the countries of the Eastern and Southern African corridors that can feed into the corridor grid (Wu, Deshmukh, Ndhlukula, Radojicic, & Reilly, 2015).
219. The technical plans and financial assessments outlined above are increasingly being backed up by a strong political will (tralac, 2018; IEA, 2019), which includes a partnership between IRENA and PIDA through the AUC and AUDA-NEPAD. This partnership will facilitate development of the infrastructure required for the clean energy corridors and so include wind and solar energy, as well as geothermal and hydro power, in PIDA infrastructure and continental energy planning to 2030 (IRENA, 2019b; AU, 2018k).

## **Inclusive science, technology and innovation policy frameworks for sustainable development**

220. If the main driver of sustainable development goals is “to leave no one behind” and “to endeavour to reach those furthest behind first” (Stuart, et al., 2016) then it is essential that the science, technology and innovation that lies behind the endeavour reflects these ideals both in its objectives and in its policy and practice. Science, Technology, Innovation and Entrepreneurship should thus be carried out in an open, well-regulated and inclusive manner, that moves beyond the traditional focus on productivity growth and business competitiveness and coherently addresses the economic, social and environmental dimensions of development. This may include emphasising for example: the equitable distribution of the fruits of STI; non-discrimination based on race, gender, age, disability, culture or creed; and the sustainability and long-term benefit for society.
221. These ideals have been well enunciated by UNESCO<sup>72</sup> which stresses the need *to create and enhance an enabling policy environment, and in particular to ... strengthen the science, policy and society interface to advance equity and social inclusion ....*
222. The lack of this sort of approach in most African national STI policies was highlighted in section 3.3 (AAS, 2018). A practical approach to address this issue has been advanced by UNCTAD with a proposal to modify its previous framework for STI Policy Reviews to directly address the SDGs and inclusivity (UNCTAD, 2018a; UNCTAD, 2011; UNCTAD, 2018b). This has been done by adding several SDG-specific elements to the review process. The end result is a review process that reflect the concepts of sustainability and inclusiveness in addition to the traditional assessment criteria of relevance, effectiveness, efficiency and coherence.

## **Pan-African and international collaboration to strengthen integration**

223. Pan-African and international collaboration in Science Technology and Innovation should be managed in a way that strengthens African integration. It should also enhance the collective bargaining power and engagement of Africans in international partnerships and enhance the bargaining power and engagement of the low-income African countries within pan-African partnerships. As well as seeking equity between Africa and other regions there is a need to promote equity among countries within Africa. Some critical elements of how STI can support, while benefitting from, Africa integration has already been discussed in section 3.4 and figures illustrating that intra-African collaboration accounts for less than 2% of sub-Saharan African research was provided in section 4.2.1 (Blom, Lan, & Adil, 2016).

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<sup>72</sup> <https://en.unesco.org/partnerships/partnering/sti-sustainable-socio-economic-development-africa>



224. A number of science programmes have been established over recent years to promote intra-African collaboration. These include programmes already highlighted in this report, such as:

- i. World Bank Centres of Excellence, (section 4.1.2)
- ii. Alliance for Accelerating Excellence in Science in Africa AESA (section 4.1.3)
- iii. African Union Research Grant Programme (section 4.1.5)

An integrated approach to addressing problems is also evident in the work of

- iv. Forum for Agricultural Research in Africa, FARA (section 6.1.2)
- v. Regional Universities Forum for Capacity Building in Agriculture, RUFORUM (section 6.1.2)
- vi. AMREF Health Africa (section 6.2.1)
- vii. The regional research and education networks connecting research institutions through the internet (section 6.3.2)
- viii. The variety of projects and programmes driving the African Space Strategy (section 6.4.3).

225. Nevertheless, there remains a long way to go. In addition to the work of Blom, Lan, & Adil (2016), Mouton & Blanckenburg (2018) and Beaudry and Mouton (2017), who found that intra-African collaborations account for around 2% of all African publications, Pouris and Ho (2014) also found that the vast majority of international collaborative publications in Africa involved partners from outside Africa. There have been a number of studies by the African Network for Drugs and Diagnostics Innovation (ANDI) that have also highlighted the need to promote more intra-African networks and collaboration to help sustainably build African driven research capability (Nwaka, et al., 2010; Nwaka, 2017). This was also reinforced by Tijssen & Kraemer-Mabula (2018) who analysed research output from the top 1% most highly cited publications from African Universities. They found that international collaboration accounted for between 45 to 83% of publications depending on the university concerned, while intra-African collaboration accounted for 0 (zero) to 11%.

226. While recognising the importance of Outside Africa collaborations and partnerships, such partnerships may be inequitable if the external partner's control of the funding is abused. The need to avoid undue exploitation in such partnerships is critical (Bockarie, 2019; European Union, 2014). The various programmes listed in the previous paragraph will contribute to stronger intra-African collaboration, as will such initiatives as the EU Intra-Africa Academic Mobility Scheme.<sup>73</sup> It is however somewhat ironic that the vast majority of these schemes remain funded from outside Africa.

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<sup>73</sup> [https://eacea.ec.europa.eu/intra-africa/funding/intra-africa-academic-mobility-scheme-2019\\_en](https://eacea.ec.europa.eu/intra-africa/funding/intra-africa-academic-mobility-scheme-2019_en)

## **Empowering Women and Youth through STI**

227. There is a need to emphasise a pro-active equitable engagement and promotion of women and youth in science, technology, innovation and entrepreneurship throughout the education and STI systems, starting with early childhood development.

### ***Empowering Women through STI***

228. Data from UNESCO<sup>74</sup> indicate that 30% of researchers employed in R&D in Africa are women, slightly exceeding the global average of 28%. Furthermore, women scientists tend to be concentrated in academic and public sector science and less in the private sector where there is often better pay and opportunities; women scientists also tend to occupy lower level positions (Muthumbi & Sommerfeld, 2015). There is evidence of increased commitment at the continental level to promote women in science. For example, the African Union declared 2015 a ‘Year of Women’s Empowerment and Development Towards Africa Agenda 2063.’ The East Africa Community has formally sought to mainstream gender in STI systems for some time (ECA, 2011a) and SADC updated their gender and development protocol to take into account the SDGs and Agenda 2063 (SADC, 2016), significantly incorporating a Monitoring, Evaluation and Results Framework that incorporated Women in Science and Technology and Women in Higher Education (SADC and SARDC, 2016). A lead paper from an international interdisciplinary conference on gender and Higher Education in Africa highlighted the importance of a gender mainstreaming approach to bring about gender equity (Aina, 2013). A global review of gender equality in science, medicine and global health (Shannon, et al., 2019) cited that

*‘Notwithstanding the evolving landscape of global gender data, the overall pattern of gender equality for women in science, medicine, and global health is one of mixed gains and persistent challenges.’*

229. A number of initiatives exist to promote women in science in Africa. These include: African Women in Science and Engineering,<sup>75</sup> the Organisation for Women in Science for the Developing World,<sup>76</sup> African Women in Science and Technology<sup>77</sup> and African Women in Agricultural Research and Development.<sup>78</sup> Women’s achievements in Science in Africa are also recognised through prizes and awards, notably the African Union Kwame Nkrumah Scientific Awards for Scientific Excellence regional awards for women<sup>79</sup> and the regional awards provided by the L’Oréal-UNESCO for Women in Science.<sup>80</sup> A powerful collection of inspiring stories from women scientists in Africa was recently published to inspire girls and young women to pursue careers in science (Network of African Science Academie, 2017).

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<sup>74</sup> <http://uis.unesco.org/>

<sup>75</sup> <http://www.aawse.org/>

<sup>76</sup> <https://owsd.net/network/africa>

<sup>77</sup> <https://educationinnovations.org/program/africa-women-science-and-technology-awist>

<sup>78</sup> <https://awardfellowships.org/>

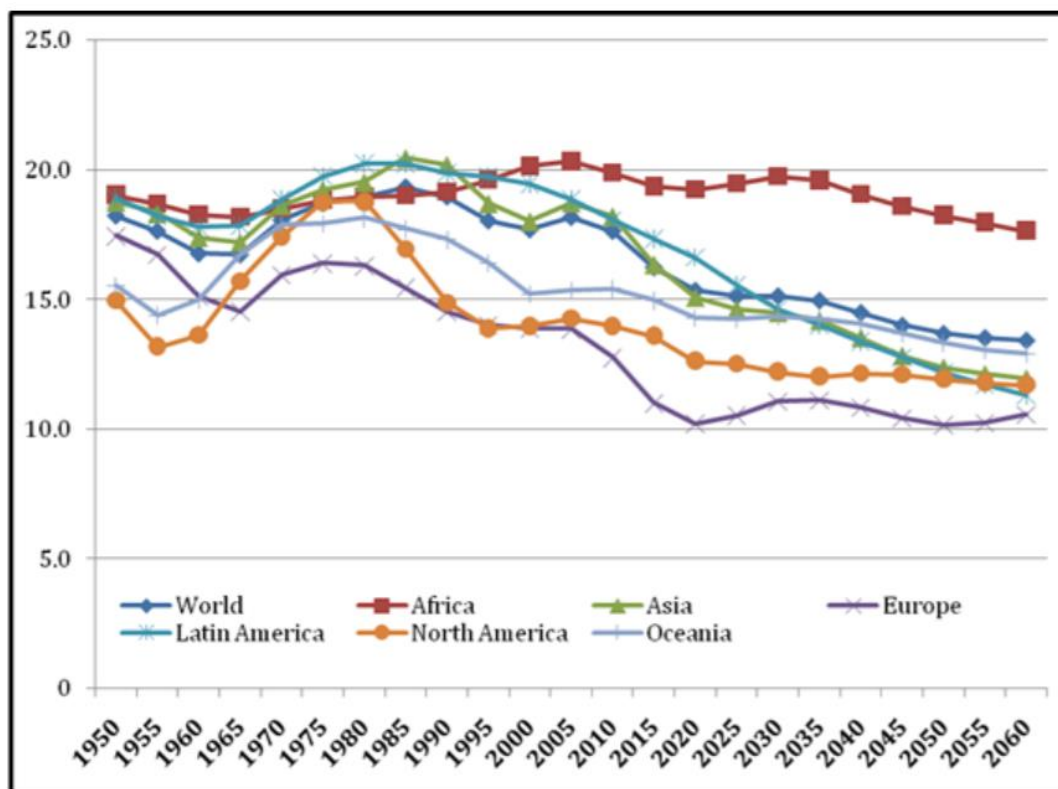
<sup>79</sup> [https://au.int/sites/default/files/announcements/34548-annc-2018\\_auknase\\_rules\\_of\\_procedure.pdf](https://au.int/sites/default/files/announcements/34548-annc-2018_auknase_rules_of_procedure.pdf)

<sup>80</sup> <https://www.forwomeninscience.com/en/>

230. Despite the challenges faced by women in education and other fields, Africa is the only region in the world where more women than men choose to become entrepreneurs (Gaye, 2018). Women however tend to remain in sectors traditionally associated with women, due in part to lack of information about other options. McKinsey have stated that the female economy has the potential to add US\$ 12 trillion to global GDP by 2025 and is the world's largest emerging market (McKinsey Global Institute, 2015) highlighting the opportunities for women entrepreneurship in Africa (Grossman, 2018). A major challenge is to facilitate financing of women entrepreneurial activities and to encourage more innovation driven businesses. As well as having the highest regional percentage of women engaged in entrepreneurship, sub-Saharan Africa also has the highest level of business discontinuation and the lowest level of perceived innovation (Kelly, et al., 2017). This is being addressed by an African Development Bank initiative for Affirmative Finance Action for Women in Africa (AFAWA) (AfDB, 2018b) that aims to mobilise US\$ 3 billion for women in Africa.

### ***Empowering Youth through STI***

231. Africa has the youngest population in the world, with 2015 data indicating that over 60% were below 25 and 19% were designated as youths, aged 15-24. The African population will continue to grow over the coming decades, with youth numbers likely to increase by 42% by 2030 (Wikipedia, c; UN, 2015c). Figure 6.5 demonstrates that through this continued growth that the African youth population will remain at around 18-20% of the overall population in the coming decades, resulting in a demographically young population. The percentage of youth in other regions is seen to fall dramatically to 10-15% giving rise to aging populations.



**Figure 6.5 Percentage distribution of the youth population (14–24 years) by region based on 2015 data from the United Nations Department of Economic and Social Affairs (ECA, 2017c).**

232. This demographic youth explosion brings with it both the opportunity for a demographic dividend based on the increased population available for productive work, and the risk of social and political upheaval if the population increase is accompanied by youth unemployment and a growth in inequity and social exclusion. The role that education, especially the development of Science Technology and Innovation and associated entrepreneurship will play in realising a demographic dividend is widely recognised.
233. From within Africa there has been a major ramping up of activity with a large number of organisations now engaged in STEM Education in Africa (Wikipedia, d). There is a critical role for youth (ECA, 2017c) and for improved data and mainstreamed youth policies (Gyimah-Brempong & Kimenyi, 2013) in inclusive development. Combining youth and innovation can help transform the continent (ECA, 2014) if impediments such as language and unequal access to ICT and quality education are addressed by governments. The role of African youth is critical for agriculture, natural resources and rural development (F. Bojang, Editor, 2013) but this needs to be informed by action-oriented research (Allen, et al., 2016). The role of STI to support the integration of young people back into society in post-conflict situations should also be recognised (AU, 2015e).

234. At a more personal and interactive level, the AUDA-NEPAD African skills portal for youth employment and entrepreneurship is a valuable source of information.<sup>81</sup> A collection of stories from young women highlight the challenges and opportunities available to youth in Africa (Alice D. Kanengoni, Editor, 2017) with specific contributions relevant to STI on: 'Addressing the Absence of Young Women in the Academies of South Africa'; 'The Value of Innovation Hubs' 'Africa's Youth and Abundant Arable Land'; 'The Opportunities that Science and Technology Offer' and how ICT can lead to 'Creative Spaces and Opportunities for Youth and Young Women in Southern Africa'. The development of African National Young Academies of Science is a development that offers promise for the future (Badre, 2017).
235. Linked to the continental activity, a G20 summit led by Germany, attended by the President of the African Development Bank promoted action to support African rural youth, linked to food security (BMZ, 2017) and led to a Berlin Charter (G20, 2017). The need for promoting technical literacy, especially in Science Technology, Engineering and Mathematics, and entrepreneurship featured prominently in a report on Global Employment Trends for Youth (ILO, 2017). A policy guide on youth entrepreneurship has been developed (UNCTAD, 2015) and the EcoSoc Youth Forum have addressed how to use science, technology and innovation to support youth engagement, development and resilience (EcoSoc Youth Forum, 2018).

### **Science Culture and Diplomacy**

236. Within the context of this report and, in particular, this section on living together and building the society, we have seen that issues surrounding science, technology and innovation go far beyond the technical outputs of research and even their financial and commercial consequences. They impact on the fabric of society as a whole.
237. The impact on the politics of society and societal relationships and power can be viewed through the lens of science diplomacy (The Royal Society, 2010), which can usefully be applied to the role of science, technology and innovation in three dimensions of policy:
- i. informing foreign policy objectives with scientific advice (science in diplomacy);
  - ii. facilitating international science cooperation (diplomacy for science);  
and
  - iii. using science cooperation to improve international relations between countries (science for diplomacy).
238. The terminology of science diplomacy is relatively new, but the practices of science diplomacy have been evident for centuries. Indeed, The Royal Society established a post of Foreign Secretary in 1723, 60 years before the British Government appointed its first Secretary of State for Foreign Affairs (The Royal Society, 2010). More recently,

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<sup>81</sup> [https://www.nepad.org/skillsportalfor youth/good\\_practices](https://www.nepad.org/skillsportalfor youth/good_practices)

UNCTAD set up a science diplomacy initiative in 2001 and the American Association for the Advancement of Science (AAAS) set up a Centre for Science Diplomacy in 2008 (Korte, 2018). UNESCO has worked to foster partnerships and international collaboration among nations in the field of science, technology and innovation (UNESCO, 2016) and The World Academy of Sciences has used the examples of international collaboration to contain the Ebola Outbreaks and to develop the Square Kilometre Array as evidence of the need and potential of Science Diplomacy (TWAS, 2017). Many of the pan-African initiatives discussed in this report could be discussed under the umbrella of science diplomacy.

239. Over the past several years, the utility of science diplomacy has been utilised to interpret events and to promote strategies. Thus, science granting councils have been viewed as potential agents of science diplomacy (SARIMA, 2017) and science diplomacy has been discussed as an engine for African integration (Toure, 2018). It has also been suggested that the AU in general and African countries in particular need a well-coordinated roadmap and science diplomacy model (Ayoubi & Akcay, 2018). As a result of this surge of interest in the field, the AAS and TWAS have initiated programmes in Africa to train scientists in science diplomacy skills (Korte, 2018). A practical outcome of such training could include a greater impact by African scientists and negotiators in determining international standards, for example food standards, such that those standards do not adversely affect African business and trade (Hornsby & Parshotam, 2018). An academic workshop on science diplomacy in Africa addressed whether the science diplomacy concept was useful for scholarly enquiry and whether local academic capacity was adequate to engage with the subject area (JIAS, 2016). There was no consensus on whether the subject area constituted a field of study in its own right, but there was a general acceptance of its practical value and that it had expanded boundaries of understanding.
240. In these days of 'fake news' and populist dismissal of scientific consensus internationally, for example the phenomenon of climate change denial in the United States (Collomb, 2014) and the issue of vaccine rejection (Smith, 2017) the need for improved scientific communication with the public and science-informed policy in Africa is as strong as ever. It has been proposed that science communication should be a core component of undergraduate and postgraduate study (Karikari, Yawson, & Quansah, 2016) and efforts have been made to engage with journalists to improve scientific reporting (WFSJ, 2017; Wendo, 2018). Interestingly South Africa's white paper on Science Technology and Innovation contains several directives related to science communication with requirements both for the scientific community and journalists (Joubert, 2019; DST Republic of South Africa, 2019). The ever-increasing engagement of the public in 'Citizen Science' will also improve public engagement and understanding of the scientific process (Irwin, 2018). Scaled up, it can make science and its culture of wonder, inquisitiveness, enquiry, objectivity and a search for truth, part of the cultural fabric of the continent. It can also contribute to high quality science (Mallapaty, 2018).

## **Conclusions**

241. Priority area 5 requires a combination of STI-based approaches interfacing with socio-political approaches for success. The development and utilisation of 'green' technologies in well-designed urban and rural environments is crucial to the future well-being of the continent's people. Many technical opportunities for innovation exist both at the macro-level of investment, such as through trans-boundary clean energy corridors on international grids, or through the establishment of micro-grids. Within this context, the continent is severely restricted by the small number of professional planners, architects and engineers required to meet the challenges of rapid urbanisation.
242. Much of Africa's future success in achieving well-being as a society will depend on how we organise ourselves to utilise and benefit from global and home-grown technology and innovation. This must incorporate policy-based approaches that value inclusivity and equitable access to technology, as well as rewarding innovators and entrepreneurs through market mechanisms. It requires an open and international approach to knowledge sharing that is compatible with African integration. There is a need to increase the very low levels of intra-African international STI collaboration (2%) compared to the high level of international collaboration with parties outside Africa. There is an urgent need to enable women and the youth, along with minority groups, to participate in the process and rewards of innovation and entrepreneurship. More women are needed in STI-related positions and at a higher level of authority. Youth must be engaged more in STI and entrepreneurship if Africa is to reap a demographic dividend from its growing youthful population. Much of these attitudes, which are required to meet the vision of Agenda 2063, can be nurtured through developing an appropriate science culture across Africa. Africa, as a whole, can benefit from a strategic and professional approach to the practice of science diplomacy that protects the interests of continent.

### **6.6. Priority Area 6: Wealth Creation**

243. Increased wealth, equitably shared, sustainably developed and sustainably managed lies at the heart of Agenda 2063 and the Sustainable Development Goals. Science Technology and innovation is seen as a prerequisite to create this wealth. However, as with the previous priority area on living together and building society, the area of wealth creation is incredibly wide ranging with extensive overlap of other priority areas. There is therefore a need to categorise specific areas of endeavour that can enable and facilitate Science Technology and Innovation to create wealth that are additional to, and complementary to, the other activities already documented in this review.
244. Areas of activity listed in Table 6.1, taken from STISA-2024 document list two main areas of activity under the priority area of wealth creation, namely: education and human resource development; and exploitation and management of natural resources, such as minerals, forests and water. To these two elements we believe

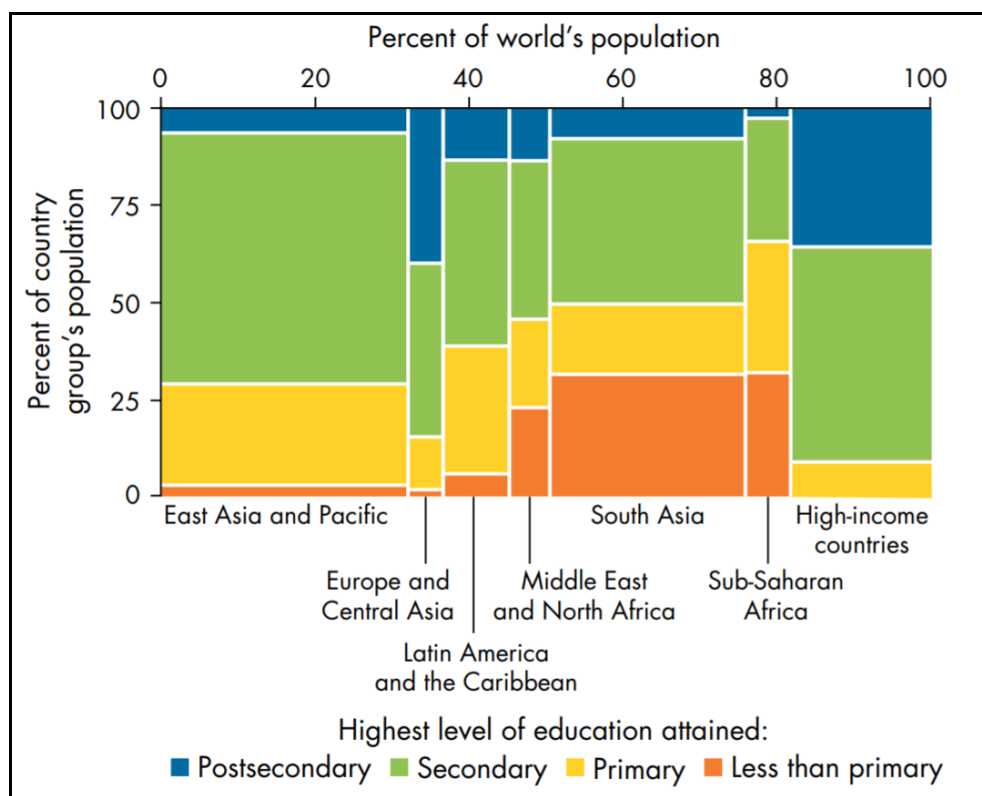


there is need to recognise the central importance of industry, business and trade as enablers of STI led wealth creation. There are a number of ongoing African Union initiatives and Agenda 2063 flagship projects that are illustrative of these areas of endeavour and they provide the structure for this section:

- i. Education: Agenda 2063 Flagship Project African Virtual and E-Learning University
- ii. Resource Management, including Agenda 2063 Flagship Project: Blue / ocean economy
- iii. Trade: Continental Free Trade Agreement

### Education, including Agenda 2063 Flagship Project: African Virtual and E-Learning University

245. The role of education and human resource development to facilitate and empower the developments of STI and associated entrepreneurship and business-led growth has permeated this report. The continental education and TEVET strategies were highlighted in Section 3.2.1 and the developments within Higher Education, notably to foster research and innovation, were highlighted in section 4. Critical publications on the status of education development over the past four years have included have included the 2018 World Development Report, which focused on Education (World Bank Group, 2018; Sow, 2017). Despite marked increase in school enrolment in Africa, the proportion of people with primary and secondary educational remained low (Figure 6.6).





**Figure 6.6 Comparison of level of educational attainment for the age range 15 years to 64 years using 2010 data** (World Bank Group, 2018)

246. More worryingly, the report highlighted the low attainment in basic reading and mathematics skills. The report cites a 2014 regional assessment on reading and mathematical capabilities of students. It found that only 42 percent of grade 6 students in West and Central Africa and 63% in East and Southern Africa were proficient in reading. The figures for proficiency in mathematics at grade 6 were 58 percent for West and Central Africa and 60 percent for East and Southern Africa. The report also provided data for high levels of absenteeism among teachers in many African countries. In response to this data, the report highlighted the need for systemic improvement in the approaches to teaching and learning on the continent. It also stressed the value of early childhood development packages that include family support for vulnerable families, pregnancy support, birth support, child health and development support and pre-school to optimise future learning capabilities. Up to date data on education in Africa, disaggregated by gender can be obtained from a purpose developed UNESCO web site.<sup>82</sup>
247. Higher Education in Africa was reviewed in a 2017 World Bank report (Darvas, Gao, Shen, & Bawany, 2017; Gandhi, 2018). The data showed that although the annual increase in African enrolment in Higher Education from 1970 to 2013 had been 4.3% against a global average of 2.8%, this expansion had not been enough to catch up with the rest of the world and that its absolute global enrolment ratio was still substantively lower than for other regions, with demand for higher education outstripping supply. The work noted the high levels of inequity in the system, with the richest in society regressively benefitting from state subsidised higher education. Within this milieu there was an increase in many countries of the numbers enrolled in private higher education, varying from 10% in Kenya to 80% in Cote d'Ivoire and a notable difference between countries promoting short-term vocational training, ranging from 10% in Mali to 70% for Cote d'Ivoire. A USAID sponsored report on Higher Education in Africa (Association for Public and Land-Grant Universities, Knowledge Center on Higher Education for African Development, 2014) was upbeat about the potential economic benefit of Higher Education in Africa, noting a report (Montenegro & Patrinos, 2013) that the return on investment on education in Africa were the highest of any region of the world, amounting to 13.4% for primary, 10.8% for secondary and 21.9% for tertiary education. It was also stressed that the return may even be higher, as the methodology may underestimate the degree of social return on educational investment. This was reinforced by Psacharopoulos and Patrinos (2018) who also noted that women provide higher economic returns on education investment, further justifying an emphasis on girls' education.

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<sup>82</sup> <http://uis.unesco.org/en/topic/education-africa>

248. Two opinion pieces from a historical perspective (Zezeza, 2018; Swaniker, 2017) have suggested that Africa is on the verge of a new paradigm for Higher Education that more accurately reflects African societal needs. One of the vehicles for such a paradigm could be the growth of e-learning, which has been promoted through the Agenda 2063 flagship project of the Virtual and E-University (see section 3.1.7). The African Virtual University was established in 1997 in Nairobi and has, over 20 years graduated over 60,000 students (Swaniker, 2017). This has now been re-established as the Africa Virtual and E-University under the auspices of the pan-Africa University (see section 3.1.7) (AU, 2017d; Waruru, 2017) with the objective of making open distance and e-learning accessible to students across the 55 countries of Africa.
249. It is worth noting that over the past several years, several other pan-African online e-learning platforms have been established through both public and private universities (Maseko, 2017). Based on current trends, it has been suggested that online education will be mainstream by 2025 (Palvia, et al., 2018). An annual conference on e-learning in Africa has been established<sup>83</sup> and a brief summary of the main conclusions of the 2018 conference is available (University World News, 2019). A list of key individuals influencing corporate online learning in Africa has been developed (Bob Little, 2018). Online and e-learning is also being explored for its general application to help meet the educational needs of sustainable development goal 4 (Ministry of Youth and ICT, Rwanda, 2017) including TVET systems (Obwoye & Kwamboka, 2016).

### **Resource Management, including Agenda 2063 Flagship Project: Blue / ocean economy**

250. This section will review a number of significant areas of natural resource management and exploitation. These will include: (i) Minerals; (ii) Forestry; and (iii) Blue/Ocean Economy.

#### ***Minerals***

251. The minerals industry of Africa is amongst the largest in the world<sup>84</sup> and is among the top producers of a number of strategically important minerals, such as: platinum group metals; phosphate; gold; diamond, bauxite for aluminium, uranium, cobalt, chromium, manganese and copper. However, it is self-evident that many in Africa are failing to benefit from this industry and this led to the establishment of the Africa Mining Vision (AU, 2009), which emphasises the need for

*“Transparent, equitable and optimal exploitation of mineral resources to underpin broad-based sustainable growth and socio-economic development”*

It was recognised that that the continent’s vast mineral resources can only play a transformative role in Africa’s development if it builds appropriate social and economic development linkages that meet national and regional developmental

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<sup>83</sup> <https://www.elearning-africa.com/>

<sup>84</sup> [https://en.wikipedia.org/wiki/Mineral\\_industry\\_of\\_Africa](https://en.wikipedia.org/wiki/Mineral_industry_of_Africa)

objectives (ECA, 2011b). The Africa Progress Report of 2013 (Africa Progress Panel, 2013) highlighted the need for increased transparency of financial flows within the sector to avoid ‘shady deals’ between mining houses and companies (Davis, 2013) that result in Africa not receiving the revenues they should be entitled to. In his Foreword to the report Kofi Annan called for countries

*“to develop national strategies that set up the terms under which their natural resources will be developed, including fiscal policies, contractual arrangements and tax regimes.”*

252. The first 10-year plan of Agenda 2063 called for the establishment and operationalisation of the African Mineral Development Centre (AMDC) to help realise the Africa Mining Vision. In 2016, a statute for the formalised creation of the AMDC as a specialised agency was approved (AU, 2016h). As a result of this the AMDC was transferred from the United Nations Economic Commission for Africa to the African Union Commission (ECA, 2019) and will be hosted in Guinea. The African Union Commission is planning an MoU with the Association of Chambers of Mines and other Mining Associations in Africa (ACMMAA) in 2020 to promote public-private collaboration within the sector. (AU, 2019). The AMDC is looking to develop synergies between the Africa Mining Vision and the Africa Caribbean Pacific Framework of the European Union (AU, ACP, AMDC & ECA, 2018). The challenge of how to increase revenue (AU, AMDC & ECA, 2016) and build local industry through value addition, technology development (Hermanus, 2017) innovation policies (Fessehaie & Rustomjee, 2018) and associated industry development, especially to service mines (Mjimba, 2018) has been a major feature of reports, meetings and publications in recent years, providing a fertile ground for AMDC to assist in the mineral sector’s development.

253. There is clearly a need to build African human resource capacity in the relevant science, technology, engineering and science diplomacy disciplines associated with sustainable mineral exploitation. This must be complemented, sustained and grown through African-driven research, innovation and entrepreneurship.

### **Forestry**

254. A cross-cutting report (African Natural Resources Centre, 2018) notes the massive coverage of Africa by forests at 22%. It notes the potential power of integrating forestry and agriculture for climate change resilient productive systems and agroforestry. It notes that economic rents from forestry, defined as revenues from forestry resources above the cost of extracting the resources, form a higher proportion of GDP in Africa than for any other region<sup>85</sup> and are over 5% for 16 countries, reaching 33% in Liberia. It notes that despite Africa’s huge forestry resources it had a trade deficit of US\$ 1 billion in forestry products between 2006 to 2013 whereas Asia showed a surplus of US\$ 66 billion. There is thus great promise in developing African forestry and

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<sup>85</sup> <https://www.indexmundi.com/facts/indicators/NY.GDP.FRST.RT.ZS>

associated industries. However, this needs to be set against the huge problem of illicit trade in timber and forest products, which led to the Zanzibar declaration (Governments of Kenya, Madagascar, Mozambique, Tanzania and Uganda, 2015) which has put pressure on the EAC and SADC member states to collaborate in addressing this issue. It has been reported that Africa loses over US\$ 17 billion per year in such illicit trade and China has been cited as a major destination for this trade (Koigi, 2018).

255. The report by the African Natural Resources Centre also highlights how Forestry may contribute to the African Development Bank's High 5 Priorities. This may be achieved through:

- i. *Light up and power Africa.* Forestry biomass products, sustainably developed and managed, and combined with fuel efficient technologies, could contribute to a low carbon economy (IEA, 2010).
- ii. *Feed Africa.* Forestry contributes to food security through: direct provision of food and protein supplementation; provision of energy; income generation and employment; and the provision of ecosystem services, such as soil fertility enhancement, water storage, pollination, windbreaks and shelter (HLPE, 2017).
- iii. *Industrialise Africa.* Forestry provides an opportunity for value addition through wood products and non-wood products, such as perennial fruits and nuts. Value added timber products e.g. building materials, furniture and paper can massively increase national income through increased exports and decreased imports. Processed cashew nuts can increase their value by 8-fold over raw nuts. Large scale, well managed forestry enterprises can generate and drive large industrial complexes, generating wealth and jobs.
- iv. *Integrate Africa.* An improved trading environment, for example through the African Continental Free Trade Agreement will greatly facilitate forestry development. At the moment intra-African trade accounts for only 11% of Africa's global trade.
- v. *Improve the quality of life for the people of Africa.* Apart from the economic benefits of sustainably well-managed forests and the potential for Forestry to support a green economy as a renewable resource, there are broader societal benefits. These include: maintaining one of the climatic buffers on which mankind depends; improved provision of water; prevention of desertification; sustainably supporting rural economies; promoting conservation of flora and fauna and maintaining sustainable ecosystems (FAO, 2018). A good example of such activity in action is the SADC based Miombo Project (WWF, 2012).

256. It is clear that Forestry and associated opportunities for science, technology and innovation offers major opportunities for enterprise and development. More forestry and environmental science programmes are called for to develop human resources that can link research to sustainable, green approaches to innovation and business development for both wood products and non-wood forest products and their application to both rural community development and industrial development (FAO, 2017). A major challenge is financing of forest development, especially greenfield forest development, which requires many years to realise a return. However, new approaches to unlock financing for the forest sector are under development (AfDB and CIF, 2017)

### **Blue / Ocean Economy**

257. Carlos Lopes, United Nations Under-Secretary-General and Executive Secretary of ECA stated the significance of the Blue / Ocean Economy very well as part of a Foreword to 'Africa's Blue Economy: A policy handbook' (ECA, 2016d).

*"Africa's "Blue word" is made of vast lakes and rivers and an extensive ocean resource base. Thirty-eight of the fifty-four African States are coastal States. More than 90 percent of Africa's imports and exports are conducted by sea and some of the most strategic gateways for international trade are in Africa, underscoring the geopolitical importance of the region. Maritime zones under Africa's jurisdiction total about 13 million square kilometres including territorial seas and approximately 6.5 million square kilometres of the continental shelf. Mauritius with its 1850 square kilometres is one of the smallest countries in Africa and in the world. However, with its territorial waters, it becomes a country with 1.9 million square kilometres, the size of South Africa. Therefore, we have another Africa under the sea. Quite rightly, the African Union call the Blue Economy the "New Frontier of African Renaissance"."*

258. The Blue Economy is constituted by all economic activities that emanate from Africa's oceans (the Atlantic and Indian), seas (the Red Sea and the Mediterranean), sea beds, lakes and rivers. Examples of blue economy activities include: seabed mining for oil, gas and minerals, generation of tidal and other renewable forms of energy; marine and lake transport and shipping; fishing and agriculture; and marine tourism. All of these areas of activity are under-developed, with huge potential for stimulating economic growth.

259. The African Union however, has carefully balanced the need for economic exploitation of the 'blue world' with environmental sustainability and conservation. The policy handbook referred to above seeks to situate

*"the aquatic and marine economies as part of integrated ecosystem services based on the harvesting of living and non-living resources, benefitting both coastal, island states and landlocked countries."*

The Blue/ocean economy is highlighted as a specific goal, goal 6, under Aspiration 1 of the Agenda 2063 10-year plan (AU, 2015b). It is immediately followed however by goal 7, which calls for environmentally sustainable economies. Aspiration 1, Goals 6 and 7 and the priority areas of each of these complementary goals is provided in Table 6.6 below.

260. The success of the Blue/Ocean Economy is closely linked to the implementation of the AU's 2050 African Integrated Maritime Strategy (AU, 2012), which was adopted in 2014. However, the complexities of this multidimensional implementation should not be underestimated (Egede, 2018) given it requires adherence to a number of international treaties and frameworks, including the Maritime Transport Charter and the United Nations Convention on the Law of the Sea (UNCLOS). As it approved the AIM strategy in 2014, the AU also set a period from 2015 - 2025 as the 'Decade of African Seas and Oceans' and the date of 25 July as the African Day of Seas and Oceans (RSA Government, 2018).

**Table 6.6. Goals and Priority Areas linked to the Blue/Ocean Economy (AU, 2015b).**

Aspiration 1. A prosperous Africa based on inclusive growth and sustainable development	
Goals	Priority Areas
6. Blue/ ocean economy for accelerated economic growth	1: <i>Marine resources and Energy</i>
	2: <i>Port Operations and Marine Transport</i>
7. Environmentally sustainable climate resilient economies and communities	1: <i>Bio-diversity, conservation and sustainable natural resource management</i>
	2: <i>Water Security</i>
	3: <i>Climate Resilience and Natural Disasters and preparedness</i>

261. A first international conference on the Blue Economy was hosted by the Government of Kenya in November 2018. Over 16,000 participants from 184 countries with 8 heads of state and 84 ministerial delegates produced a comprehensive technical report (SBEC Technical Committee, 2018). There was a '*Nairobi Statement of Intent on Advancing a Sustainable Blue Economy*' that covered nine priority areas for global attention.

- i. Smart shipping, ports, transportation and global connectivity
- ii. Employment, job creation and poverty eradication
- iii. Cities, tourism, resilient coasts and infrastructure
- iv. Sustainable energy, mineral resources and innovative industries
- v. Managing and sustaining marine life, conservation and sustainable economic activities

- vi. Ending hunger, securing food supplies and promoting good health and sustainable fisheries
- vii. Climate action, agriculture and fisheries, waste management and pollution-free oceans
- viii. Maritime security, safety and regulatory enforcement and
- ix. People, culture, communities and societies – the inclusive blue economy

262. The meeting led to voluntary non-monetary and monetary commitments amounting to approximately USD172.2 billion, categorised into 10 sectors of the blue economy:

- i. Plastics and waste management
- ii. Marine and water resources protection
- iii. Partnerships
- iv. Infrastructure
- v. Policy and regulatory measures
- vi. Private sector support
- vii. Biodiversity and climate change
- viii. Technical assistance and capacity building
- ix. Fisheries development
- x. Inclusivity

263. The level of interest and financial contributions demonstrated by this conference suggests that there is potential for Africa to benefit from a sustainable blue economy. What is required in the short term is a well-defined strategic plan, which is currently under development, and a well-coordinated political, technical, business and administrative effort.

### **Free Trade and the Continental Free Trade Area**

264. In order to fully realise the benefits of national innovation there is a need to access regional, continental and international markets. This requires a well-structured and organised industrialisation and trade framework. There is a need to boost intra-African Trade (Moyo, 2014). A recent study (Afreximbank, 2018b) indicated that intra-African trade is low, at 15 percent of the total trade, illustrating that most African trade, 85%, is directed to countries and economic groupings outside Africa rather than within Africa. By comparison, intra-regional trade for other areas are: Europe (67 percent), Asia (58 percent), North America (48 percent) and Latin America (20 percent).

265. Despite African countries' reliance on extra-African trade, only South Africa and Egypt have any extensive experience of WTO based trade negotiations.<sup>86</sup> Even within the current Regional Economic Communities there are substantive tariff and non-tariff barriers to intra-African trade, including visa restrictions on business travel. There are two major initiatives to promote free trade on the continent. The first is the agreement

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<sup>86</sup> COMESA Secretariat presentation at Malawi Tripartite Workshop, 5 - 6 October 2017, Lilongwe, Malawi

establishing a Tripartite Free Trade (TFTA) area among the Common Market for Eastern and Southern Africa (COMESA), the East African Community (EAC) and the Southern African Development Community (SADC) (tralac, 2015). The second which may potentially supersede the tripartite agreement, is the agreement to establish a Continental Free Trade Area (CFTA) across Africa (AU, 2018f). The African Continental Free Trade Agreement (AfCFTA) was submitted for signature at an Extraordinary Summit of the African Union from 17-21 March, 2018. At the same the following documents were presented: (i) Kigali Declaration for the launch of the CFTA; and (ii) Protocol to the Treaty Establishing the African Economic Community relating to the Free Movement of Persons, Right to Residence and Right to Establishment. Among the 55 AU member states, 44 signed the consolidated text of the AfCFTA Agreement, 47 signed the Kigali Declaration and 30 signed the Protocol on Free Movement (tralac, 2019).

266. As of March 2019, only three countries had not signed the AfCFTA Agreement, namely Benin, Eritrea and Nigeria. Nigeria is among the largest economies on the continent and has long been a leading participant in discussions about the creation of a CFTA. Its failure to sign the Agreement has therefore been a cause for debate. Nigerian Government representatives have stated that they wish to engage in further internal consultations to assess the benefits of the Agreement to Nigeria and have further stated that they do not wish to undermine local manufacture and become “a dumping ground for finished goods”. This has led some to openly express their scepticism about the potential of the CFTA (Ubi, 2018), while others believe the objections of Nigeria will be overcome, noting the length of time taken to negotiate trade agreements around the world (Dzimwasha, 2018).
267. The general consensus remains that Intra-African trade and industrialisation are crucial to the future inclusive prosperity of the continent as outlined in Agenda 2063. Science Technology and Innovation is a crucial driver of industrialisation, and hence trade. It is also a driver of value addition and diversification of exports, reducing the risk and vulnerability of countries being reliant on a small number of exportable products. There will therefore need to be a close institutional interface between institutions, businesses and ministries associated with science, technology and innovation and those associated with trade and industry. The recent revival of the Pan-African Private Sector Trade and Investment Committee (PAFTRAC) by the African Union, in partnership with Afreximbank (BFTonline, 2018) provides one potential interface for this dialogue (see section 3.1.8).
268. The PAFTRAC secretariat will be hosted by Afreximbank. Membership of the Committee is drawn from leading private sector institutions and corporate entities across Africa, as well as from a range of continental and regional institutions, including: (i) Business organizations and traders with a significant continental footprint; (ii) Regional and sub-regional business associations and councils; (iii) Chambers of commerce; (iv) Industry associations; (v) Financial institutions; (vi) Professional, and



policy research institutions; and (vii) Other relevant entities and strategic partners involved with trade and investment issues. PAFTRAC will therefore provide a framework to facilitate African Private Sector participation and engagement in trade and investment issues. This may include, trade and investment policy formulation and trade negotiations in support of the sustainable development of African economies, in line with Agenda 2063. It is anticipated that PAFTRAC could serve as a stepping-stone toward the establishment of the African Business Council, which is envisaged under the African Continental Free Trade Agreement (CFTA) Architecture.

## **Conclusions**

269. Wealth creation is the crucial outcome of the strategic approach to Science, Technology and Innovation that seeks to deliver on Agenda 2063. Without the generation of wealth, none of the other priority areas can be realised. Education, and the development of human resources, is a prerequisite for a strong STI performance and economic analyses show the economic benefit of every extra year a child spends in education in Africa, especially in Higher Education. Efforts are needed to enhance access to, and improve the quality of, education at all levels and to take advantage of innovations such as online education.
270. The efficient and effective use of natural resources is critical to sustainable wealth creation. Increased attention must be paid to minerals, forests and the blue economy and to support their ethical and sustainable exploitation to yield both primary products and innovative value-added products and services for continental economic benefit. There is need for an enhanced control of illegal mining and logging on the one hand and enhanced investment for secure resource management and exploitation on the other hand. The blue economy flagship project offers a huge potential for the continent in areas of natural resources exploitation, food security and conservation, and other sectors such as tourism and transport. The development of the blue economy is potentially valuable but also complex. Developments will take time and large-scale investments. The results from the first international conference on the Blue Economy in November, 2018 suggest that there is a strong degree of international will to make a success of this endeavour.
271. Last, but not least, wealth creation resulting from innovation and entrepreneurship will require a strong and well-regulated trading environment that promotes free trade and free movement as much as possible. The African Continental Free Trade Agreement provides an opportunity to create such an environment and increase intra-continental trade from the current low levels of 15% to higher levels in line with more developed regions. The development of continental free trade and industrial development supported by STI go hand in hand, each reinforcing the other. Together, these two elements can help drive continental integration and the realisation of the aspirations of Agenda 2063.

## 7. Concluding Remarks – 10 Take Home Messages

272. There are several recurring themes in this report that can help conceptualise STI in general and STISA-2024 in particular within the broader context of Agenda 2063. These constitute 10 take home messages.

- i. STISA-2024, if fully integrated into the Agenda 2063 planning and implementation process, could represent the equivalent of an R&D arm of a large conglomerate, providing research and technical analysis linked to innovation and entrepreneurship to help deliver on agenda 2063's aspirations and its goals;
- ii. The STI concept moves beyond promoting academic research alone; it links the generation of knowledge to innovations, in the form of products and services, and entrepreneurship that can create a market and/or social return on investment;
- iii. STI in this context needs to recognise the importance and significance of engineering as a critical driver of innovation and development and fully incorporate engineering disciplines into STI frameworks;
- iv. STI, through applied and operational research, and through monitoring and evaluation approaches, can contribute to large scale projects, whether in agriculture, health or infrastructure development, and in turn large scale projects can be used as a platform to develop STI, engineering, planning, managerial and entrepreneurial capacity for the future.
- v. STI policy and practice must be aligned broadly to sustainable socio-economic and environmental development and not restricted to market-oriented deliverables;
- vi. STI in practice, with regard to (v) can be a force to respond to, and support, the equitable empowerment of women, youth and children and help realise Africa's demographic dividend;
- vii. STI is heavily dependent on, and contributes to, a strong education system, especially a strong higher education system, that includes technical and vocational education and training;
- viii. STI can only deliver its potential economic return within an open and well-regulated trading environment and through well-designed trade and industry policies;

- ix. Linked to (viii) appropriate policies and management of intellectual property is a critical prerequisite for large scale investment in innovation.
- x. STI can only deliver on its promise if there are well-designed financial vehicles available to support both early stage research, its transition into development and its conversion into products and services that can respond to market and/or developmental needs.

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