Studies in Space Policy

Annette Froehlich · André Siebrits

# Space Supporting Africa

## Volume 1: A Primary Needs Approach and Africa's Emerging Space Middle Powers

ESPI
European Space Policy Institute

Springer

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Volume 20

Edited by: European Space Policy Institute, Vienna, Austria
Director: Jean-Jacques Tortora

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ISSN 1868-5307 ISSN 1868-5315 (electronic)
Studies in Space Policy
ISBN 978-3-030-12172-3 ISBN 978-3-030-12173-0 (eBook)
https://doi.org/10.1007/978-3-030-12173-0

Library of Congress Control Number: 2019931917



This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

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# Abbreviations

| | |
|---|---|
| 1KUNS-PF | First Kenyan University Nano Satellite-Precursor Flight |
| AAQS | Ambient Air Quality Standards |
| AARSC | Association of Arab Remote Sensing Centres |
| AARSE | African Association of Remote Sensing of the Environment |
| ACCNNR | African Convention on the Conservation of Nature and Natural Resources |
| ACDEG | African Charter on Democracy, Elections and Governance |
| ACHR | African Commission on Human and Peoples' Rights |
| ACMAD | African Centre of Meteorological Application for Development |
| ADCS | Attitude Determination and Control System |
| AEC | African Economic Community |
| AfCFTA | African Continental Free Trade Area |
| AFRIGIST | African Regional Institute for Geospatial Science and Technology |
| AF-SGW | African Space Generation Workshop |
| AGA | African Governance Architecture |
| AGEOS | L'Agence Gabonaise d'Etudes et d'Observation Spatiales |
| AIDS | Acquired Immune Deficiency Syndrome |
| AIMS | Africa's Integrated Maritime Strategy |
| AIS | Automatic Identification System |
| AIT | Assembly, Integration, and Test |
| AITDC | Assembly, Integration, Testing and Design Centre |
| ALC | African Leadership Conference on Space Science and Technology for Sustainable Development |
| AlComSat | Algerian Communication Satellite |
| ALC-YF | African Leadership Conference on Space Science and Technology for Sustainable Development Youth Forum |
| ALG | Liptako-Gourma Region Integrated Development Authority |
| AlSat | Algeria Satellite |
| AMCOST | African Ministerial Conference on Science and Technology |
| AMDC | African Minerals Development Centre |
| AMU/UMA | Arab Maghreb Union |

| | |
|---|---|
| ANU-SSTL | All Nations University Space Systems Technology Laboratory |
| APRM | African Peer Review Mechanism |
| APRSAF | Asia-Pacific Regional Space Agency Forum |
| APSA | African Peace and Security Architecture |
| ArabSat | Arab Satellite Communications Organisation |
| ARCSSTE | Regional Centres for Space Science and Technology Education |
| ARDC | African Regional Data Cube |
| ARM | African Resource Management |
| ARMS-C | African Resource Management Satellite Constellation |
| ARV | Anti-Retroviral |
| ASA | African Space Agency |
| ASAL | Agence Spatiale Algérienne |
| ASF | African Space Foundation |
| ASI | Agenzia Spaziale Italiana/Italian Space Agency |
| ASPI | African Space Policy Institute |
| ASPS | African Space Policy and Strategy |
| ASReG | Aerospace Systems Research Group |
| ASRT | Academy of Scientific Research and Technology, Egypt |
| AU | African Union |
| AUC | African Union Commission |
| AUFS | Africa Union Financial Services |
| AVN | African Very Long Baseline Interferometry Network |
| Birds | Joint Global Multi-Nation Birds Satellite project |
| BRICS | Brazil, Russia, India, China, and South Africa |
| CAST | China Academy of Space Technology |
| CDC | Centres for Disease Control and Prevention |
| CDS | Centre for Satellite Design |
| CEMAC | Central African Economic and Monetary Community |
| CEN–SAD | Community of Sahel–Saharan States |
| CEOS | Committee on Earth Observation Satellites |
| CEST | Telecommunication Systems Operating Centre |
| CFA | Communauté Financière Africaine (African Financial Community) |
| CGWIC | China Great Wall Industry Corporation |
| CILSS | Permanent Interstate Committee for Drought Control in the Sahel |
| CMA | Common Monetary Area |
| CNCT | National Centre for Mapping and Remote Sensing/Centre National de la Cartographie et de la Télédétection/Tunisian National Centre for Mapping and Remote Sensing/Centre National de la Cartographie et de la Télédétection |
| CNES | Centre National d'Études Spatiales |
| CNN | Cable News Network |
| CNTS | Centre National des Techniques Spatiales |
| COMESA | Common Market for Eastern and Southern Africa |
| CongoSat | Congo Satellite |

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|---|---|
| COPUOS | Committee on the Peaceful Uses of Outer Space |
| CPUT | Cape Peninsula University of Technology |
| CREIS | Centre de Réception et d'Exploitation des Images Satellitaires |
| CRSPM | Centro Ricerche Progetto San Marco/San Marco Project Research Centre |
| CRTEAN | Centre Régional de Télédétection des Etats de l'Afrique du Nord/ Regional Centre for Remote Sensing of North Africa States |
| CRTS | Moroccan Royal Centre for Remote Sensing |
| CSIR | Council for Scientific and Industrial Research, South Africa |
| DARA | Development in Africa through Radio Astronomy |
| DMC | Disaster Monitoring Constellation |
| DMCii | DMC International Imaging |
| DMN | Directorate of National Meteorology, Morocco |
| DRC | Democratic Republic of the Congo |
| DSA | Defence Space Administration, Nigeria |
| DST | Department of Science and Technology, South Africa |
| DVSA | Developed Space Actor |
| EAC | East African Community |
| EACO | East African Communications Organisation |
| ECA | (United Nations) Economic Commission for Africa |
| ECCAS | Economic Community of Central African States |
| ECGLC | Economic Community of the Great Lakes Countries |
| ECI | Economic Complexity Index |
| ECOWAS | Economic Community of West African States |
| EEZ | Exclusive Economic Zone |
| EHF | Extremely High Frequency |
| EIC | Earth Imaging Camera |
| EIS | Environmental Information Systems |
| ELEO | Extreme Low Earth Orbit |
| EMI | Mohammadia School of Engineers, Mohamed V University, Rabat |
| EMSA | Emerging Space Actors |
| EO | Earth Observation |
| EOSat | Earth Observation Satellite |
| ERS | European Remote Sensing satellites |
| ESA | European Space Agency |
| ESL | Electronic Systems Laboratory |
| ESPI | European Space Policy Institute |
| ESSS | Ethiopian Space Science Society |
| EU | European Union |
| F'SATI | French South African Institute of Technology |
| FGM | Female Genital Mutilation |
| FIPEX | Flux-Φ-Probe Experiment |
| FTA | Free Trade Area |
| FUTA | Federal University of Technology, Akure, Nigeria |

| | |
|---|---|
| GC | Governing Council |
| GDP | Gross Domestic Product |
| GEO | Geostationary/Geosynchronous Orbit |
| GEO | Group on Earth Observations |
| GEOSS | Global Earth Observation System of Systems |
| GERD | Gross Domestic Expenditure on R&D |
| GGPEN | Gabinete de Gestao do Programa Espacial Nacional, Angola |
| GhanaSat | Ghana Satellite |
| GIMAC | Gender Is My Agenda Campaign |
| GIS | Geographic Information System |
| GMA | Ghana Meteorological Agency |
| GNI | Gross National Income |
| GNSS | Global Navigation Satellite System |
| GORS | General Organisation of Remote Sensing |
| GPS | Global Positioning System |
| GSD | Ground Sample Distance |
| GSM | Global System for Mobile Communications |
| GSSTC | Ghana Space Science and Technology Centre |
| HartRao | Hartebeesthoek Radio Astronomy Observatory, South Africa |
| HDI | Human Development Index |
| HEO | High Earth Orbit |
| HF | High Frequency |
| HiRI | High-Resolution Imager |
| HIV | Human Immunodeficiency Virus |
| HSRP | Hybrid Sounding Rocket Program |
| IAF | International Astronautical Federation |
| IASE | Intra-African Space Engagement |
| IAU | International Astronomical Union |
| IAV | Agronomy and Veterinary Institute HASSAN II, Morocco |
| ICC | International Criminal Court |
| ICJ | International Court of Justice |
| ICTs | Information and Communications Technologies |
| IGAD | Intergovernmental Authority on Development |
| IGADD | Intergovernmental Authority on Drought and Development |
| IGO | Intergovernmental Organisation |
| IISL | International Institute of Space Law |
| IKUNS | Italian-Kenyan University NanoSatellite |
| ILR | Institut für Luft- und Raumfahrt |
| IMU | Inertial Measurement Unit |
| INPT | National Institute of Posts and Telecommunications, Morocco |
| IOC/COI | Indian Ocean Commission |
| IREC | Intercollegiate Rocket Engineering Competition |
| ISE | International Space Engagement |
| ISRA | Institute of Space Research and Aerospace, Sudan |

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|---|---|
| ISRO | Indian Space Research Organisation |
| ISS | International Space Station |
| ISSA | Institute for Satellite and Software Applications, South Africa |
| ISSE | Institute of Space Sciences & Engineering, Nigeria |
| ISU | International Space University |
| ITSO | International Telecommunications Satellite Organisation |
| ITU | International Telecommunication Union |
| JAXA | Japan Aerospace Exploration Agency |
| JICA | Japan International Cooperation Agency |
| KAT | Karoo Array Telescope |
| KYUTECH | Kyushu Institute of Technology |
| LBSC | Luigi Broglio Space Centre, Kenya |
| LCRSSS | General Authority for Remote Sensing in Sudan; Libyan Centre for Remote Sensing and Space Sciences, Libya |
| LEO | Low Earth Orbit |
| LEOP | Launch and Early Orbit Phase |
| LGBTI | Lesbian, Gay, Bisexual, Transgender/Transsexual, and Intersex |
| LSC | Legal Subcommittee |
| MEO | Medium Earth Orbit |
| MEST | Ministry of Environment, Science and Technology, Ghana |
| MHz | Megahertz |
| MINURSO | United Nations Mission for the Referendum in Western Sahara |
| MINUSCA | United Nations Multidimensional Integrated Stabilisation Mission in the Central African Republic |
| MINUSMA | United Nations Multidimensional Integrated Stabilisation Mission in Mali |
| MIR | Mid-Infrared |
| MirSat | Mauritius Satellite |
| MisrSat | Egypt Satellite |
| MONUSCO | United Nations Organisation Stabilisation Mission in the Democratic Republic of the Congo |
| MoST | Ministry of Science and Technology, Ethiopia |
| MoU | Memorandum of Understanding |
| MP | Member of Parliament |
| NamSat | Namibia Satellite |
| NAOMI | New AstroSat Optical Modular Instrument |
| NARSS | National Authority for Remote Sensing and Space Sciences, Egypt |
| NASA | National Aeronautics and Space Administration |
| NASRDA | National Space Research and Development Agency, Nigeria |
| NCIP | Northern Corridor Infrastructure Projects |
| NCOSA | National Commission for Outer Space Affairs, Tunisia |
| NEAP | National Environmental Action Plan, Sub-Saharan Africa |
| NEPAD | New Partnership for Africa's Development |
| NGO | Non-Governmental Organisation |

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|---|---|
| NigCom LTD | Nigerian Communications Satellite Limited |
| NigComSat | Nigerian Communications Satellite |
| NigeriaSat | Nigeria Satellite |
| NileSat | Nile Satellite |
| NIR | Near-Infrared |
| NMS | National Meteorological Services (African Centre of Meteorological Application for Development) |
| NRF | National Research Foundation, South Africa |
| NRSC | National Remote Sensing Centre, Sudan |
| OAD | Office of Astronomy for Development (International Astronomical Union) |
| OAU | Organisation of African Unity |
| ODC | Open Data Cube |
| OECD | Organisation for Economic Co-operation and Development |
| OIC | Organisation of Islamic Cooperation |
| OSCAR | Observing Systems Capability Analysis and Review Tool |
| OTRAG | Orbital Transport und Raketen Aktiengesellschaft |
| PAL | Phase Alternating Line |
| PAN | Panchromatic |
| PAUSS | Pan-African University for Space Sciences |
| PSN | Programme Spatial National |
| R&D | Research and Development |
| RAL | Rutherford Appleton Laboratory |
| RASCOM | Regional African Satellite Communication Organisation |
| RCMRD | Regional Centre for Mapping Resource for Development |
| REC | Regional Economic Community |
| RECTAS | Regional Centre for Training in Aerospace Survey |
| RGB | Red-Green-Blue |
| RRA | Retroreflector Array |
| RSA | Remote Sensing Authority, Sudan |
| RSSA | Remote Sensing and Seismology Authority |
| RURA | Rwanda Utilities Regulatory Authority |
| SA | South Africa |
| SAAO | South African Astronomical Observatory |
| SAC | Satellite Applications Centre |
| SAC | Space Applications Centre |
| SACU | Southern African Customs Union |
| SADC | Southern African Development Community |
| SADCC | Southern African Development Coordination Conference |
| SALT | Southern African Large Telescope |
| SANAE | South African National Antarctic Expedition |
| SANSA | South African National Space Agency |
| SAR | Synthetic Aperture Radar |
| SARGG | South African Rocket Research Group |

| | |
|---|---|
| SASA | South African Space Association |
| SDGs | Sustainable Development Goals |
| SDI | Solemn Declaration Index |
| SDL | Survey Department Libya |
| SDR | Software-Defined Radio |
| SDSC | Satish Dhawan Space Centre |
| SEC | Sub-Regional Economic Community |
| SEIC | Space Engineering International Course |
| SGAC | Space Generation Advisory Council |
| SKA | Square Kilometre Array |
| SLR | Satellite Laser Ranging |
| SLV | Space Launch Vehicle |
| SNSA | Sudan National Survey Authority |
| SPOT | Satellite Pour l'Observation de la Terre |
| SRM | Space Resource Mining |
| SSA | Sub-Saharan Africa |
| SSC | Surrey Space Centre |
| SSO | SANSA Space Operations |
| SST | Surrey Satellite Technology |
| SSTL | Surrey Satellite Technology Ltd |
| STC | Space Technology Centre |
| STEM | Science, Technology, Engineering, and Mathematics |
| STI | Science, Technology, and Innovation |
| STISA | Science, Technology and Innovation Strategy for Africa |
| STL | Space Technology Ladder |
| STSC | Scientific and Technical Subcommittee |
| SunSat | Stellenbosch University Satellite |
| SWG | Space Working Group |
| TB | Tuberculosis |
| TIR | Thermal Infrared |
| TRL | Technology Readiness Level |
| TT&C | Telemetry, Tracking, and Command |
| TUB | Technical University of Berlin |
| TUBSAT | Technical University of Berlin Satellite |
| UDPS | Small Satellite Development Centre |
| UEMOA | West African Economic and Monetary Union |
| UHF | Ultra-High Frequency |
| UK | United Kingdom |
| UKSA | UK Space Agency |
| UN | United Nations |
| UNAMID | The African Union—United Nations Hybrid Operation in Darfur |
| UNDP | United Nations Development Programme |
| UNECA | United Nations Economic Commission for Africa |
| UNESCO | United Nations Educational, Scientific and Cultural Organisation |

| | |
|---|---|
| UN-GGIM | United Nations Global Geospatial Information Management |
| UNICEF | United Nations Children's Fund |
| UNISFA | United Nations Interim Security Force for Abyei |
| UNMISS | United Nations Mission in South Sudan |
| UNOOSA | United Nations Office for Outer Space Affairs |
| UN-SPIDER | United Nations Space-based Information for Disaster Management and Emergency Response |
| US | United States |
| USAID | United States Agency for International Development |
| USGS | U.S. Agency for Geological Studies |
| VHDL | VHSIC Hardware Description Language |
| VHF | Very High Frequency |
| VHSIC | Very High Speed Integrated Circuit |
| VIS | Visible Imaging System |
| VLBI | Very-Long-Baseline Interferometry |
| VLF | Very Low Frequency |
| VNIR | Visible and Near-Infrared |
| VSAT | Very Small Aperture Terminal |
| WAMZ | West African Monetary Zone |
| WEF | World Economic Forum |
| WHO | World Health Organisation |
| WIA | Women in Aerospace Africa |
| WMO | World Meteorological Organisation |
| XinaBox | X in a Box |
| YRSC | Yemen Centre for Remote Sensing and GIS |
| YSDO | Yuzhnoye State Design Office |
| ZACUBE | South African Cube Satellite |
| ZDS | Zodiac Data Systems |
| ZINGSA | Zimbabwe National Geospatial and Space Agency |

# Chapter 1
# Africa and the Space Arena

**Abstract** In order to take stock of Africa's progress in the space arena, and to determine how far advanced the space sector is across the continent, this chapter provides the foundation for the subsequent study of the African space ecosystem. The continent's political background and context is examined, with particular emphasis on the African Union and the Regional Economic Communities that constitute its key organs. This is followed by a discussion of the general socio-economic situation (including the African economy and promise of the "digital renaissance") within a framework of the primary needs approach to African space activities. These identify priority areas of critical importance, which must be supported by space if it is to make a meaningful contribution to Africa's development and the lives of ordinary Africans. The identified areas are climate and biodiversity, health, water, education, and space-related capacity building. Alongside this, concepts of *ubuntu* (a uniquely African worldview), and emerging middle powers, are utilised as novel frameworks to be drawn on throughout the subsequent chapters. Throughout the discussion, focus is placed on the African Union's Agenda 2063 as the core policy document on a continental level that will guide Africa towards a sustainable development future, in line with the United Nations Sustainable Development Goals (SDGs). Methods used for ranking African space capabilities are reviewed, as is the background of African space activities up to the end of the twentieth century. The chapter concludes with a review of the African Space Policy and Strategy that frames Africa's "Astronaissance", followed by a review of debates around the establishment of an African Space Agency.

## 1.1 Introduction

> I have walked that long road to freedom. I have tried not to falter; I have made missteps along the way. But I have discovered the secret that after climbing a great hill, one only finds that there are many more hills to climb. I have taken a moment here to rest, to steal a view of the glorious vista that surrounds me, to look back on the distance I have come. But I can rest



A. Froehlich, A. Siebrits, *Space Supporting Africa*, Studies in Space Policy 20,
https://doi.org/10.1007/978-3-030-12173-0_1

only for a moment, for with freedom comes responsibilities, and I dare not linger, for my long walk is not yet ended.

Nelson Mandela[1]

Former South African President Nelson Mandela's words are not only a reflection of his own life but of Africa's journey as a whole. This is equally true in the space arena. Africa has made tremendous progress over the past several decades, and its accomplishments are worth recognising and celebrating. However, a long road still lies ahead before Africa's aspirations of "shared prosperity and well-being, for unity and integration, for a continent of free citizens and expanded horizons, where the full potential of women and youth, boys and girls are realized, and with freedom from fear, disease and want", as outlined in the African Union Agenda 2063,[2] are realised. There is, however, an increasing awareness of the importance of space and space-related technology and applications in fulfilling this aspiration and in meeting Africa's socio-economic needs. For example, the African Space Strategy recognises that "overcoming Africa's economic, political, environmental and social challenges is contingent upon a collective effort to formalise and sustain an indigenous space sector that is responsive to these challenges".[3] This is an important recognition because Martinez reminds us that "[s]pace is so much a part of the 'plumbing' of modern life that it is often taken for granted".[4] Therefore, it comes as little surprise that there remains a general lack of appreciation of the potential and importance of space activities[5] and that this is coupled with more pointed criticisms of the expenses associated with space activities.[6]

In order to take stock of Africa's progress—and remaining challenges—in the space arena, and to determine how far advanced the space sector is across the continent, this study, the first in a series, will review the continent's space-related activities, capacities, infrastructure, and institutions (in short, the African space ecosystem), framed by the primary needs approach to African space activities, discussed below. The next volume will build on this by delving deeper into the space applications and policies of Africa, as well as the relationship between the European Union (and European Space Agency) and the African Union in the space

[1]Nelson Rolihlahla Mandela, *Long Walk to Freedom* (London: Abacus, 1994), 751.

[2]African Union Commission, *Agenda 2063: The Africa We Want (Popular Version)*, 2015, Addis Ababa, 1. https://au.int/sites/default/files/pages/3657-file-agenda2063_popular_version_en.pdf (accessed June 14, 2018).

[3]African Union Commission, *African Space Strategy: Towards Social, Political and Economic Integration*, 2017, Addis Ababa, 5. https://au.int/sites/default/files/newsevents/workingdocuments/33178-wd-african_space_strategy_-_st20445_e_original.pdf (accessed July 7, 2018).

[4]Peter Martinez, "Space Science and Technology in South Africa: An Overview," *African Skies/Cieux Africains*, 2008, no. 12: 46.

[5]Peter Martinez, "The African Leadership Conference on Space Science and Technology for Sustainable Development," *Space Policy* 28, (2012): 33.

[6]Paul Boateng, "Outer Space is the Place for Africa's Future," *Mail and Guardian*, May 26, 2016, https://mg.co.za/article/2016-05-26-00-outer-space-is-the-place-for-africas-future (accessed June 12, 2018).

arena, and present an assessment of the potential for further Europe/Africa collaboration in space. The overall aim of this work is thus to provide a useful overview of how far advanced the space sector is across Africa and which policy initiatives support, and are supported by, it. This is a response to Giannopapa's observation[7] that not enough work has been done in relation to analysing those space activities and technologies that are used to meet African objectives and support African policies or about the relationship between Africa and Europe in the space arena. Accordingly, this work is fundamentally about Africa's international space engagement, since outer space has always been conceived of as an international arena, for example, in the Outer Space Treaty.[8] Moreover, Peter argues that from the start, "international cooperation has been a central element of the strategy of most countries involved in space activities" and "[i]nternational cooperation is now an integral part of the space policy and strategy of different space agencies around the world".[9] To this end, innovative emerging ideas originating from Africa in the field of international relations theory will also be applied in tandem with the primary needs approach to African space activities to help explain African behaviour and actions in relation to space.

Two important concepts will be used throughout the volumes in this regard—*ubuntu* and emerging middle powers. This is a novel endeavour since *ubuntu*, as a unique African worldview and international relations perspective, has never been coupled with the space arena and since the emerging middle powers concept will help, along with *ubuntu*, to further an understanding of how Africa's regional powers fit into the global system and to give explanations to their behaviour and actions, particularly on continental level. This is useful since it will be shown that African space initiatives are largely driven by regional powers, and some, such as Aganaba-Jeanty,[10] argue that the best way to expand Africa's space capabilities is through a regional approach.

This introductory chapter is organised into five sections. First, a broad background will be presented to contextualise Africa as a challenged, but rising, continent. This will be followed by a discussion of the general socio-economic situation, after which the concepts of *ubuntu* and emerging middle powers will be discussed in relation to African politics. These analytical frameworks will be drawn on throughout this study and will be coupled with an overview of various approaches to rank and sort African countries in relation to their space activities and capabilities, to aid analysis. An overview of the broad continental activities in the space arena, as well as a discussion of Africa's background in space until roughly the year 2000, will follow. Finally, an overview of the following chapters will be provided.

[7] Christina Giannopapa, "Improving Africa's Benefit from Space Applications: The European-African Partnership," *Space Policy* 27, (2011): 99.

[8] United Nations, *Treaties and Principles on Outer Space* (New York: United Nations, 2002).

[9] Nicolas Peter, "The Changing Geopolitics of Space Activities," *Space Policy* 37, (2016): 145.

[10] Timiebi Aganaba-Jeanty, "Precursor to an African Space Agency: Commentary on Dr. Peter Martinez 'Is There a Need for an African Space Agency?'," *Space Policy* 29, (2013): 173.

## 1.2 Situating Africa: Background and Context

In order to provide the foundation and context for the African space ecosystem, this section will review the demographics and politics of the African continent. Africa is the world's second largest continent and covers an area of 30.3 million km$^2$ (one-fifth of the Earth's land area). This includes a great diversity in physical geography, with eight distinct major physical regions, namely, savannah, rainforest, the Swahili Coast, the Ethiopian Highlands, Sahara, Sahel, African Great Lakes, and the Southern African region.[11] Figure 1.1, depicting African land cover, highlights these regions as well as the great complexity in natural environments across the continent. Compiled using a year's worth of data (180,000 images) from the Sentinel 2A satellite, this land cover map is the "the first high-resolution map classifying land cover types on the entire African continent".[12]

The continent is home to 54 sovereign states,[13] including the island nations off the western and eastern coasts, with the territory of Western Sahara disputed between Morocco and the Sahrawi Arab Democratic Republic (Fig. 1.2).

According to the United Nations Economic Commission for Africa (UNECA), the population of Africa increased from 478 million in 1980 to about 1.2 billion in 2016, with a high growth rate of 2.5% in this period.[14] Ten countries accounted for 61% of this growth—Nigeria, Ethiopia, the Democratic Republic of the Congo, Egypt, Tanzania, Kenya, Uganda, Sudan, South Africa, and Algeria. It is important to note that this "demographic dividend" is one of Africa's key opportunities, which "will be achieved by investing in its youthful and increasingly techno-savvy population".[15]

Roughly 40% of the continent's population is currently urbanised, with the most urbanised countries being Gabon (87.2%), Libya (78.6%), the Democratic Republic of the Congo (77.3%), Djibouti (77.3%), Algeria (70.7%), Cabo Verde (65.5%), Tunisia (66.8%), the Republic of the Congo (65.4%), and South Africa (64.8%) and

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[11]National Geographic, "Africa: Physical Geography," 2018, https://www.nationalgeographic.org/encyclopedia/africa-physical-geography/ (accessed June 17, 2018).

[12]This European Space Agency image of African land cover "contains modified Copernicus Sentinel data (2015–2016), processed by Land Cover CCI, ESA"; European Space Agency, "African Land Cover," *Space in Images*, 2017, http://www.esa.int/spaceinimages/Images/2017/10/African_land_cover (accessed August 27, 2018); European Space Agency, "Africa Classified," *Earth Online*, 2017, https://earth.esa.int/web/guest/content/-/article/africa-classified (accessed August 27, 2018).

[13]It should be noted that the country of Eswatini will still be referred to by the name of Swaziland in this study, a while Cabo Verde will be referred to as Cape Verde, and The Gambia as Gambia.

[14]United Nations Economic Commission for Africa, *The Demographic Profile of African Countries*, 2016, Addis Ababa, VII, https://www.uneca.org/sites/default/files/PublicationFiles/demographic_profile_rev_april_25.pdf (accessed June 17, 2018).

[15]Samsana Ismail and Ilunga Mpyana, "The Great Enabler: Aerospace in Africa," *Airbus*, 2018, 8, https://www.airbus.com/content/dam/corporate-topics/publications/brochures/TheGreatEnable_AerospaceinAfrica.pdf (accessed December 5, 2018).

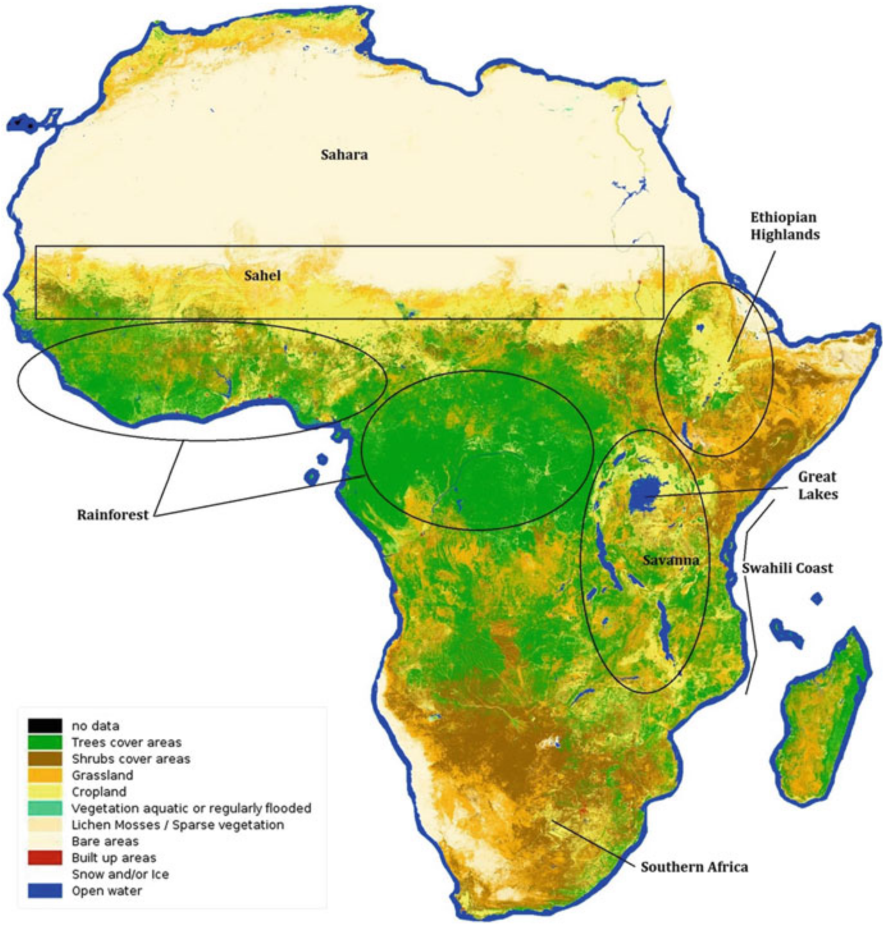


**Fig. 1.1** African land cover and major physical regions. This European Space Agency image of African land cover "contains modified Copernicus Sentinel data (2015–2016), processed by Land Cover CCI, ESA"; European Space Agency, "African Land Cover," *Space in Images*, 2017, http://www.esa.int/spaceinimages/Images/2017/10/African_land_cover (accessed August 27, 2018); European Space Agency, "Africa Classified," *Earth Online*, 2017, https://earth.esa.int/web/guest/content/-/article/africa-classified (accessed August 27, 2018). Regions are approximations, for example, savanna is widespread, but notable example is the African Great Plains in Kenya and Tanzania

the least urbanised being Burundi (12.1%), Uganda (16.1%), Malawi (16.3%), Niger (18.7%), South Sudan (18.8%), Ethiopia (19.5%), Swaziland (21.3%), Chad (22.5%), Kenya (25.6%), and Lesotho (27.3%).[16] Africa also has a very young

[16]United Nations Economic Commission for Africa, *The Demographic Profile of African Countries*, 7.


**Fig. 1.2** Africa's political divisions (54 sovereign states plus Western Sahara). All maps used in this study, unless otherwise stated, are generated with https://mapchart.net/ and countries for which no data are available are excluded from relevant maps

age structure, with about 60% of the population being under 25 years of age (with 40% being 0–14 and 20% being 15–24).[17] Population density varies widely across the continent, with the highest density recorded in Mauritius (627 people per km$^2$), followed by Rwanda (471 people per km$^2$), Burundi (435 people per km$^2$), the Comoros (423.7 people per km$^2$), and Nigeria (200 people per km$^2$).[18] Conversely, the least densely populated countries all have less than 10 people per km$^2$, namely, Namibia, Botswana, the Central African Republic, Angola, Chad, Mauritania, Mali, Niger, and Libya.[19]

[17]Ibid., IX.

[18]Ibid., 7–8.

[19]Ibid., 8.

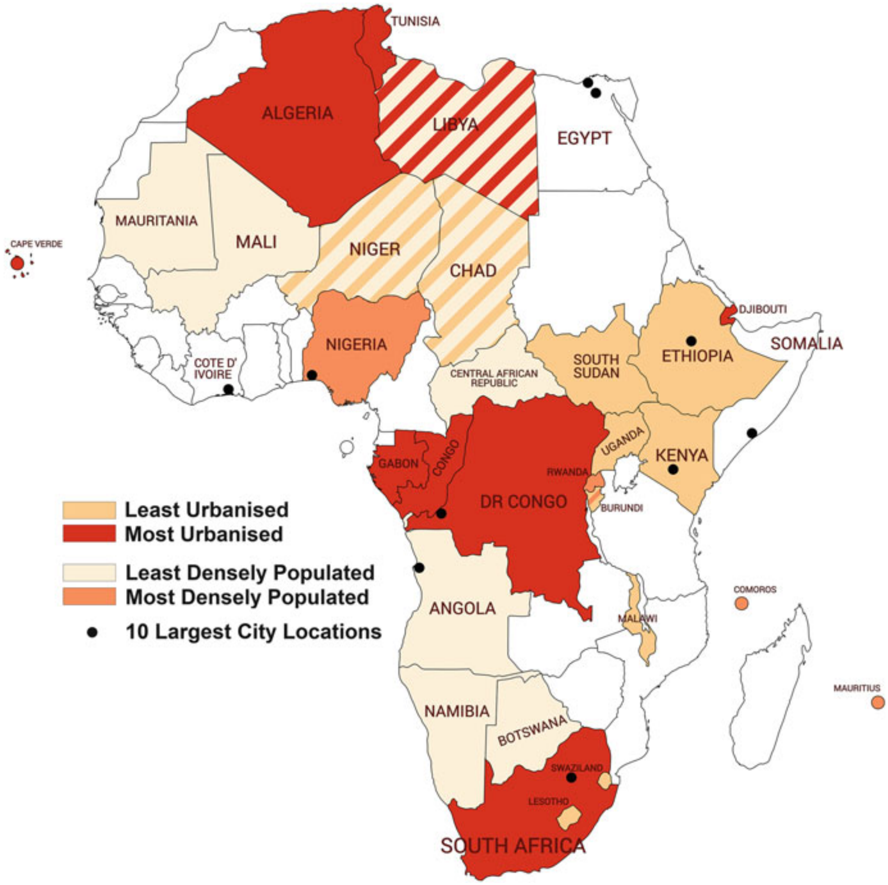


**Fig. 1.3** Most and least urbanised and densely populated African countries, with largest cities

The ten largest cities in Africa (in 2017) were Lagos, Nigeria (21.0 million); Cairo, Egypt (20.4 million); Kinshasa, Democratic Republic of the Congo (13.3 million); Luanda, Angola (6.5 million); Nairobi, Kenya (6.5 million); Mogadishu, Somalia (6.0 million); Abidjan, Côte d'Ivoire (4.7 million); Alexandria, Egypt (4.7 million); Addis Ababa, Ethiopia (4.6 million); and Johannesburg, South Africa (4.4 million).[20] These cities and the most and least urbanised and most and least densely populated countries are depicted in Fig. 1.3.

One of the greatest challenges facing continental cooperation is the immense diversity in linguistic, cultural, and political arenas, as well as the large differences in

[20]James Karuga, "15 Biggest Cities in Africa," *worldatlas.com*, April 25, 2017, https://www.worldatlas.com/articles/15-biggest-cities-in-africa.html (accessed July 7, 2018).

technological capabilities, and economic and industrial levels, between countries.[21] Despite these differences however, all countries have come together to form the African Union (AU), which is the vehicle of Africa's unity and solidarity.

### *1.2.1 Africa's Political Organisation*

The AU is the most politically important organisation on the continent, with all 54 sovereign African states as members, in addition to the Sahrawi Arab Democratic Republic.[22] Its vision is to create "[a]n integrated, prosperous and peaceful Africa, driven by its own citizens and representing a dynamic force in the global arena".[23] Figure 1.4 details the organisational structure of the AU and the AU Commission.

The AU can be subdivided into eight intergovernmental organisations—the Regional Economic Communities (RECs)—that constitute the "building blocks" of the union, having been proposed as a mechanism for regional and continental African integration, through the Lagos Plan of Action for the Economic Development of Africa (1980) and the Abuja Treaty (1991).[24] All 54 countries are members of at least one REC, with some having membership in more than one. The reasons for this overlap are both political and economic, as the example of Tanzania (which left the Common Market for Eastern and Southern Africa in favour of the Southern Africa Development Community) shows. It is argued that Tanzania "pulled out of the Common Market for Eastern and Southern Africa (COMESA) on the pretence it did not wish to remain concurrently a member of that group as well as SADC", with

[21] Martinez, "The African Leadership Conference on Space Science and Technology for Sustainable Development," 36.

[22] The AU inherited most of its membership from its predecessor, the Organisation of African Unity (OAU). All 32 independent African states joined in 1963 to found the OAU, and a further 21 joined by 2002, when the AU was created to succeed the OAU. Article 29 of the Constitutive Act of the African Union stipulates that any African country may notify the Chairman of the AU Commission that they wish to join, after which a vote is held by all members. A simple majority is needed for membership. For this reason, while the Sahrawi Arab Democratic Republic is not formally recognised by most states worldwide, it could join the OAU (in 1982) since most African states recognise it. Morocco left the OAU in protest over the admission of the Sahrawi Arab Democratic Republic in 1984 but rejoined the AU in 2017. African Union, "Constitutive Act of the African Union," 2000, https://au.int/sites/default/files/pages/32020-file-constitutiveact_en.pdf (accessed August 28, 2018); African Union, "Member State Profiles," https://au.int/memberstates (accessed August 28, 2018).

[23] African Union Commission, "Regional Economic Communities (RECs)," https://au.int/en/organs/recs (accessed June 17, 2018).

[24] African Union Commission and New Zealand Crown, *African Union Handbook 2018: A Guide for those working with and within the African Union* (Addis Ababa, Ethiopia: African Union Commission and Wellington, New Zealand: Ministry of Foreign Affairs and Trade/Manatū Aorere, 2018, fifth edition), 10–11, https://au.int/sites/default/files/pages/31829-file-african_union_handbook_2018_english-2.pdf (accessed December 5, 2018).

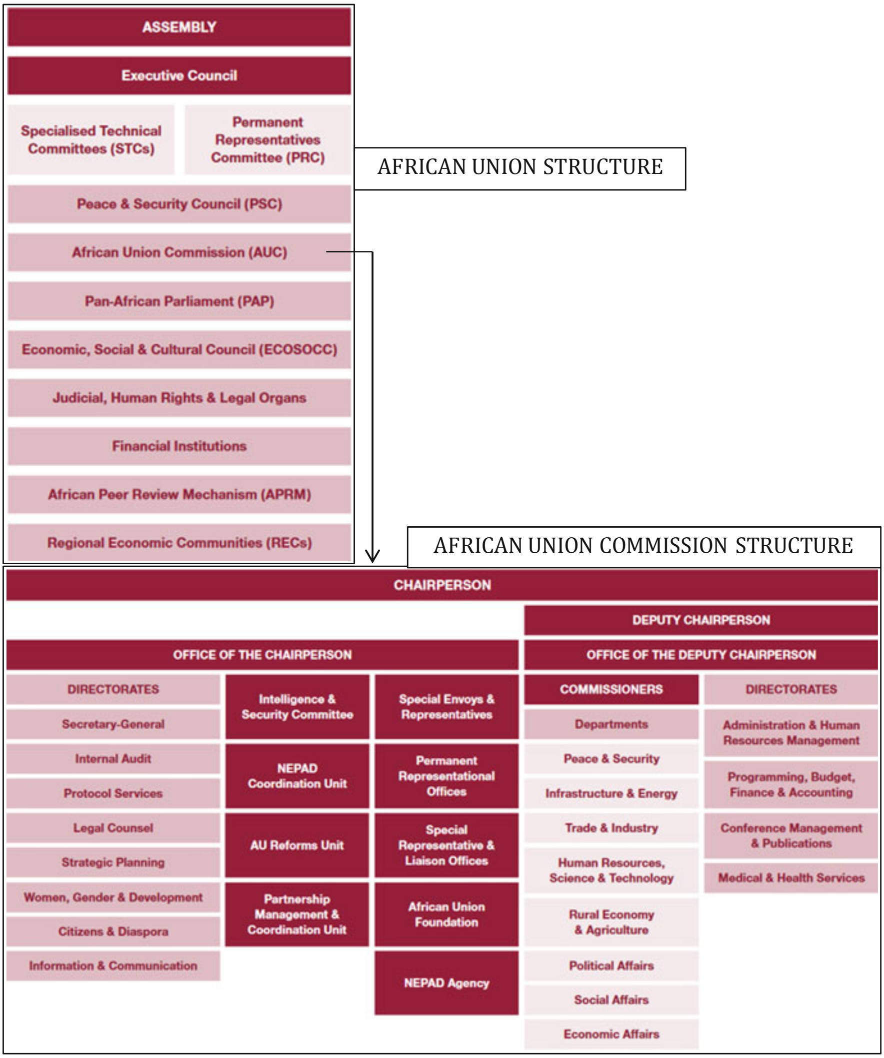


**Fig. 1.4** AU and AU Commission structures. African Union Commission and New Zealand Crown, *African Union Handbook 2018: A Guide for those working with and within the African Union* (Addis Ababa, Ethiopia: African Union Commission and Wellington, New Zealand: Ministry of Foreign Affairs and Trade/Manatū Aorere, 2018, fifth edition), 10–11, https://au.int/sites/default/files/pages/31829-file-african_union_handbook_2018_english-2.pdf (accessed December 5, 2018)

its continued presence in the East African Community described as “half-hearted”.[25] A possible reason for this is because:

> of its fear that its industries and businesses could never hope to succeed in any open and fair competition with the Kenyan sub-regional powerhouse. It has also yet to really recover from the collapse of the first East African integration experiment whose breakup, it believes, unfairly favoured Kenyan interests.[26]

While this is only one possible reason for Tanzania’s decision to leave COMESA, it nevertheless demonstrates that countries make calculated decisions based on economic and political factors regarding what would best serve their interests. However, the number of overlapping memberships can create competition or unnecessary duplication, even potentially adding to what is known as the “spaghetti bowl” phenomenon, which is a proliferation of overlapping and often competing trading agreements bringing complexities and duplications.[27] However, since they predate the creation of the AU itself, these RECs have somewhat different structures and roles, and their broad mandate of fostering regional economic integration has evolved to include coordination in wider areas such as governance, development, and security.

The RECs are thus key organs of the AU. They are the Arab Maghreb Union (UMA), the Common Market for Eastern and Southern Africa (COMESA), the Community of Sahel-Saharan States (CEN-SAD), the East African Community (EAC), the Economic Community of Central African States (ECCAS), the Economic Community of West African States (ECOWAS), the Intergovernmental Authority on Development (IGAD), and the Southern African Development Community (SADC). This study will make use of the RECs in its analysis of African space activities and policies, for the same reason that has been advanced for building an African Regional Space Regime Complex from the RECs instead of through a pan-African Space Agency approach, which could elicit a leadership competition at a continental level (more on this later). It has also been argued that each of the RECs has at least one national space agency, and since they are in effect the “implementing arm of the African Union” and the building blocks of its economic integration, building a broader continental “appetite” for space collaboration and integration through the RECs is thus a sensible idea.[28] Thus, the analysis in Chap. 3 will follow a structure based on the RECs.

In several cases, these RECs also overlap with subregional economic communities (SECs), which are not considered pillars of the AU, but are important at the local

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[25]Peterson Tumwebaze, “Tanzania should choose between EAC and SADC,” *The New Times*, August 21, 2013, https://www.newtimes.co.rw/section/read/68537 (accessed August 28, 3018).

[26]Ibid.

[27]Jagdish N. Bhagwati, “U.S. Trade Policy: The Infatuation with FTAs,” Discussion Paper Series No. 726, 1995, https://academiccommons.columbia.edu/doi/10.7916/D8CN7BFM (accessed August 28, 2018).

[28]Aganaba-Jeanty, “Precursor to an African Space Agency: Commentary on Dr. Peter Martinez ‘Is There a Need for an African Space Agency?’,” 173.

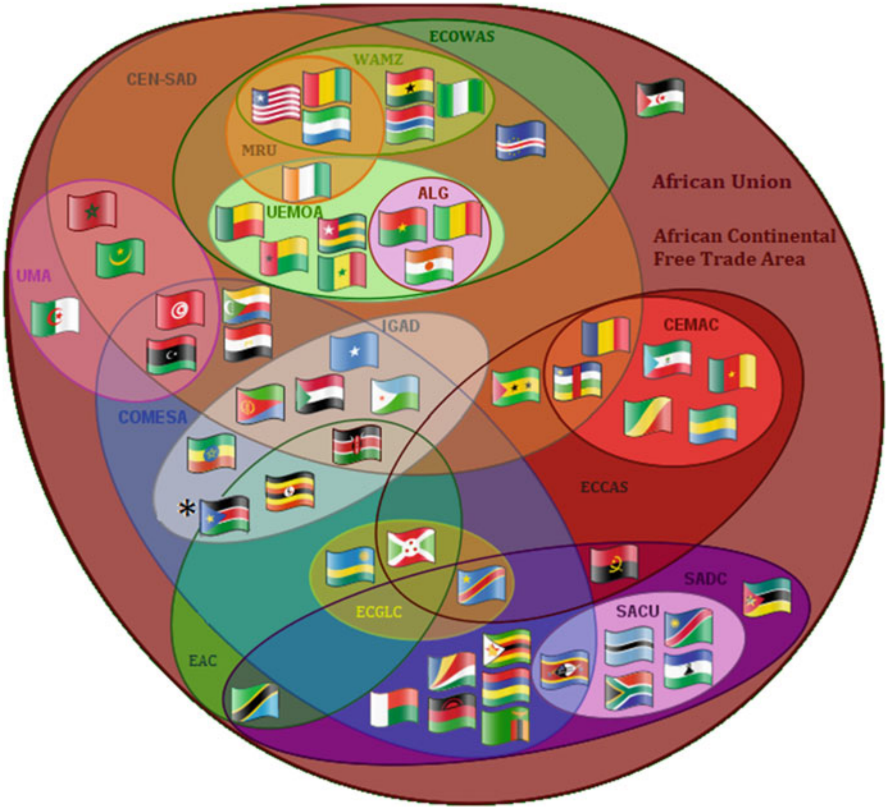


**Fig. 1.5** Supranational African bodies. Wikimedia Commons, "Supranational African Bodies," 2018, https://commons.wikimedia.org/wiki/File:Supranational_African_Bodies-en.svg (accessed August 28, 2018). Modified to include Cape Verde in CEN-SAD and to include South Sudan in East African Community (* Note: South Sudan is *not* a member of COMESA; it is only a member of the AU, IGAD, and EAC). Indian Ocean Commission not indicated in figure

level. Figure 1.5 provides an overview of the various RECs and SECs and how they overlap with each other. It is also notable that all AU members have recently agreed to create the African Continental Free Trade Area (AfCFTA), which is currently being ratified by member states and will come into effect 30 days after ratification by a minimum of 22 AU members.[29] The objectives of the AfCFTA include creating a "single continental market for goods and services, with free movement of business persons and investments, and thus pav[ing] the way for accelerating the establishment of the Continental Customs Union"; expanding "intra African trade through

[29]Landry Signé, "Africa's big new free trade agreement, explained," *The Washington Post*, March 29, 2018, https://www.washingtonpost.com/news/monkey-cage/wp/2018/03/29/the-countdown-to-the-african-continental-free-trade-area-starts-now/?noredirect=on&utm_term=.048473ec1b83 (accessed August 28, 2018).

better harmonization and coordination of trade liberalization and facilitation regimes and instruments across RECs and across Africa in general"; resolving "the challenges of multiple and overlapping memberships and expedite the regional and continental integration processes"; and enhancing "competitiveness at the industry and enterprise level through exploiting opportunities for scale production, continental market access and better reallocation of resources".[30] There is thus a direct link to integrating the continent and the RECs more closely, precisely because "[m]any African countries belong to multiple RECs, which tends to limit the efficiency and effectiveness of these organizations" and "most RECs are underperforming, with a low level of compliance by member states, which has delayed successful integration".[31] However, the progress that has been made at the REC level is to be the foundation of the AfCFTA, as Article 5 of the agreement identifies (as one of the principles of the AfCFTA) "RECs' Free Trade Areas (FTAs) as building blocks for the AfCFTA".[32]

While it was agreed that the AfCFTA would come into effect within 18 months of signing of the framework,[33] it is reported that there are some concerns that the "time frame may be too short, especially given the need for debate and negotiations within each signatory nation".[34] The AfCFTA has been "billed as the world's largest"[35] free trade area and:

> tries to solve . . . the terrible state of trade within Africa. While trade within Europe makes up 67% of trade, in Africa it is just around 12%. That is, every African country trades more with another continent than with their neighbour.[36]

As of August 8, 2018, six countries had ratified the AfCFTA.[37] Since the RECs (and the SECs) remain important, and are the building blocks of the AU and the AfCFTA, they will be discussed in turn below.

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[30] African Union, "CFTA – Continental Free Trade Area," https://au.int/en/ti/cfta/about (accessed August 28, 2018).

[31] Signé, "Africa's big new free trade agreement, explained."

[32] African Union, "Agreement Establishing the African Continental Free Trade Area," March 21, 2018, https://au.int/sites/default/files/treaties/34248-treaty-consolidated_text_on_cfta_-_en.pdf (accessed August 28. 2018).

[33] Ibid.

[34] Signé, "Africa's big new free trade agreement, explained."

[35] Fin24, "Ramaphosa signs declaration on African free trade region," March 21, 2018, https://www.fin24.com/Economy/sa-signs-african-free-trade-agreement-20180321 (accessed August 28, 2018).

[36] Feyi Fawehinmi, "CFTA: A Free Trade Area Is Not The Same As a Free Trade Agreement," *Medium*, March 26, 2018, https://aguntasolo.co/cfta-a-free-trade-area-is-not-the-same-as-a-free-trade-agreement-73b34404b299 (accessed August 28, 2018).

[37] African Union, "List of countries which have signed, ratified/acceded to the agreement establishing the African Continental Free Trade Area," August 8, 2018, https://au.int/sites/default/files/treaties/34248-sl-agreement_establishing_the_african_continental_free_trade_area.pdf (accessed August 28, 2018).


**Fig. 1.6** Arab Maghreb Union (UMA)

## Arab Maghreb Union (UMA)

The Arab Maghreb Union in the north is the smallest REC, with five members (Fig. 1.6). It was established in 1989 through the Marrakesh Treaty,[38] to promote prosperity and strengthen the ties between its members; to facilitate the movement of people, goods, services, and capital; and to defend the national rights of its members.[39] The secretariat of this political-level organisation is located in Rabat, Morocco.

## Common Market for Eastern and Southern Africa (COMESA)

The Common Market for Eastern and Southern Africa, established in 1993, is the second largest REC on the continent, with 21 members (Fig. 1.7). The primary purpose of the organisation, as stated in the COMESA Treaty,[40] is to create a free trade region to support the economic development and growth of its members; to coordinate their economic activity; to foster foreign, regional, and domestic investment; to build stronger relations globally; and to support peace and security in the region.[41] The secretariat of COMESA is located in Lusaka, Zambia.

One of Africa's SECs, the Indian Ocean Commission (COI),[42] comprises Indian Ocean COMESA members, namely, Madagascar, Seychelles, Mauritius, the

[38]Treaty instituting the Arab Maghreb Union (with declaration). Concluded at Marrakesh on 17 February 1989. http://www.wipo.int/wipolex/en/other_treaties/text.jsp?file_id=201318 (accessed September 23, 2018).

[39]African Union Commission, "Regional Economic Communities (RECs)," https://au.int/en/organs/recs (accessed June 17, 2018).

[40]Treaty Establishing the Common Market for Eastern and Southern Africa, http://www.comesa.int/wp-content/uploads/2016/06/COMESA-Treaty.pdf (accessed September 23, 2018).

[41]Ibid.

[42]Established through the General Victoria Agreement of 1984.

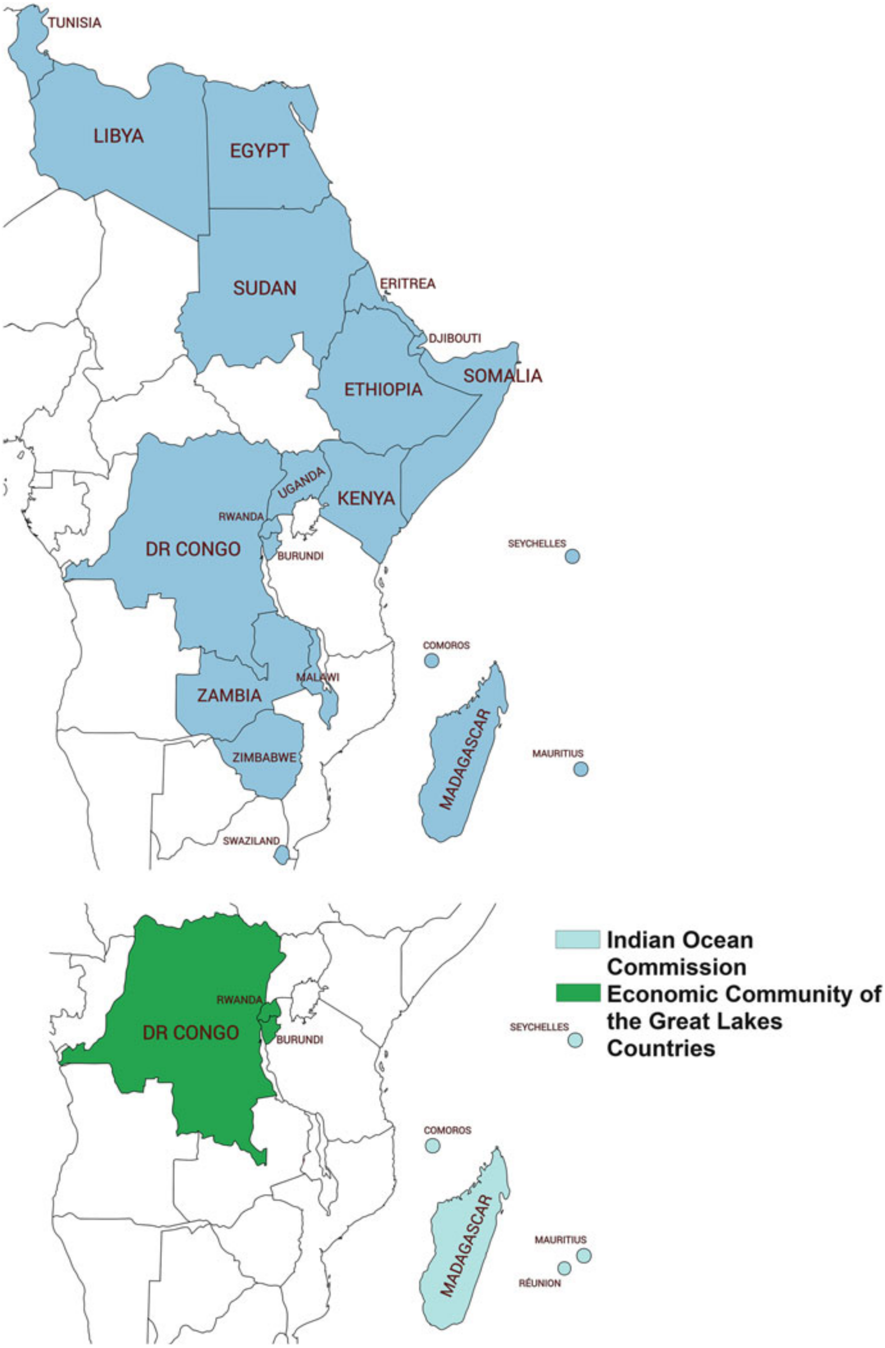



**Fig. 1.7** Common Market for Eastern and Southern Africa (COMESA) and SECs

Comoros, and Reunion Island (France) as members.[43] It functions as a vehicle for the development of the Indian Ocean states and provides a framework for its members to "conduct external collective actions of integration and cooperation with the Eastern and Southern Africa region, the African continent (AU), the South (South–South collaboration) and the rest of the world, and with multilateral institutions and various donors".[44] It also aims to promote tourism and trade.[45] Actions and projects have been initiated in several areas such as the environment, tourism, intra-regional trade, fisheries, telecommunications, culture, climate change, health, and gender issues.[46]

Another SEC within COMESA is the Economic Community of the Great Lakes Countries (ECGLC),[47] with the Democratic Republic of the Congo, Rwanda, and Burundi as members and which operates with the aim of fostering economic cooperation and integration in the region.[48]

For reference regarding the Indian Ocean region, Fig. 1.8 shows the political boundaries in greater detail, including the areas administered by France and the United Kingdom.

### Community of Sahel-Saharan States (CEN-SAD)

The Community of Sahel-Saharan States, with 29 members, is the largest of the RECs. Founded in 1998[49] to promote social, political, cultural, and economic integration among its members, its focus includes the promotion of free movement of people and capital, as well as foreign trade and closer telecommunications and transport links in the region.[50] It also focuses on establishing an economic union,

[43] Commission De L'Océan Indien, "Accueil," 2018, http://www.commissionoceanindien.org/accueil/ (accessed July 7, 2018).

[44] Commission De L'Océan Indien, "Qui sommes nous?," English Translation, 2018, http://commissionoceanindien.org/a-propos/qui-sommes-nous/ (accessed July 7, 2018).

[45] Seychelles Trade Portal, "Trade Agreements," http://www.seychellestradeportal.gov.sc/trade-agreements (accessed September 23, 2018).

[46] Department of Foreign Affairs of the Republic of the Seychelles, "International Relations: International Organisations," http://www.mfa.gov.sc/static.php?content_id=33 (accessed September 23, 2018).

[47] The Convention Establishing the Economic Community of the Great Lakes Countries (CEPGL), Concluded at Gisenyi on 20 September 1976, https://wits.worldbank.org/GPTAD/PDF/archive/CEPGL.pdf (accessed September 23, 2018).

[48] Communauté Economique des Pays des Grands Lacs, "Accueil," 2015, http://www.cepgl.org/ (accessed July 7, 2018).

[49] CEN-SAD was established on February 4, 1998, following the Conference of Leaders and Heads of States held in Tripoli, with a revised treaty of the Community of Sahel-Saharan States (CEN-SAD), adopted on February 16, 2013, by the Conference of Heads of State and Government from the organisation.

[50] African Union Commission, "Regional Economic Communities (RECs)," https://au.int/en/organs/recs (accessed June 17, 2018).


**Fig. 1.8** Western Indian Ocean. University of Texas Libraries, "Indian Ocean—West (Political) 1996", 2018, http://legacy.lib.utexas.edu/maps/islands_oceans_poles/indian_ocean_w_96.jpg (accessed August 27, 2018)

with particular emphasis on agriculture, industry, energy, society, and culture. It also aims to coordinate the educational systems of its members and to foster scientific and technical cooperation. The CEN-SAD secretariat is located in Tripoli, Libya.[51]

[51]United Nations Economic Commission for Africa, "CEN-SAD – The Community of Sahel-Saharan States," https://www.uneca.org/oria/pages/cen-sad-community-sahel-saharan-states (accessed June 17, 2018).

Member countries are predominantly located in the northern half of the continent (Fig. 1.9).

### East African Community (EAC)

The East African Community, formed in 1999,[52] today includes a customs union and a common market, spanning six states (Fig. 1.10). Its aim is to foster cooperation between members in an array of fields including the economy, politics, society, culture, security and defence, technology, and law.[53] The ultimate aim is to create a political federation. The East African Community headquarters is located in Arusha, Tanzania.

### Economic Community of Central African States (ECCAS)

The Economic Community of Central African States, with 11 member states (Fig. 1.11), was established in 1983,[54] and aims to improve the living conditions of its citizens through the promotion of economic and social development.[55] It also strives to maintain economic stability in the region. Other priorities include the recognition of peace and security as a necessary foundation for development and the creation of local capacities in order to uphold peace and security, as well as economic (including monetary) integration. The administrative centre of ECCAS is in Libreville, Gabon. Within ECCAS, the Central African Economic and Monetary Community (CEMAC) SEC was formed in 1994[56] to promote greater economic integration among countries that share a common currency, the CFA franc.[57] Members include Cameroon, the Central African Republic, Chad, the Republic of the Congo, Equatorial Guinea, and Gabon. The organisation is dedicated to removing internal economic barriers between these countries and the establishment of a common market and economic union.[58]

[52]Treaty for the Establishment of the East African Community (as amended on 14th December, 2006 and 20th August, 2007), http://eacj.org//wp-content/uploads/2012/08/EACJ-Treaty.pdf (accessed September 23, 2018).

[53]African Union Commission, "Regional Economic Communities (RECs)," https://au.int/en/organs/recs (accessed June 17, 2018).

[54]Treaty Establishing the Economic Community of Central African States, http://www.wipo.int/edocs/trtdocs/en/eccas/trt_eccas.pdf (accessed September 23, 2018).

[55]Ibid.

[56]CEMAC Traité constitutive signé le 16 mars 1994, http://www.internationaldemocracywatch.org/attachments/173_CEMAC%20Treaty%20(French).pdf (accessed September 23, 2018).

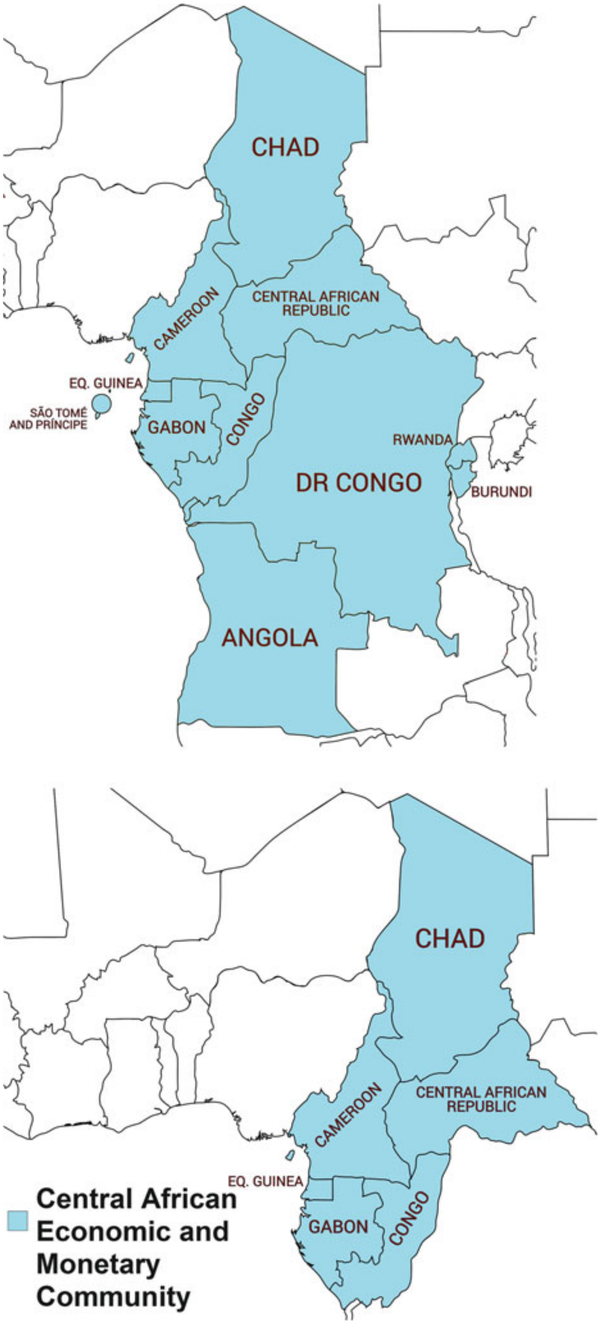
[57]International Democracy Watch, "Central African Economic and Monetary Community," 2012, http://www.internationaldemocracywatch.org/index.php/central-african-economic-and-monetary-community (accessed July 7, 2018).

[58]Ibid.


**Fig. 1.9** Community of Sahel-Saharan States (CEN-SAD)


**Fig. 1.10** East African Community (EAC)

**Fig. 1.11** Economic Community of Central African States (ECCAS) and Central African Economic and Monetary Community (CEMAC)



### Economic Community of West African States (ECOWAS)

Founded in 1975,[59] the Economic Community of West African States strives for "collective self-sufficiency" through cooperation and integration among its 15 members (Fig. 1.12).[60] Cooperation includes a broad range of economic spheres, as well as cultural and political matters, and ECOWAS operates today as a large trading bloc with a goal of a single currency and further macroeconomic convergence. The administrative centre of ECOWAS is in Abuja, Nigeria.

Four SECs operate within ECOWAS. The first is the West African Economic and Monetary Union (UEMOA) created in 1994,[61] with Benin, Guinea-Bissau, Côte d'Ivoire, Mali, Niger, Senegal, and Togo as members, operating within ECOWAS to "create a common market among the Member States, based on the free movement of persons, goods, services, and capital, the right of establishment of self-employed or salaried persons, as well as a common external tariff and common market policy".[62] The second, the West African Monetary Zone (WAMZ), was formed in 2000,[63] is dedicated to "a common West African Central Bank and the launching of a single currency".[64] Its member states are Gambia, Ghana, Guinea, Liberia, Nigeria, and Sierra Leone. The third, the Mano River Union,[65] comprises Liberia, Sierra Leone, Guinea, and Côte d'Ivoire and aims to foster collaboration in areas such as security, commerce, and others.[66] The fourth is the Liptako-Gourma Region Integrated Development Authority (ALG), formed by Mali, Burkina Faso, and Niger in 1970.[67] Its mission is to focus on the "harmonious and integrated development" of its members and to "promote sectoral integration, i.e. the integration of sectors, coherence and complementarity of actions" and "articulate the regional program

[59]ECOWAS Revised Treaty 1993, http://www.ecowas.int/wp-content/uploads/2015/01/Revised-treaty.pdf (accessed September 23, 2018).

[60]Economic Community of West African States, "Basic Information," 2016, http://www.ecowas.int/about-ecowas/basic-information/ (accessed June 18, 2018).

[61]Traité Modifié de l'Union Economique et Monetaire Ouest Africaine (UEMOA), http://www.uemoa.int/en/system/files/fichier_article/traitreviseuemoa.pdf (accessed September 23, 2018).

[62]West African Economic and Monetary Union, "The Amended Treaty," http://www.uemoa.int/en/amended-treaty (accessed July 7, 2018).

[63]Agreement of the West African Monetary Zone, http://www.wami-imao.org/sites/default/files/WAMZ%20Agreement.docx (accessed September 23, 2018).

[64]West African Monetary Institute, "Welcome to WAMI," 2018, http://www.wami-imao.org/ (accessed July 7, 2018).

[65]The Mano River Declaration, 1973, https://wits.worldbank.org/GPTAD/PDF/archive/MRU.pdf (accessed September 23, 2018).

[66]Front Page Africa, "Mano River Union Countries to Establish Legislative Body," April 19, 2016, https://frontpageafricaonline.com/politics/mano-river-union-countries-to-establish-legislative-body/ (accessed July 7, 2018).

[67]Traité Revisé de l'Autorité de Developpement Intégré des Etats du Liptako-Gourma, http://www.g5sahel.org/images/Docs/TRAITE_REVISE-VERSION_SIGNEE.pdf (accessed September 23, 2018).

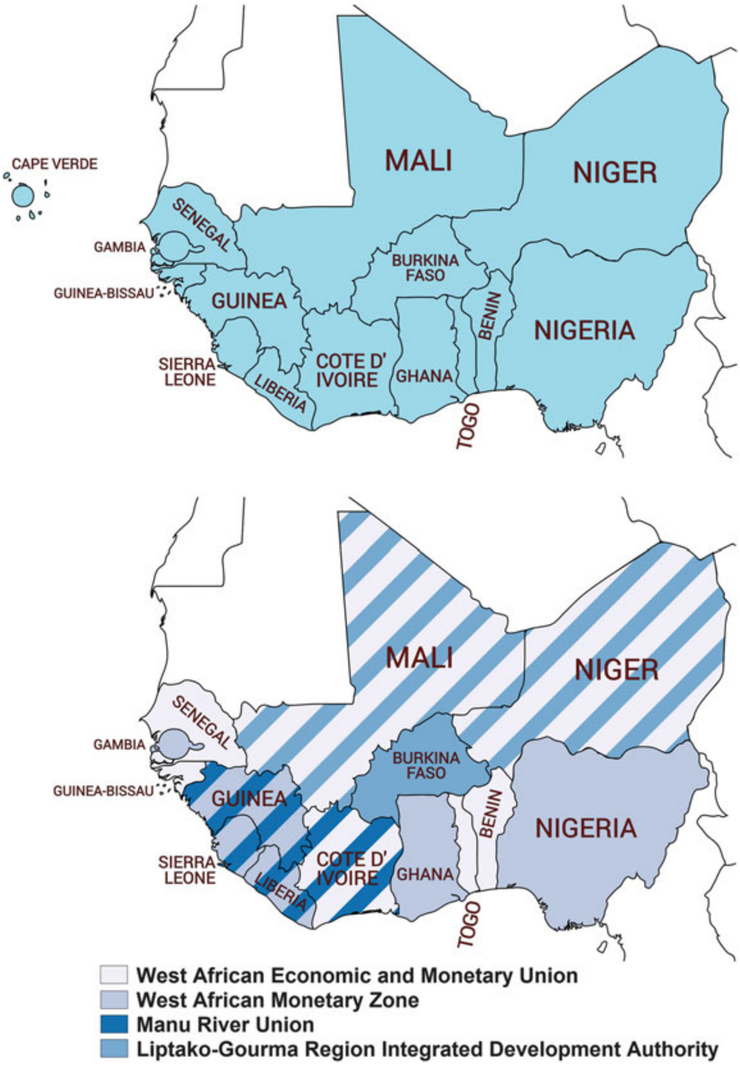



**Fig. 1.12** Economic Community of West African States (ECOWAS)

with actions at the level of States and other IGOs".[68] Its particular emphasis is on resources including "agro-pastoral, hydraulic, mining, and energy resources", which often "exceeds the financial capacities of a single State" to effectively manage and gain benefit from.[69] The memorandum of understanding between the three member

[68]Liptako-Gourma Region Integrated Development Authory, "Mission," http://www.liptakogourma.org/index.php/presentation/mission (accessed August 28, 2018). Translated from French.

[69]Ibid.


**Fig. 1.13** Intergovernmental Authority on Development (IGAD)

states to establish the ALG was signed in 1970, making the ALG "one of the first sub-regional integration organizations in West Africa", and, as mentioned, focused on "the optimal development of the mining, energy, hydraulic, agro-pastoral and fish resources of the Liptako-Gourma Region".[70]

## Intergovernmental Authority on Development (IGAD)

Located in Eastern Africa and headquartered in Djibouti, the Intergovernmental Authority on Development was founded in 1996 as the successor to the Intergovernmental Authority on Drought and Development (IGADD), which was founded in 1986.[71] The eight member states of this organisation (Fig. 1.13) have been subject to the effects of national disasters, particularly as a result of droughts that have led to famine, making it "one of the most vulnerable regions on the African continent for climatic variations", coupled with land and environmental degradation.[72]

[70]Liptako-Gourma Region Integrated Development Authory, "Création," http://www.liptakogourma.org/index.php/presentation/creation (accessed August 28, 2018). Translated from French.

[71]It was decided in 1995 to revitalize IGADD and expand areas of regional cooperation and adopt a new organisational structure, which became known as IGAD in 1996. Intergovernmental Authority on Development, "About Us," 2018, https://igad.int/index.php?option=com_content&view=article&id=93&Itemid=124 (accessed September 23, 2018). Agreement Establishing the Inter-Governmental Authority on Development (IGAD), 1996, http://www.ifrc.org/docs/idrl/N527EN.pdf (accessed September 23, 2018).

[72]Intergovernmental Authority on Development, "The IGAD Region," 2018, https://www.igad.int/about-us/the-igad-region (accessed June 18, 2018).

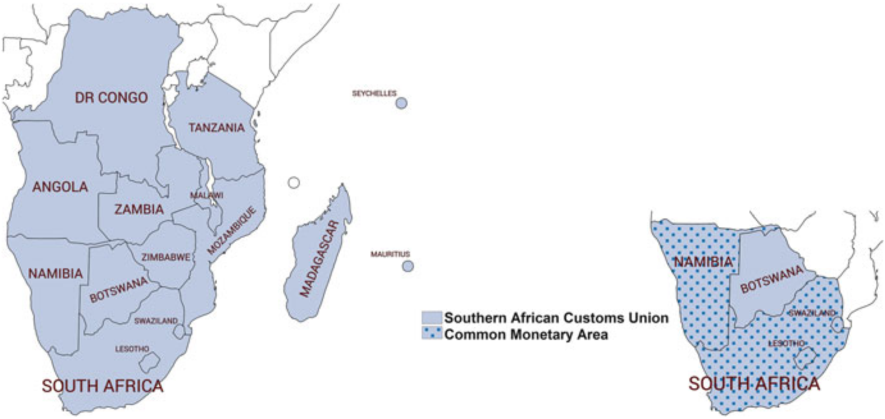



**Fig. 1.14** Southern African Development Community (SADC)

Accordingly, IGAD focuses on issues such as food security, sustainable development of natural resources, harmonisation of the policies of member states, and peace and security.[73]

## Southern African Development Community (SADC)

With 15 member states (Fig. 1.14), the Southern African Development Community, founded in 1992, is the successor to the Southern African Development Coordinating Conference (SADCC), which was founded in 1980.[74] The broad goals of SADC include economic growth and development and peace and security, with the aim of raising the standard of living in the region, reducing poverty, and supporting the socially disadvantaged. A free trade zone was established within the region, with maximum tariff liberalisation attained in 2012.[75] SADC's Executive

[73] African Union Commission, "Regional Economic Communities (RECs)," https://au.int/en/organs/recs (accessed June 17, 2018).

[74] Southern African Development Community, "SADC Overview," 2012, https://www.sadc.int/about-sadc/overview/ (accessed June 18, 2018). The reason for the change was that SADCC was originally formed to advance the cause of national political liberation in Southern Africa and to reduce dependence particularly on the then apartheid South Africa. After Nelson Mandela's release in 1990 and the dawning of democracy in South Africa, this focus shifted in 1992 to spearhead economic integration of Southern Africa. Southern African Development Community, "History and Treaty," 2012, https://www.sadc.int/about-sadc/overview/history-and-treaty/ (accessed September 23, 2018). Declaration and Treaty of the Southern African Development Community, 1992, https://www.sadc.int/files/8613/5292/8378/Declaration__Treaty_of_SADC.pdf (accessed September 23, 2018).

[75] Southern African Development Community, "Free Trade Area," 2012, https://www.sadc.int/about-sadc/integration-milestones/free-trade-area/ (accessed June 18, 2018).

Secretary is based in Gaborone, Botswana. SADC goals include establishing a common market, a monetary union, and a single currency.

Within SADC, one SEC exists, namely, the Southern African Customs Union (SACU), with five members (Botswana, Lesotho, Namibia, South Africa, and Swaziland), founded by the 1910 SACU Agreement[76] and headquartered in Windhoek, Namibia.[77] One of the goals of SADC is to expand this customs union across the region.[78] Allied to SACU is the Common Monetary Area (CMA), which covers all SACU members except Botswana. The CMA originated in 1921 when the South African pound was made the only legal tender in SA, Bechuanaland (now Botswana), Lesotho, Swaziland, and Namibia after the South African Reserve Bank was established.[79] Botswana withdrew from the CMA in 1975, but the currencies of the remaining countries remain pegged to the South African rand,[80] and it is reported that "[w]ith SA accounting for more than 90% of the CMA's GDP, trade and population, the rand is still the only de facto common currency in the CMA".[81]

Together, these RECs and the smaller SECs make up the African Economic Community (AEC), which has laid the groundwork for African economic integration since its founding in 1991 through the Abuja Treaty. This treaty called for the strengthening of existing RECs and the creation of RECs in areas where none existed, in order to facilitate broad continental economic integration, with a free trade zone and customs union, a common market, and free movement of people, goods and services, and capital, and the creation of a single African currency.[82] The AEC and the RECs thus form an integral part of the AU, and in addition to their economic roles, they also support political and social integration. For this reason, the RECs will form a key part of the approach taken in this study in the analysis of African space activities, as mentioned. The RECs are powerful vehicles for economic and political integration. Sustained growth and development in Africa (including in the space arena) depends on "multiple growth poles", with every subcontinental region needing strong drivers of growth.[83] Moreover, since the

[76]Southern African Customs Union Agreement 2002 (as amended on April 12, 2013), http://www.sacu.int/docs/agreements/2017/SACU-Agreement.pdf (accessed September 23, 2018).

[77]Southern African Customs Union, "About SACU," 2013, http://www.sacu.int/show.php?id=394 (accessed June 18, 2018).

[78]Southern African Development Community, "Free Trade Area," 2012, https://www.sadc.int/about-sadc/integration-milestones/free-trade-area/ (accessed June 18, 2018).

[79]Times Live, "History of the common monetary area," *The Sunday Times*, May 29, 2011, https://www.timeslive.co.za/sunday-times/lifestyle/2011-05-29-history-of-the-common-monetary-area/ (accessed August 30, 2018).

[80]After independence, Namibia joined in 1992, replacing the CMA with the Multilateral Monetary Agreement (MMA) of 1992.

[81]Ibid.

[82]Organisation of African Unity, *Treaty Establishing the African Economic Community*, 1991, Abuja, 12–14. https://au.int/sites/default/files/treaties/7775-treaty-0016_-_treaty_establishing_the_african_economic_community_e.pdf (accessed June 19, 2018).

[83]Godwell Nhamo, "New Global Sustainable Development Agenda: A Focus on Africa," *Sustainable Development*, 2016: 1.

SECs, in particular, work towards the removal of tariffs and other economic barriers on a regional level, the spread of space technologies can be facilitated through this intra-regional engagement. Accordingly, the analysis in Chap. 2 will highlight the leading space actors in every REC since these can act as the gateway towards expanding African participation in the space sector.

The next section will consider some of the major political challenges confronting Africa, since the space sector and its operations are necessarily rooted and embedded within the political sphere. Thus, a holistic understanding of the political challenges facing the continent is necessary, since the space sector must navigate these in order to meet the socio-economic challenges. This also explains why in far too many cases space activities have taken a backseat to other more politically pressing concerns. The following section will consider socio-economic factors, and thus, a brief overview of some of the main trends and drivers of change in Africa leading up to 2025 is relevant here. A report by the European Union's Institute for Security Studies highlights several trends facing Africa in the coming years, including two socio-political trends, namely, "the disappearance of ageing long-standing rulers" and the "expansion of the youth bulge".[84] Two security trends are also highlighted, namely, the "consolidation of multi-layered security challenges on the one hand and, on the other, the persistence of religious extremism as a vector of violent mobilisation", while two economic and structural trends are "challenges of growing resource depletion and land pressures, complemented by patterns of diverging growth and inequality".[85] Underlying these are drivers of change, defined as factors that "frame the environment in which . . . trends will unfold, thereby to some extent conditioning how they will develop and with what impact".[86] These drivers of change include systemic ones, namely, climate change, technological developments, international economic policies, and global order, while macrosocial drivers of change are demographics, epidemics, gender attitudes, education, and corruption. Many of these will be considered throughout the course of this study.

### *1.2.2 Political Challenges*

Laudable progress in democratisation and governance is being made across Africa.[87] Political liberalisation is progressing as many of the longest-serving African leaders have recently exited office, including Robert Mugabe, Yahya Jammeh, and José Eduardo dos Santos. Joseph points out that about one-third of the states in

[84]Valérie Arnould and Francesco Strazzari, *African futures: Horizon 2025* (Paris: EU Institute for Security Studies, 2017), 6–7.

[85]Ibid.

[86]Ibid.

[87]Samuel Oyewole, "Space Research and Development in Africa," *Astropolitics* 15, no. 2 (2017): 200.

sub-Saharan Africa are "substantially democratic", buoyed up by the third wave of democratisation starting in the early 1990s, which left a lasting legacy emphasising the rule of law, good governance, accountability, transparency, and human rights.[88] Similarly, the Mo Ibrahim Foundation reports in its 2017 Ibrahim Index of African Governance that one-third of African countries are driving the overall improvement in governance on the continent, but 40 countries have shown positive improvements in overall governance in the last decade.[89] The countries with the best overall governance score were Mauritius, Seychelles, Botswana, Cape Verde, Namibia, South Africa, Tunisia, Ghana, Rwanda, and Senegal, while the worst performers were Somalia, South Sudan, Eritrea, the Central African Republic, Sudan, Libya, the Democratic Republic of the Congo, and Chad.[90] The measures used include safety and rule of law, participation and human rights, sustainable economic opportunity, and human development. Specifically in terms of safety and the rule of law, increasing improvements were seen in 11 countries (over a decade).[91] However, 21 countries have shown a consistent slowing or increasing deterioration in this area.[92] This is troubling because without strong rule of law and safety all development is placed in jeopardy.

Indeed, many political challenges still confront African countries and threaten socio-economic development and progress in sectors, including space. Many countries are still politically fragile, such as Somalia, the Central African Republic, Burundi, and South Sudan.[93] Corruption remains a serious challenge, with much of Africa continuing to perform poorly according to Transparency International's 2017 Corruption Perceptions Index, which ranks countries on a scale of 0–100 (0 being highly corrupt and 100 being very clean).[94] The best performing African country is Botswana, ranking 34th out of 180 countries, with a score of 61 (for

[88]Richard Joseph, "Is Good Governance Necessary For Economic Progress in Africa?," *The Brookings Institution*, August 4, 2013, https://www.brookings.edu/opinions/is-good-governance-necessary-for-economic-progress-in-africa/ (accessed June 19, 2018).

[89]Mo Ibrahim Foundation, "Mo Ibrahim Index of African Governance 2017: Key Findings," 2018, http://mo.ibrahim.foundation/iiag/2017-key-findings/ (accessed June 19, 2018).

[90]Mo Ibrahim Foundation, *2017 Ibrahim Index of African Governance: Index Report*, 2017: 16. http://s.mo.ibrahim.foundation/u/2017/11/21165610/2017-IIAG-Report.pdf?_ga=2.205005072.146642425.1529417846-97260619.1529417846#page=25 (accessed June 19, 2018).

[91]Namibia, Senegal, Tanzania, Tunisia, Togo, Swaziland, Côte d'Ivoire, Uganda, Kenya, Ethiopia, and Zimbabwe.

[92]Benin, Malawi, Algeria, Mauritania, Eritrea, Sudan, Botswana, Cape Verde, Ghana, Gabon, Niger, Mozambique, Djibouti, Gambia, Cameroon, Congo, Equatorial Guinea, Burundi, Libya, the Central African Republic, Somalia, and South Sudan.

[93]Caroline Kende-Robb, "These are the 8 reasons why 2018 could be Africa's year," *World Economic Forum*, March 15, 2018, https://www.weforum.org/agenda/2018/03/africa-s-year-of-opportunity (accessed June 18, 2018).

[94]Transparency International, "Corruption Perceptions Index 2017," 2018, https://www.transparency.org/news/feature/corruption_perceptions_index_2017?gclid=EAIaIQobChMIvfHPt8Pd2wIVzZkbCh1B8QIQEAAYASAAEgI0afD_BwE, (accessed June 18, 2018).

reference, the best global performer is New Zealand with a score of 89). The worst performing country is Somalia, placed 180th, with a score of 9. Only six African countries have a score of 50 or higher,[95] indicating that for the majority of Africa corruption remains a very serious challenge. An overview of African performance is given in Fig. 1.15.

A similar troubling image emerges when more broadly considering the political scene across Africa. Freedom House produces its annual Freedom in the World Index, which rates countries on their political rights and civil liberties, with the former considering the electoral process, political pluralism and participation, and the functioning of government and the latter considering issues of expression and belief, personal autonomy and individual rights, associational and organisational rights, and the rule of law.[96] The average ratings of political rights and civil liberties are then taken to produce the freedom rating (free, partly free, not free). Here too, most of Africa performs poorly. Eritrea is the worst performer, with an aggregate score of 3 out of 100 (the same as North Korea), while Cape Verde scores the best on the continent with 90 out of 100 (the same score as France).[97] Overall, less than a fifth (10 out of 55) of African countries and territories (including Western Sahara) are considered free[98] (Fig. 1.15). Clearly there is much progress that must still be made in terms of the rule of law, civil rights, and the political process.

Peace and security is another political arena where many challenges remain. Seven out of the UN's current 14 peacekeeping operations are active in Africa (Table 1.1).[99]

Amnesty International reports in its 2017/2018 review that significant challenges remain in the following seven categories: repression of dissent, armed conflict and violence, people on the move, impunity, discrimination and marginalisation, right to housing and forced evictions, and business and corporate accountability (some of these will be reviewed in the socio-economic section).[100] Another challenge, to be explored in a future study, includes lack of birth certificates and other official documentation, with "potentially dire consequences in regard to education, health care, job prospects, and legal rights" for millions of Africans.[101]

[95]Botswana, Seychelles, Cape Verde, Rwanda, Namibia, and Mauritius.

[96]Freedom House, "Freedom in the World 2018: Methodology," 2018, https://freedomhouse.org/report/methodology-freedom-world-2018 (accessed June 18, 2018).

[97]Freedom House, "Freedom in the World 2018: Democracy in Crisis," 2018, https://freedomhouse.org/report/freedom-world/freedom-world-2018 (accessed June 18, 2018).

[98]South Africa, Namibia, Botswana, Benin, Ghana, Cape Verde, Tunisia, Mauritius, Senegal, and São Tomé & Príncipe.

[99]United Nations Peacekeeping, "Where we operate," https://peacekeeping.un.org/en/where-we-operate (accessed June 18, 2018).

[100]Amnesty International, "Africa 2017/2018," 2018, https://www.amnesty.org/en/countries/africa/report-africa/ (accessed June 19, 2018).

[101]Independent, "Hundreds of millions of children 'lack any record of their birth'," September 16, 2017, https://www.independent.co.uk/news/world/africa/invisible-children-unicef-birth-registration-campaign-india-uganda-somalia-birth-certificate-a7950056.html (accessed September 23, 2018).

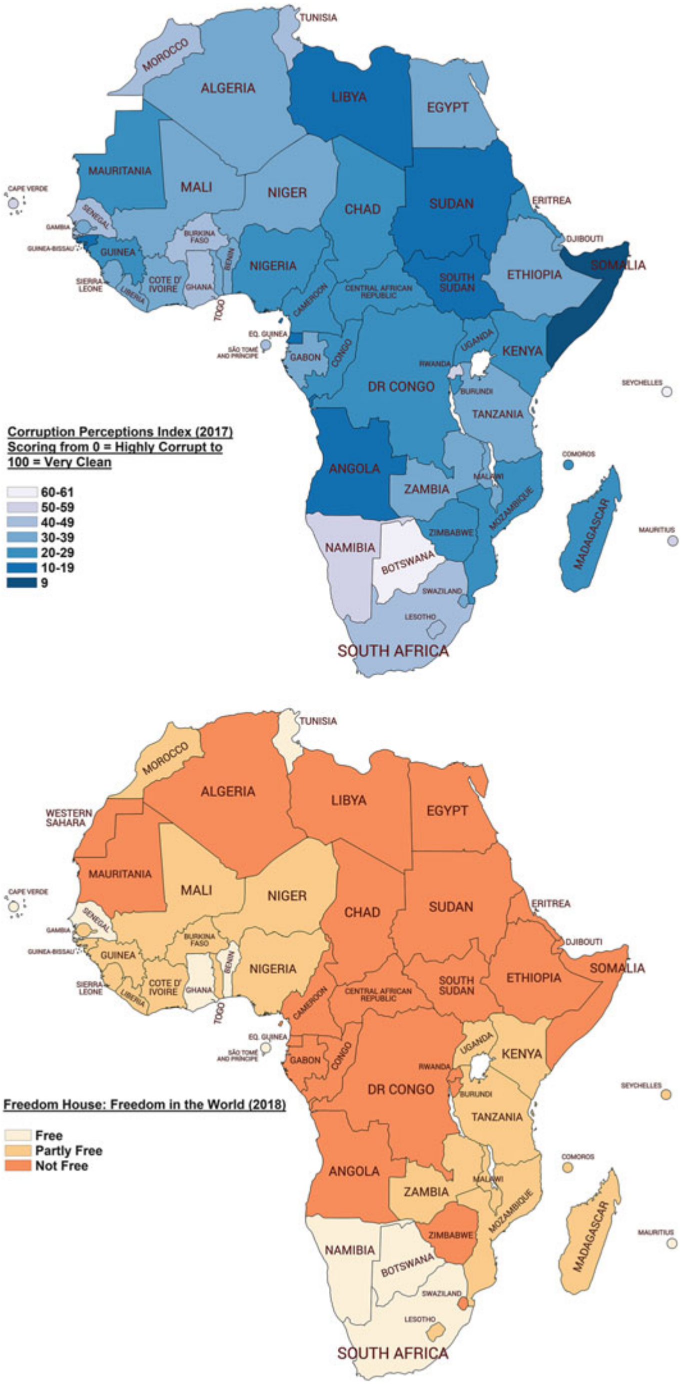



**Fig. 1.15** Corruption Perceptions Index for Africa, 2017 (Transparency International), and Freedom in the World Index, 2018 (Freedom House)

**Table 1.1** UN peacekeeping operations in Africa

| Peacekeeping operation and date established | Location |
|---|---|
| United Nations Mission for the Referendum in Western Sahara (MINURSO)—1991 | Western Sahara |
| The African Union-United Nations Hybrid Operation in Darfur (UNAMID)—2007 | Darfur, Sudan |
| United Nations Organization Stabilization Mission in the Democratic Republic of the Congo (MONUSCO)—2010 | Democratic Republic of the Congo |
| United Nations Interim Security Force for Abyei (UNISFA)—2011 | Abyei, Sudan |
| United Nations Multidimensional Integrated Stabilization Mission in Mali (MINUSMA)—2013 | Mali |
| United Nations Mission in the Republic of South Sudan (UNMISS)—2011 | South Sudan |
| United Nations Multidimensional Integrated Stabilization Mission in the Central African Republic (MINUSCA)—2014 | Central African Republic |

In terms of repression of dissent, it is reported that rights to peaceful protest were denied in more than 20 countries through harassment, excessive force, arbitrary arrests, and unlawful bans, making freedom of assembly "the exception rather than the rule".[102] Of particular note in this regard are Angola, Chad, the Democratic Republic of the Congo, Ethiopia, Sudan, Togo, Sierra Leone, and Uganda. Human rights and opposition activists, as well as journalists, were attacked, arrested, harassed, or otherwise repressed in Cameroon, Chad, Equatorial Guinea, Eritrea, Mauritania, Ethiopia, Madagascar, Sudan, Zambia, Zimbabwe, and Uganda. Regressive laws, and shrinking political space, were observed in Angola, Côte d'Ivoire, Nigeria, and Malawi. Media freedom was also curtailed, with journalists facing some form of criminalisation in more than 30 countries, with Uganda, Cameroon, Botswana, Togo, and Ethiopia standing out. Political repression and election violence were observed in Rwanda, Burundi, and Angola.

Armed conflict and violence is another major area of concern.[103] The conflicts in Sudan, South Sudan, the Central African Republic, and the Democratic Republic of the Congo, as well as the activities of Boko Haram and the troubling military actions by Nigeria and Cameroon (both accused of gross human rights violations and crimes in their response to Boko Haram), are noteworthy in this regard. The Boko Haram and al-Shabaab armed groups have perpetrated attacks and violence against a range of countries, including Cameroon, the Democratic Republic of the Congo, the Central African Republic, Somalia, Mali, Nigeria, and Niger. Other acts of violence on the continent including torture and ill treatment were identified in several states, including Burkina Faso, Cameroon, Eritrea, Mauritania, Nigeria, Ethiopia, and Sudan.

[102] Amnesty International, "Africa 2017/2018."
[103] Ibid.

In recent times, Africa has grappled with several major refugee and migration crises, including major internal displacements.[104] For example, in their 2017/2018 review, Amnesty International reported that half the Somali population required humanitarian aid, with more than one million internally displaced by a combination of drought and conflict. This was in addition to the 1.1 million people who were already internally displaced. More than a quarter of a million Somali refugees were situated in Kenya. The conflict in the Central African Republic also contributed to several hundred thousand people being internally displaced or seeking refuge in neighbouring countries. Boko Haram's operations displaced nearly two million people within Nigeria, while nearly half a million refugees were to be found in Chad as a result of conflicts in the Central African Republic, Sudan, the Democratic Republic of the Congo, and Nigeria. Thousands of people also fled the dire human rights situation in Eritrea, while almost four million people in South Sudan were displaced since 2013 due to conflict. These internal and cross-border movements placed enormous strain on the limited resources of countries in the region, leading to extremely dire situations for people fleeing conflict.

Concerns around impunity have been identified in the Central African Republic, where a special criminal court to address human rights violations and crimes during the 14-year-long conflict has not yet become operational, meaning "impunity remained the norm".[105] Three transitional justice bodies planned for South Sudan have also not yet become operational, while no findings have yet been made available in Nigeria as a result of a probe into violations of human rights by the military, and secret trials for suspected members of Boko Haram have been held. In Ethiopia, the government rejected calls for investigations into violations committed by the military and police in 2015/2016. Meanwhile, divisions are apparent regarding the International Criminal Court (ICC), with Nigeria, Senegal, Cape Verde, Tanzania, Malawi, Liberia, Tunisia, and Zambia rejecting calls for a mass withdrawal of African countries from the ICC, while Burundi withdrew from the ICC, and South Africa attempted to do the same until the North Gauteng High Court determined the move invalid without parliamentary approval.[106]

Discrimination and marginalisation is also rampant, especially for women and girls, people with albinism, and lesbian, gay, bisexual, transgender, and intersex people.[107] A range of countries were implicated, with Sierra Leone, Equatorial Guinea, Tanzania, Liberia, Malawi, Mozambique, South Africa, and Swaziland displaying gender-based violence and discrimination. Mozambique and Malawi were noted for attacks against people with albinism, while discrimination, persecution, and violence occurred against LGBTI people in Senegal, Ghana, Malawi, and Nigeria.

[104] Ibid.

[105] Ibid.

[106] Ibid.

[107] Ibid.

The political challenges in Africa thus remain significant. However, Africa has not remained passive in the face of these challenges. One of the core concepts used as both an expression of Africa's hope for the future and a driver of change is that of an African Renaissance. Its aim is a "golden age of Africa's social economic and political institution building through good governance and improved state-society relations".[108] The concept gained traction during the presidency of Thabo Mbeki in South Africa, one of its main drivers, between 1999 and 2008, during which he emphasised that Africans should determine their own future and create the conditions for political, economic, and social renewal.[109] The African Renaissance became the vision to inspire, and create fertile ground for, the rebirth of the continent. Mbeki was the chief architect of the New Partnership for Africa's Development (NEPAD) (2001) and the creation of the African Union (2002), which aim to give substance to the vision.[110] The governance instrument of NEPAD is the African Peer Review Mechanism (APRM), which is "a mutually agreed-upon instrument for self-monitoring by participating member States of the African Union", with the aim of reinforcing good governance.[111] While it is an entirely voluntary mechanism, 35 states across the continent have signed up.[112] The mandate of the APRM is "to ensure that policies and practices of participating Member States conform to the agreed political, economic and corporate governance values, codes and standards contained in the African Union Declaration on Democracy, Political, Economic and Corporate Governance".[113] While the APRM has suffered from its own challenges, including lack of funding contributions from member states, it has recently been tasked with monitoring the progress made on the governance aspects of Agenda 2063 and the United Nations Sustainable Development Goals (SDGs).[114] The APRM has been presented as evidence of African agency in improving political, corporate, and socio-economic structures.[115]

Agenda 2063 is the core policy document on a continental level that will guide Africa towards a sustainable development future, in line with the United Nations Sustainable Development Goals (SDGS). It harkens back to the foundation of the

[108] Rosaline M. Achieng, "Can We Speak of African Agency?: APRM and Africa's Agenda 2063," *African Sociological Review* 18, no 1. (2014): 54.

[109] Adekeye Adebajo, "Mbeki's dream of Africa's renaissance belied South Africa's schizophrenia," *The Conversation Africa*, April 24, 2016, https://theconversation.com/mbekis-dream-of-africas-renaissance-belied-south-africas-schizophrenia-58311 (accessed June 20, 2018).

[110] Ibid.

[111] Achieng, "Can We Speak of African Agency?: APRM and Africa's Agenda 2063," 53–54.

[112] African Union Commission, "African Peer Review Mechanism (APRM)," https://au.int/en/organs/aprm (accessed June 20, 2018).

[113] African Peer Review Mechanism, "About APRM," 2017, https://www.aprm-au.org/page-about/ (accessed June 20, 2018).

[114] Carien Du Plessis, "African Peer Review Mechanism: Back with a, uhm, Bang?," *Daily Maverick*, March 16, 2018, https://www.dailymaverick.co.za/article/2018-03-16-african-peer-review-mechanism-back-with-a-uhm-bang/#.WypdwCB9jIU (accessed June 20, 2018).

[115] Achieng, "Can We Speak of African Agency?: APRM and Africa's Agenda 2063," 50.

Organisation of African Unity (OAU) in 1963, which was transformed into the African Union in 2002. It thus presents a vision of Africa after a century of African self-determination. At its core, Agenda 2063 is a strategic framework that builds on and accelerates previous and current initiatives to achieve sustainable development and economic growth and lays the foundation for the socio-economic transformation of Africa over a 50-year period.[116] The document encapsulates the vision of the continent to "become an integrated, prosperous and peaceful Africa, driven by its own citizens and representing a dynamic force in [the] global arena",[117] and operationalises this vision through seven core aspirations. These aspirations are then subdivided into goals, and priority areas, at national level (summarised in Table 1.2). Each of these aspirations entails broad issues and action areas, while the priority areas in turn have associated targets and indicative strategies for 2063, as discussed later.

Via a critical document and discourse analysis approach, Nhamo identified the top ten issues in Agenda 2063, namely, women, peace, youth, technology, trade, gender, education, governance, infrastructure, and inclusiveness, revealing the four core intersecting issue areas of women, education, technology, and inclusiveness.[118] However, it was again cautioned that major obstacles must be overcome to achieve the continent's vision for 2063. As such, "this rising will not be realized if Africa continues to look elsewhere for resources" including financial resources.[119] Agenda 2063 does place an emphasis on self-reliance, a step in the right direction: "it is about time for us to look at what we have at our disposal—the forests, minerals, land, water and people—and put these resources into effective and appropriate use", while the 2008 global financial crisis revealed "the fragility of relying on some of the so-called 'advanced' finance and investment schemes".[120] The scourge of corruption was further lamented, and the tendency for African leadership to "think of the value chain in Africa on a micro scale", while sustainable development demands large-scale thinking.[121] These comments are worth repeating because they encapsulate the shift underlying Agenda 2063. This is well summarised by the sentiment that "the time for Africa to be its own master has come and the citizens must come to the realization that hand-outs and begging for aid are a thing of the past . . . Africa [needs] to get up and raise financial and other resources domestically".[122]

Agenda 2063 furthermore identifies 12 key flagship projects for the continent, one of which is the Africa Outer Space Strategy. The aim of this flagship programme

[116]African Union Commission, "What is Agenda 2063?," https://au.int/en/agenda2063 (accessed June 21, 2018).

[117]African Union Commission, "Vision and Mission," https://au.int/en/about/vision (accessed June 21, 2018).

[118]Nhamo, "New Global Sustainable Development Agenda: A Focus on Africa," 9.

[119]Ibid., 10.

[120]Ibid., 11.

[121]Ibid., 12.

[122]Ibid., 13.

**Table 1.2** Agenda 2063 aspirations, goals, and priority areas (AU Commission)

| Aspirations | Goals | Priority areas |
|---|---|---|
| 1. A prosperous Africa, based on inclusive growth and sustainable development | A high standard of living, quality of life, and well-being for all citizens | • Incomes, jobs, and decent work<br>• Poverty, inequality, and hunger<br>• Social security and protection, including persons with disabilities<br>• Modern, affordable, and liveable habitats and quality basic services |
| | Well-educated citizens and skills revolution underpinned by science, technology, and innovation | • Education and science, technology, and innovation (STI)-driven skills revolution |
| | Healthy and well-nourished citizens | • Health and nutrition |
| | Transformed economies | • Sustainable and inclusive economic growth<br>• STI-driven manufacturing, industrialisation, and value addition<br>• Economic diversification and resilience<br>• Tourism/hospitality |
| | Modern agriculture for increased productivity and production | • Agricultural productivity and production |
| | Blue/ocean economy for accelerated economic growth | • Marine resources and energy<br>• Port operations and marine transport |
| | Environmentally sustainable and climate-resilient economies and communities | • Sustainable natural resource management<br>• Biodiversity conservation, genetic resources, and ecosystems<br>• Sustainable consumption and production patterns<br>• Water security<br>• Climate resilience and natural disaster preparedness and prevention<br>• Renewable energy |
| 2. An integrated continent, politically united, based on the ideals of pan-Africanism and the vision of African Renaissance | A united Africa (federal or confederate) | • Frameworks and institutions for a united Africa |
| | Continental financial and monetary institutions established and functional | • Financial and monetary institutions |
| | World-class infrastructure criss-crosses Africa | • Communications and infrastructure connectivity |

(continued)

**Table 1.2** (continued)

| Aspirations | Goals | Priority areas |
|---|---|---|
| 3. An Africa of good governance, democracy, respect for human rights, justice, and the rule of law | Democratic values, practices, universal principles of human rights, justice, and the rule of law entrenched | • Democracy and good governance<br>• Human rights, justice, and the rule of law |
| | Capable institutions and transformative leadership in place | • Institutions and leadership<br>• Participatory development and local governance |
| 4. A peaceful and secure Africa | Peace, security, and stability are preserved | • Maintenance and preservation of peace and security |
| | A stable and peaceful Africa | • Institutional structure for AU<br>• Instruments on peace and security<br>• Defence, security, and peace |
| | A fully functional and operational APSA (African Peace and Security Architecture) | • Fully operational and functional<br>• APSA pillars |
| 5. Africa with a strong cultural identity, common heritage, values, and ethics | African cultural renaissance is pre-eminent | • Values and ideals of pan-Africanism<br>• Cultural values and African Renaissance<br>• Cultural heritage, creative arts, and businesses |
| 6. An Africa whose development is people-driven, relying on the potential offered by African people, especially its women and youth, and caring for children | Full gender equality in all spheres of life | • Women and girls empowerment<br>• Violence and discrimination against women and girls |
| | Engaged and empowered youth and children | • Youth empowerment and children's rights |
| 7. An Africa as a strong, united, and influential global player and partner | Africa as a major partner in global affairs and peaceful co-existence | • Africa's place in global affairs<br>• Partnerships |
| | Africa takes full responsibility for financing her development | • African capital markets<br>• Fiscal systems and public sector revenue<br>• Development assistance |

African Union Commission, *Agenda 2063: The Africa We Want—First Ten-Year Implementation Plan 2014–2023* (Addis Ababa, 2015), 19–21. https://au.int/sites/default/files/documents/33126-doc-ten_year_implementation_book.pdf (accessed June 22, 2018) is to strengthen the use of outer space to support and reinforce Africa's development.[123] It encapsulates the recognition that African development is critically dependent on outer space and space technology. Moreover, it contends that the products of space technology are "no longer a matter of luxury" and access to space technology and products must be sped up.[124] It also recognises that satellite technology is more accessible than ever to African countries. The discussion within the Agenda 2063 framework document relating to space will be further deliberated in the section on the African space arena later in this chapter.

In order to actualise the goals and targets encapsulated in Agenda 2063, five 10-year implementation plans, prepared by the African Union Commission, form the basis over the medium term for the preparation of development plans in the individual AU states, RECs, and AU organs.[125] These 10-year implementation plans serve to identify the goals and priority areas based on the current development situation on the continent; provide a vision or snapshot of what the continent will look like at the end of the 10-year period; provide outlines of the targets and indicative strategies, key process actions, and milestones on national, regional, and continental level; identify financing needs and implementation arrangements to ensure financing; provide recommendations on partnerships; provide for monitoring and evaluation; and identify key stakeholders and their roles and the principles to guide the stakeholders.[126]

The first 10-year implementation plan covers the decade between 2014 and 2023. All flagship programmes are included in this plan. Specific targets to be reached by 2023 and the key process actions/targets towards 2023 are also given, but because of the large number of targets and actions, only those speaking to primary needs will be highlighted here. In terms of Africa's political challenges, Table 1.3, as follows, presents the targets to be reached by 2023.

### *1.2.3 Socio-economic Overview*

To further contextualise the African space sector, this section will provide background to and discussion of the broad socio-economic state of affairs on the continent. This will include the main challenges confronting Africa, and while many of these are well known, they will be summarised here since the use of space technology in Africa must speak to these challenges in order to be viewed as

[123] African Union Commission, "The Key Agenda 2063 Flagship Programmes Projects," https://au.int/sites/default/files/documents/33126-doc-04_the_key_agenda_2063_flagship.pdf (accessed June 21, 2018).

[124] Ibid.

[125] African Union Commission, *Agenda 2063: The Africa We Want – First Ten-Year Implementation Plan 2014–2023*, 2015, Addis Ababa, 15. https://au.int/sites/default/files/documents/33126-doc-ten_year_implementation_book.pdf (accessed June 21, 2018).

[126] Ibid., 15–16.

**Table 1.3** Political priority areas and targets for 2023 (AU Commission)

| | | |
|---|---|---|
| **Aspiration 3**. An Africa of good governance, democracy, respect for human rights, justice, and the rule of law | **Goal 11**. Democratic values, practices, universal principles of human rights, justice, and the rule of law entrenched | • **Priority area 1**. Democratic values and practices are the norm<br>*National targets (2023):*<br>1. At least 70% of the people believe that they are empowered and are holding their leaders accountable<br>2. At least 70% of the people perceive that the press/information is free and freedom of expression pertains<br>3. At least 70% of the public perceive election to be free, fair, and transparent by 2020<br>4. Accredited electoral observers certify elections to be free and fair<br>5. A functional national focal point responsible for implementation of AU shared values is in place by 2017<br>6. All reporting obligations with respect to compliance of AU shared values instruments are met by 2017<br>7. Zero tolerance for unconstitutional changes in government is the norm<br>8. African Charter on Democracy is signed, ratified, and domesticated by 2020<br>*Continental targets (2023):*<br>1. AGA Clusters on Democracy; Governance; Human Rights; Constitutionalism and Rule of Law and Humanitarian Assistance fully functional and operational<br>2. The African Governance Platform reviews at least 23 state reports under the ACDEG and provides technical support to state parties towards effective implementation<br>3. APRM acceded to by all member states<br>4. Frameworks for the computation of governance metrics for African island states is in place by 2025 |
| | | • **Priority area 2**. Human rights, justice, and the rule of law<br>*National targets (2023):*<br>1. At least 70% of the people perceive the judiciary to be independent and to deliver justice on a fair and timely basis |

| | | |
|---|---|---|
| | | 2. At least 70% of the people perceive they have free access to justice<br>3. At least 70% of the people perceive the entrenchment of the culture of respect for human rights, the rule of law, and due process<br>*Continental targets (2023):*<br>1. All member states are implementing the APRM<br>2. All member states comply with the framework provision on the reporting of Article 62 of the ACHR<br>3. All member states have functioning human rights commissions |
| | **Goal 12**. Capable institutions and transformed leadership in place at all levels | • **Priority area 1**. Institutions and leadership<br>*National targets (2023):*<br>1. At least 70% of the public acknowledge the public service to be professional, efficient, responsive, accountable, impartial, and corruption free<br>2. At least 70% of the public acknowledge the relevance and good functioning of the legislature as a key component of democracy<br>*Continental targets (2023):*<br>1. At least 70% of member states are implementing the African Charter on the Values and Principles of Public Administration<br>2. At least 70% of member states are implementing the AU Convention on Preventing and Combating Corruption |

African Union Commission, *Agenda 2063: The Africa We Want—First Ten-Year Implementation Plan 2014–2023*, 2015, Addis Ababa, 73–74. https://au.int/sites/default/files/documents/33126-doc-ten_year_implementation_book.pdf (accessed June 21, 2018) valuable and successful. The discussion will begin by deliberating on the primary needs approach to African space activities model, which frames this study. The broad socio-economic situation across the continent will then be considered. Through this, many of the socio-economic challenges that Africans are grappling with will be explored. However, since Africa is not only a continent of challenges, but also of many positive developments, assets, and strengths, these will also be highlighted. Throughout, the foundation will be on those primary needs often associated with the basic needs approach to poverty, which emphasises provision of "opportunities for the full development of the individual",[127] with particular emphasis on the needs of health, water, education, and capacity building, with the additions of biodiversity and climate, given that human well-being powerfully depends on the natural environment. Since healthcare and education, and social services in general, depend on the ability of the national government to provide them, the economy of African states will necessarily form a critical component of the discussion. First, a broad overview of the African economy and general human development will be provided. Second, education will be considered, followed by health, third. Fourth, water and related challenges will be discussed, followed finally by climate and biodiversity, fifth. In each case, the Agenda 2063 targets for the first 10-year plan (ending in 2023) will be highlighted since these are Africa's own priority areas, and many challenges remain in fulfilling these targets. A brief discussion will then reflect on the digital revolution in Africa in terms of smartphones and Internet access, including some challenges relating to further rollout.

## The Primary Needs Approach to African Space Activities

As space and space-related products and services are "woven into the fabric of our daily life as never before",[128] their impact on those priority areas that are of critical importance for improving human development and welfare in Africa will be the focus of this study. All human activity and welfare depend powerfully on the climate and on biodiversity, and these areas are thus placed at the foundation of the primary needs approach to African space activities model (Fig. 1.16). They directly feed into health and water. Education, without which no lasting, genuine progress can be made in the space sector or any other, is also here regarded as a primary need, since it "increases the capacity of the people to transform their vision of the society into operational reality, an essential means for sustainable human development".[129] This

[127]Paul. P. Streeten, "Basic Needs: Premises and Promises," *Journal of Policy Modeling*, 1979, no. 1: 136–146.

[128]Keith Gottschalk, "Astronaissance: Communicating Astronomy & Space to the African Imagination," *The Re-emergence of Astronomy in Africa: A Transdisciplinary Interface of Knowledge Systems Conference*, Maropeng, South Africa, September 10–11, 2012: 1.

[129]Oyewole, "Space Research and Development in Africa," 200.

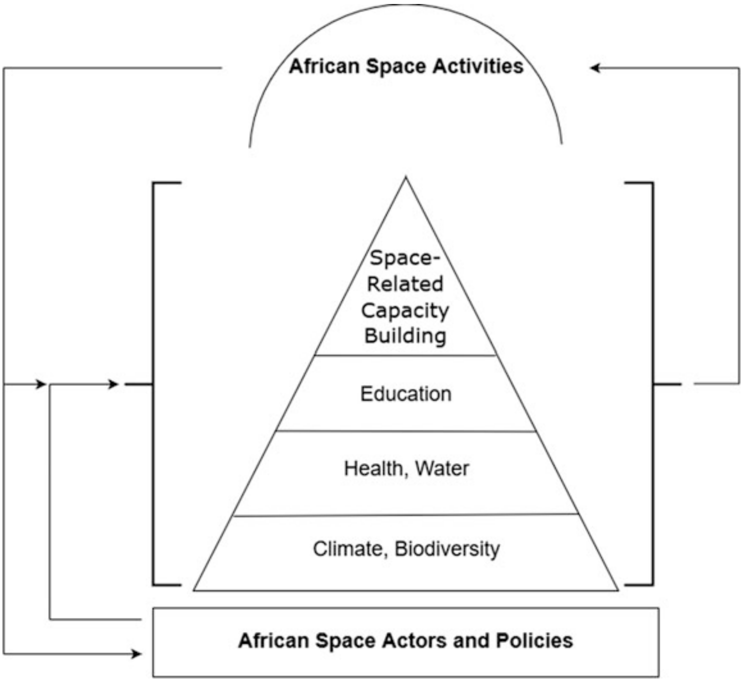



**Fig. 1.16** Primary needs approach to African space activities: model

then feeds into space-related capacity building, which, in its turn, is a primary need for the African space sector to take off and address the socio-economic development needs of the continent. All these factors then directly feed into Africa's space activities and infrastructure, which will be analysed in Chap. 3. These then filter back into the areas of climate, biodiversity, health, water, education, and space-related capacity building since space activities, services, and technologies are used to support these. The next volume will consider related space applications and policies.

An important note here is that these primary needs are all closely linked to the United Nations Sustainable Development Goals 2030. Climate is linked to SDG 13 ("Take urgent action to combat climate change and its impacts"), biodiversity is linked to SDG 14 ("Conserve and sustainably use the oceans, seas and marine resources for sustainable development") and SDG 15 ("Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss"), health is linked to SDG 3 ("Ensure healthy lives and promote well-being for all at all ages"), water is linked to SDG 6 ("Ensure availability and sustainable management of water and sanitation for all"), education is linked to SDG 4 ("Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all"), and space-related capacity building is arguably linked to SDG 9 ("Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation").[130] The key to success in relation to the SDGs is how they are domesticated and implemented on regional and national levels, and thus Africa's own related goals will be highlighted in each section below dealing with the individual primary needs. In turn, these primary needs will guide the rest of the study (including the next volume) although, first, a broader overview of the African economy and digital renaissance is needed.

### The African Economy and the Promise of the Digital Renaissance

An enduring theme of Africa's development is its unevenness. Africa is a continent of immense diversity, and it is always worth cautioning against viewing all its 54 states in the same light. Three times the size of Europe, with roughly half a billion more residents, and as mentioned, a very young population, Africa presents immense opportunities and potential. Many political leaders such as Thabo Mbeki[131] have looked at the twenty-first century with the hope that it will become the African century, a time in which the ideals of the African Renaissance will be achieved and Africa will take its rightful place in the world. Space, as will be discussed later in this chapter, is seen as a cornerstone of this renaissance, with the promise of spurring on Africa's socio-economic development. However, first a detailed view of the current status of the African economy must be taken in order to identify the scope of the challenge and of the promise.

A useful guide to begin the overview of Africa's socio-economic development is the World Bank's Country and Lending Groups classification, which purely considers gross national income (GNI) per capita, calculated using the World Bank's Atlas method.[132] Four categories emerge: high-income economies (GNI per capita of $12,056 or more), upper middle-income economies (GNI per capita between $3,896 and $12,055), lower middle-income economies (GNI per capita between $996 and $3,895), and low-income economies (GNI per capita of $995 or less). Of the 54 countries in Africa (excluding Western Sahara), only one—Seychelles—falls into the high-income category. Eight are upper middle-income economies, 18 are lower middle-income economies, and the remaining 27 fall into the low-income category. This is summarised in Fig. 1.17. However, this measure alone does not provide the full scope of development on the continent, such as human well-being. For this, a broader measure is needed.

The yearly Human Development Index (HDI), compiled by the United Nations Development Programme (UNDP), is an excellent tool to provide insight into the

[130] United Nations, "Sustainable Development Goals," https://sustainabledevelopment.un.org/?menu=1300 (accessed December 6, 2018).

[131] British Broadcasting Corporation, "Thabo Mbeki's victory speech," BBC.co.uk, June 3, 1999, http://news.bbc.co.uk/2/hi/world/monitoring/360349.stm (accessed June 30, 2018).

[132] World Bank, "World Bank Country and Lending Groups," https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups (accessed June 27, 2018).

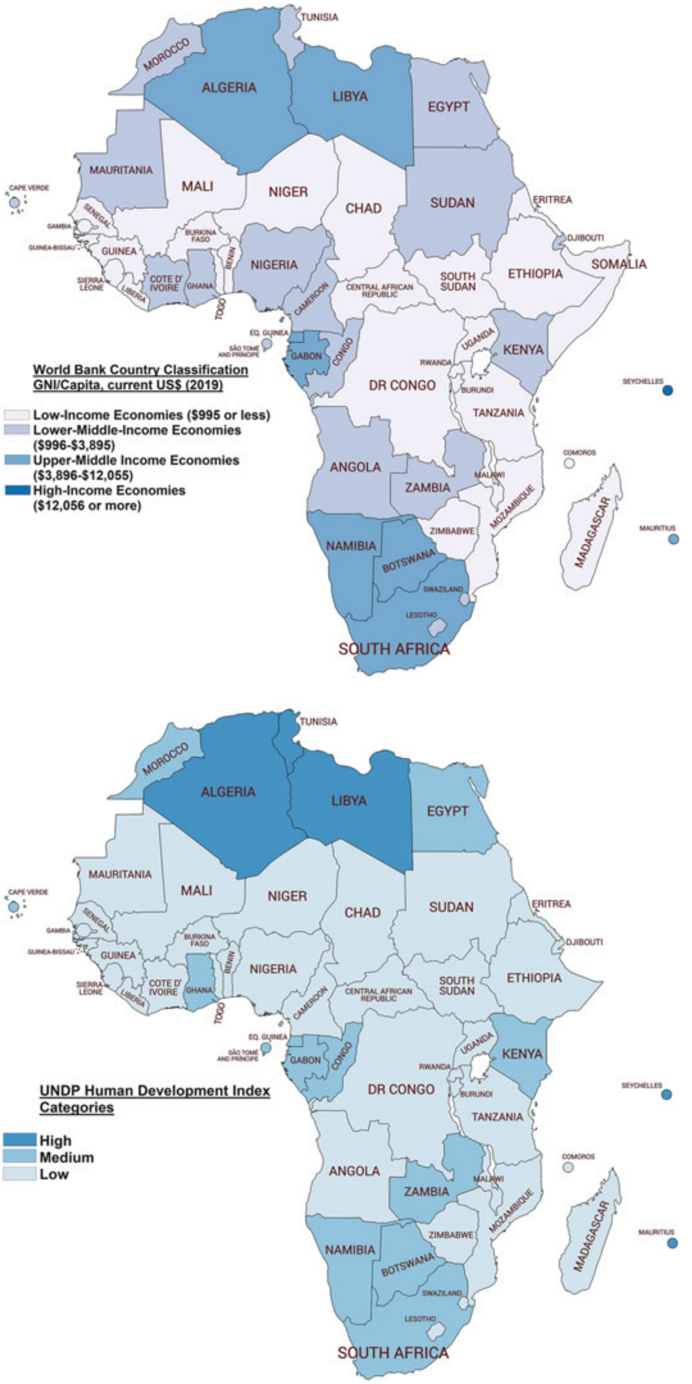



**Fig. 1.17** Gross national income (GNI) per capita and human development in Africa (World Bank, United Nations Development Programme)

well-being of the residents of various countries since it places a variety of dimensions of human development, including life expectancy, health, and education, alongside economic factors such as standard of living.[133] The latest report was issued in 2017 and presents four categories: very high, high, medium, and low human development (all for 2015).[134] No African country displays very high levels of human development. Only five display high levels, with the Seychelles achieving the highest African rank of 63rd out of 188 countries, followed by Mauritius at 64th. Thirteen states fall into the medium human development category, while (apart from Western Sahara and Somalia, which are unranked) all remaining 35 countries are characterised by low human development. This provides a slightly clearer picture than the World Bank classification and is also presented in Fig. 1.17 as a comparison. The HDI clearly reveals that human development is one of Africa's most significant challenges. However, despite its more comprehensive overview, the HDI does not consider inequality or poverty levels. For this, another measure is needed.

For an insight into the inequality prevalent in societies, the Gini coefficient is a valuable tool. It presents the wealth or income distribution within a country, measured between 0 (perfect equality) and 1 (perfect inequality, with all wealth owned by one person). While perfect equality and perfect inequality are unattainable in reality, the Gini coefficient provides a clear insight into the overall levels of equality or inequality within a nation. The only drawback of the Gini coefficient is that data is often incomplete for a range of countries, but the World Bank provides a database of values for most states, while it is important to note not all data are from the same year.[135] Some countries will have recent (e.g. 2016) data, while others will have more outdated information (e.g. 2012 or earlier). Some will have no data. Nevertheless, the most unequal country in the world is South Africa, with a Gini index of 0.63 (2014). For reference, World Bank Gini data indicated that the most equal country on Earth is Ukraine with an index of 0.25 (2016). The most equal country in Africa is Algeria with 0.276 (2011). There is thus a broad Gini spectrum present in Africa. Therefore, to provide an overview for Africa, Fig. 1.18 will display increments of 0.05. It should be noted however that the data here are drawn only from the World Bank, and other agencies, such as the US Central Intelligence Agency, have Gini indexes that may have slightly different values. Since inequality is a major challenge facing Africa, these slight variations are not noteworthy here, and this discussion serves to provide an overview of Africa's socio-economic status and challenges (which must align with the uses of space technology).

[133]United Nations Development Programme, "Human Development Reports: Human Development Index (HDI)," http://hdr.undp.org/en/content/human-development-index-hdi (accessed June 27, 2018).

[134]United Nations Development Programme, "Human development reports, Table 1: Human Development Index and Its Components," http://hdr.undp.org/en/composite/HDI (accessed June 27, 2018).

[135]World Bank, "GINI index (World Bank estimate)," 2018, https://data.worldbank.org/indicator/SI.POV.GINI (accessed June 27, 2018).

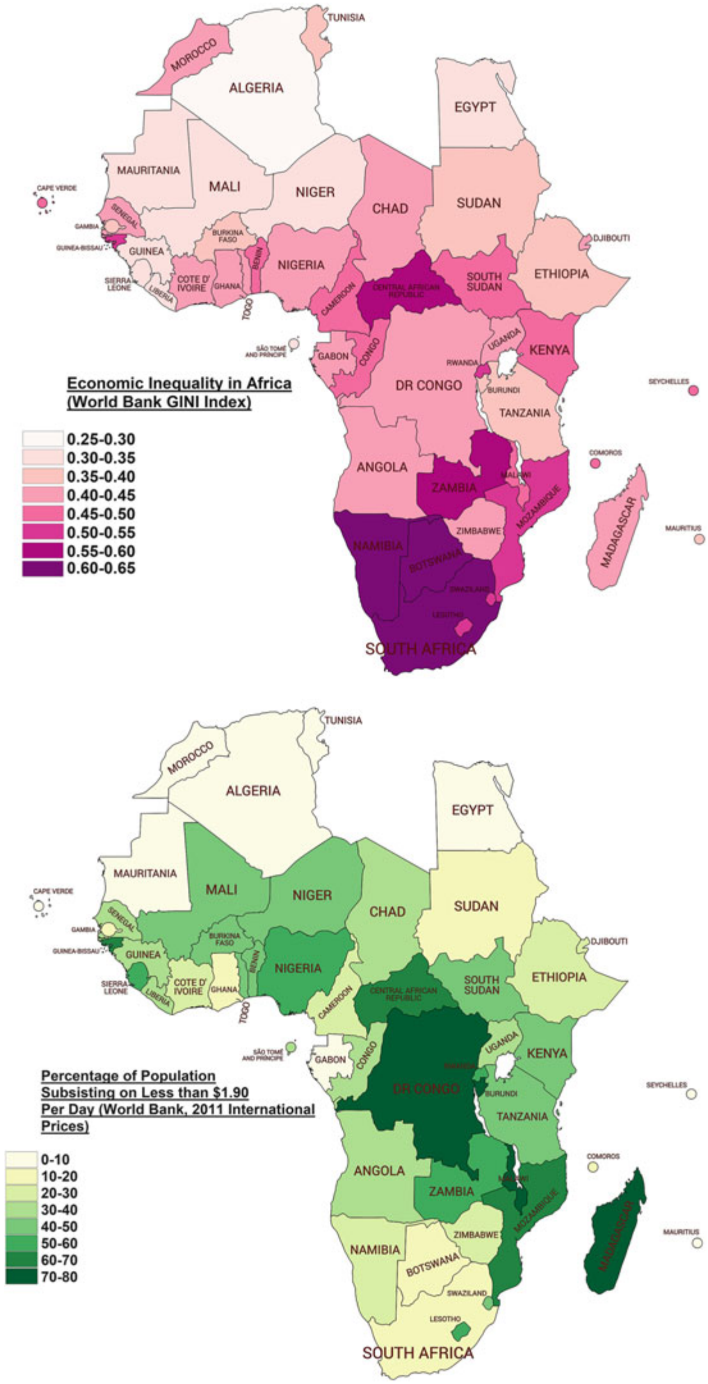



**Fig. 1.18** African Gini index and population below international poverty line (World Bank)

Figure 1.18 reveals that inequality is most prevalent in sub-Saharan Africa, specifically Southern Africa. North Africa and the Sahel region, as well as some West African states, are generally more equal. The reason why inequality is such an important measure is that a wide wealth disparity is associated with increased instability, while tending to exacerbate both "rent-seeking and predatory market behaviours" which negatively influence economic growth.[136] Greater inequality has also been associated with increased crime rates, while also being associated with greater political inequality where a small wealthy minority wields disproportionate political power.[137] It should again be emphasised that inequality in wealth distribution says nothing about the level of wealth in a country, as the World Bank data in Fig. 1.17 showed earlier. Therefore, many relatively equal countries in Africa (such as Mali and Niger) are still extremely poor. Thus, considering the overall poverty rates in Africa is instructive as well.

In this regard, the World Bank provides data on the percentage of population living on less than $1.90 a day (at 2011 international prices) which, since 2015, has been considered the international poverty line.[138] Again, data are not always available for the same year, and other sources may indicate slightly different levels, but this data serves as a good overview of the extreme poverty in Africa, in other words, where primary needs are most urgent to the well-being of the population. These data are displayed in Fig. 1.18 to compare with inequality data. According to this data, Madagascar and the Democratic Republic of the Congo have the largest percentage of people in extreme poverty in Africa (77.6% and 77.1%, respectively, both 2012). While these figures are seven years old and there is hope for improvement since then, the fact that more recent data are unavailable indicates the challenge related to data collection in these countries. The states with the least extreme poverty are Algeria and Mauritius, both with 0.5%.

From this comparison it can be observed that the most unequal states, concentrated in Southern Africa, generally have lower poverty rates than many of the more equal states. Additionally, the Indian Ocean states of Seychelles and Mauritius, and the North African states, again fare very well. It also reinforces, along with Fig. 1.17, the immense disparity in development across the continent. To further understand the prevalence of poverty in Africa, an overview of the main contributing sectors to gross domestic product (GDP) and the main employment sectors is valuable.

In terms of economic activity, the three-sector theory has been used for decades as a measure of development as economies moved away from relying on the primary sector of agriculture and mining, towards the secondary sector of industry and

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[136]Nicholas Birdsong, "The Consequences of Economic Inequality," *Seven Pillars Institute for Global Finance and Ethics*, February 5, 2015, https://sevenpillarsinstitute.org/consequences-economic-inequality/ (accessed June 27, 2018).

[137]Ibid.

[138]World Bank, "Poverty headcount ratio at $1.90 a day (2011 PPP) (% of population)," https://data.worldbank.org/indicator/SI.POV.DDAY (accessed June 27, 2018).

manufacturing, and ultimately towards the tertiary sector of services.[139] Despite criticism of the three-sector theory, it still provides a useful framework for assessing the dominant sectors that drive African economies. As Fig. 1.19 reveals, the tertiary services sector is predominant.[140] However, the caveat should be added that this depicts only the largest GDP contributor and, in some cases, this lead is very small, such as in Guinea-Bissau where agriculture contributes 44.1% of GDP but services follow closely at 43%. It does however serve to reveal that most African countries heavily rely on the services sector for economic growth. Of course, contribution to GDP does not always match employment, and Fig. 1.19 also compares this data, with the same caveat that it only displays the largest employment sector, and again not all from the same year. The stark contrast in Fig. 1.19 clearly reveals that while much of African GDP is generated by services, most people are still employed in, and dependent on, agriculture. Even for those countries with no data, it is impossible to imagine that most people do not depend on agriculture for their livelihoods (with the possible exception of Botswana). For this reason, the backbone of Africa's growth and development agenda remains agriculture.[141] The contrast between GDP contributing sectors and leading employment sectors is clearly demonstrated by Burundi where, as stated, services contribute 44.1% of GDP but where 93.6% of people are employed in agriculture.[142] These figures also reinforce the notion of the vulnerability of African societies to the effects of climate change and famine.

While the leading contributing sectors to GDP provide valuable insight into the mainstay of African economies, they do not reveal the extent of Africa's vulnerability in its exports. By considering the main exports of Africa, an even clearer picture emerges—one overwhelmingly dominated by primary exports, with the accompanying vulnerability to unstable commodity prices. Figure 1.20 delves into these exports. Again, these are not the totality of African exports, only the largest earning export commodities.[143] Here again it becomes clear that Africa as a whole overwhelmingly depends on primary exports for vital foreign exchange earnings, with mining, oil and petroleum, fish, and agricultural goods being the main exports of 50 states (and also Western Sahara). Only four have manufactured goods as their

[139]Alex Schafran, Conor McDonald, Ernesto Lopez Morales, Nihan Akyelken and Michele Acuto, "Replacing the services sector and three-sector theory: urbanization and control as economic sectors, Regional Studies," *Regional Studies*, 2018.

[140]All data are drawn from the Central Intelligence Agency's *The World Factbook* and again do not necessarily depict data for the same year, https://www.cia.gov/library/publications/the-world-factbook/fields/2012.html#ag (accessed June 26, 2018).

[141]Nhamo, "New Global Sustainable Development Agenda: A Focus on Africa," 11.

[142]Central Intelligence Agency, *The World Factbook*, 2018, https://www.cia.gov/library/publications/the-world-factbook/fields/2012.html#ag (accessed June 27, 2018).

[143]These data were amalgamated from a variety of (sometimes contradicting) sources: World Bank, "World Integrated Trading Solution," 2018, https://wits.worldbank.org/Default.aspx / The Observatory of Economic Complexity, 2018, https://atlas.media.mit.edu/en/ / Trading Economics, 2018, https://tradingeconomics.com/ / and the Central Intelligence Agency World Factbook, https://www.cia.gov/library/publications/the-world-factbook/fields/2049.html#ag (all accessed June 27, 2018).

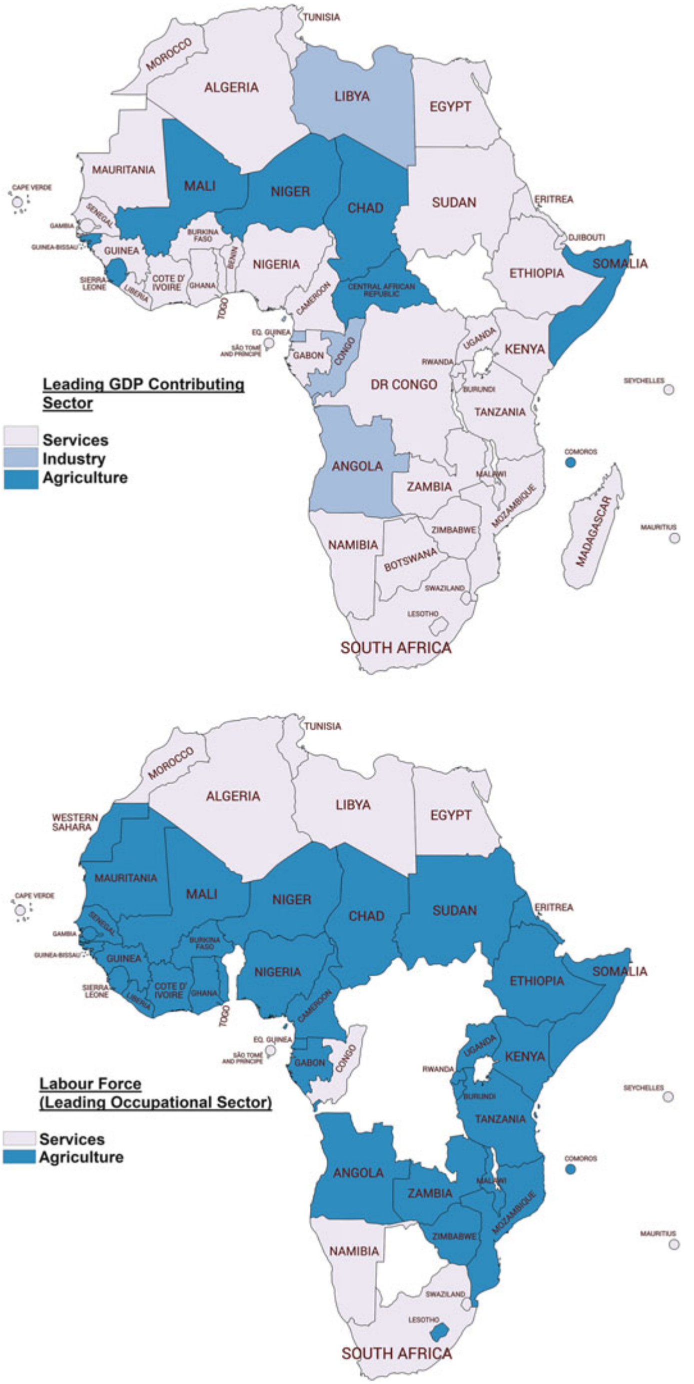


Fig. 1.19 Largest contributing sector to GDP and largest employment sector (Central Intelligence Agency)

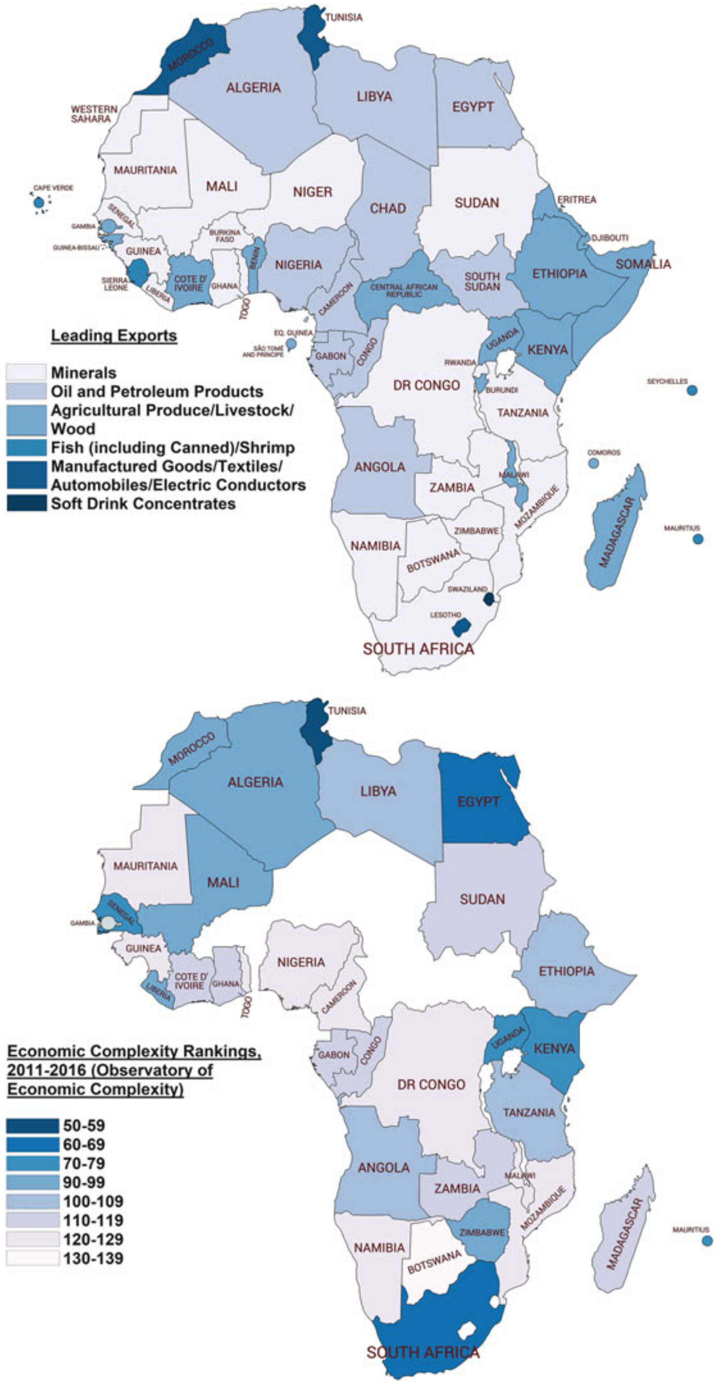


**Fig. 1.20** Africa's leading export commodities (see Footnote 143 for sources) and Economic Complexity Index based on knowledge intensity of overall exports (Observatory of Economic Complexity)

leading exports, namely, Morocco, Tunisia, Swaziland, and Lesotho. Even for these, the exports are not from global leading sectors, but consist of clothing, soft drink concentrates, automobiles, and electric conductors. There is thus an urgent need to continue efforts, as encapsulated in the Agenda 2063 first 10-year implementation plan (Table 1.4), to pursue value addition, economic diversification, and manufacturing and industrialisation driven by science, technology, and innovation (STI).[144]

Since the overview of the leading export commodities does not give deeper insight into the overall exports of African countries, the Economic Complexity Index (ECI), created by the Observatory of Economic Complexity, is useful to present a more holistic picture. Since the ECI measures "the relative knowledge intensity of an economy . . . by considering the knowledge intensity of the products it exports", it also provides a gauge of how well aligned African economies currently are with economic development driven by the knowledge economy.[145] It is also a very useful indicator of how well African countries are poised to fulfil the economic goals of Agenda 2063 (Table 1.4) and of their ability to contribute to, and benefit from, the space economy (which is inherently knowledge intensive). A total of 131 countries are ranked per half decade starting in 1966–1970, with the most recent being 2011–2016. Again some countries do not have data for every year, thus necessitating the ranking per half decade. For 2011–2016, Tunisia is the top African country in terms of economic complexity (58th, 2016). The second ranked African country is South Africa at 63rd with Egypt third at 65th. That no African country makes it into the top 50 in terms of economic complexity and that only three make it into the top half is a profound sermon on the challenges Africa must overcome to fully partake in, and benefit from, the global knowledge economy. It also suggests an urgent need for more advanced skills across the continent. Figure 1.20 summarises this data and sheds further light on the leading African exports.

Since the annual GDP growth rate target for 2023 is 7%, a brief overview of World Bank data is useful to consider the current performance by African states in this regard. Most data are for 2017, with a few from 2016, thus giving a recent picture.[146] Figure 1.21 provides a convenient overview of the continent's GDP growth rates. Libya, emerging from a turbulent period in its history after the fall of Muammar Gaddafi, achieved a 26.67% GDP growth rate in 2017, as its economy recovered from a period of negative growth. Apart from this rebound, Africa's most stellar performance was seen in Guinea (12.7% growth for 2017 and 10.45% for 2016) and Ethiopia (10.24% for 2017 and 7.56% for 2016). Strong growth was also observed in Ghana (8.5% for 2017), Côte d'Ivoire (7.79%, 2017), and Tanzania (7.1%, 2017), as well as several other states achieving a 6% or higher GDP growth

[144]African Union Commission, *Agenda 2063: The Africa We Want – First Ten-Year Implementation Plan 2014–2023*, 45–47 and 55–58.

[145]Observatory of Economic Complexity, "Economic Complexity Rankings (ECI)," https://atlas.media.mit.edu/en/rankings/country/neci/ (accessed June 29, 2018).

[146]World Bank, "GDP growth (annual %)," 2018, https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG (accessed June 30, 2018).

**Table 1.4** Economic priority areas and targets for 2023 (AU Commission)

| | | |
|---|---|---|
| **Aspiration 1**. A prosperous Africa based on inclusive growth and sustainable development | **Goal 1**. A high standard of living, quality of life, and well-being for all | • **Priority area 1**. Incomes, jobs, and decent work<br>*National targets (2023):*<br>1. Increase 2013 per capita income by at least 30%<br>2. Reduce 2013 unemployment rate by at least 25%<br>3. Reduce youth and women unemployment rate by 2% per annum<br>4. Reduce underemployment rate by 50%<br>5. Reduce 2013 vulnerable unemployment rate by at least 25%<br>• **Priority area 2**. Poverty, inequality, and hunger<br>*National targets (2023):*<br>1. Reduce 2013 levels of poverty by at least 30%<br>2. Reduce poverty among women by at least 50%<br>3. Improve the 2013 Gini coefficient by at least 20%<br>4. Reduce 2013 levels of proportion of the population who suffer from hunger by at least 80%<br>5. Reduce stunting in children to 10% and underweight to 5% |
| | **Goal 4**. Transformed economies and job creation | • **Priority area 1**. Sustainable inclusive economic growth<br>*Targets (2023):*<br>1. Annual GDP growth rate of at least 7%<br>2. At least 30% of total non-extractive sector industrial output is from locally owned firms<br>3. Locally owned firms generate at least 20% of the extractive sector's industrial output<br>4. 20% of informal sector ventures graduate into small formal enterprise category a year<br>5. At least 50% of informal sector ventures that grow into small formal enterprise category a year will be owned by women |
| | | • **Priority area 2**. STI-driven manufacturing/industrialisation and value addition<br>*National targets (2023):*<br>1. Real value of manufacturing in GDP is 50% more than the 2013 level<br>2. Share of labour-intensive manufacturing output is 50% more than that of 2013 level |

(continued)

**Table 1.4** (continued)

| | | |
|---|---|---|
| | | 3. At least 20% of total output of the extractive industry is through value addition by locally owned firms<br>4. At least five commodity exchanges are functional<br>5. Gross domestic expenditures on R&D (GERD) as a percentage of GDP has reached 1% by 2023<br>*Regional/continental targets (2023):*<br>1. Hubs for industrialisation/manufacturing linked to global value chains fully functional in all RECs<br>2. African Mineral Development Centre (AMDC) is fully operational |
| | | • **Priority area 3**. Economic diversification and resilience<br>*National targets (2023):*<br>1. Improvement in diversification index of 2013 is at least 20%<br>2. Reduce 2013 level of food imports by at least 50%<br>3. Contribution of the creative arts to GDP in real terms is increased by at least 100%<br>4. Level of intra-African trade in agricultural commodities is increased by at least 100% in real terms<br>5. Level of intra-African trade in services is increased by at least 100% in real terms<br>6. At least 1% of GDP is allocated to science, technology, and innovation research and STI-driven entrepreneurship development<br>*Regional/continental targets (2023):*<br>1. At least two regional commodity exchanges are in place |

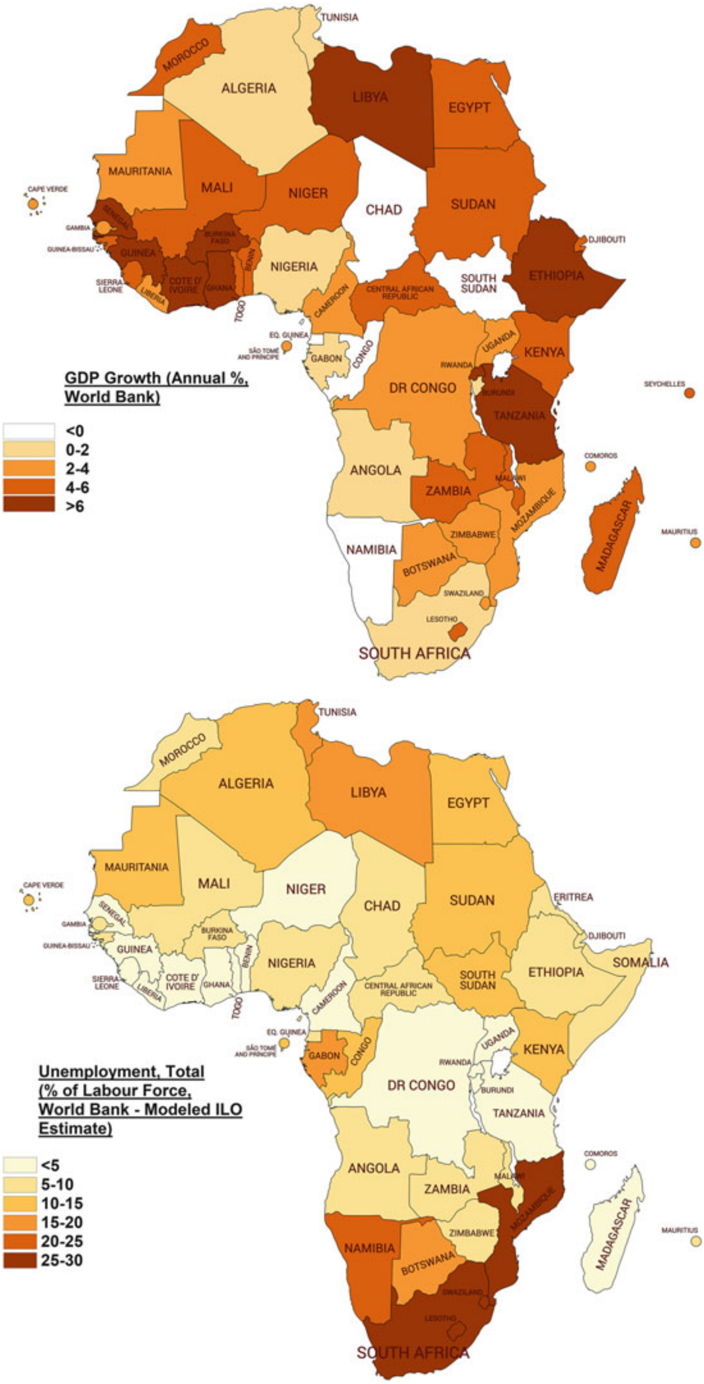


**Fig. 1.21** Annual GDP growth rates (%) and unemployment rates (%) (World Bank)

rate. The most troubling situation was in South Sudan, where the economy severely contracted by 13.83% in 2016, with no data for 2017, due to the conflict there. Equatorial Guinea displayed sustained economic contraction in 2017 (−3.22%), its third year of negative growth figures. The Republic of the Congo also displayed its second year of negative growth, at −4.58% for 2017 and −2.8% for 2016. Chad similarly had its second year of negative figures with −2.95% for 2017 and −6.25% in 2016. Namibia previously displayed positive growth but dipped down to −0.77% for 2017. Once again, the great diversity of economic performance is apparent, as well as the serious challenges many countries will have to face and overcome to achieve a 7% annual continental GDP growth rate by 2023. One of these challenges is the unemployment rate, which in some cases is severe. World Bank data,[147] reflecting the share of the labour force that is without work but which is available and seeking employment (all for 2017), is compared with Africa's economic growth in Fig. 1.21. Southern Africa performs by far the worst in this regard, again reflecting the high inequality in the region discussed above. In fact, South Africa has the highest youth unemployment in the world, and it is noted that "a startling 57.4% of our youth are unemployed", with Swaziland fourth worst at 54.8%, Namibia ninth worst at 45.5%, Mozambique 12th at 42.7%, Lesotho 16th at 38.5%, and Botswana 22nd at 22% of labour force aged 15–24 unemployed.[148]

In order to grow and create jobs, economies rely on an attractive business environment, which is also a prerequisite foreign investment. Here too the World Bank provides an excellent in-depth assessment of a range of factors affecting business in its Ease of Doing Business report.[149] It ranks 190 countries on 10 factors (starting a business, dealing with construction permits, getting electricity, registering property, getting credit, protecting minority investors, paying taxes, trading across borders, enforcing contracts, and resolving insolvency). Together these provide a good indication of a country's business environment. These factors are also crucial for businesses in the space sector. Unfortunately, Africa performs very poorly. Only one country manages to make the top 25 in terms of ease of doing business, namely, Mauritius at 25th in its overall rank (2017). Only one more makes the top 50—Rwanda at 41st. Apart from these two, only seven others make the top 100—Morocco at 69th, Kenya at 80th, Botswana at 81st, South Africa at 82nd, Zambia at 85th, Tunisia at 89th, and Seychelles at 95th. Of the remaining 45 countries, 18 rank between 100 and 149, and, very troubling, the remaining 27 countries (half of Africa) fall between 150 and 190. Therefore, in terms of the measures identified, businesses in most of Africa fight an uphill battle, and two of Africa's most

[147]World Bank, "Unemployment, total (% of total labor force) (modeled ILO estimate)," 2018, https://data.worldbank.org/indicator/SL.UEM.TOTL.ZS (accessed June 27, 2018).

[148]The Citizen, "SA has highest youth unemployment in the world," October 19, 2018, https://citizen.co.za/news/south-africa/2025384/sa-has-highest-youth-unemployment-in-the-world/#.W8nNRhIputM.facebook (accessed December 5, 2018).

[149]World Bank, "Doing Business: Measuring Business Regulations, Economy Rankings," 2017, http://www.doingbusiness.org/rankings (accessed June 30, 2018).

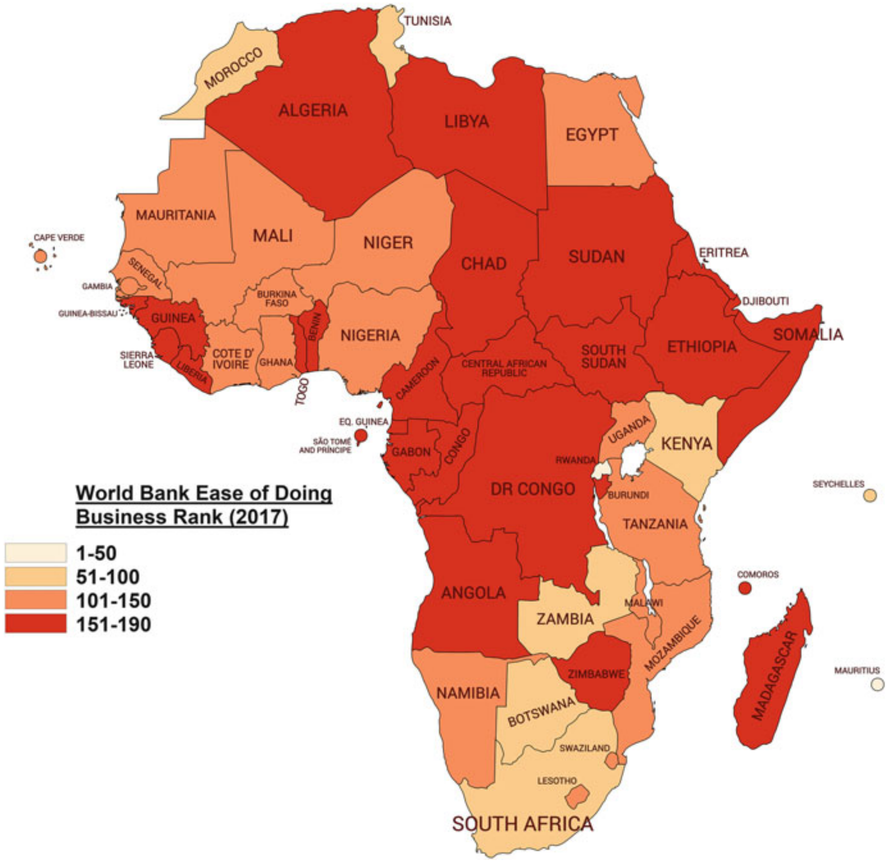


**Fig. 1.22** Ease of Doing Business 2017 (World Bank)

promising space nations—Algeria and Ethiopia—are included here. Figure 1.22 summarises the data for all of Africa.

The World Economic Forum (WEF) similarly ranks countries in terms of its Global Competitiveness Index.[150] This index ranks states according to 12 pillars, subdivided into a broad and comprehensive range of factors affecting economic competitiveness. While several African countries are unranked, a remarkably similar picture to the World Bank's Ease of Doing Business report emerges. Mauritius is Africa's most competitive economy, at 45th out of 137 (2017), followed by Rwanda at 58th, South Africa at 61st, Botswana at 63rd, Morocco at 71st, Algeria at 86th,

[150]World Economic Forum, "Global Competitiveness Index, 2017–2018", 2018, http://reports.weforum.org/global-competitiveness-index-2017-2018/competitiveness-rankings/ (accessed June 30, 2018).

Namibia at 90th, Kenya at 91st, Tunisia at 95th, and Egypt at 100th. All other African states fall below this.

Despite these many challenges, information and communications technologies (ICTs) have made rapid inroads into Africa as a result of the mobile phone revolution, and it has been argued that "many lesser developed countries have embraced cell phone technology to leap-frog the cost barrier of landline phones".[151] It was reported in 2014 that Africa had become the second most connected continent, as well as the fastest growing region, by mobile subscriptions.[152] By mid-2017, mobile subscriptions in Africa had reached 985 million, with Nigeria showing the highest growth in Africa (at three million new subscribers).[153] Alongside this rapid expansion of mobile devices came access to the Internet, which has been described as a "game changer".[154] One of the first areas to be revolutionised by this development was the financial services sector, making it easier for people to send and receive money even without bank accounts. Alongside finance, the retail sector, where mobile commerce helped to expand access to goods, often concentrated in urban areas, outside of which organised retail penetration was historically low. Mobile devices also greatly expanded access to healthcare information and medical services providers, weather information, and agricultural market prices.

The key driver of the African digital revolution was, and remains, lower smartphone prices.[155] Between 2014 and 2016, smartphone connections increased twofold in Africa, to 226 million, with a total of over half a billion mobile subscribers. While Africa still lags behind other developing regions, particularly in mobile broadband use, the main drivers of high data usage were the more technologically advanced countries of South Africa, Nigeria, Kenya, and Egypt, while others like the Democratic Republic of the Congo, Cameroon, and Algeria were effectively leveraging 3G technology.[156] The economic advantages of this revolution cannot be overstated, since by 2015 mobile services and technologies generated $17 billion in taxes, 6.7% of the African GDP, 3.8 million direct jobs, and 2.43 million indirect ones.[157]

[151]Robert C. Harding, *Space Policy in Developing Countries: The Search for Security and Development on the Final Frontier* (London: Routledge, 2013), 146.

[152]Nmachi Jidenma, "How Africa's mobile revolution is disrupting the continent," *CNN*, January 24, 2014, https://edition.cnn.com/2014/01/24/business/davos-africa-mobile-explosion/index.html 2014 (accessed June 30, 2018).

[153]Matshelane Mamabolo, "Africa edges closer to 1bn mobile subscriptions," *ITWebAfrica.com*, June 23, 2017, http://www.itwebafrica.com/mobilex/339-africa/238062-africa-edges-closer-to-1bn-mobile-subscriptions (accessed June 30, 2018).

[154]Ibid.

[155]Abdi Latif Dahir, "Smartphone use has doubled in Africa in two years," *Quartz Africa*, August 3, 2016, https://qz.com/748354/smartphone-use-has-more-than-doubled-in-africa-in-two-years/ (accessed June 24, 2018).

[156]Ibid.

[157]Ibid.

While the impact of mobile connections in Africa is evident, *The Economist* warned in 2016 that the digital divide between urban and rural areas could expand due to mobile ownership being concentrated in urban areas and due to the immense challenges of providing service to a population scattered across small villages and farms.[158] On top of this, powering phone masts is a challenge with diesel being the most popular power source, while the "masts also need a way to transmit calls and data to and from the broader network, so phone companies spend another fortune laying cables or buying bandwidth on satellites to do so".[159] The result is that Internet usage in particular suffers, with three-quarters of Africa's population not using the Internet (2016 data), only 43% able to get a 3G signal, and 16% able to get 4G mobile broadband. Of course, due to the rapid improvements in technology, it was reported in mid-2017 that by 2018 4G is expected to overtake GSM in terms of access technology share for mobile phones.[160] Moreover, in sub-Saharan Africa alone, smartphone penetration is expected to reach 80% by 2022.[161] Nevertheless, due to the long route data must travel via submarine cables and long overland routes, seven of the ten countries in the world with the highest fixed-broadband costs are African (particularly the landlocked ones).[162] Furthermore, Africa's expenditures outside the continent to access the digital world amount to $400 billion, while the continent's contribution to creating its own digital wealth is a mere $5 billion.[163] This is a major imbalance and challenge facing Africa.

Despite these challenges, solar-powered mobile masts and other innovations have meant that profitable business can still be conducted with people who spend no more than $2 per month on their mobile devices.[164] Thus, the market is there, and satellite Internet is another promising development to help tap into this market. *The Economist* does, however, raise concern over the high tax rates many governments are placing on businesses and sales in the sector, such as Tanzania where "phone companies pay almost half their revenues to the government" and Ghana where handset costs are taxed at "almost 38%".[165] The conclusion of *The Economist* in 2016 was that the benefits of the smartphone revolution for the economies and citizens of Africa "will not happen if governments keep standing in its way".[166] In

[158]The Economist, "Mobile phones are transforming Africa," December 10, 2016, https://www.economist.com/middle-east-and-africa/2016/12/10/mobile-phones-are-transforming-africa (accessed June 24, 2018).

[159]Ibid.

[160]Mamabolo, "Africa edges closer to 1bn mobile subscriptions."

[161]Chris Tredger, "85% mobile subscription penetration in Sub-Saharan Africa," *ITWebAfrica.com*, November 16, 2016, http://www.itwebafrica.com/mobile/339-africa/237068-85-mobile-subscription-penetration-in-sub-saharan-africa (accessed June 30, 2018).

[162]The Economist, "Mobile phones are transforming Africa."

[163]Tidiane Ouattara, "Earth Observation Service: Key pillar of the African Outer Space Programme in support to the implementation of the Agenda 2063," October 2018, 5, presentation at 12th AARSE Conference, Alexandria, Egypt.

[164]Ibid.

[165]Ibid.

[166]Ibid.

2017, *The Economist* reported that while "[c]orrupt governments are still terrible at building roads, and state-monopoly power utilities are still awful at providing electricity . . . tech-savvy entrepreneurs are finding ways to connect people, electrify their homes and alleviate all manner of social problems".[167] Yet, despite the potentials of solar power to help bridge the electricity gap, which would require $63 billion per year to build a traditional power grid for the two-thirds of Africans without it, and the potentials of 3D printing and robotics to encourage African production previously hampered by the importance of scale in manufacturing, the conclusion was that "many African governments are energetically discouraging the spread of technology" through a series of barriers, including too little scientific and research investment, overly complicated visa systems that hamper skilled immigration, and, as they observed in 2016, punitive taxes and fees amounting to 35% of turnover in 12 African countries.[168] The Democratic Republic of the Congo is a case in point, where 17% of the national government's revenues came exclusively from taxing mobile operators, contributing to the country's status of having some of the lowest phone penetration on Earth. While some have argued that, despite this, the ratio of tax to GDP in Africa (below 17% on average) is still much lower than in the Organisation for Economic Co-operation and Development (OECD) countries (35%), taxes in particular are harming the spread of "the most powerful tools yet to alleviate poverty, boost growth and ultimately catch up with the rich world".[169]

Indeed, the importance of the digital economy to Africa cannot be overstated. By 2025 the Internet's contribution to African GDP is expected to be $300 billion, with 600 million Internet users.[170] Unlocking this potential is contingent upon successfully meeting challenges in this field, which should thus be a top priority for all countries on the continent.

### Education

It is undeniable that the knowledge economy depends powerfully on education—a notion reinforced by the Economic Complexity and Global Competitive Indices. The African Union also recognises this, and the first 10-year implementation plan of Agenda 2063[171] reflects the targets identified in Table 1.5. A brief consideration of the most basic educational achievements—African literacy rates and basic (primary) education enrolment rates—derived from the United Nations Children's Fund

[167]The Economist, "How the taxman slows the spread of technology in Africa," November 9, 2017, https://www.economist.com/middle-east-and-africa/2017/11/09/how-the-taxman-slows-the-spread-of-technology-in-africa (accessed June 30, 2017).

[168]Ibid.

[169]Ibid.

[170]Ouattara, "Earth Observation Service: Key pillar of the African Outer Space Programme in support to the implementation of the Agenda 2063," 25.

[171]African Union Commission, *Agenda 2063: The Africa We Want – First Ten-Year Implementation Plan 2014–2023*, 51.

**Table 1.5** Education priority areas and targets for 2023 (AU Commission)

| | | |
|---|---|---|
| **Aspiration 1**. A prosperous Africa based on inclusive growth and sustainable development | **Goal 2**. Well-educated citizens and skills revolution underpinned by science, technology, and innovation | • **Priority area 1**. Education and STI-driven skills revolution<br>*National targets (2023):*<br>1. Enrolment rate for early childhood education is at least 300% of the 2013 rate<br>2. Enrolment rate for basic education is 100%<br>3. Increase number of qualified teachers by at least 30% with focus on STEM<br>4. Universal secondary school (including technical high schools) with enrolment rate of 100%<br>5. At least 30% of secondary school leavers go into tertiary education with at least 40% being female<br>6. At least 70% of secondary school students not entering the tertiary sector are provided with a range of options for further skills development<br>7. At least 70% of the public perceive quality improvements in education at all levels<br>*Continental targets (2023):*<br>1. African Education Accreditation Agency is fully operational<br>2. Common continental education qualification system is in place<br>3. African e-University is established<br>4. Pan-African University is consolidated with at least 25 satellite centres<br>5. African Education Observatory is fully operational<br>6. At least 50% of member states have national accreditation systems in place by 2023<br>7. Framework for harmonisation of teacher education is completed by 2018 |
| **Aspiration 6**. An Africa whose development is people-driven, relying on the potential of the African people, particularly its women and youth and caring for children | **Goal 17**. Full gender equality in all spheres of life | • **Priority area 1**. Women empowerment<br>*National targets (2023):*<br>1. Equal economic rights for women, including the rights to own and inherit property, sign a contract, save, register and manage a business, and own and operate a bank account by 2025<br>2. At least 20% of rural women have access to and control productive assets, including land and grants, credit, inputs, financial service, and information<br>3. At least 30% of all elected officials at local, regional, and national levels are women as well as in judicial institutions<br>4. At least 25% of annual public procurement at national and subnational levels are awarded to women<br>5. Increase gender parity in decision-making positions at all levels to at least 50–50 between women and men |

(continued)

**Table 1.5** (continued)

| | | |
|---|---|---|
| | | 6. Solemn Declaration Index (SDI) developed by GIMAG and ECA on gender is computed biannually and used in making policy/resource allocation decisions<br>*Continental targets (2023):*<br>1. Increase gender parity in decision-making positions at all levels in pan-African organisations to at least 50–50 between women and men<br>2. High-level panel on women empowerment operational by 2016<br>3. Fund for African women is operational by 2017 |
| | | • **Priority area 2**. Violence and discrimination against women and girls<br>*National targets (2023):*<br>1. Reduce 2013 levels of violence against women and girls by at least 20%<br>2. End all harmful social norms and customary practices against women and girls (e.g. FGM, child marriages) and those that promote violence and discrimination against women and girls<br>3. Eliminate all barriers to quality education, health, and social services for women and girls by 2020<br>4. End all forms of political, legal, or administrative discrimination against women and girls by 2023<br>5. Reduce by 50% all harmful social norms and customary practices against women and girls and those that promote violence and discrimination<br>*Continental targets (2023):*<br>1. Fully implement Executive Council Decision on Gender Parity in the African Union by 2020 |

African Union Commission, *Agenda 2063: The Africa We Want—First Ten-Year Implementation Plan 2014–2023*, 51–52 and 86–88

(UNICEF) and World Bank data will shed light on how far some countries still have to go to achieve these targets. While the literacy data available for many African countries (both UNICEF's and the World Bank's) are often outdated, with some data up to 10 years old, the clear realisation emerges, as depicted in Fig. 1.23, that a large swath of Africa's Sahel region fares incredibly poorly in terms of UNICEF's definition of the "population aged 15 years and over who can both read and write with understanding a short simple statement on his/her everyday life".[172] In almost all cases, female literacy rates are lower than male literacy rates, reflecting the enduring gender disparity in education. Agenda 2063 does focus on gender equality as well, as Table 1.5 indicates. However, the net primary education enrolment rate in Africa does give reason for optimism, as indicated by more recent United Nations Educational, Scientific and Cultural Organisation (UNESCO) data, reported by the World Bank.[173] This data, drawn from different years for different states depending on the latest available data, is also depicted in Fig. 1.23 and reveals that the largest challenges are faced by South Sudan (32.11% net primary school enrolment for 2015) and Liberia (37.68% for the same year), with Equatorial Guinea and Eritrea being further causes for concern.

Critically, the Pan-African University, which has graduated 364 students from 33 countries, will establish its Southern African (and fifth) hub in South Africa, which will be dedicated to space sciences (Pan-African University Space Sciences, PAUSS), through a consortium of eight universities (led by the Cape Peninsula University of Technology).[174] According to the Pan-African University, talks are under way with the European Union (EU) and the United States (US) to become thematic partners with PAUSS.[175]

The WEF Global Information Technology Report (2016) includes a compound measure of education under its skills category, constituting the fifth pillar of the Networked Readiness Index.[176] This includes an assessment of the quality of a country's education system, the quality of its maths and science education, its secondary education gross enrolment rate, and the adult literacy rate. This provides an excellent broad-level assessment of how well (or how poorly) African countries are doing in terms of education. The rankings in terms of this fifth pillar indicate that the median rank of the 36 African countries included in the index is 116.5 out of 139 countries.[177] The best performer is Mauritius at 53rd, while the worst is Chad at 139th.

[172]United Nations Children's Fund, "Education is vital to meeting the Sustainable Development Goals," June, 2018, https://data.unicef.org/topic/education/overview/ (accessed June 29, 2018).

[173]World Bank, "School enrollment, primary (% net)," 2018, https://data.worldbank.org/indicator/SE.PRM.NENR?view=chart (accessed June 29, 2018).

[174]Pan African University, "About us," 2018, https://pau-au.net/about-us/ (accessed June 29, 2018).

[175]Ibid.

[176]Silja Baller, Soumitra Dutta, and Bruno Lanvin, eds., *The Global Information Technology Report 2016: Innovating in the Digital Economy* (Geneva: World Economic Forum, 2016). http://www3.weforum.org/docs/GITR2016/WEF_GITR_Full_Report.pdf (accessed July 1, 2018).

[177]Ibid., 18.

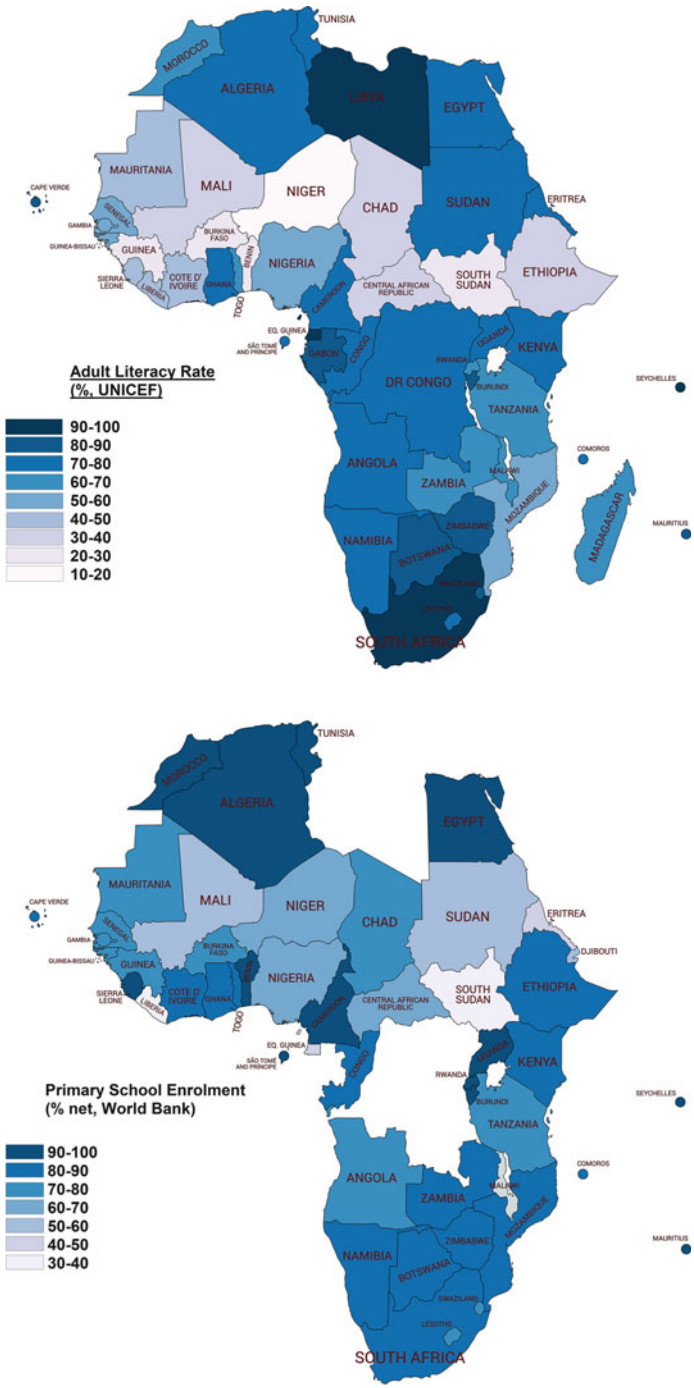


**Fig. 1.23** Adult literacy rates (UNICEF) [Compiled by UNICEF in October 2015, but again reflecting different years for states depending on latest available data. United Nations Children's Fund, "Literacy," 2018, https://data.unicef.org/topic/education/literacy/ (accessed June 29, 2018)], and net primary school enrolment rates (World Bank)

Moreover, the picture is even more worrying when considering the two subcomponents of education system quality and maths and science education quality. These two factors are based on the WEF's Executive Opinion Survey, drawing on over 14,000 business executives around the world, and they are measured on a scale of 7 (best) to 1 (worst).[178] What makes these indicators particularly valuable is that they reflect the experience of the business community in terms of the skills they need from the education system and thus also help to indicate how well education is meeting the skills needs of the private sector (and the economy as a whole). In relation to the quality of the education system as a whole (based on the question "How well does the education system meet the needs of a competitive economy?"), the African median improves to 86 out of 139.[179] Zambia is the best performer, ranked 35th globally, while, of grave concern, South Africa and Egypt ranked 137th and 138th, respectively—the third and second worst globally. Of particular concern is that the most active African countries in space fall below the African mean and achieve some of the poorest ranks globally. Of even more concern is the quality of Africa's maths and science education—crucial sectors for a competitive economy and active space sector—scoring a median rank of 94.5 out of 139 (based on the question "How do you assess the quality of maths and science education?"), and apart from Tunisia and Morocco, the leading African space states fare abysmally, with South Africa last in the world, Nigeria third worst, Egypt fourth worst, and Algeria 15th worst. While this index does not include all countries in the world, this bodes ill for future African prospects in the space sector and suggests that it will be many years before Africa can produce the space-related maths and science skills in such a desperately short supply already. The WEF data are displayed in Table 1.6.

### Health

It has been argued that addressing population growth is one of the "challenging omissions" of the Sustainable Development Goals and Agenda 2063.[180] Some have called this a "ticking time bomb that cannot be left unchecked if we wish to be sustainable, silence the guns, diffuse the bomb and have peace", and it has been argued that population growth rates and future projections for Africa are very concerning, especially when coupling these with "limited and dwindling land resources" in countries such as Rwanda.[181] Naturally, population growth and density are directly related to the challenges of healthcare. As indicated in Table 1.7, the AU has identified ten specific healthcare areas of immediate concern leading up to 2023.[182]

[178] Ibid., 36.

[179] Ibid., 232.

[180] Nhamo, "New Global Sustainable Development Agenda: A Focus on Africa," 13.

[181] Ibid.

[182] African Union Commission, *Agenda 2063: The Africa We Want – First Ten-Year Implementation Plan 2014–2023*, 53–54.

**Table 1.6** Skills rankings from the Networked Readiness Index (World Economic Forum Global Information Technology Report 2016)

| Fifth pillar: readiness sub index—skills | | | Quality of the education system | | | Quality of maths and science education | | |
|---|---|---|---|---|---|---|---|---|
| Rank (out of 139) | | Rating (7–1) | Rank (out of 139) | | Rating (7–1) | Rank (out of 139) | | Rating (7–1) |
| 53 | Mauritius | 5.3 | 35 | Zambia | 4.3 | 17 | Côte d'Ivoire | 5.2 |
| 74 | Seychelles | 5.0 | 36 | **Kenya** | 4.3 | 50 | Mauritius | 4.4 |
| 75 | Cape Verde | 5.0 | 38 | Seychelles | 4.3 | 53 | **Tunisia** | 4.4 |
| 85 | **Tunisia** | 4.7 | 39 | Gambia | 4.3 | 54 | Zimbabwe | 4.4 |
| 87 | Botswana | 4.6 | 42 | Zimbabwe | 4.2 | 56 | Seychelles | 4.3 |
| 89 | **Algeria** | 4.6 | 44 | Lesotho | 4.2 | 59 | Rwanda | 4.3 |
| 95 | **South Africa** | 4.4 | 45 | Rwanda | 4.2 | 66 | Cameroon | 4.1 |
| 96 | **Kenya** | 4.2 | 48 | Côte d'Ivoire | 4.1 | 72 | Ghana | 4.0 |
| 99 | Swaziland | 4.2 | 49 | Mauritius | 4.1 | 74 | **Morocco** | 4.0 |
| 100 | Zimbabwe | 4.1 | 55 | Cape Verde | 4.0 | 77 | Cape Verde | 4.0 |
| 102 | Ghana | 4.1 | 63 | Senegal | 3.8 | 78 | **Kenya** | 3.9 |
| 107 | Cameroon | 3.8 | 68 | Ethiopia | 3.7 | 81 | Zambia | 3.9 |
| 108 | Lesotho | 3.8 | 72 | Cameroon | 3.6 | 82 | Senegal | 3.9 |
| 109 | Namibia | 3.8 | 76 | Ghana | 3.6 | 86 | Swaziland | 3.7 |
| 110 | **Morocco** | 3.7 | 77 | Botswana | 3.6 | 87 | Ethiopia | 3.7 |
| 111 | **Egypt** | 3.7 | 80 | Swaziland | 3.5 | 91 | Madagascar | 3.6 |
| 114 | Zambia | 3.6 | 81 | Uganda | 3.5 | 93 | Gambia | 3.6 |
| 116 | Gabon | 3.5 | 83 | Liberia | 3.5 | 94 | Liberia | 3.5 |
| 117 | Rwanda | 3.5 | 89 | **Tunisia** | 3.3 | 95 | Botswana | 3.5 |
| 119 | Burundi | 3.3 | 91 | **Algeria** | 3.3 | 98 | Burundi | 3.5 |
| 121 | Gambia | 3.2 | 96 | Namibia | 3.2 | 100 | Lesotho | 3.4 |
| 123 | Côte d'Ivoire | 3.1 | 98 | Tanzania | 3.2 | 105 | **Algeria** | 3.3 |
| 125 | Tanzania | 2.9 | 104 | Malawi | 3.1 | 108 | Gabon | 3.3 |
| 126 | Uganda | 2.9 | 109 | Mali | 3.1 | 109 | Benin | 3.2 |
| 128 | Senegal | 2.8 | 115 | Madagascar | 2.9 | 110 | Mali | 3.2 |
| 129 | Madagascar | 2.8 | 118 | Mozambique | 2.8 | 111 | Uganda | 3.2 |
| 130 | Malawi | 2.7 | 119 | Gabon | 2.8 | 115 | Guinea | 3.1 |
| 131 | Ethiopia | 2.5 | 121 | **Morocco** | 2.8 | 120 | Chad | 3.0 |
| 132 | Liberia | 2.4 | 123 | Chad | 2.7 | 121 | Namibia | 2.9 |
| 133 | Benin | 2.4 | 124 | **Nigeria** | 2.7 | 123 | Mauritania | 2.9 |
| 134 | **Nigeria** | 2.4 | 126 | Burundi | 2.6 | 128 | Malawi | 2.7 |
| 135 | Mali | 2.4 | 130 | Mauritania | 2.5 | 129 | Tanzania | 2.6 |
| 136 | Mozambique | 2.1 | 132 | Guinea | 2.4 | 130 | **Egypt** | 2.6 |
| 137 | Guinea | 2.1 | 134 | Benin | 2.4 | 131 | **Nigeria** | 2.6 |
| 138 | Mauritania | 1.9 | 137 | **South Africa** | 2.2 | 132 | Mozambique | 2.5 |
| 139 | Chad | 1.9 | 138 | **Egypt** | 2.1 | 139 | **South Africa** | 2.0 |

**Table 1.7** Health priority area and targets for 2023 (AU Commission)

| | | |
|---|---|---|
| **Aspiration 1**. A prosperous Africa based on inclusive growth and sustainable development | **Goal 3**. Healthy and well-nourished citizens | • **Priority area 1**. Health and nutrition<br>*Targets (2023):*<br>1. Increase 2013 levels of access to quality basic healthcare and services by at least 40%<br>2. Increase 2013 levels of access to sex and reproductive health services to women and adolescent girls by at least 30%<br>3. Reduce 2013 maternal, neonatal, and child mortality rates by at least 50%<br>4. Reduce 2013 proportion of deaths attributable to HIV/AIDS, malaria, and TB by at least 50%<br>5. Reduce under 5 mortality rate attributable to malaria by at least 80%<br>6. Reduce the 2013 incidence of HIV/AIDS, malaria, and TB by at least 80%<br>7. Reduce the 2013 level of prevalence of malnutrition by at least 50%<br>8. Reduce stunting to 10%<br>9. Reduce the 2013 proportion of deaths attributable to dengue fever and chikungunya by 50% (for island states)<br>10. Access to antiretroviral (ARV) drugs is 100%<br>*Continental targets (2023):*<br>1. African Centres for Disease Control and Prevention is operational<br>2. Africa Volunteer Health Corp is established and operational by 2018<br>3. African Medicines Harmonisation Framework is completed and operational by 2017 |

African Union Commission, *Agenda 2063: The Africa We Want—First Ten-Year Implementation Plan 2014–2023*, 53–54

No healthcare goals can be achieved without access to quality basic healthcare and services. At the most basic level, access means the number of qualified medical professionals and healthcare workers that a population has access to. According to the latest available data from the World Health Organisation (WHO)—again from different years for different countries—only five African countries have more than one physician per 1000 population.[183] These are South Africa, Mauritius, Algeria, Tunisia, and Libya. By comparison, France had 3.238 physicians per 1000 population in 2016 and Germany 4.191 in 2015. In terms of nursing and midwifery personnel per 1000, where France and Germany had 10.605 (2015) and 13.794 (2015), respectively, only South Africa and Libya had more than 5 per 1000 population, and Algeria, Tunisia, Egypt, Sudan, Kenya, Seychelles, Mauritius,

[183]World Health Organisation, "Global Health Observatory Data Repository, Density per 1000 Data by country," 2018, http://apps.who.int/gho/data/node.main.A1444 (accessed July 1, 2018).

Zimbabwe, Swaziland, Cape Verde, Gambia, São Tomé and Príncipe, Botswana, Namibia, Angola, Gabon, and Nigeria had more than 1 per 1000 population. Therefore, in order to increase access to basic health services, more skilled and qualified healthcare personnel are required, which goes hand in hand with education, *especially* in maths and science.

Without sufficient and easy access to qualified healthcare personnel, the fight against the three great scourges of Africa—HIV/AIDS, malaria, and tuberculosis—remains an area of grave concern. Africa has the highest number of HIV-positive people of any region in the world, with an estimated 22.9–28.6 million people of all ages living with the virus in 2016.[184] South Africa has the largest total HIV-positive population, 7.1 million (2016), and Nigeria, Mozambique, Kenya, Tanzania, Uganda, Zimbabwe, Zambia, and Malawi (plus India) all have over 1 million HIV-positive people.[185] While the WHO reports that there was a 37% decrease in worldwide malaria incidence between 2000 and 2015 and a 62% decrease in global malaria deaths over the same period, 88% of the estimated 214 million malaria cases in 2015 occurred in Africa.[186] The incidence of tuberculosis also remains the highest in the world at 254 per 100,000 population.[187] Dengue fever and yellow fever, as well as chikungunya, and the major outbreak of Ebola between 2014 and 2016, all compound the healthcare situation. Amnesty International also summarises some of the other healthcare challenges that confronted Africa in 2017.[188] These included lack of medical equipment, medication, and staffing, which placed pregnant women and infants at serious risk, in countries such as Burkina Faso. Female genital mutilation continues despite being outlawed. Unsafe abortions and obstacles to legal abortion services in places such as South Africa placed women at risk, including the refusal of healthcare professionals to provide abortions. In Angola, a parliamentary vote on legislation to decriminalise abortion in limited cases was also postponed indefinitely.

One of the positive developments was the inauguration of the Africa Centres for Disease Control and Prevention (CDC) in 2017, as called for in the AU Agenda 2063 10-year implementation goals (Table 1.7). The Africa CDC "supports all African Countries to improve surveillance, emergency response, and prevention of infectious diseases . . . include[ing] addressing outbreaks, man-made and natural disasters, and

[184] World Health Organisation, "Global Health Observatory data repository, Number of people (all ages) living with HIV estimates by WHO region," 2017, http://apps.who.int/gho/data/view.main.22100WHO?lang=en (accessed July 1, 2018).

[185] World Health Organisation, "Global Health Observatory data repository, Number of people (all ages) living with HIV estimates by country," 2017, http://apps.who.int/gho/data/view.main.22100WHO?lang=en (accessed July 1, 2018).

[186] World Health Organisation, "Global Health Observatory (GHO) data, Number of malaria cases estimated cases, 2000–2015," 2018, http://www.who.int/gho/malaria/epidemic/cases/en/ (accessed July 1, 2018).

[187] World Health Organisation, *Global Tuberculosis Report 2017*, 2017, Geneva, 218, http://www.who.int/tb/publications/global_report/en/ (accessed July 1, 2018).

[188] Amnesty International, "Africa 2017/2018."

public health events of regional and international concern ... [while] [i]t further seeks to build the capacity to reduce disease burden on the continent".[189]

### Water

Table 1.8 depicts the priority area of water security in the first 10-year implementation plan of Agenda 2063.[190] Africa is one of the driest continents on Earth, and its vulnerability to droughts is well known, as major droughts have affected large regions such as the Horn of Africa and Eastern Africa over the past decades. It was reported that in March 2017 at least 17 countries in Africa were struggling with the effects of drought, leaving over 38 million people at risk, including 5.7 million people in Ethiopia, 6.7 million in Malawi, 2.6 million in Kenya, 6.2 million in Somalia, 4.6 million in Sudan, and 4.1 million in Zimbabwe.[191] While water is a critical requirement for human survival, only a miniscule amount (0.3% of total water) is fit for human consumption, mainly in the form of groundwater and surface freshwater sources such as rivers.[192] Of this small amount of water, the overwhelming majority is used for agriculture in Northern and sub-Saharan Africa[193] and also accounts for the devastating results of drought on food security in Africa.

It is virtually inevitable that, with the effects of population growth and climate change (including more frequent droughts), more of Africa will have to confront the reality of water stress in the future—a condition whereby local sources become insufficient to supply demands.[194] As discussed in the following section concerning climate, South Africa is a good example of where this is already the case. Moreover, mismanagement of water resources and pollution often compound the problem, and with about 50,000 litres of raw or partially treated sewage being dumped into South Africa's rivers every second in July 2017, and with the effective "collapse" of the municipal water system—"[o]f the 824 treatment plants, maybe only 60 release clean water"—inevitable human health impacts follow.[195] Another potential crisis

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[189]Africa Centres for Disease Control and Prevention, "About the Africa Centres for Disease Control and Prevention (Africa CDC)," 2018, http://www.africacdc.org/about/about-us (accessed July 7, 2018).

[190]African Union Commission, *Agenda 2063: The Africa We Want – First Ten-Year Implementation Plan 2014–2023*, 64.

[191]Obi Anyadike, "Drought in Africa 2017," *IRIN*, March 17, 2017, https://www.irinnews.org/feature/2017/03/17/drought-africa-2017 (accessed July 8, 2018).

[192]Christoffel Kotze, "Towards Total Water Awareness: A Technology Framework," in *Post 2030-Agenda and the Role of Space: The UN 2030 Goals and Their Further Evolution Beyond 2030 for Sustainable Development*, ed. Annette Froehlich (Cham, Switzerland: Springer International Publishing AG, 2018), 29.

[193]Ibid., 30.

[194]Ibid.

[195]Sipho Kings, "50,000 litres of sewage flow into SA's rivers every second," *Mail & Guardian*, July 21, 2017, https://bit.ly/2ttvuSV (accessed September 23, 2018).

**Table 1.8** Water security priority area and targets for 2023 (AU Commission)

| | | |
|---|---|---|
| **Aspiration 1**. A prosperous Africa based on inclusive growth and sustainable development | **Goal 1**. A high standard of living, quality of life and well being for all | • **Priority Area 4**. Modern and liveable habitats and basic quality services<br>*National targets (2023)*:<br>1. Reduce 2013 level of proportion of the population without access to safe drinking water by 95%<br>2. Reduce 2013 level of proportion of the population with poor sanitation facilities by 95%<br>3. At least 5% of the national budget is allocated to water and sanitation by 2016<br>4. At least 70% of the population indicate an increase in access to quality basic services (water, sanitation, electricity, transpiration, internet connectivity |
| | **Goal 6**. Blue/ocean economy for accelerated economic growth | • **Priority Area 1**. Marine resources and energy<br>*National targets (2023)*:<br>1. At least 50% increase in value addition in the fishery sector in real term is attained by 2023<br>2. Build at least one Giant Aquaculture showpiece<br>3. Marine bio-technology contribution to GDP is increased in real terms by at least 50% from the 2013 levels<br>4. At least 10% of renewable energy sources is from wave energy<br>5. Commission and complete prospection of seabed's for minerals and hydrocarbon potentials by 2023 |
| | **Goal 7**. Environmentally sustainable climate resilient economies and communities | • **Priority Area 2**. Water security<br>*National targets (2023)*:<br>1. Increase 2013 levels of water demand satisfaction by 25%<br>2. Increase 2013 levels of water productivity from rain-fed agriculture and irrigation by 60%<br>3. At least 10% of rain water is harvested for productive use<br>4. At least 10% of waste water is recycled for agricultural and industrial use |

facing South Africa and the world is the contamination of water supplies by microplastic, with the drinking supplies of both Johannesburg and Tshwane contaminated with unknown consequences for human health.[196] There is thus an overall urgent need for solutions to secure Africa's water supply for future generations, including the use of space applications.

### Climate and Biodiversity

Despite the fact that Africa has contributed the least to anthropogenic climate change, according to the United Nations Environment Programme, Africa will be the continent hardest hit by the impacts of climate change.[197] Furthermore, the limited adaptive capacity and widespread poverty increase the risks of climate change in Africa, and it is the most vulnerable populations who will have their livelihoods most threatened. It is important to frame any discussion or approach to climate change from the outset with the reality that climate change is already affecting the continent, in at least eight ways.[198] First, as weather patterns are impacted, the intensity of both flooding and drought increase. Flooding is already the most prevalent natural disaster in North Africa; the second most prevalent in Eastern, Southern, and Central Africa; and the third most prevalent in Western Africa.[199] Severe droughts, such as that in 2011–2012 in East Africa, have widespread consequences, especially for the most vulnerable people. Second, water supply and quality are already affected, not only through melting glaciers on Mount Kilimanjaro but through fluctuating river and dam levels, changing rainfall patters, increases in scarcity, and falling hydroelectric power potentials.[200] South Africa's recent and ongoing water crisis is a good example of the scale of the impact of climate change, as the worst drought in a century has forced severe water restrictions on the city of Cape Town.[201]

Third, in a combination of the first and second effects, fluctuating rainfall, worsening droughts, and floods, as well as heat stress, can significantly hamper agricultural productivity and lead to food shortages, as the shortages in Kenya,

[196]Melanie Gosling, "Drinking water contaminated with micro plastic pollution in Gauteng," *News24*, July 25, 2018, https://www.news24.com/Green/News/drinking-water-contaminated-with-micro-plastic-pollution-in-gauteng-20180725 (accessed September 23, 2018).

[197]United Nations Environment Programme, "Responding to Climate Change," https://www.unenvironment.org/regions/africa/regional-initiatives/responding-climate-change (accessed July 3, 2018).

[198]350africa.org, "8 ways climate change is already affecting Africa," December 12, 2014, https://350africa.org/8-ways-climate-change-is-already-affecting-africa/ (accessed July 3, 2018).

[199]Ibid.

[200]Ibid.

[201]Derek Van Dam, "Cape Town contends with worst drought in over a century," *CNN*, June 1, 2017, https://edition.cnn.com/2017/05/31/africa/cape-town-drought/index.html (accessed July 3, 2018).

Somalia, and Ethiopia have demonstrated.[202] Coupled with the high degree of dependence of most of Africa on agriculture (and especially rain-fed agriculture), as discussed earlier, the vulnerability to climate change is a cause for serious concern. Fourth, human health, which is inseparable from the environment, is another area of concern. Malnutrition can be greatly worsened by lower agricultural yields or crop losses, while malaria rates can increase in areas receiving increased levels of rainfall or floods. Worsening air quality, associated with heat waves, can also negatively impact respiratory illnesses. Fifth, natural disasters that destroy homes and villages can add to, and worsen, the mass migrations of people within or between countries and further affect those already displaced. Sixth, all these consequences disproportionately affect women and children and can place further burdens on women especially, for example, "water scarcity places an additional burden on African women, who walk hours and sometimes even days, to fetch it".[203] Seventh, conflicts over dwindling natural resources such as water have the potential to worsen the security challenges facing African states such as Nigeria, especially in tandem with cross-border migration. Lastly, climate change has serious consequences for African ecosystems and habitats, and there are already cases of "changes in freshwater and marine ecosystems in eastern and southern Africa, and terrestrial ecosystems in southern and western Africa".[204]

In terms of biodiversity, the United Nations Environmental Programme reports that the African continent houses a quarter of global biodiversity across its diverse range of biomes.[205] In fact, of the 19 Like-Minded Megadiverse Countries—which together contain 36% of all terrestrial protected areas, 480 of the total 821 terrestrial ecoregions, 89 marine ecoregions, 20% of identified Important Bird and Biodiversity Areas, 61% of all Identified Alliance for Zero Extinction sites, and 25% of other Key Biodiversity Areas—5 are in Africa.[206] These are South Africa, Kenya, Ethiopia, Madagascar, and the Democratic Republic of the Congo.

Africa's rich natural heritage has been the source of intense conservation efforts but still faces immense challenges in relation to "reconciling human well-being with environmental and economic prosperity", especially when considering rising human pressures due to population growth, urbanisation, and the expansion of cultivated lands.[207] The plight of Africa's rhinos, elephants, lions, and other large mammals is well known, as is the ever-present threat of poaching. This threat, and that of habitat

[202] 350africa.org, "8 ways climate change is already affecting Africa."

[203] Ibid.

[204] Ibid.

[205] United Nations Environmental Programme World Conservation Monitoring Centre, *The State of Biodiversity in Africa: A mid-term review of progress towards the Aichi Biodiversity Targets*, Cambridge, UK, IV, https://wedocs.unep.org/bitstream/handle/20.500.11822/9944/Biodiversity_Review_AFRICA.pdf?sequence=1&isAllowed=y (accessed July 3, 2018).

[206] United Nations Environmental Programme, "Like-Minded Mega-Diverse Countries Carta to Achieve Aichi Biodiversity Target 11," December 7, 2016, https://www.cbd.int/doc/meetings/cop/cop-13/information/cop-13-inf-45-en.pdf (accessed July 3, 2018).

[207] Ibid.

loss, can only be sustainably addressed by coupling conservation efforts with human welfare and local community buy-in. Successful examples abound, such as the all-female antipoaching unit known as the Black Mambas.[208] Therefore, the need for clear and actionable targets in relation to the environment and climate led to the targets listed in Table 1.9 in the AU 10-year implementation plan.

## 1.3 Theoretical Framework

### *1.3.1 African Contributions:* Ubuntu *and Emerging Middle Powers*

The two concepts from international relations (IR) literature mentioned earlier—*ubuntu* and emerging middle powers—will be discussed here and aligned with the objectives of the study, namely, to provide an overview of the space sector across the continent. These concepts can help position Africa's rising powers globally and illuminate African states' behaviour in this arena.

While the five major space-related treaties and related principles adopted by the UN General Assembly, forming the canon of international law in the space arena, will not be repeated here, the key concept of *space as international* has been enshrined since UN General Assembly Resolution 1962 (XVIII). This Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space made it explicit that outer space is the province of all mankind, open to all states without discrimination, while subject to the sovereignty of none.[209] Therefore, as an international arena, theoretical contributions from IR theory can provide valuable insight. Since this study pertains specifically to Africa, bringing uniquely African IR concepts into the study of space (and adapting them accordingly) is valuable for an analysis of African actors and actions in this area.

There has been a recent effort in the field of IR theory to seek non-Western, including African, concepts to enrich a discipline that is still primarily dominated by work from the United States and Europe.[210] One such concept is *ubuntu*. It must be emphasised that there is no single "African view" and that this is only one view that has recently made its way into IR discourse and scholarship. It does however reinforce the notion of Smith that Africa has always possessed agency in the world system and has not simply been "acted upon" by others.[211] This agency has been

[208] Christina Goyanes, "These Badass Women Are Taking on Poachers—and Winning," *National Geographic*, October 12, 2017, https://www.nationalgeographic.com/adventure/destinations/africa/south-africa/black-mambas-anti-poaching-wildlife-rhino-team/ (accessed July 3, 2018).

[209] United Nations, *Treaties and Principles on Outer Space*, 39.

[210] Karen Smith, "Contrived boundaries, kinship and Ubuntu: A (South) African view of 'the international'," in Thinking International Relations Differently, ed. Arlene B. Tickner and David L. Blaney (London: Routledge, 2012).

[211] Smith, "Contrived boundaries, kinship and Ubuntu: A (South) African view of 'the international'," 304.

**Table 1.9** Environment and climate priority areas and targets for 2023 (AU Commission)

| | | |
|---|---|---|
| **Aspiration 1**. A prosperous Africa based on inclusive growth and sustainable development | **Goal 7**. Environmentally sustainable climate-resilient economies and communities | • **Priority area 1**. Biodiversity, conservation, and sustainable natural resource management<br>*National targets (2023):*<br>1. At least 30% of agricultural land is placed under sustainable land management practice<br>2. At least 17% of terrestrial and inland water and 10% of coastal and marine areas are preserved<br>3. All national parks and protected areas are well managed on the basis master and national plans<br>4. Genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives including other socio-economically as well as cultural valuable species are maintained<br>*Regional/continental targets (2023):*<br>• Harmonised and binding agreements and regulatory frameworks on fair, equitable, and sustainable management and exploitation of transboundary natural resources (water, parks, wild life, and oceans) in place<br>• Sustainable use and management of transboundary (shared) water, wild life, and other natural resources are used as a basis for regional cooperation and are treated as natural capital of beneficiary countries<br>• The ratification of the African Convention on the Conservation of Nature and Natural Resources (ACCNNR) is completed |
| | | • **Priority area 3**. Climate resilience and natural disasters and preparedness<br>*National targets (2023):*<br>1. At least 30% of farmers, pastoralist, and fisher folks practise climate-resilient production systems<br>2. Reduce to 2013 levels emissions arising from agriculture bio-diversity loss, land use, and deforestation<br>3. Reduce deaths and property loss from natural and man-made disasters and climate extreme events by at least 30%<br>4. Reduce proportion of fossil fuel in total energy production by at least 20%<br>5. All cities meet the WHO's Ambient Air Quality Standards (AAQS) by 2025<br>*Continental targets (2023):*<br>1. African Climate Fund is fully operational |

African Union Commission, *Agenda 2063: The Africa We Want—First Ten-Year Implementation Plan 2014–2023*, 62–65 clarified by arguing that its uniqueness “lies in its qualification ‘African’ which is both self and place bound” and the role of Afrocentricity within this agency in the sense that “Afrocentricity emerges as a methodology that consciously operates within African ways of knowing and existence and results in the implementation of principles, methods, concepts and ideas that are derived from our own African cultural experiences”.[212]

However, no attempt has been made to bring such unique African insights into the outer space literature, and even in the IR theory field, it is a new development. The first concept here, *ubuntu*, is well known in Africa in terms of human rights, peace building, and conflict resolution, but it remains a peripheral concept in IR scholarly work.[213] *Ubuntu* has been argued to be an indigenous worldview, and although the word itself originates from Southern Africa, specifically the Nguni language family, manifestations of *ubuntu* can be found across Africa, legitimising it as an African view of the international.[214] While direct translation of the term into English is difficult, it approximates, if literally translated, “collective personhood” or “the African principle of transcendence through which an individual is pulled out of himself or herself back towards the ancestors, forward towards the community, and towards the potential each one of us has”.[215] The term *ubuntu* is encapsulated in the well-known isiXhosa proverb *Ubuntu ungamntu ngabanye abantu*, which means “people are people through other people”.[216] Its value in IR, and thus space literature, is that it puts forth an alternative collectivist understanding in contrast to the Western individualist ontology.[217] *Ubuntu* is a valuable tool in IR since it can explain behaviour among African states that may seem “perplexing” to Western observers, such as the tendency for African leaders to be unwilling to criticise other leaders publicly or to even refuse to arrest Sudanese President al-Bashir in contravention of the International Criminal Court (ICC).

*Ubuntu* goes beyond the predominant IR relationship dichotomy of friend or enemy and instead proffers the “metaphor of the African family and community structure”.[218] In this African family, neighbouring states are seen as “part of the clan”, while other states in Africa are seen as more broadly “part of the tribe” where shared values and solidarity are still strong. For this reason, some scholars have presented the example that (from a South African perspective) dealing with other

[212]Achieng, “Can We Speak of African Agency?: APRM and Africa’s Agenda 2063,” 52.

[213]Karen Smith, “Reshaping International Relations: Theoretical Innovations from Africa,” *All Azimuth* 7, no. 2 (2018): 88.

[214]Smith, “Contrived boundaries, kinship and Ubuntu: A (South) African view of ‘the international’,” 311.

[215]Drucilla Cornell, “*uBuntu*, Pluralism and the Responsibility of Legal Academics to the New South Africa,” *Law Critique*, 2009, no. 20: 47.

[216]Smith, “Contrived boundaries, kinship and Ubuntu: A (South) African view of ‘the international’,” 311.

[217]Smith, “Reshaping International Relations: Theoretical Innovations from Africa,” 87.

[218]Smith, “Contrived boundaries, kinship and Ubuntu: A (South) African view of ‘the international’,” 307–312.

Southern African states is not seen as "international", as reflected in the popular discourse of referring to countries beyond Africa as "overseas".[219] Evidence of *ubuntu* in international relations can be seen in the statement of then Minister of International Relations and Cooperation Nkoana-Mashabane, who stated in 2009 that "Our [aim] is to export Ubuntu and partnership amongst our people, people of the continent and the world. Let their problem(s) be our problem".[220]

*Ubuntu*, then, is a concept of group solidarity and support and, like in an extended family, provides for "corrective mechanisms" of family discussion and association with peers, often evidenced by "quiet diplomacy".[221] Smith summarises Tieku's three features of *ubuntu* that contribute to a better understanding of African relations.[222] The first is consensual decision-making. This reveals the African preference for reaching decisions through consensus, which is reinforced by Africa's colonial experience (whereby Africans were given little or no say in how their lives were managed), and this explains the strong African emphasis on respect for sovereignty.[223] Immediately this identifies a confluence with the decision-making within the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS), which is also based on consensus, and invites the question as to why African participation in this forum has historically been lacklustre. This issue will be further explored in the next chapter.

The second feature and manifestation of *ubuntu* within African relations is groupthink.[224] Closely related to consensual decision-making, groupthink places a premium on maintaining harmony and conformity within the group. Former Tanzanian President Nyerere summarised these two features neatly in his statement, "We talk until we agree".[225]

The third feature is the norm of pan-African[226] solidarity, which combines the previous two features and adds it to the collectivist ontology of familial solidarity as described above. Smith points to the "strong preference for soft tools" and that AU members "are not allowed to criticise offending states in public" as manifestations of this.[227] Combined, these features also explain why Africa's preferred form of international engagement is multilateralism.[228] While it is true that not all Africans

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[219]Ibid., 308.

[220]Ibid., quoted in Smith, 312.

[221]Ibid., 313.

[222]Smith, "Reshaping International Relations: Theoretical Innovations from Africa," 88–89.

[223]Smith, "Contrived boundaries, kinship and Ubuntu: A (South) African view of 'the international'," 303.

[224]Karen Smith, "Reshaping International Relations: Theoretical Innovations from Africa," 88.

[225]Ibid., quoted in Smith, 88.

[226]Pan-Africanism is the belief that people of African descent have common interests and should be unified. South African History Online, "Pan-Africanism," May 22, 2015, https://www.sahistory.org.za/article/pan-africanism (accessed September 23, 2018).

[227]Ibid., 88.

[228]Smith, "Contrived boundaries, kinship and Ubuntu: A (South) African view of 'the international'," 313.

manifest the principles of *ubuntu*, as evidenced by the xenophobic attacks in South Africa against migrants from other African states, as stated earlier, there is no single African view of the international. It is, however, a powerful analytical tool for explaining the behaviour of African states internationally. Throughout this work, *ubuntu* will be drawn on to explain, for instance, the strong preference on a political level for an African Space Agency, while arguments have been proffered as to why it is premature to create such an agency. This will be returned to later in the study.

The second concept to be incorporated is that of emerging middle powers. The middle power literature is well-established in IR, but an important adjustment was made by a South African scholar to distinguish between *traditional* and *emerging* middle powers. The general definition of the concept sees middle powers as "states that are neither great not small in terms of international power, capacity and influence, and demonstrate a propensity to promote cohesion and stability in the world system".[229] Traditional middle powers include states such as Canada, Australia, Sweden, and Norway. However, while there are similar features in their foreign policy behaviours, there are also important differences between these and the emerging middle powers, which include South Africa, Nigeria (not coincidentally the two leading space-capable states in Africa), Brazil, and Malaysia. First, and most fundamentally, middle powers are states that uphold the global status quo.[230] In doing so, they prefer multilateral engagements within global institutions and adopt more of an "activist" posture in pursuing conflict resolution and compromise with international partners. They do not challenge or threaten the global economic or military balance and support liberal democracy as a desirable ideology.

Secondly, middle powers tend to stabilise and legitimise the world order since they occupy relatively privileged positions within it, whether that privilege is global (for traditional middle powers) or regional (for emerging middle powers).[231] They therefore pursue security and order internationally, as well as incremental and gradual reform, and strongly uphold international law since it secures their interests and reduces threats. Because middle powers do not have the ability of the great powers to directly change global structures, they prefer to build legitimacy through multilateral arrangements in international organisations. In turn, middle powers help to legitimise global power relations since international organisations reflect these power relations in their structure (including "institutionalised global inequality").[232]

The differences between traditional and emerging middle powers include both constitutive and behavioural elements. First, in contrast to traditional middle powers, emerging middle powers possess not only deep social divides, but also in many cases, democracy is far from consolidated, and "undemocratic practices" are still prevalent.[233] Second, because emerging middle powers do not, like traditional

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[229]Eduard Jordaan, "The Concept of a Middle Power in International Relations: Distinguishing Between Emerging and Traditional Middle Powers," *Politikon* 30, no. 2 (2003): 165.

[230]Ibid., 167.

[231]Ibid., 167–169.

[232]Ibid., 170.

[233]Ibid., 171.

middle powers, have to mediate between two superpowers locked in the Cold War, they place more of an emphasis on economic matters and issues of justice and equality than on military or political ones. This is another feature visible in Africa's space posture. Third, emerging middle powers tend to fall in the medium human development category, and despite having great economic inequalities, they have elites who are closely tied and integrated into the global economy.[234]

Fourth, because emerging middle powers are dominant in their regions, such as South Africa and Nigeria, they are much more in favour of regional cooperation and integration. Traditional middle powers are much more doubting of the prospect of regional integration since they are not the most powerful states in their regions. The reluctance of Scandinavian countries to engage in regional organisations is an example of this (both for the European Union in the case of Norway and the North Atlantic Treaty Organisation in the case of Sweden).[235] This also explains why emerging middle powers in Africa are drivers of regional structures, such as South Africa in the case of SADC and Nigeria in ECOWAS, while presidents Obasanjo and Mbeki were some of the key figures in promoting NEPAD.[236] Regionally emerging middle powers "seek to exploit their dominance . . . [while] they attempt to smooth over the destabilising effects of their regional dominance".[237] The lingering distrust and scepticism by many African states of South Africa, due to its Apartheid history, the "imperialist posture" of South African corporations in business dealings on the continent, and "instances where Pretoria has pursued its narrow interests at the expense of other African countries" are examples of this.[238] Emerging middle powers are regarded globally as more neutral precisely since they tend to focus on their regional associations,[239] such as the example of South Africa being more accepted in global institutions than in regional ones, such as the World Trade Organisation or BRICS.[240] In line with this, emerging middle powers are also more likely than traditional middle powers to be active members (and leaders) of associations dominated by the South, such as the UN General Assembly and the Non-Aligned Movement.[241] This has been called the "tightrope" that emerging middle countries must walk in mediating between their regional, and narrower, interests and the demands of the great or hegemonic powers in the world system.[242]

[234]Ibid., 172.

[235]Ibid., 172.

[236]Ibid., 173.

[237]Ibid., 177.

[238]Oluwaseun Tella, "Space as a Fulcrum of Nigeria's External Relations and Regional Hegemony," *Space Policy*, (2018): 2.

[239]Jordaan, "The Concept of a Middle Power in International Relations: Distinguishing Between Emerging and Traditional Middle Powers," 177.

[240]Tella, "Space as a Fulcrum of Nigeria's External Relations and Regional Hegemony," 2.

[241]Jordaan, "The Concept of a Middle Power in International Relations: Distinguishing Between Emerging and Traditional Middle Powers," 177.

[242]Ibid., 178.

In terms of behaviour, emerging middle powers have depended on internationally prominent leaders to construct their middle power identity, and the roles of Nelson Mandela in mediating in a series of international conflicts (including the Israeli-Palestinian conflict, Northern Ireland, war in the Democratic Republic of the Congo, etc.) is a case in point.[243] Thabo Mbeki, Olusegun Obasanjo, and other high profile leaders in Brazil, Argentina, and Malaysia in establishing their states as middle powers are further examples. Additionally, emerging middle powers tend to be more reformist than traditional middle powers, while still being averse to fundamental change.[244]

This concept of a middle power (traditional or emerging) has never been applied to the space arena before. In doing so, the features discussed above will be specifically applied to the space activities and relations of (African) countries. The goal and advantage of this is that it provides a framework for identifying and classifying the emerging space nations of Africa and provides a model for predicting states' behaviour (activities and relations) vis-à-vis space. The hypothesis is that the emerging (space) middle powers of Africa (primarily South Africa and Nigeria, plus others identified through this study) will carry forth these principles in their space postures as well. Thus, these middle powers are expected to (1) be strong proponents of the existing order in relation to outer space and will be advocates of international law in this field (evidenced by their roles and actions in UNCOPUOS and other space organisations and ratification of UN treaties on outer space); (2) stabilise and legitimise this order through multilateral arrangements in international organisations; (3) place strong emphasis on the socio-economic benefits of space technology as opposed to military or security objectives; (4) strongly favour and drive regional and continental efforts to create space institutions and structures (including policy) in Africa while taking a leading or dominant position in these; (5) tend to mediate or foster relationships between global powers and other African states; and (6) seek gradual reforms in international bodies to increase the profile of Africa. This framework allows us to identify several emerging "space middle powers" in Africa that uphold the international order in space and contrast them to those states that have challenged the international order, such as Kenya, Uganda, and the then Zaire which were signatories to the Bogotá Declaration.[245]

This concept of emerging space middle powers also contains an important distinction from that of more traditional regional powers. The features of regional powers are summarised as states that conceive of themselves as leaders in their region; possess power projection capabilities; influence regional affairs; influence the "political-ideational construction" of their region; use their influence in regional governance structures; strongly influence the regional security agenda; present a

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[243] Ibid., 175.

[244] Ibid., 176.

[245] The Bogotá Declaration was made in 1978 by eight equatorial countries in which they claimed sovereignty over geostationary orbit above their territories. The Bogotá Declaration, https://bogotadeclaration.wordpress.com/declaration-of-1976/ (accessed September 23, 2018).

common regional identity or project; provide or assist in providing a collective good for the region; are recognised globally for their regional leadership; and represent their regions in global forums.[246] While there are many similarities, the concept of regional powers misses the crucial distinction of middle powers as upholders of the global status quo (since they have a stake in it to maintain their relative advantage) and as mediators in legitimising that status quo in their regions. Thus, if the active participation of all (or most) African states in the space arena is to be achieved, the role of the emerging space middle powers in legitimising the governance structures and "status quo" (treaties, etc.) is crucial. These emerging space middle powers must be the bridge between Africa and outer space.

### *1.3.2 Methods for Ranking African Space Capabilities*

In the literature, a variety of frameworks are employed to facilitate analysis of national space capabilities. These will be considered in the following chapters and applied during the analysis of African space activities and infrastructure, as part of identifying those emerging space middle powers that are the drivers of developments in the space arena. The first approach, taken by Wood and Weigel, uses the Space Technology Ladder to provide a framework to chart the path countries have taken in terms of their technological capacity in space technology.[247] It provides four major technology categories that allow for the mapping of the historical achievements of countries. These categories emphasise the milestones representing "steps forward in capability building and technological learning" and thus increase in technological complexity, namely, (1) establishing a national space office or agency; (2) having a satellite in low Earth orbit (LEO); (3) having a satellite in geostationary orbit; and (4) having independent launch capability.[248] What makes the Space Technology Ladder such a powerful analytical tool is that within each of these categories, subcategories are found that clearly identify where countries are in terms of technological complexity. It is thus particularly suited to studying the space achievements of emerging space countries, since large players such as the United States, Europe, Russia, China, and India have already achieved all milestones. The milestones are ranked *within* each category in terms of their "technical complexity and managerial autonomy" but not necessarily *between* categories. For example, building an LEO satellite locally ranks higher in terms of complexity and autonomy than procuring a GEO satellite from abroad, explaining why milestones are not always ranked between categories.

[246]Tella, "Space as a Fulcrum of Nigeria's External Relations and Regional Hegemony," 1–2.

[247]Danielle Wood and Annalisa Weigel, "Charting the Evolution of Satellite Programs in Developing Countries – The Space Technology Ladder," Space Policy 28, (2012).

[248]Wood and Weigel, "Charting the Evolution of Satellite Programs in Developing Countries – The Space Technology Ladder," 16–17.

Wood and Weigel's Space Technology Ladder is also useful since it allows for the creation of a graphical timeline, comparing the achievements of various African countries. Wood and Weigel only did so for Algeria, Nigeria, and Egypt, up to 2012, and thus this study will take their framework further up to the present, for all African countries that have achieved at least one of the milestones. This will be done in Chap. 3, along with modifications found in literature related to the Space Technology Ladder. Such an analysis will inform the discussion of how space is currently being used in Africa to support the primary needs discussed earlier, and this particular framework is well-suited to unpacking the space-related capacity-building efforts of various countries, such as through procuring an LEO satellite with training services from abroad.

The second framework was created by Harding and provides a larger picture that identifies two main groups of countries.[249] The first group is the category of developed space actors (DVSAs). These are the actors with a "full range of capabilities".[250] The United States, Russia, Japan, and Europe fall in this category.[251] The second group is that of emerging space actors (EMSAs).[252] This category is itself further subdivided into three tiers. The first-tier EMSAs are the "largest and most capable" states within their group and are China, India, and Brazil.[253] More important for this study are the second- and third-tier EMSAs, which Harding describes as "smaller but no less enthusiastic states [that] now make up the majority of the world's space actors".[254] Harding explains the differences between second- and third-tier EMSAs as follows:

> The 'second tier' states are those that produce some of their own space technology, have basic launch capacity (typically sounding rockets), have national space agencies, and frequently, out of necessity, collaborate with more advanced states' programs in the production of space technology. The 'third tier' states occasionally make contributions in space-related technology, almost always purchase space-related technology from more advanced producers, and almost always collaborate with other more developed space actors to achieve their space policy goals. Rather than being space-faring, third tier space actors have made the policy decision to invest in space technology to accomplish what could not be done otherwise.[255]

For Harding, the only African country falling within the second tier is South Africa, for the following reason:

> While, in almost every case, these second tier space programs' projects have included plans with dedicated socioeconomic designs, such as remote-sensing satellites to improve agricultural production, the underlying rationale for second tier programs conforms to the central thesis of this book. Given sufficient investment potential, the space activities of most second

249 Harding, *Space Policy in Developing Countries*.

250 Ibid., 81.

251 Ibid., X.

252 Ibid., 6.

253 Ibid., 14.

254 Ibid., 14.

255 Ibid., 79.

> tier EMSAs began as security-oriented programs that, as was the case with space programs in the developed world, were at best projects in which a country's military has had great institutional interest and occasional participation, and at worst mere window dressing for furthering ballistic missile development programs. However, for some second tier space actors, their bellicose beginnings have transformed over time into purely civilian programs with the sole purpose of contributing to national socio-economic development.[256]

Third-tier states do sometimes make contributions in space-related technology but "almost always" collaborate with more developed space actors and purchase space-related technology from these.[257] Thus, while these states are not space-faring per se, they have made policy decisions to "invest in space technology to accomplish what could not have been done otherwise".[258]

While South Africa's space endeavours have undergone this transformation into serving purely civilian ends (with the exception of one military reconnaissance satellite—more on this later in the study), it underscores the point that all of the space activities in the rest of Africa began with a focus on socio-economic benefit, not military ends. For third-tier space actors, "the definition of national security now transcends the traditional realist paradigm to include a plethora of socioeconomic and political benefits derived from ownership of a slice of the space pie".[259] Harding also makes the critical point—that goes beyond Wood and Weigel's ladder—that countries do not have to own their own satellites to take part in the space arena: "[q]uite a few developing states today utilize space-based assets for a wide variety of applications, including communications, weather monitoring, and resource planning, even if the data is merely purchased from more developed space actors".[260] This point has been underscored by the argument that it "has become apparent . . . that a nation does not need to have a satellite in space to be space capable", for example, "[s]everal countries are space capable, are avid users of Earth observation data, and do not yet have any specific space-based assets of their own".[261] For this reason, it has also been cautioned against jumping over "fundamental steps" of building local space expertise and indigenous scientific and technological skills and infrastructure in any race to pursue participation in space, since such participation "does not necessarily mean a physical presence in space and satellites and space vehicles, nor does it necessarily mean that a given country should be able to deploy payloads in space with its roaring rockets".[262] This is also echoed by Sharpe, the business manager of the Square Kilometre Array (SKA) in South Africa, that "[s]pace science and technology is not just rockets. It's everything from data analytics,

[256]Ibid., 123–124.

[257]Giorgio Petroni and Davide Gianluca Bianchi, "New Patterns of Space Policy in the Post-Cold War World," *Space Policy* 37, (2016): 14.

[258]Ibid.

[259]Ibid., 145.

[260]Ibid., 145.

[261]Adigun Ade Abiodun, "Trends in the Global Space Arena – Impact on Africa and Africa's Response," *Space Policy* 28, (2012): 285–288.

[262]Ibid., 288.

data storage and transport and more. There are so many areas of development within the arena which are classified as space science".[263] This is a potent response to those criticisms, discussed below, that Africa is wasting money on grandiose space projects instead of focusing on more pressing concerns.

Thus, the approach of Harding will be used to augment that Space Technology Ladder of Wood and Weigel in this study, and it will be investigated whether any African third-tier EMSA has joined the second tier.

The third framework that adds more detail than the Space Technology Ladder is the European Space Agency's Technology Readiness Level (TRL). Although this TRL applies to the "technical maturity of instruments and spacecraft sub-systems with respect to a specific space application",[264] it is not difficult to see some overlap with Wood and Weigel's ladder when viewed in a broader sense. The TRL consists of nine levels, increasing in complexity: (1) basic principles observed and reported; (2) technology concept and/or application formulated; (3) analytical and experimental critical function and/or characteristic proof of concept; (4) component and/or breadboard functional verification in laboratory environment; (5) component and/or breadboard critical function verification in relevant environment; (6) model demonstrating the critical functions of the element in a relevant environment; (7) model demonstrating the element performance for the operational environment; (8) actual system completed and accepted for flight ("flight qualified"); and (9) actual system "flight proven" through successful mission operations.[265] While it is outside the scope of this study to analyse technical components to this degree, some reference will be made in tandem with the Space Technology Ladder to, for example, satellites that are accepted for flight but not yet in space (thus not yet appearing on the ladder). Thus, the TRL will only be used to supplement the other frameworks where relevant.

The regional approach discussed earlier will form the final framework. As Aganaba-Jeanty argues, it makes more sense to approach space activities in Africa from such an REC-based approach than through a pan-African one, since the RECs are both the building blocks of the AU and have at least one space agency each.[266] The reduction of trading and tariff barriers within the SECs also means that space technology can make easier inroads in a region from the inside and via local partnerships. While some of the RECs have overlapping membership, the study will approach African space activities, infrastructure, and capabilities from REC-based perspective. This will greatly facilitate the discussion of space-related policies as well. Indeed, as was mentioned earlier, it has been argued that Africa needs a variety of subregional "growth poles"[267]—and for the purposes of this study

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[263] Chris Giles, "Africa Leaps Forward into Space Technology," *CNN*, August 10, 2017, https://edition.cnn.com/2017/08/10/africa/africa-space-race/index.html (accessed July 1, 2018).

[264] European Space Agency, "Technology Readiness Level (TRL)," 2017, http://sci.esa.int/sci-ft/50124-technology-readiness-level/ (accessed July 8, 2018).

[265] Ibid.

[266] Aganaba-Jeanty, "Precursor to an African Space Agency: Commentary on Dr. Peter Martinez 'Is There a Need for an African Space Agency?'," 173.

[267] Nhamo, "New Global Sustainable Development Agenda: A Focus on Africa," 1.

these include *space* growth poles. Indeed, one of the key themes of this volume is to identify these African space growth poles.

## 1.4 The African Space Arena

Today, space forms an integral part of the everyday lives of people on all continents and in all countries. While the role of space technology often goes unseen, it has become an integral part of the global economy, and modern life is made possible because of the data that comes from, or through, space.[268] Weather forecasts, satellite navigation, communications, Earth observation (EO), and monitoring of the natural environment, including disasters, all these are dependent on space data and space technology. The global space economy reached $345 billion worldwide in 2016.[269] This can be broken down into two main categories: the satellite industry ($260.5 billion) and the non-satellite industry ($84 billion), with the latter consisting almost entirely of government budgets ($82.9 billion) plus a small ($1.1 billion) commercial human spaceflight segment. The biggest segment of the satellite industry is made up of television services ($97.7 billion) followed by satellite ground equipment ($60.8 billion) and GNSS chipsets and related technology ($52.6 billion). Fixed satellite service made up a further $17.4 billion, followed by satellite manufacturing ($13.9 billion), launch services ($5.5 billion), satellite radio ($5 billion), mobile satellite service ($3.6 billion), and broadband and commercial remote sensing (both $2 billion). The non-satellite industry can be broken down into US government spending ($47.5 billion) and non-US government spending ($35.4 billion) with China and Europe dominating this category. Furthermore, the space economy is expected only to grow in the future, giving more urgency for all countries to become more involved. Over the next three decades, the Bank of America Merrill Lynch expects the space economy to grow to “at least” $2.7 trillion.[270]

When reflecting on these figures, it is worth emphasising that all money is spent on the ground, where it creates jobs and stimulates large sectors of the economy, including those commercial enterprises indirectly taking part in the space arena and those that depend on space-related data. The same is true for space-related tourism, of which 99% takes place on the ground (astronomy tourism in South Africa is a good example of this).[271] It is thus of little surprise that many countries are showing

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[268] Deganit Paikowsky, Gil Baram, and Isaac Ben Israel, “Trends in Government Space Activity and Policy in 2013,” *Astropolitics* 12, no. 2–3 (2014): 108.

[269] Bryce Space and Technology, “Global Space Industry Dynamics,” 2017, 1, https://brycetech.com/downloads/Global_Space_Industry_Dynamics_2017.pdf (accessed July 4, 2018).

[270] Michael Sheetz, “The space industry will be worth nearly $3 trillion in 30 years, Bank of America predicts,” *CNBC*, October 31, 2017, https://www.cnbc.com/2017/10/31/the-space-industry-will-be-worth-nearly-3-trillion-in-30-years-bank-of-america-predicts.html (accessed July 7, 2018).

[271] Gottschalk, “Astronaissance: Communicating Astronomy & Space to the African Imagination,” 7.

growing interest in space and in participating in space activities. This is because apart from the symbolic significance of space in terms of technological achievement and prestige, today, space investment constitutes a "tangible national need".[272]

Today, the space sector, of which Africa forms part, looks different from that which was dominated by the Cold War superpowers. For one, the very fact that there are more independent states today due to the breakup of the colonial empires during the Cold War, and the Soviet Union at its end, has resulted in greater system complexity.[273] On top of this, the growing presence of non-state actors alongside state actors in space has created a very different landscape than that which was characterised by US-Soviet rivalry. While state actors will continue to dominate the space arena for the foreseeable future, it is clear that non-state actors will play an increasingly important role. Apart from the change in actors, the motivations for states to participate in the space sector have also expanded. During the early phase of the Cold War, space was an extension of the ideological struggles between the superpowers, and security and military concerns were predominant. For example, the first-generation satellites were dedicated to military purposes, especially espionage, and space activities were subjected to Cold War logic.[274] By the latter part of the Cold War, scientific activities and commercial concerns (especially in communications, as was seen in the modern space economy) had become major parts of the space arena, and today even though space technology maintains its dual-use characteristic, "the market for military use is falling and the market of civil use is on the rise".[275] On top of this, space-faring countries are now making use of space as a political tool to build relationships with nontraditional partners, such that "foreign policy and space are now increasingly overlapping, and therefore reinforcing the radical restructuring that started in the 1990s".[276] While Africa has not been absent from space, it was only by the last decade of the twentieth century that national space programmes were formed or consolidated, and only during and after the 1990s have African countries moved from consumers of space-related services to generators thereof. The next section will provide a brief consideration of this shift.

### *1.4.1 African Space Activities up to the End of the Twentieth Century*

While Africa has taken part in the space sector since its earliest days, and in astronomy since humans first began observing the night sky, Africa's participation

[272]Paikowsky, Baram, and Israel, "Trends in Government Space Activity and Policy in 2013," 108.

[273]Peter, "The Changing Geopolitics of Space Activities," 152.

[274]Giorgio Petroni and Davide Gianluca Bianchi, "New Patterns of Space Policy in the Post-Cold War World," *Space Policy* 37, (2016): 14.

[275]Ibid., 13.

[276]Peter, "The Changing Geopolitics of Space Activities," 153.

in contemporary space activities only truly took off around the turn of the twenty-first century. While this study is not dedicated to an in-depth analysis of the history of African space activities, this section will provide a brief overview of this background to contextualise the in-depth analysis of contemporary African space activities and infrastructure in Chap. 3.

Gottschalk notes that evidence exists to support the notion that astronomy began in Africa at least 35,000 years ago.[277] During the colonial period, the foundations of modern astronomy were laid by European astronomers, such as Nicholas-Louis de Lacaille, who pioneered southern hemisphere astronomy through observations made at the Cape of Good Hope.[278] Additionally, the first permanent telescopic observatory on the continent—the South African Astronomical Observatory (SAAO)—was established by the British Royal Navy in 1820.[279] However, Africans themselves were excluded from these developments, and as Anguma, Jurua, and Asiimwe point out, little consideration was given by missionaries to science and astronomy in early colonial school curricula.[280]

During the twentieth century, African involvement in the space arena gradually increased. In South Africa, involvement in space activities can be traced to the early "Moonwatch" programme that observed the orbits of American and Soviet satellites, and institutional satellite tracking activities continued until the 1970s.[281] Meanwhile, the US National Aeronautics and Space Administration (NASA) built a Deep Space Network station—DSS 51—at Hartebeesthoek to support both its early robotic and later manned lunar missions. This station was transferred to the South African government in 1974 as sanctions against the *apartheid* regime gained ground, and it remains an important centre for radio astronomy in the country. Ground-based astronomy and space physics also gained ground in South Africa from the 1970s, and apart from the Hartebeesthoek Radio Astronomy Observatory, other efforts included the Hermanus Magnetic Observatory and a research base in Antarctica.[282] These and other facilities will be discussed further in Chap. 3. South Africans also took part in amateur rocket experiments via the South African Rocket Research Group (SARRG), formed in 1959.[283] However, South Africa's space endeavours took a military turn in the early 1960s, when the *apartheid* regime began expanding its military-industrial sector, and civilian rocket experiments were closed down and absorbed into a military rocket programme with Israel as partner.[284] In this regard,

[277]Gottschalk, "Astronaissance: Communicating Astronomy & Space to the African Imagination," 2.

[278]N. Heeralall-Issur, "The Development of Astronomy in Mauritius," *African Skies/Cieux Africains*, 2012, no, 16: 24.

[279]Ibid., 5.

[280]S.K. Anguma, E. Jurua, and J.A. Asiimwe, "Development of Education and the Establishment of an Astronomy Curriculum in Uganda," *African Skies/Cieux Africains*, 2012, no. 16: 11.

[281]Martinez, "Space Science and Technology in South Africa: An Overview," 46.

[282]Ibid., 46.

[283]Keith Gottschalk, "South Africa's Space Programme – Past, Present, Future," *Astropolitics* 8, no. 1 (2010): 2.

[284]Ibid., 3; Harding, *Space Policy in Developing Countries*, 138.

South Africa is the only African second-tier space actor, as per Harding's definition,[285] because its space activities had "specific direct as well as indirect benefits to . . . national security and developmental goals", with space specifically seen and utilised as a "force multiplier". These efforts went alongside the development of nuclear weapons.

South Africa was not the only African country with space ambitions or activities. In Zambia, the well-known case of Edward Makuka Nkoloso, and his plans in the 1960s to take Zambians to the moon and Mars in an effort to beat the United States and Soviet Union,[286] demonstrates that Africa was not devoid of space ambition. Nkoloso also coined the term Afronauts. His efforts were derided, and Nkoloso was described as a crackpot and Zambia's village idiot.[287] Others have described him as an inspirational figure because in "the year of which he had such a huge dream, it was just highly impossible to think like that in Zambia".[288] In other parts of Africa, space activities were undertaken by European countries, such as the launch of France's first rockets between 1952 and 1967 from the Hammaguir launch facility in the Algerian Sahara,[289] and the Italian activities in Kenya at the Luigi Broglio Space Centre in Malindi and the San Marco offshore launch platform, starting in the 1960s.[290] Non-governmental activities were also undertaken by European actors, such as the controversial operations of the West-German *Orbital Transport und Raketen Aktiengesellschaft* (OTRAG) in the then Zaire and Libya.[291]

Elsewhere in Africa, fitful efforts were undertaken to establish national space programmes. In Egypt, "half-hearted" efforts were undertaken in the late 1950s,[292] while President Nasser's envisioned full-fledged space agency in the 1960s never came to fruition.[293] In Zambia, the idea of the Zambian Space Administration was

[285]Harding, *Space Policy in Developing Countries*, 123–4.

[286]China Central Television, "Faces of Africa 09/09/2013 Makuka Nkoloso: the Afronaut," *CCTV.com*, September 9, 2013, http://english.cntv.cn/program/facesofafrica/20130909/100179.shtml (accessed July 4, 2018).

[287]Namwali Serpell, "The Zambian "Afronaut" Who Wanted to Join the Space Race," *The New Yorker*, March 11, 2017, https://www.newyorker.com/culture/culture-desk/the-zambian-afronaut-who-wanted-to-join-the-space-race (accessed July 4, 2018).

[288]China Central Television, "Faces of Africa 09/09/2013 Makuka Nkoloso: the Afronaut."

[289]GlobalSecurity.org, "Hammaguir/Hamaguir," 2011, https://www.globalsecurity.org/wmd/world/france/hammaguir.htm (accessed July 4, 2018).

[290]Agenzia Spaziale Italiana, "'Luigi Broglio' Space Center," 2009, https://www.asi.it/en/agency/bases/broglio (accessed July 4, 2018).

[291]Oyewole, "Space Research and Development in Africa," 189.

[292]Peter Schwartzstein, "The Bizarre Tale of the Middle East's First Space Program," *Smithsonian.com*, October 17, 2016, https://www.smithsonianmag.com/history/bizarre-tale-middle-easts-first-space-program-180960808/ (accessed July 4, 2018).

[293]Africa Times, "Egypt's space program takes another step toward liftoff," September 27, 2017, https://africatimes.com/2017/09/27/egypts-space-program-takes-another-step-toward-liftoff/ (accessed July 4, 2018).

touted in 1991 but "unfortunately died a natural death".[294] However, as the twentieth century drew to a close, the end of the Cold War and the fall of the apartheid regime in South Africa signalled a fundamental transformation of the space arena and the rapid development of more concerted, formal, civilian space programmes in Africa—in Egypt (1971), Nigeria (1999), Algeria (2002), and South Africa (2010). More followed after these, and they and their space activities will be analysed in following chapters.

As Harding[295] argues, at the end of the Cold War, the emerging third-tier space actors (such as Egypt, Nigeria, and Algeria) "genuinely embraced space activities as legitimate long-term means to promote socioeconomic development", and the second-tier EMSAs began to view national security in a much broader sense to include human well-being, as mentioned earlier. For this reason, Gottschalk refers to the synergy and merger of the African Renaissance, the resurgence of African astronomy, and the rise of space science and astronautics as the Astronaissance—a term originating from the organisers of the first International Astronautical Congress held in Africa in 2011 in Cape Town, South Africa.[296] This term powerfully encapsulates the recognition that is now afforded to space in achieving Africa's developmental goals. The next section reflects on how space has been harnessed in the AU's African Space Policy and Strategy, a guiding document for the development of the sector on the continent. Debates around the establishment of an African Space Agency will also be considered.

### *1.4.2 The Astronaissance: The African Space Policy and Strategy and the African Space Agency*

Africa has particular natural advantages that make it well-suited for advances in the space sector, particularly astronomy and space sciences. Southern Africa, for example, is a favourable location for large optical and radio astronomy projects because of "excellent climatic conditions", political stability, and an adequate industrial base and infrastructure,[297] while Ethiopia's "topography, its proximity to the equator, and the dry atmospheric conditions on its highlands qualify it as one of the very few countries in the world that is best suited for space science and astronomy research".[298] Southern Africa's location between Australia and Chile also allows for "uninterrupted long baseline observations in the Southern hemisphere", and the

[294] P. Sibanda and L.A. McKinnell, "Space Science and Technology in Zambia: Recent Developments," *African Skies/Cieux Africains*, 2008, no. 12: 50.

[295] Harding, *Space Policy in Developing Countries*, 145–146.

[296] Gottschalk, "Astronaissance: Communicating Astronomy & Space to the African Imagination," 1.

[297] Martinez, "Space Science and Technology in South Africa: An Overview," 47.

[298] S.B. Tessema, "Astronomy and Space Science Development in Ethiopia," *African Skies/Cieux Africains*, 2012, no. 16: 41.

benefit to astronomy of having in Sutherland (in South Africa) "one of the observatories with the darkest skies on Earth" cannot be overstated.[299]

Despite these natural advantages, when considering government spending on space, Africa is a very small player in the space arena. Considering the figures listed earlier of total government space budgets in 2016 ($82.9 billion), African space budgets are a very modest share of this: Euroconsult reports that, for the same year, only seven African countries spent more than $10 million.[300] These were Algeria ($115 million), Morocco ($73 million), Angola ($63 million), Nigeria ($61 million), Egypt ($53 million), the Democratic Republic of the Congo ($20 million), and South Africa ($20 million). Of South Africa, it was remarked in 2010 that it is "on the tightest budget of any space player",[301] but this remains a good characterisation of Africa as a whole. At the same time, despite the previous space investments made in South Africa, there is clear evidence of the willingness to commit to the development of the space sector since the "democratic black state has committed more funds to Astronomy during its first 15 years than all the earlier colonial and apartheid regimes spent over the previous 150 years".[302] Yet, it is argued that government investment in space is lagging in Africa, and this has a very negative consequence since "[w]ithout government investment in space, you don't get an industry that burgeons around it".[303] This is where the recognition by the AU of the importance of space, and the laying out of why Africa needs to take part in the space economy and what it needs to do to get there, is so important.[304] For this reason, the adoption of the African Space Policy and Strategy (ASPS) in 2016 by the African Union Heads of State and Government, drawn up by the African Union Working Group on Space, was such an important milestone for the space sector on the continent. Additionally, the Science, Technology and Innovation Strategy for Africa 2024 (STISA),[305] adopted in 2014, also recognises the space sector's importance.

The African Space Strategy is built upon, and supports, five core principles: (1) development of the services and products required to respond effectively to the socio-economic needs of the continent; (2) development of indigenous capacity to operate and maintain core space capabilities; (3) development of an industrial capability that is able to translate innovative ideas from research and development

[299] R. Sefako, "The Astronomy Geographic Advantage Act – Protecting South African Astronomy," *African Skies/Cieux Africains*, 2012, no. 16: 38.

[300] Euroconsult, "Government Spending in Space Programs Reaches $62 Billion in 2016," May 30, 2017, http://euroconsult-ec.com/30_May_2017 (accessed July 5, 2018).

[301] Gottschalk, "South Africa's Space Programme – Past, Present, Future," 3.

[302] Ibid., 7–8.

[303] Sarah Wild, "Making the case for African investment in space programmes," *AfricaPortal.org*, February 6, 2018, https://www.africaportal.org/features/making-case-african-investment-space-programmes/ (accessed July 5, 2018).

[304] Ibid.

[305] African Union Commission, *STISA-2024: Science, Technology and Innovation Strategy for Africa 2024*, 2014, Addis Ababa. https://au.int/sites/default/files/newsevents/workingdocuments/33178-wd-stisa-english_-_final.pdf (accessed July 1, 2018).

into the public and commercial sectors; (4) coordination of space activities across member states and regions to minimise duplication, but maintaining sufficient critical mass; and (5) fostering international cooperation within Africa and with the rest of the world as a means of realising the full value proposition of the space sector.[306] The strategy recognises that the implementation of the continent's policy frameworks "is highly dependent on space technologies and applications" and that decision-making depends on "sound, secure spatial data".[307] It also places an emphasis on the need for indigenous capabilities and space programmes, so as to avoid Africa remaining a net importer of space technologies.

Four key areas of space technology and applications are highlighted for their value to Africa's socio-economic development. These are Earth observation, navigation and positioning, satellite communications, and space science and astronomy.[308] The strategy sets out the vision for "[a]n African space programme that is user-focused, competitive, efficient and innovative" with two broad goals[309]: first, the provision of "[s]pace-derived products and services used for decision-making and addressing economic, political, social and environmental challenges" and, second, the development of "[a]n indigenous space capability, in both the private and the public sectors, for a coordinated, effective and innovative African-led space programme".[310] The five associated strategic actions to make these possible are listed in Table 1.10.

Some of the indicators listed in Table 1.10 will be discussed in greater depth in later chapters, particularly under African space activities, as well as in the subsequent volume. The strategy further delves into specific interventions in relation to each of the four key areas of space technology and applications listed earlier.[311] It also recognises that in order to actualise these specific technical interventions, supporting programmes are required focusing on human capital and on generating and promoting space awareness.[312] Infrastructure, industrial involvement, and international partnerships are further supporting programmes. However, the best way to summarise the strategy is to consider its projected outcomes, which are listed on 1-year, 5-year, and 10-year timescales. Some of these are very ambitious, and others, like the creation of an African space programme, are subjects of intense debate regarding the appropriateness of establishing such an agency within the given timescale. These outcomes are listed in Table 1.11, with the note that the policy and strategy documents were adopted in 2016, thus meaning 2018 constitutes the second year.

[306] African Union Commission, *African Space Strategy: Towards Social, Political and Economic Integration*, 3.

[307] Ibid., 5.

[308] Ibid., 6.

[309] Ibid., 13.

[310] Ibid., 13.

[311] Ibid., 18–21.

[312] Ibid., 21.

**Table 1.10** Strategic goals, actions, and associated indicators of the African Space Strategy

| | | |
|---|---|---|
| Strategic objectives | 1. *Addressing user needs*: harnessing the potential of space science and technology to address Africa's socio-economic opportunities and challenges | |
| | 2. *Accessing space services*: strengthening space mission technology on the continent to ensure optimal access to space-derived data, information services, and products | |
| | 3. *Developing the regional and international market*: developing a sustainable and vibrant indigenous space industry that promotes and responds to the needs of the African continent | |
| | 4. *Adopting good governance and management*: adopting good corporate governance and best practices for the coordinated management of continental space activities | |
| | 5. *Coordinating the African space arena*: maximising the benefit of current and planned space activities and avoiding or minimising the duplication of resources and efforts | |
| | 6. *Promoting international cooperation*: promoting an African-led space agenda through mutually beneficial partnerships | |
| Strategic actions and indicators | 1. *Leveraging space-derived benefits*<br>Space-derived benefits must transcend all spheres of government, from continental level right down to municipal level. In addition, benefits for women and the youth must be factored into the outcomes of these initiatives | *Indicators:*<br>a. Number of communities of practice<br>b. Returns on investment |
| | 2. *Strengthening research, development, and innovation*<br>Research, development, and innovation initiatives should provide opportunities for the scientific and engineering space workforce to internalise the current intellectual capital and excel in the development of next-generation technology platforms, products, and services | *Indicators:*<br>a. Number of services and products using African capacities<br>b. Number of publications<br>c. Number of patents<br>d. Number of industrial designs<br>e. Number of space-related research centres |
| | 3. *Developing and using human capital*<br>Investment in human capital development should ensure that higher education and training institutions, including the special purpose Pan-African University Space Science Institute, are capacitated to produce the next cohort of scientists and engineers | *Indicators:*<br>a. Number of graduates in space-related fields<br>b. Number of space-related experts employed in space-related professions |
| | 4. *Institutionalising a corporate governance structure*<br>A corporate governance structure, including rules and procedures, should be adopted for the management of Africa's space programme and activities | *Indicators:*<br>a. A formal corporate governance structure established<br>b. Achievement of strategic goals |
| | 5. *Adhering to regulatory requirements*<br>A regulatory framework should be | *Indicators:*<br>a. A regulatory framework that is |

(continued)

**Table 1.10** (continued)

| | | |
|---|---|---|
| | institutionalised to support Africa's space activities so that the continent can compete effectively in the global space market, in line with international treaties, conventions, and principles. It is also important to ensure effective African participation in international multilateral forums to secure Africa's access to space, including the assignment and use of orbital slots and the frequency spectrum, for both space infrastructure and ground-based infrastructure | supportive of space activities<br>b. Number of contributions made in multilateral forums crucial for the peaceful uses of outer space<br>c. Coordination of mechanisms instituted by AU member states<br>d. Number of orbital slots obtained for Africa |
| | 6. *Building critical infrastructure*<br>An integrated network linking regional and continental institutions should be established to build appropriate infrastructure. It is also necessary to develop an integrated network and complementary data processing facilities dedicated to the provision of data to users for applications at continental, regional, and local levels<br>African governments should be encouraged to create an enabling environment for the development of an indigenous space-related industry. The African Resource Management Constellation initiative should be leveraged and the participation of other African countries encouraged | *Indicators:*<br>a. Number of early warning systems on the continent<br>b. Number of space missions<br>c. Number of space receiving/transmitting/processing facilities<br>d. Number of networks created and percentage of coverage |
| | 7. *Fostering regional coordination and collaboration*<br>Joint technology development, knowledge sharing, technology transfer, and the management of intellectual property should be promoted and strengthened | *Indicators:*<br>a. Number of collaborative intracontinental programmes |
| | 8. *Promoting strategic partnerships*<br>All partnerships should be underpinned by complementary contributions and mutual benefits | *Indicators:*<br>a. Number of public-private partnerships<br>b. Number of intra-Africa institutional partnerships<br>c. Number of international partnerships |
| | 9. *Funding and sustainability*<br>Funding should be secured from African governments, the private sector, and philanthropists. A financial mechanism/instrument should be developed to generate the funds needed for the African space programme | *Indicators:*<br>a. Level of long-term funding secured from the continent<br>b. Financial mechanism for the raising of funds developed |

African Union Commission, *African Space Strategy: Towards Social, Political and Economic Integration*, 3

**Table 1.11** Projected outcomes of the African Space Strategy

| |
|---|
| *Projected 1-year outcomes:* |
| 1. Establishment of the governance elements needed for a sustainable space programme, including regional centres of excellence |
| 2. Approval and implementation of an intercontinental and international partnership plan |
| 3. Approval and implementation of a human capital and infrastructure development plan |
| 4. Ongoing research, development, and technology transfer programmes that will contribute to building the foundations for a continental space programme |
| *Projected 5-year outcomes:* |
| 1. An established continental space programme |
| 2. Appropriate technology platforms in place to support the various components of a continental space programme |
| 3. Advances in human capital development that support the continental space programme |
| 4. Strategic partnerships, both intercontinental and international, through projects that promote research and technology development |
| 5. Operational and ongoing developments of space application services and products for the broader public good |
| 6. Well-defined funding mechanisms for sustainability |
| *Projected 10-year outcomes:* |
| 1. A continental space programme that is globally positioned and ranked in the world's top 10 |
| 2. Independent Earth observation high-resolution satellite data available for all of Africa from a constellation of satellites designed and manufactured in Africa |
| 3. Appropriate services and products relating to space applications |
| 4. Indigenous space capacity, in terms of both technology platforms and human capital |
| 5. Spin-off enterprises emanating from space activities and programmes |
| 6. Strategic partnerships, both within and outside Africa, that are translated into viable space missions, applications, products, and services |

African Union Commission, *African Space Strategy: Towards Social, Political and Economic Integration*, 24

The Africa Space Strategy works in tandem with the African Space Policy, which at its core "provides the main tenets and guiding principles for the establishment of a formal African space programme".[313] The policy begins by setting out some of the ways in which space is already benefiting the African continent. These include space applications, which "are effective tools for monitoring and conducting assessments of the environment, managing the use of natural resources, providing early warnings of and managing natural disasters, providing education and health services in rural and remote areas, and connecting Africa with people around the world" while also being "heavily employed in transportation services, which is another essential component of sustainable development in Africa . . . [since] transportation allows mobility, promotes commerce, and fosters education and health".[314] This is not done by accident, since in Africa there is always a "need to justify expenditure on space-

[313] Ibid., 25.

[314] African Union Commission, *African Space Policy: Towards Social, Political and Economic Integration*, 2017, Addis Ababa, 6. https://au.int/sites/default/files/newsevents/workingdocuments/33178-wd-african_space_policy_-_st20444_e_original.pdf (accessed July 3, 2018).

related endeavours", and not without reason.[315] Any expenditure on space, however modest, must always compete against many other pressing socio-economic needs. This goes hand in hand with the continued need to spread public and political awareness about the impact of space on people's everyday lives. The criticisms levelled against African space endeavours have been based on the idea that these expenditures have been a waste and do not contribute to development. For instance, in 2013 the UK government came under fire for giving aid to Nigeria amounting to 300 million pounds in 2013 and 1.14 billion pounds over 5 years, which was also meant to support the Nigerian space programme. Fierce criticism included UK Members of Parliament remarking "don't worry, we will feed your public for you while you waste your money on all sorts of other projects", while another MP commented "it was folly to give billions in aid to Bongo Bongo land".[316] This underlying current of thought that space spending is wasteful for African governments is a major reason for the need to continue awareness campaigns regarding the benefits and everyday roles of space technology in supporting modern life. It is also rightly argued as "a wakeup call to Nigeria [and other African governments] to expedite its space human capacity programme and its goal of self-reliance in space science and technology".[317]

Consequently, it is argued that one of the needs for the African Space Policy is to counter the lack of political commitment to space and satellite applications on the continent and to establish a clear link between "priorities of the various African countries and how space can assist in achieving them".[318] The policy is also needed to establish sufficient coordination in space at both the regional and continental levels. The specific policy goals, objectives, and principles encapsulated in the policy document, which together form the "guiding framework for the formalisation of an African space programme",[319] are given in Table 1.12.

In concert with the African Space Policy and Strategy, the earlier-mentioned STISA-2024 is a critical document and African Union policy framework for the space sector since it situates "science, technology and innovation at the epicentre of Africa's socio-economic development and growth".[320] The strategy identifies six priority areas (Table 1.13) and four mutually reinforcing pillars. These pillars are "building and/or upgrading research infrastructures; enhancing professional and technical competencies; promoting entrepreneurship and innovation; and providing

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[315]Luncedo Ncofe and Keith Gottschalk, "The Growth of Space Science in African Countries for Earth Observation in the 21st Century," *South African Journal of Science* 109, no. 1/2 (2013): 3.

[316]Tella, "Space as a Fulcrum of Nigeria's External Relations and Regional Hegemony," Quoted in Tella, 4.

[317]Ibid., 4.

[318]Giannopapa, "Improving Africa's Benefit from Space Applications: The European-African Partnership," 101–102.

[319]African Union Commission, *African Space Policy: Towards Social, Political and Economic Integration*, 15.

[320]African Union Commission, *STISA-2024: Science, Technology and Innovation Strategy for Africa 2024*, 10.

**Table 1.12** The high-level policy goals, objectives, and principles of the African Space Policy

| *High-level policy goals:*<br>1. 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<br>2. To develop a regulatory framework that supports an African space programme and ensures that Africa is a responsible and peaceful user of outer space | |
|---|---|
| *Policy objectives:* | *Policy principles:* |
| 1. Addressing user needs | a. To improve Africa's economy and the quality of life of its people |
| | b. To address the essential needs of the African market |
| | c. To develop the requisite human resources for addressing user needs |
| | d. To develop products and services using African capacities |
| | e. To establish communities of practice |
| | f. To develop and enhance early warning systems on the continent |
| 2. Accessing space services | a. To use existing space infrastructure |
| | b. To coherently develop, upgrade, and operate cutting-edge African space infrastructure |
| | c. To promote capacity building for the development of space services |
| | d. To develop and increase our space asset base |
| | e. To establish regional and subregional centres of space competencies |
| | f. To adopt data-sharing protocols |
| 3. Developing the regional market | a. To develop a globally competitive African space programme |
| | b. To create an industrial capability |
| | c. To promote public-private partnerships |
| | d. To promote R&D-led industrial development |
| | e. To use indigenous space technologies, products, and services |
| 4. Adopting good governance and management | a. To establish an organisational framework |
| | b. To support the African space programme financially |
| | c. To maintain an efficient and sustainable African space programme |
| | d. To promote knowledge sharing |
| | e. To conduct and maintain an awareness campaign |
| | f. To monitor and evaluate space activities |
| 5. Coordinating the African space arena | a. To commit funds to optimise and improve effectiveness |
| | b. To harmonise and standardise all infrastructure |
| | c. To regulate space activities |
| | d. To secure the space environment for Africa's use |
| | e. To preserve and maintain the long-term sustainability of outer space |
| 6. Promoting intra-Africa and other international cooperation | a. To promote intracontinental partnerships |
| | b. To forge international partnerships |
| | c. To foster partnerships across all sectors |
| | d. To facilitate equitable partnerships |
| | e. To ensure a reasonable and significant financial and/or social return |
| | f. To influence international agreements |

African Union Commission, *African Space Policy: Towards Social, Political and Economic Integration*, 8–14

**Table 1.13** Science, technology, and innovation strategy for Africa 2024: priorities, research, and innovation areas

| Priorities | Research and/or innovation areas |
|---|---|
| 1. Eradicate hunger and ensure food and nutrition security | a. Agriculture/agronomy in terms of cultivation technique, seeds, soil, and climate<br>b. Industrial chain in terms of conservation and/or transformation and distribution infrastructure and techniques |
| 2. Prevent and control diseases and ensure well-being | a. Better understanding of endemic diseases—HIV/AIDS, malaria, hemoglobinopathy<br>b. Maternal and child health<br>c. Traditional medicine |
| 3. Communication (physical and intellectual mobility)—physical communication in terms of land, air, river, and maritime routes equipment | a. Physical communication in terms of land, air, river, and maritime routes equipment<br>b. Infrastructure and energy<br>c. Promoting local materials<br>d. Intellectual communications in terms of ICT |
| 4. Protect our space | a. Environmental protection including climate change studies<br>b. Biodiversity and atmospheric physics<br>c. *Space technologies*, maritime, and sub-maritime exploration<br>d. Knowledge of the water cycle and river systems as well as river basin management |
| 5. Live together—build the society | a. Citizenship, history, and shared values<br>b. Pan-Africanism and regional integration<br>c. Governance and democracy, city management, mobility<br>d. Urban hydrology and hydraulics<br>e. Urban waste management |
| 6. Create wealth | a. Education and human resource development<br>b. Exploitation and management of mineral resources, forests, aquatics, marines, etc.<br>c. Management of water resources |

African Union Commission, *STISA-2024: Science, Technology and Innovation Strategy for Africa 2024*, 24

an enabling environment for STI development in the African continent".[321] As with the Agenda 2063 10-year implementation plan, STISA-2024 is actualised on three different levels, namely, continental, where the "African Union Commission (AUC), NEPAD Agency and their partners should advocate and create awareness, mobilize necessary institutional, human and financial resources, track progress and monitor implementation"; regional, where the RECs and "regional research institutions, networks and partners should leverage the strategy in designing and coordinating initiatives"; and, most fundamentally, national, where STISA must be incorporated within the development plans of the various African states.[322] What is critical about STISA-2024 is that it recognises space and space technology as critical to Africa's

[321]Ibid.

[322]Ibid.

development. Specifically it states, under priority area 4 (Protection of our space), that "Earth Observation and Monitoring of Africa's abundant natural resources, including minerals, and biodiversity (and associated indigenous knowledge), are important for conserving the welfare of current and future generations", while:

> Space presents a unique opportunity for the continent to collectively address socio-economic development issues through derived services such as Earth Observation, Navigation and Positioning, Satellite Communication Space Science and Astronomy. It further provides a platform for Member States to cooperate and share the enabling infrastructure and data and jointly manage programmes of mutual interest such as disease outbreaks; natural resources and the environment; hazards and disasters; weather forecasting (meteorology); climate change mitigation and adaptation; marine and coastal areas, agriculture and food security; peacekeeping missions and conflicts.[323]

Despite the overriding push for an African space programme within these AU-level documents, and from other high-level sources, there is an ongoing debate within the literature about the merits of such a continental programme. The African Space Strategy in particular is very ambitious in this regard, calling for a continental space programme to be established by 2021 (bearing in mind the policy was formally adopted in 2016 and this is a 5-year goal), and for this programme to rank among the top ten in the world by 2026 (although the strategy is silent on which measures will be used to establish its rank). The next section will highlight the arguments for and against the establishment of such a programme within this timeframe, again with the recognition of the immense disparities in African development identified earlier.

As before, the Agenda 2063 10-year implementation plan provides related priority areas and targets, provided in Table 1.14.[324]

Importantly, one of the key process actions/milestones for this priority area is that an African common position on the international space agenda must have been attained by 2018 (the next volume explores how the statute of the African Space Agency was accepted in 2018). This African position internationally will be explored further in Chap. 2, including the challenges of engaging African states in international space fora.

### *1.4.3 Debates Around the Establishment of the African Space Programme*

While the ASPS does not specifically call for the creation of an African Space Agency, it does, as mentioned, speak of a continental space programme. The desire for an agency is, however, encapsulated in the 2012 Khartoum Declaration, made at the Conference of Ministers in Charge of Communication and Information

[323] Ibid.

[324] African Union Commission, *Agenda 2063: The Africa We Want – First Ten-Year Implementation Plan 2014–2023*, 91.

**Table 1.14** Global affairs priority areas and targets for 2023 (AU Commission)

| | | |
|---|---|---|
| **Aspiration 7**. Africa as a strong, united, resilient, and influential global partner and player | **Goal 19**. Africa as a major partner in global affairs and peaceful co-existence | • **Priority area 1**. Africa's place in global affairs<br>*National targets (2023):*<br>1. National infrastructure for African networked space research and exploration in place<br>2. National systems/infrastructure for research and development that will contribute to the stock of global intellectual property rights is fully functional<br>3. Increase 2013 level of exports by 20% in real terms<br>*Regional/continental targets (2023):*<br>1. Africa speaks with one voice on global affairs<br>2. African Space Agency established and is fully operational<br>3. Strategic freight maritime task force is established<br>4. AU standalone department for maritime affairs to be responsible for AIMS implementation established<br>5. African island states are fairly represented in appointments to regional/ continental and international bodies<br>6. All colonies are free by 2020 |

Technologies, held in Sudan. The declaration issues the request to the AU Commission to "IMPLEMENT the recommendations of the feasibility study on the African Space Agency (AfriSpace) and DEVELOP a space policy for the Continent in collaboration with relevant stakeholders; taking in to account remote sensing applications and satellite imagery processing".[325] The latter part, the development of a space policy, has been completed, but as CNN reports, although the AU approved the feasibility study in 2010 and Sudanese President al-Bashir repeated the call for this in 2012 (in tandem with the Khartoum Declaration), "[i]t largely fell on deaf ears".[326] However, it is difficult to see how a "formal African space programme"—as the African Space Strategy puts it—will be implemented without a continental agency, especially since the same strategy states that "[a]ppropriate governance structures will be mandated to ensure that this strategy is implemented to ensure the effective development and coordination of an African space programme, which

[325] African Union Conference of Ministers in Charge of Communication and Information Technologies, "2012 Khartoum Declaration," *African Union*, 2012, 4, https://au.int/sites/default/files/newsevents/pressreleases/27218-pr-declaration_khartoum_citmc4_eng_final_0.pdf (accessed July 5, 2018).

[326] Giles, "Africa Leaps Forward into Space Technology."

will draw on the capacities of member states and regional programmes".[327] Indeed, the AU Agenda 2063 framework document and the 10-year implementation plan make it clear that the AU is determined to establish the African Space Agency. The framework document states "Africa will also be in a position to finance the Union Government, and other key strategic initiatives, inter alia the African Space Agency", while the implementation plan clearly states that "[a]n African Space Agency would have been established by 2023".[328] Therefore, debates with strong positions regarding the establishment of an African Space Agency abound.

It is interesting to note how the sides of the debate still reflect the enduring rift in Africa between the Casablanca and the Monrovia Groups of the 1960s. The Casablanca Group was an informal association of states in Northern and Western Africa that pushed for Africa's unification and radical deep integration on the continent, while the Monrovia Group favoured nationalism over pan-Africanism, and although they still supported cooperation on the continent, they were reluctant to pursue the level of integration sought by the states of the Casablanca Group. While the formation of the Organisation of African Unity (OAU) in 1963 was a compromise, the Casablanca Group ultimately failed in their desire for African unification, although those themes were still echoed by former Libyan leader Muammar Gaddafi and still strongly featured in current AU discourse, for instance, in realising an African passport. While these two groups no longer exist, the tension between full and limited integration endures, including in the space arena.

On the one hand, proponents highlight the need for such an agency by arguing that "this agency will enhance the contribution of other African countries towards space science", and criticism is countered through arguments that "the development of the ASA could provide the vehicle for the continent to negotiate better offers for satellite construction, space launches, technology transfer and infrastructure, than could individual countries alone", whilst "working on a regional basis is no longer an option, but a necessity for development".[329] This sentiment is echoed elsewhere through lamentations that Africa "is dissected into many other negotiating blocks that include our colonial boundaries and continued ties with former colonial masters, all of which make life and negotiations on a common agenda difficult", summarising this view by arguing that the "divide and rule tactic remains alive in global negotiating platforms".[330] This strongly echoes the sentiments issued by Ghanaian President Nkrumah (a member of the Casablanca Group) on the eve of the formation of the OAU that "[w]e must unite now or perish", based on the theme that "[u]nless we

[327]African Union Commission, *African Space Strategy: Towards Social, Political and Economic Integration*, 25.

[328]African Union Commission, "Agenda 2063: The Africa We Want, Framework Document," 2015, Addis Ababa, 42. https://au.int/sites/default/files/documents/33126-doc-framework_document_book.pdf (accessed July 6, 2018); African Union Commission, *Agenda 2063: The Africa We Want – First Ten-Year Implementation Plan 2014–2023*, 24.

[329]Ncofe and Gottschalk, "The Growth of Space Science in African Countries for Earth Observation in the 21st Century," 3.

[330]Nhamo, "New Global Sustainable Development Agenda: A Focus on Africa," 13.

do this by our concerted efforts, within the framework of our combined planning, we shall not progress at the tempo demanded by today's events and the mood of our people", with the question being that "[b]y belonging to different economic zones, how will we break down the currency and trading barriers between African states, and how will the economically stronger amongst us be able to assist the weaker and less developed states?".[331]

On the other hand, the contrary view is encapsulated in the argument that an "African Space Agency will be beneficial in the long term but is a little premature" because "countries need to develop and grow their own capabilities first".[332] A new pan-African space entity thus does not need to be established to achieve closer African cooperation or advance the continental space agenda.[333] Arguments that such an agency is needed to foster competition are also repudiated on the basis that the African Resources Management Satellite Constellation (ARMS-C—more on this in Chap. 2) came about without such an agency and is based on the similar objectives of the partner countries.[334] It is also maintained that those who call for the European model of a continental space agency miss the crucial fact that space capabilities were initially developed within various European countries and that initiatives such as the European Launcher Development Organisation created the experience and critical mass required to sustain the success of the European Space Agency (ESA). This included established national space programmes, which remain in place today, and the creation of a cadre of capable scientists and engineers.

African development, as discussed earlier in this chapter, is very uneven, and there is a dearth of skills that would enable Africa as a whole to benefit from a continental space agency. In this way, it is maintained that "it is difficult to see how a top-down approach of multilateral cooperation can lead to purposeful programmes that cannot be executed more effectively and efficiently among a few partners", while the majority of African countries "scarcely have the resources to plough into science and technology activities in general, let alone in the space domain".[335] More likely, the result of "creating a new multilateral space agency with partners having very limited space experience" would be "a dilution of the individual efforts".[336] In contrast to the arguments that a space agency will place Africa in a stronger negotiating position, the risk could also be that "an African space agency could be an attractive proposition for the global space industry seeking a single point to access African markets ... [which] could lead to a situation where the agency would become a sort of clearinghouse to consider proposals from entities outside of

[331]Kwame Nkrumah, "Power of Words: Kwame Nkrumah speaks in Addis Ababa in 1963," *Joburg Post*, May 26, 2017, http://www.joburgpost.co.za/2017/05/26/power-words-kwame-nkrumah-speaks-addis-ababa-1963/ (accessed July 5, 2018).

[332]Giles, "Africa Leaps Forward into Space Technology."

[333]Peter Martinez, "Is There a Need for an African Space Agency?," *Space Policy* 28, (2012): 145.

[334]Ibid., 143.

[335]Ibid., 143.

[336]Ibid., 144.

Africa".[337] Additionally, rather than creating a new continental institution, there is a case to be made for strengthening existing ones and supporting them better. An example of this is the African Regional Centre for Space Science and Technology, of which two were established on the continent under the UN Programme on Space Applications. These will be further deliberated in Chap. 2, but the case in point is that the Nigerian centre, which supports the English language, is an example of the "host country shouldering the lion's share of the costs" even though many other countries benefit from the training services there, underscoring the need to better fund existing continental institutions and centres before opening new ones.[338] The African Leadership Conference on Space Science and Technology for Sustainable Development (ALC) at its fourth conference in 2011 (more on this in Chap. 2) agreed that an African Space Agency would be premature.

One of the alternatives to the European model is the Asian example of the Asia-Pacific Regional Space Agency Forum (APRSAF), which is a forum for the exchange of information and views and is a platform for the discussion of future space cooperation.[339] The ALC could potentially evolve into an equivalent APRSAF if given more influence. Three major stumbling blocks to a new continental space agency are foreseen—first, without African champions, such an endeavour is unlikely to succeed, with arguments made that there is an "apparent lack of visible support from space capable African countries"; second, the benefits accruing from a continental space agency would unfairly advantage those countries with no existing space programmes, while simultaneously they would be able to contribute least given the absence of space industries, and thus a European *juste retour* principle would be unlikely to succeed; and third, some African countries, particularly in Northern Africa, are currently more aligned to other cooperative space organisations such as the Inter-Islamic Network on Space Sciences and Technology (more on this in Chap. 2), calling into question whether a new pan-African initiative could succeed given the multitude of directions countries are turning to for cooperation outside the region.[340] As mentioned earlier, a regionally focused approach is proposed instead, in line with the argument that multiple growth poles are needed. It is cautioned that while Africa might be considering developmental leapfrogs, "running too fast can lead to grazed knees", since human capacity remains a serious problem, for example, with a "lack of appropriate skills to analyse and interpret remote sensing data and to maintain local and regional collaboration".[341] Arguments have instead been made for African countries to make greater use of established networks of international cooperation, such as the regional centres mentioned, since they are already "geared

[337]Ibid.

[338]Ibid.

[339]Aganaba-Jeanty, "Precursor to an African Space Agency: Commentary on Dr. Peter Martinez 'Is There a Need for an African Space Agency?'," 172.

[340]Ibid.

[341]Ibid., 173.

towards capacity building in Africa".[342] As if to reinforce the notion that an African Space Agency is premature, the troubling observation has been made that:

> the recent focus has not been the programmes or plans to make the African space economy a reality. Rather, it is who gets to host the African Space Agency. Although the creation of a space agency is not explicitly mentioned in either the policy or the strategy, this is the issue that is getting attention—rather than the governance framework and implementation plan which are what the space strategy lays out as the next steps for developing space on the continent.[343]

This view is echoed through the caution that "Africa also must not forget the decades'-long individual national attitude of its member states towards science and technology, the indisputable foundation of any space programme", and African attempts to bypass these foundations over the years have "won it either bench warmer status at international meetings or exclusion".[344] This participation in international fora will be explored in Chap. 2.

## 1.5 Conclusion

In this chapter, the foundation has been provided for the discussion of Africa's contemporary international space ecosystem, discussed in Chap. 2, and for the analysis of African states' space-related capabilities and infrastructure, discussed in Chap. 3. The aim here was to contextualise the broad political and socio-economic landscape of the continent and to explore the "Astronaissance" that has taken hold since the relatively limited involvement of Africa in space during the twentieth century. This rebirth of African space efforts is accompanied by the African Union's Space Policy and Strategy, which will undoubtedly have an important role in coordinating the efforts of individual states and in stirring further debate about the nature of African space activities in coming years (such as the proposed African Space Agency), but about which little has been published to date.

Focus was also placed on African theoretical contributions, drawn from international relations literature, which will be applied to the space arena throughout these chapters (and volumes). This is an important effort since the "awkward silence"[345] of Africa in the realm of theory is a grave concern, especially since the continent has much to contribute to theory generation if scholars would listen. Together, these theoretical contributions, and the political and socio-economic context and background, are refracted through the prism of the primary needs approach to African space activities, which prioritises the continent's efforts in the realms of climate,

[342] Ibid., 173.

[343] Wild, "Making the case for African investment in space programmes."

[344] Abiodun, "Trends in the Global Space Arena – Impact on Africa and Africa's Response," 288.

[345] Ashley Harris, "An awkward silence: Reflections on theory and Africa," *Kunapipi* 34, no. 1 (2012): 1.

biodiversity, health, water, education, and space-related capacity building. The importance of these primary, or basic, needs is clear when considering the efforts of all states in meeting the United Nations Sustainable Development Goals 2030, which also prioritises these fundaments to human dignity and quality of life. If space is to make any meaningful contribution to Africa, it must be in supporting the meeting of these needs, and in improving the lives of ordinary African citizens. Africa is rising. Its people, its states, and its ambitions are on the move. Now is the time of taking seriously African efforts and activities in space. As Nelson Mandela indicated, our long walk is not yet ended.

# Chapter 2
# The African International Space Ecosystem

**Abstract** The states of Africa find themselves embedded within an international space ecosystem, which, in this chapter, is argued to consist of three closely related dimensions. These are intra-African space relations and activities, African participation in global space fora (with emphasis on the United Nations Committee on the Peaceful Uses of Outer Space, UNCOPUOS), and the engagement with Africa by other global space actors. These are explored in turn, with various key intergovernmental organisations and non-governmental organisations within the African continent explored first, followed by a ranking of the engagements of African states through the Intra-African Space Engagement Matrix. This provides a clear indication of which states lead in space engagements on the continent. Next, Africa's participation in international fora beyond the continent is considered, with participation ranked via the International Space Engagement Matrix. Together, these matrices clearly identify African outliers in the space arena and enable the identification of Africa's emerging space middle powers. Finally, key space-related activities, agreements, and initiatives of non-African actors on the continent are examined. This chapter therefore provides a comprehensive overview of space-related initiatives involving Africa and which African states are leading in this regard.

## 2.1 Introduction

> As the Secretary General of the United Nations, an organization of the 147 member states who represent almost all of the human inhabitants of the planet Earth, I send greetings on behalf of the people of our planet. We step out of our solar system into the universe seeking only peace and friendship, to teach if we are called upon, to be taught if we are fortunate. We know full well that our planet and all its inhabitants are but a small part of this immense universe that surrounds us and it is with humility and hope that we take this step.
>
> Kurt Waldheim, United Nations Secretary General, 1977[1]

[1] Astrobiology Magazine, "Voyage of The Voyagers: First Quarter-Century," *Astrobio.net*, August 20, 2002, https://www.astrobio.net/news-exclusive/voyage-of-the-voyagers-first-quarter-century/ (accessed September 3, 2018).

 
A. Froehlich, A. Siebrits, *Space Supporting Africa*, Studies in Space Policy 20,
https://doi.org/10.1007/978-3-030-12173-0_2

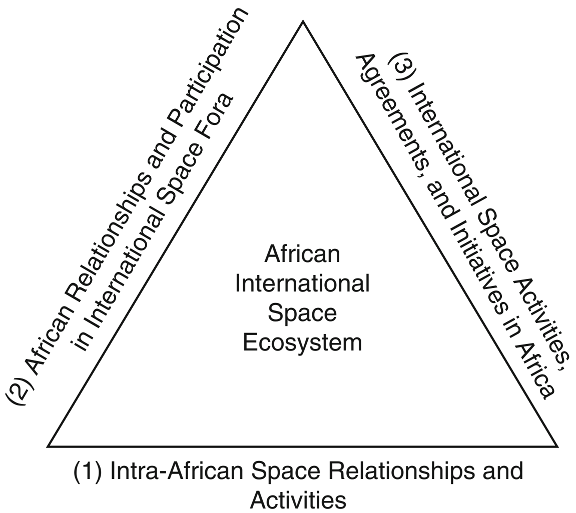


**Fig. 2.1** African international space ecosystem

Just over 40 years ago, as the Voyagers 1 and 2 spacecraft began their long journeys to the stars, the then-Secretary General of the UN contributed the above message to the now-famous golden records accompanying the Voyagers. It paints a picture of a relatively unified planet, whose inhabitants stand together as they step out into space. This example reinforces both points made in the previous chapter—that international cooperation and partnerships are fundamental tenets of humanity's approach to space and that an engagement with space is therefore also an engagement with the international. What the message of the Secretary General does not reveal however is the extent to which the participation and involvement of various countries and regions differ in relation to space and how various international relations and partnerships on multiple levels shape the international space ecosystem.

This chapter is therefore dedicated to analysing the African international space ecosystem (Fig. 2.1). This international ecosystem is conceptualised here as consisting of three dimensions, each of which will be explored in turn. The first of these dimensions concerns intra-African space relations and activities taking place between various countries on the continent. The second dimension revolves around African relations and participation in international fora, with emphasis on the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS) as the official intergovernmental decision-making body on outer space. The third dimension is concerned with the involvement of international space actors on the African continent, as well as various other international agreements and initiatives (with the relationship between Africa and the European Space Agency/European Union being explored in greater depth in a separate chapter in the next volume).

The two concepts discussed in the previous chapter—*ubuntu*[2] and emerging space middle powers—will be incorporated into the discussion of the African international space ecosystem to help explain the behaviour and actions of African states in the space arena. These concepts will also be critical in identifying the major drivers or promoters of space in Africa, since these states are best suited to bridge the gap between the rest of Africa and space. Themes of African unity and self-determination will also be highlighted in this discussion as cornerstones of African international relations. In line with the primary needs approach to African space activities identified in the previous chapter, the emphasis will be placed on international space relations that promote climate, biodiversity, health, water, education, and space-related capacity building initiatives.

This chapter consists of three main sections dedicated to the dimensions of the African international space ecosystem identified above. Accordingly, intra-African space relations and activities will be considered first. This will include a discussion of various international projects taking place such as the African Resource Management Satellite Constellation (ARMS-C), the Square Kilometre Array (SKA), and other continental initiatives. These will be analysed through the Intra-African Space Engagement (IASE) Matrix, a tool that helps to identify emerging space middle power candidates via the regional dimensions of the middle powers concept as discussed in Chap. 1. The following section will explore Africa's involvement in international space fora, most notably UNCOPUOS. This will in turn be analysed through the International Space Engagement (ISE) Matrix, which will identify emerging space middle power candidates based on the international dimensions of the concept. Together, the IASE and ISE Matrices will identify Africa's emerging space middle powers and help to account for their actions, along with *ubuntu*, within the international space ecosystem. After this, the subsequent section will consider various international efforts taking place within Africa, such as African agreements with foreign partners, and international bodies such as the ARCSSTE (African Regional Centre for Space Science and Technology Education) and UN-SPIDER (Space-based Information for Disaster Management and Emergency Response) initiatives of the United Nations Office for Outer Space Affairs (UNOOSA). Finally, the conclusion will summarise the chapter and discuss key points.

## 2.2 Intra-African Space Relations and Activities

This section explores the main space-related relationships and joint activities between African countries, both of intergovernmental and non-governmental natures. The African Space Policy and Strategy, AU flagship projects, and

[2]One example of *ubuntu* will be evident throughout this chapter through the use of "international" and "foreign" to refer to relations between Africa and the rest of the world, not *within* Africa – one of the features discussed in the definition of *ubuntu* in Chap. 1.

Pan-African University Space Sciences initiatives discussed in the previous chapter will not be included here. An important point in this regard is that intra-African space-related cooperation is a relatively new phenomenon due to the relatively recent establishment of African space agencies or government space offices, which are important drivers for cooperation. These will be explored in depth in the next chapter.

### *2.2.1 Intergovernmental Organisations (IGOs) and Relations*

The first focus here will be placed on key IGOs operating within Africa in the space arena. Ten in particular have been identified, operating in areas of satellite communication, resource management, policy, science and astronomy, geospatial and Earth observation, geographic information systems, meteorology, and governance. Together, these ten IGOs demonstrate that African states are active in a broad spectrum of space-related activities and that the political leadership of the continent recognises value in participating in these activities.

#### The Regional African Satellite Communication Organisation (RASCOM)

The first pan-African space initiative was RASCOM, established in 1992.[3] A feasibility study was undertaken between 1987 and 1990, which focused on the African telecommunications arena and which involved 50 African countries and hundreds of experts, with support from the International Telecommunication Union (ITU), the United Nations Development Programme (UNDP), and the African Development Bank (ADB).[4] This was the most comprehensive study ever carried out in the arena of telecommunications in Africa. Two key findings from this study were that a telecommunications satellite "tailored to well-defined specifications is the best technological choice for satisfying Africa's telecommunications needs, globally and optimally" and that it must be designed and undertaken on a continental scale to be financially viable.[5]

RASCOM is made up of three key organs: the Assembly of Parties, which is made up of the member governments and meets every 2 years; the Board of Directors, which is responsible for the "design, development, construction, establishment, operation and maintenance of the RASCOM space segment and any other activities which RASCOM is authorized to undertake" and meets every 3 months;

[3]Ngcofe and Gottschalk, "The growth of space science in African countries for Earth observation in the twenty-first century," 3.

[4]Regional African Satellite Communication Organisation, "Background," http://www.rascom.org/info_detail.php?langue_id=2&id_r=23&id_sr=0&id_gr=2 (accessed September 7, 2018).

[5]Ibid.


**Fig. 2.2** Member states of the Regional African Satellite Communication Organisation (RASCOM). Regional African Satellite Communication Organisation, "Members", http://www.rascom.org/info_detail.php?langue_id=2&id_r=25&id_sr=0&id_gr=2 (accessed September 7, 2018)

and finally the Executive Organ, which, under a Director General, oversees daily operations.[6] The secretariat is based in Abidjan, Côte d'Ivoire. Currently, 45 African countries are members, highlighted in Fig. 2.2, and telecommunications operators, including regulatory bodies, have signed the RASCOM operating agreement in 43 of these.[7] RASCOM's mission is stated as follows: "to design, implement, operate and maintain the space segment of the African telecommunications satellite system and

[6]Regional African Satellite Communication Organisation, "Organs", http://www.rascom.org/info_detail.php?langue_id=2&id_r=24&id_sr=0&id_gr=2 (accessed September 7, 2018).

[7]Regional African Satellite Communication Organisation, "Members," http://www.rascom.org/info_detail.php?langue_id=2&id_r=25&id_sr=0&id_gr=2 (accessed September 7, 2018).

translate into services and tools for African integration, all the opportunities provided by satellites by linking it, where necessary, with any other appropriate technology". Six key objectives are outlined, namely, to (i) provide an affordable infrastructure on a large scale to rural areas of the continent by using appropriate technology; (ii) improve and/or develop interurban communications in each country; (iii) establish direct links between all African countries without exception; (iv) provide facilities for radio and television broadcast in each country and enable the exchange of radio and television programmes between African countries; (v) support international connectivity and pursue connectivity where others cannot go; and (vi) provide a range of services, voice, data, multimedia, tele-education, telemedicine, video conferencing, etc.[8]

RASCOM's satellite operations are managed by a private company registered in Mauritius in 2002, named RascomStar, which extended the first satellite contract to Thales Alenia Space in 2003 to build the RASCOM-QAF1, which was launched in 2007.[9] Unfortunately, due to a helium (propellant) leakage, the lifespan of the satellite was reduced to 3 years, and a replacement satellite RASCOM-QAF1R was launched in 2010, thus "providing the first pan-African satellite with coverage of the entire continent and off-shore islands with a single C-band and two Ku-band (North and South) footprints".[10] RascomStar has two satellite control centres—one in Gharyan, Libya, and one in Fucino, Italy, which is operated in partnership with Telespazio—while the network control centre is located in Douala, Cameroon, which "controls and manages all RascomStar Ground Services, such as our Rural GSM Extension Service and our Rural Fixed-line Extension Service, plus our VSAT Service", and one customer service centre, also in Douala, Cameroon.[11] RascomStar provides a range of services across Africa, including Bandwidth Lease Service, GSM Extension Service, Telephony Extension Service, GSM Backhaul Solutions, VSAT Solutions, Hybrid Solutions, combined satellite and Wi-Fi, as well as television broadcast services.[12]

Despite long delays related to intergovernmental negotiations and in "implementing long-promised commitments", as well as "two of the three locations [Côte d'Ivoire and Libya] having been affected by civil wars", RASCOM has proven

[8]Regional African Satellite Communication Organisation, "Our Objectives," http://www.rascom.org/info_detail.php?langue_id=2&id_r=19&id_sr=0&id_gr=2 (accessed September 7, 2018).

[9]RascomStar, "Our History," http://rascomstar.com/about-us/our-history/ (accessed September 7, 2018).

[10]Ibid.

[11]RascomStar, "Ground Stations," http://rascomstar.com/our-resources/ground-stations/ (accessed September 7, 2018).

[12]RascomStar, "Our Solutions," http://rascomstar.com/our-solutions/ (accessed September 7, 2018).

its resilience.[13] The roughly 20-year period it took to become operational also “offers a realistic time frame for future Pan-African space initiatives”.[14]

In relation to the primary needs model outlined in Chap. 1, RASCOM fulfils important functions in education (since educational services often rely on satellite communications in Africa) and space-related capacity building (since it was Africa’s first continental space initiative and has generated valuable experience in telecommunications operations in the countries where its ground facilities are located). Indeed, RASCOM can support education since “[i]nvestment in communication satellites can help to digitize education and enhance literacy in the region”.[15]

### The African Resource Management Satellite Constellation (ARMS-C)

The ARMS-C is a multilateral satellite project focused on African needs. This collaborative initiative between four countries—Algeria, Kenya, Nigeria, and South Africa—was originally conceived around 2003.[16] A series of meetings were held between the four governments in 2005, with other workshops taking place between 2006 and 2008, in order to lay the groundwork for the agreement, which was signed in December 2009 as a Memorandum of Understanding in Algiers, Algeria, at the third African Leadership Conference on Space Science and Technology for Sustainable Development (see below for more information on the ALC).[17] The ARMS-C was conceived as a data-sharing agreement between the four countries to pool their satellite imagery, and negotiations took 6 years to be completed.[18]

The need for the ARMS-C is evident due to the widespread use of medium- and high-resolution image data in Africa by end users in a variety of fields, including infrastructure, disaster management, water resource management, land use, food security, and public health—data that existing satellites such as SPOT 5 could not provide in a timely or cost-effective manner. For example, it was noted that SPOT 5 required a 16-month period to image the whole of South Africa alone, due to prevailing cloud cover patterns.[19] Thus, by creating a satellite constellation, more timely data could be provided, and by pooling their efforts via the data-sharing

[13]Ngcofe and Gottshalk, “The growth of space science in African countries for Earth observation in the twenty-first century,” 3.

[14]Ibid.

[15]Samuel Oyewole, “Space Research and Development in Africa,” *Astropolitics* 15, no. 2 (2017): 199.

[16]Sias Mostert, “The African Resource Management (ARM) Satellite Constellation,” *African Skies/Cieux Africains*, 2008, no. 12:56.

[17]Simon Adebola, “African Resource Management Satellite (ARMC) Constellation,” *iinitiative*, December 21, 2009, https://iinitiative.wordpress.com/2009/12/21/african-resource-management-satellite/ (accessed September 5, 2018).

[18]Luncedo Ngcofe and Keith Gottschalk, “The growth of space science in African countries for Earth observation in the twenty-first century,” *South African Journal of Science* 109, no. 1/2 (2013): 3.

[19]Mostert, “The African Resource Management (ARM) Satellite Constellation,” 53.

agreement, individual member countries would not have to purchase satellite imagery separately (thus saving costs).

Accordingly, in the conceptualisation phase of the ARMS-C initiative, user requirements were identified and collected from the four countries and prioritised, with the top five user requirements identified as (i) agriculture, climate, and environment (3–5 m multispectral resolution, monthly revisit times); (ii) environmental impact assessment, farmer settlement, housing, planning and urban planning, and border monitoring (0.6–1 m PAN and RGB resolution, 1–2 year revisit time); (iii) disaster monitoring (1–250 m PAN, VIS, NIR, MIR, TIR resolution, twice daily revisit time—night and day); (iv) land use, cover mapping (0.5–5 m PAN resolution, once per 2 days revisit time); and (v) water management, land use, and land care (10 m multispectral resolution with twice per year or quarterly revisit times).[20] From these, the core technical requirements for the constellation were identified, divided into three phases. ARM 1 was proposed to have a 3–5 m multispectral resolution with once per 2 days revisit time, to be focused on applications in the following fields: agriculture, climate, environment, disaster monitoring, land use/cover mapping, managed agriculture, water resources management, and mineral, oil, and gas exploration.[21] ARM 2 would have a requirement for 20–30 m multispectral resolution with a swath of 600 km and daily or twice-daily revisit times, aimed at disaster monitoring, water management, land use and land care, mapping food vulnerability, drought status, food security, mineral, oil, and gas exploration, and fishing application.[22] Finally ARM 3 would have a requirement of 0.5 m Pan, RGB resolution with once per annum revisit time, supporting applications of environmental impact assessment; farmer settlement; housing; planning and urban planning; border monitoring; disaster monitoring; land use/cover mapping; water resources management; mineral, oil, and gas exploration; and peace-keeping missions.[23]

Following this conceptualisation phase, the final design specifications of the first-phase satellites were decided. According to Draft Version 3 of the ARMS-C User Needs and Technical Requirements section of the agreement, these specifications for ARM 1 would be a 2.5 m resolution panchromatic imager with a 12 m multispectral imager with bands blue, green, red, and NIR, a maximum swath width of 180 km, and a 3-day revisit time with four satellites.[24] However, other sources report

[20]Agreement between The Government of the People's Democratic Republic of Algeria and The Government of the Republic of Kenya and The Government of the Federal Republic of Nigeria and The Government of the Republic of South Africa Concerning a Framework for Co-operation in Relation to the African Resource and Environmental Management Satellite Constellation, ftp://ftp.earthobservations.org/AfriGEOSS/Data_Infrastructure_Coordination_Team/References/ARMC%20Agreement%20Docs.pdf (accessed September 7, 2018).

[21]Mostert, "The African Resource Management (ARM) Satellite Constellation," 55.

[22]Ibid.

[23]Ibid.

[24]Agreement between The Government of the People's Democratic Republic of Algeria and The Government of the Republic of Kenya and The Government of the Federal Republic of Nigeria and The Government of the Republic of South Africa Concerning a Framework for Co-operation in

specifications of a 2.5 m resolution panchromatic imager and a 5 m resolution multispectral imager in six multispectral bands.[25,26]

With these specifications in mind, it was agreed that each country would contribute a satellite with "identical payload specifications" to the constellation and where "the data generated by the satellites are shared by the Parties for their mutual benefit".[27] Accordingly, ARMS-C satellites would be "optimised for the use of African countries for regional conditions" to meet their domestic needs for regular, high-resolution data over the continent for resource management applications, thus creating a "combined space asset that collectively serves a unique need for regular up-to-date monitoring of the African environment".[28] Beyond meeting the need for data, the ARMS-C joint project also serves to promote capacity building as well as the development of low-cost receiving stations.[29] One of the strengths of the constellation is that, based on the common set of requirements agreed upon, the countries are under no obligation to harmonise the technology they use, develop, or procure to meet the requirements. This facilitates cooperation and removes additional barriers related to harmonisation.

Thus far, only Nigeria has placed its required generation 1 ARMC satellite in orbit, with Algeria, South Africa, and Kenya yet to do so. While satellites will be discussed in greater depth in the next chapter, the Nigerian contribution is NigeriaSat-2, launched in 2011, making it "the first satellite in the African Resource Management (ARM) constellation",[30] with specifications reported as:

> NigeriaSat-2 (N2) is an Earth observation mission. N2 is a space-based optical sensor system that provides accurate and timely images of the Earth. The N2 imaging payload provides very high resolution 2.5 m panchromatic and 5 m 5-band multispectral high resolution imaging. N2 is a contributing sensor to the Disaster Monitoring Constellation [sic]. Imagery

Relation to the African Resource and Environmental Management Satellite Constellation, Appendix 1, ftp://ftp.earthobservations.org/AfriGEOSS/Data_Infrastructure_Coordination_Team/References/ARMC%20Agreement%20Docs.pdf (accessed September 7, 2018).

[25] Adebola, "African Resource Management Satellite (ARMC) Constellation."

[26] Mohamed Yahia Edries, "African Satellite Collaborative Projects (Past, Present and Future)," *National Authority for Remote Sensing and Space Sciences (NARSS)*, December 11, 2017, http://www.unoosa.org/documents/pdf/psa/activities/2017/SouthAfrica/slides/Panel01.pdf (accessed September 5, 2018).

[27] Agreement between The Government of the People's Democratic Republic of Algeria and The Government of the Republic of Kenya and The Government of the Federal Republic of Nigeria and The Government of the Republic of South Africa Concerning a Framework for Co-operation in Relation to the African Resource and Environmental Management Satellite Constellation, 2–4, ftp://ftp.earthobservations.org/AfriGEOSS/Data_Infrastructure_Coordination_Team/References/ARMC%20Agreement%20Docs.pdf (accessed September 7, 2018).

[28] Mostert, "The African Resource Management (ARM) Satellite Constellation," 53–56.

[29] Edries, "African Satellite Collaborative Projects (Past, Present and Future)."

[30] Surrey Satellite Technology Ltd, "Nigeria's new satellite demonstrates hi-res capability," September 28, 2011, https://www.sstl.co.uk/media-hub/latest-news/2011/nigeria%E2%80%99s-new-satellite-demonstrates-hi-res-capabi (accessed December 6, 2018).

transmitted to ground stations will be used for humanitarian, environmental and commercial applications.[31]

According to the World Meteorological Organisation's Observing Systems Capability Analysis and Review Tool (OSCAR), NigeriaSat-2's expected end of life is 2018, although its current status is unclear.[32] It has also served the needs of the Disaster Monitoring Constellation (DMC) of which Nigeria is a member and which will be discussed later in this chapter. Algeria's satellites AlgeriaSat (AlSat) 2A and 2B, both reported by UNOOSA as being "Earth observation satellite[s] equipped with a camera with a spatial resolution of 2.5 m in panchromatic mode and 10 m in multispectral mode", were launched in 2010 and 2016, respectively.[33] AlSat 2B has an expected end of life of 2021 according to the World Meteorological Organisation and also contributes data to the DMC.[34] However, while these satellites also conform to the general requirements of the ARMC-C, they are not part of the constellation, and "four countries agreed to the constellation in 2009, but so far, only Nigeria has any satellites in orbit".[35] South Africa's contribution will be EOSat-1, planned for launch in 2020, with an expected lifetime of 7 years, although challenges are being reported: "the programme is hampered by a lack of funding—in addition to the satellite, the ground station and launch also need to be funded".[36] No details on Kenya's future contribution are yet available. Beyond these four countries, the ARMS-C is open to all other interested African countries to join (Fig. 2.3).

When aligning the AMRS-C with the primary needs model, it is clear that the constellation speaks to the full range of issues (as indicated by the wide variety of applications supported by ARM 1), including climate and environment, biodiversity, land use/cover mapping, water resources management, health (via disaster monitoring), education, and capacity building (both directly through practical experience related to managing the constellation and indirectly via easy access to satellite data for end users in Earth observation fields, which also includes educational uses and

[31]United Nations Office for Outer Space Affairs, "Online Index of Objects Launched into Outer Space," *NigeriaSat*, http://www.unoosa.org/oosa/osoindex/search-ng.jspx?lf_id= (accessed September 7, 2018).

[32]World Meteorological Organisation, "NigeriaSat-2," *OSCAR: Observing Systems Capability Analysis and Review Tool*, 2018, https://www.wmo-sat.info/oscar/satellites/view/314 (accessed September 7, 2018).

[33]United Nations Office for Outer Space Affairs, "Algeria," *Online Index of Objects Launched into Outer Space*, http://www.unoosa.org/oosa/osoindex/search-ng.jspx?lf_id= (accessed September 7, 2018).

[34]World Meteorological Organisation, "AlSat-2B," *OSCAR: Observing Systems Capability Analysis and Review Tool*, 2018, https://www.wmo-sat.info/oscar/satellites/view/10 (accessed September 7, 2018).

[35]Sarah Wild, "Launching satellite is space agency's big focus," *Business Day*, February 3, 2017, https://www.pressreader.com/south-africa/business-day/20170203/281711204380878 (accessed December 6, 2018).

[36]Guy Martin, "South Africa to increase focus on space," *Defenceweb.co.za*, April 17, 2018, http://www.defenceweb.co.za/index.php?option=com_content&view=article&id=51386:south-africa-to-increase-focus-on-space&catid=35:Aerospace&Itemid=107 (accessed September 7, 2018).


**Fig. 2.3** Member states of the African Resource Management Satellite Constellation (ARMS-C)

capacity building). Beyond the four member countries, the ARMS-C agreement also stipulates that data can be made available to non-signatory countries if all signatories approve it.[37] South Africa has also indicated that data from EOSat-1 "will be made available for use by all African countries".[38] The data can therefore be valuable to the entire continent in relation to all layers of the primary needs model.

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[37]Agreement between The Government of the People's Democratic Republic of Algeria and The Government of the Republic of Kenya and The Government of the Federal Republic of Nigeria and The Government of the Republic of South Africa Concerning a Framework for Co-operation in Relation to the African Resource and Environmental Management Satellite Constellation, ftp://ftp.earthobservations.org/AfriGEOSS/Data_Infrastructure_Coordination_Team/References/ARMC%20Agreement%20Docs.pdf (accessed September 12, 2018).

[38]Valanthan Munsami, "DRAFT Statement by South Africa: The ISF 2017-International Space Forum at Ministerial Level: The Africa Chapter," *South African National Space Agency*, February

Two important notes in relation to the ARMS-C initiative can be made here. First, while the example of this project reveals the great difficulty in aligning political timelines to actualise such a multinational endeavour, the requirements set out for the three phases remain valid and worth pursuing. Second, future projects will need to sidestep such political barriers and challenges related to bilateral and multilateral projects (and the very long timelines demonstrated by RASCOM as well) by engaging in focused public-private partnerships in the form of commercial enterprises with large numbers of partners and sustainability (through users integrated and dependent on timely services). One example of such an upcoming project is the HyperFarm hyperspectral nano-satellite constellation focused on agriculture, of which South African commercial satellite company SCS Space[39] and small South African start-up FarmPin[40] (incubated by AfroLabs and Agro Innovation Lab) are part.[41] By 2021 HyperFarm is planning to have 24 satellites in orbit working as a constellation, with a 5-day revisit time. Political projects such as ARMS-C remain important for building capacity across the continent and generating support for space-related initiatives, but more emphasis will need to be placed on commercial space enterprises to build a successful and sustainable African space sector.

### The African Leadership Conference (ALC) on Space Science and Technology for Sustainable Development

The ALC originated as a result of a proposal by the Nigerian delegation at UNCOPUOS in 2004 to promote an appreciation of the role of space technology in achieving African development goals among both the political leadership and other key decision-makers on the continent (including those of the AU and the New Partnership for Africa's Development, NEPAD).[42] It was formally established in 2005 by the governments of Algeria, Kenya, Nigeria, and South Africa.[43] The goals of the ALC are to (i) raise awareness among African leaders of the importance of space science and technology, (ii) provide a regular forum for information exchange among African countries regarding their space activities, and (iii) enhance intra-African cooperation in the development and applications of space technology.[44]

13, 2018, http://www.iafastro.org/wp-content/uploads/2018/03/20180213-ISF-africa-chapter-SA-statement.pdf (accessed September 12, 2018).

[39] See http://scs-space.com/.

[40] See https://farmpin.com/#sien-wat-anchor.

[41] HyperFarm Hyperspectral Nano-Satellite Constellation, 2018, http://hyperfarm.space/ (accessed December 6, 2018).

[42] Peter Martinez, "The African Leadership Conference on Space Science and Technology for Sustainable Development," *Space Policy* 28, (2012): 33.

[43] African Leadership Conference Youth Forum, "Home," https://alcyouthforum.wordpress.com/ (accessed September 13, 2018).

[44] Ibid., 33.

Its vision is to "be a forum which offers continuous advisory services and support to African Member States on space related activities", while its mission is to "improve cooperation among African space professionals and to raise awareness among African Governments of the important benefits of space S[cience] and T[echnology] for Africa's sustainable development through a regional platform".[45] The ALC draws a wide range of participants. For example, at the 2011 ALC, 165 participants from space-related agencies around the world attended, while a range of African countries were represented (including Algeria, Nigeria, South Africa, Egypt, Tanzania, Sudan, Ghana, Burkina Faso, Morocco, and Kenya), as well as other organisations such as UNOOSA.[46]

The ALC consists of two governance levels, namely, the ALC Steering Committee and Secretariat and the ALC Programme Committee.[47] The former is responsible for the long-term building of the ALC, is made up of African space experts, and is chaired by the country that hosted the last conference, with a goal to represent all four major regions of Africa equally (North, South, East, West). The ALC Secretariat is also hosted by the last host of the conference. In contrast, the Programme Committee is tasked with developing the next conference's programme and is also comprised of "eminent African and international space experts", chaired by the host of the next conference.[48] Thus far, the ALC has been hosted by Nigeria (2005), South Africa (2007), Algeria (2009), Kenya (2011), Ghana (2013), Egypt (2015), and again by Nigeria (2018).[49] One of the outcomes of the 2015 ALC was "a major resolution for the formation of [an] African Space Agency and ad[o]ption of African Policy and Strategies on Space Science and Technology by the Africa Union".[50]

The ALC thus provides a platform for exchanging ideas and holding discussions, for example, around joint projects. It was thus at the 2009 Algerian ALC that the ARMS-C agreement was signed, not coincidentally by the hosts of the first four conferences.[51] At the same conference, an agreement was also signed between Algeria and UNOOSA in relation to Algeria hosting a UN-SPIDER regional office (more on this later in the chapter). At the 2011 Kenyan ALC, issues surrounding the formation of an African Space Agency were discussed by space agencies or related entities from Algeria, Egypt, Ghana, Kenya, South Africa, and Sudan, and it was

[45]Margaret W. Maimba, "4th African Leadership Conference on Space Science and Technology for Sustainable Development," *Ministry of Higher Education, Science and Technology, Kenya*, February, 2012, http://www.unoosa.org/pdf/pres/stsc2012/tech-29E.pdf (accessed September 8, 2018).

[46]Ibid.

[47]Ibid., 34.

[48]Ibid.

[49]Ibid.

[50]Regional Centre for Mapping of Resources for Development, "RCMRD attends the 6th African Leadership Conference in Egypt," http://www.rcmrd.org/archives/380-rcmrd-attends-the-6th-african-leadership-conference-in-egypt (accessed September 8, 2018).

[51]Martinez, "The African Leadership Conference on Space Science and Technology for Sustainable Development," 35.

determined at that time that an African Space Agency would be premature, and not a necessity for space-related cooperation in light of the ARMS-C and (at the time) the bid for the Square Kilometre Array.[52] The output of that ALC was the Mombasa Declaration, which "is essentially an affirmation of the commitment of Africa's space leaders to take concrete and collective action to address a number of needs and challenges".[53] Eight broad areas were identified, along with a range of actions, which are presented in Table 2.1. These actions, committed to by the participants of the ALC (including Algeria, Nigeria, South Africa, Egypt, Tanzania, Sudan, Ghana, Burkina Faso, Morocco, and Kenya), are worth outlining here in detail since they encapsulate the commitments related to space by the major space-related African actors. Some of these themes will be discussed later in this chapter, and others will be elaborated on in the next two chapters.

At the 2015 ALC in Egypt, additional measures were adopted, as encapsulated in the ALC—2015 Resolution listed in Table 2.2.

While the ALC is an important forum for space affairs in Africa, as a pan-African forum, it must confront four particular challenges. First, the great linguistic, industrial, and economic differences in Africa present a challenge to the ALC as it attempts to foster cooperation, although it has crucially been noted that "the participants in the ALC feel a common bond of being Africans and facing a set of common African challenges".[54] This is directly related to the spirit of *ubuntu*. Second, the ALC continues to face the challenge of integrating itself into the continent's political structures and of promoting space in the development agendas of the AU and NEPAD.[55] Third, the ALC is grappling with the challenge of increasing and broadening the participation of African countries, since it "is still a very long way away from having representation from all 5[4] African countries", partly due to expensive intra-African travel costs and linguistic barriers.[56] Fourth, the ALC continues to face challenges around building sufficient capacity to implement its recommendations and to conduct its work in-between sessions.[57]

The most recent ALC was hosted by Nigeria in November 2018, where a range of issues were discussed such as leveraging on a regional space programme for the sustainable development of Africa, growing the space science sector in Africa by Africans and for the African continent, the role of the start-ups/commercial space ecosystem in the proposed African Space Agency, key elements for the successful implementation of the African space programme, long-term sustainability of the African Space Policy and Strategy, and discussions on Space Resource Mining

[52] Ibid., 36.

[53] Ibid.

[54] Martinez, "The African Leadership Conference on Space Science and Technology for Sustainable Development," 36.

[55] Ibid.

[56] Ibid.

[57] Ibid.

**Table 2.1** Actions related to African space arena, Mombasa Declaration

| | |
|---|---|
| 1. For protection of Africa's *natural environment and the collective management of the continent's resources* for sustainable socio-economic development, action should be taken: | a. To develop and implement the African Resource Management Constellation<br>b. To make maximum use of existing capabilities in worldwide satellite coverage<br>c. To assess the infrastructure related to data availability, archiving, and dissemination in Africa, particularly in regard to freely available fundamental data<br>d. To promote data exchange among African countries and to develop data exchange policies and models |
| 2. For the enhancement of *human security, development, and welfare*, action should be taken: | a. To improve public health services by expanding and coordinating space-based services for telehealth and telemedicine<br>b. To implement an integrated regional disaster management system, in coordination with existing international efforts, such as UN-SPIDER and its Regional Support Offices in Africa<br>c. To improve literacy and enhance education by implementing and coordinating satellite-based tele-education programmes and the related ground-based infrastructure |
| 3. For the development of *Africa's human capital resources* in space science and technology, action should be taken: | a. To improve access to high-level education and training in space science and technology on the continent<br>b. To acknowledge and harness the expertise already present on the African continent through the development of a comprehensive database of African space science and technology experts<br>c. To align with existing human capital development initiatives of the African Union<br>d. To utilise existing training centres in Africa and to promote greater cooperation among education and training institutions to develop appropriate training programmes in space science and technology that respond to Africa's needs<br>e. To encourage African countries to increase their utilisation of and support for the Regional Centres for Space Science and Technology Education, affiliated to the United Nations, located in Morocco and Nigeria<br>f. To promote knowledge sharing through regional space conferences and through scholarly interaction among African institutions<br>g. To support the existing networks and associations of space professionals in Africa<br>h. To encourage the development and |

(continued)

**Table 2.1** (continued)

| | |
|---|---|
| | implementation of university curricula in space science and technology in Africa |
| 4. For the advancement of *scientific knowledge of outer space and to protect the space environment* for future generations, action should be taken: | a. To promote and strengthen intra-African cooperative activities in areas such as astronomy, space physics, and the study of near-Earth objects and to encourage participation of African institutions in global lunar and planetary exploration efforts<br>b. To protect the near-Earth space environment through responsible actions in outer space, including the implementation of the Space Debris Mitigation Guidelines of the United Nations Committee on the Peaceful Uses of Outer Space, and other established international best practices in this regard<br>c. To ensure that the activities of African States do not introduce electromagnetic interference that may disrupt space applications or interfere with Earth observation in certain bands or with ground-based astronomical activities |
| 5. For the advancement of the widest possible *adherence to international treaties* governing the use of outer space for peaceful purposes, action should be taken: | a. To encourage African States to accede to the existing United Nations treaties governing the peaceful uses of outer space in order to protect their legitimate rights and interests in space activities<br>b. To encourage African states to develop national policies and regulatory frameworks to govern the activities of States and their space agencies at the level of domestic legal order and to regulate such activities under their legal jurisdictions<br>c. To encourage closer cooperation and dialogue between universities and institutions with established space law programmes and those wishing to develop such programmes, for the benefit of students and professionals in the public and private sector<br>d. To promote overall capacity building in space law in Africa, for which regional coordination and cooperation could play an important role |
| 6. For the enhancement of *public awareness* of the importance of space activities, action should be taken: | a. To promote the celebration, in all African countries, of World Space Week, proclaimed by the United Nations General Assembly to be celebrated annually from October 4 to 10<br>b. To increase awareness among decision-makers and the general public in Africa of the importance of utilising space infrastructure to improve the common economic and social welfare of humanity<br>c. To encourage all African countries to |

(continued)

**Table 2.1** (continued)

| | |
|---|---|
| | provide their children and youth, of both genders, with opportunities to learn more about space science and technology and its importance to human development, as an investment in the future<br>d. To develop a mechanism for the sharing of experiences, knowledge, and resources to improve space awareness in Africa |
| 7. For the strengthening of space activities in the *African Union*, action should be taken: | a. To establish, within the African Union, the African Leadership Conference on Space Science and Technology for Sustainable Development as a consultative mechanism on space science and technology<br>b. To encourage participation of a greater number of African states in the ALC though engagement with the African Union<br>c. To establish a special African Union fund for the purpose of implementing the recommendations of the ALC conferences |
| 8. For the strengthening of African participation in the *United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS)* and *other global space fora*, action should be taken: | a. To reaffirm the importance for African member states of UNCOPUOS and to participate actively in the sessions of UNCOPUOS and its Scientific and Technical Subcommittee and Legal Subcommittee<br>b. To promote better coordinated African participation in UNCOPUOS and other global space fora, to ensure that the agendas in those fora address Africa's needs and to engage in those fora with well-developed African positions on key issues<br>c. To affirm, through statements in UNCOPUOS, the value of the United Nations Programme on Space Applications for Africa and the importance of ensuring the provision of adequate resources for the continuation of this Programme<br>d. To take note of the outcomes and recommendations of other regional conferences for Asia and the Pacific and Latin America and the Caribbean that are relevant to efforts to promote cooperation in the peaceful uses of outer space at the regional, interregional, and global levels |

African Leadership Conference, "The Mombasa Declaration on Space and Africa's Development", *Space Policy* 28, (2012): 68–69. Emphasis added

**Table 2.2** Measures adopted at the 2015 ALC in Sharm El-Sheikh, Egypt

| |
|---|
| 1. To pursue the establishment of the African Leadership Conference on Space Science and Technology for Sustainable Development as a think-tank and a consultative body for the benefits of the African governmental entities and institutions on space science and technology and its applications |
| 2. To finalise the constitution of the African Leadership Conference (ALC) |
| 3. To encourage greater participation of African states, institutions, and professionals in the ALC |
| 4. To assist the capacity development of African Young Professionals and African Women in Aerospace and encourage gender equity in space science and technology |
| 5. To encourage the establishment of the African Space Agency |
| 6. To encourage the participation of the African Diaspora in the implementation of space science and technology on a continental level |
| 7. To encourage the Pan-African University Space Sciences to partner with other relevant African universities |
| 8. To promote intra-Africa cooperation as well as collaboration with other regional and international organisations |
| 9. To promote coordination between the Institute of African Research and Studies, Cairo University in Egypt, and other relevant African universities to conduct and prepare studies in space policies and strategies |
| 10. To recommend strengthening of Africa's flagship projects and initiatives in space communication and navigation |

African Leadership Conference, "ALC—2015 Resolution," 2015, http://www.alc.narss.sci.eg/webroot/attachments/ALC2015-Egypt-Declaration.pdf (accessed September 12, 2018)

(SRM), among others.[58] Ethiopia was selected as host for the eighth ALC in 2019 (Fig. 2.4).

In relation to the primary needs model, the ALC is a critical forum that speaks to all primary needs, as evidenced by the Mombasa Declaration. The ALC fulfils the critical needs of raising awareness of the importance of space among political leaderships, exchanging ideas and building dialogue, and enhancing intra-African cooperation. None of the primary needs can be addressed without these functions. Moreover, by committing to the Mombasa Declaration, a number of countries (including Algeria, Nigeria, South Africa, Egypt, Tanzania, Sudan, Ghana, Burkina Faso, Morocco, and Kenya) have undertaken to "harness space science and technology for the betterment of the human condition in Africa".[59]

The ALC also has a Youth Forum (ALC-YF), which was formed to be a platform for young space sector professionals and students to "interact, share knowledge and experiences, and contribute towards space development in the continent", and this

[58] Space in Africa, "All about the ongoing African Leadership Conference on Space Science and Technology," *Africa Space News*, November 6, 2018, https://africanews.space/all-about-the-ongoing-african-leadership-conference-on-space-science-and-technology/ (accessed December 6, 2018).

[59] African Leadership Conference, "The Mombasa Declaration on Space and Africa's Development," 68.

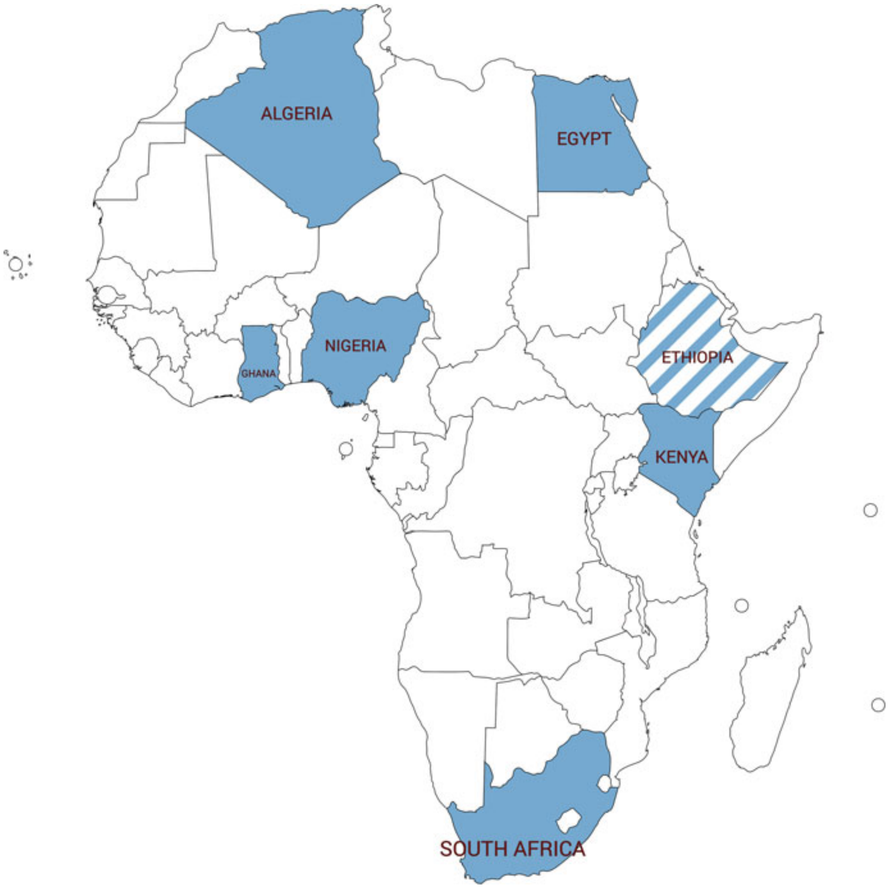


**Fig. 2.4** Host states of the African Leadership Conference (ALC)

effort is based on the recognition that “in the future, young professionals will take up the leadership of ALC”.[60] The specific focus of the ALC-YF is on serving “as a platform for youth participation in space issues and policies in Africa”, to “influence government decisions through public campaigns organized for the citizens, and lobbying the members of the political class” and to “provide opportunities for African students and young professionals to contribute to space development (satellite technology, space sciences, space law, etc.) in Africa”.[61]

[60] African Leadership Conference Youth Forum, “Home.”

[61] African Leadership Conference Youth Forum, “Vision, Mission and Objectives,” https://alcyouthforum.wordpress.com/about/objectives/ (accessed September 13, 2018).

### The Square Kilometre Array (SKA)

The SKA represents the goal of 12 member states and over 100 organisations from about 20 countries to build the world's largest radio telescope with an eventual collecting area of over one square kilometre.[62] The 12 member states are represented on the SKA Board of Directors by national organisations. These member states and their representative organisations are Australia (Department of Industry and Science), Canada (National Research Council), China (Ministry of Science and Technology of the People's Republic of China), France (National Centre for Scientific Research), India (National Centre for Radio Astrophysics), Italy (National Institute for Astrophysics), New Zealand (Ministry of Economic Development), South Africa (National Research Foundation), Spain (Ministry of Science, Innovation and Universities), Sweden (Onsala Space Observatory), the Netherlands (Netherlands Organisation for Scientific Research), and the United Kingdom (Science and Technology Facilities Council).[63] A variety of developed and developing countries are thus participating in the project.

What makes the SKA project particularly exciting for intra-African space relations is that while both South Africa and Australia were selected as co-hosts for the array, due to factors including "atmospherics above the desert sites, through to the radio quietness, which comes from being some of the most remote locations on Earth",[64] eight other African countries will also host extended facilities (Botswana, Ghana, Kenya, Madagascar, Mauritius, Mozambique, Namibia, and Zambia).[65] This is depicted in Fig. 2.5. The SKA thus represents an international partnership both globally and within Africa, and while it promises to expand our knowledge on a range of topics, including "insight into the formation and evolution of the first stars and galaxies after the Big Bang, the role of cosmic magnetism, the nature of gravity, and possibly even life beyond Earth",[66] it also promises spin-off benefits to the participating countries and space communities since large-scale astronomy projects "in addition to the scientific benefits . . . also provide lucrative opportunities for local industry"[67] and skills development.

Prior to being awarded the right to co-host the SKA, South Africa had constructed the Karoo Array Telescope (KAT), in particular the KAT-7 (a seven-dish array), which was "the world's first radio telescope array consisting of composite antenna

[62]Square Kilometre Array, "The SKA Project," 2018, https://www.skatelescope.org/the-ska-project/ (accessed September 9, 2018).

[63]Square Kilometre Array, "Square Kilometre Array Project," 2018, https://www.skatelescope.org/participating-countries/ (accessed September 9, 2018).

[64]Square Kilometre Array, "The SKA Project."

[65]Square Kilometre Array, "Africa," 2018, https://www.skatelescope.org/africa/ (accessed September 9, 2018).

[66]Square Kilometre Array, "SKA Science," 2018, https://www.skatelescope.org/science/ (accessed September 9, 2018).

[67]Peter Martinez, "Space Science and Technology in South Africa: An Overview," *African Skies/Cieux Africains*, 2008, no. 12: 47.


**Fig. 2.5** Square Kilometre Array locations across Africa. Based on: Brian Sandberg, "South Africa—home to "The Greatest Know on Earth"?," *Viva Afrika*, May 31, 2012, https://vivaafrika.wordpress.com/tag/square-kilometre-array/ (accessed September 9, 2018)

structures".[68] This was also accompanied by "an extensive human capital development programme" in an effort to bolster support for the South African bid for the SKA.[69] The KAT-7 was an "important testing ground" for the MeerKAT array of 64 dishes, currently under construction, and which now forms part of the first phase of the SKA.[70] This will be integrated into the SKA1 MID, which will be the SKA's mid-frequency instrument (the low-frequency aperture array antennas will be hosted

[68]Square Kilometre Array South Africa, "KAT-7," http://www.ska.ac.za/gallery/kat-7/ (accessed September 9, 2018).

[69]Martinez, "Space Science and Technology in South Africa," 47–48.

[70]Square Kilometre Array, "Africa."

by Australia), and will be complemented with an additional 130 dishes, bringing the SKA MID1 up to almost 200 dishes in the Karoo region of South Africa.[71] Phase 1 of the SKA is expected to be completed by 2023.[72] Phase 2 will see the construction of about 2000 dishes across Africa and up to 250 Mid-Frequency Aperture Array Stations also in Africa (although these are not confirmed).[73] Phase 2 is expected to last until the late 2020s.[74]

The MeerKAT project has already started to produce a cadre of "young scientists and engineers with world-class expertise in the technologies which will be crucial in the next 10–20 years, such as very fast computing, very fast data transport, large networks of sensors, software radios and imaging algorithms".[75] In addition, the African SKA Human Capital Development Programme has awarded nearly 1000 grants between 2005 and 2017 for studies in fields of astronomy and engineering, from undergraduate to post-doctoral levels, and "[a]stronomy courses are being taught as a result of the SKA Africa project in Kenya, Mozambique, Madagascar and Mauritius (which has had a radio telescope for many years) and are soon to start in other countries".[76] With an estimated total value of €2 billion, and an annual operations cost of between €150 million and €200 million, the SKA is a formidable and valuable project for African-participating countries.[77] It is also a powerful catalyst for astronomy and space science development on the continent, as well as skills development, as witnessed by the fact that "1054 (as at February 2018) students have benefited from SKA South Africa bursaries and scholarships, including many students from other African countries".[78] In terms of the primary needs model, the SKA thus speaks directly to both education and space-related capacity building. This includes the fostering of valuable skills in fields related to astronomy, including computer science, statistics, and eResearch technologies.[79] It also "increases the prospects of science, technology, engineering, and math (STEM) education in Africa".[80]

[71] Ibid.

[72] Square Kilometre Array, "SKA Technology," 2018, https://www.skatelescope.org/technology/ (accessed September 9, 2018).

[73] Square Kilometre Array, "The Location of the SKA," 2018, https://www.skatelescope.org/location/ (accessed September 9, 2018).

[74] Square Kilometre Array, "SKA Technology."

[75] Square Kilometre Array South Africa, "The Project," https://www.ska.ac.za/about/the-project/ (accessed September 9, 2018).

[76] Ibid.

[77] Samuel Oyewole, "Space Research and Development in Africa," *Astropolitics* 15, no. 2 (2017): 194.

[78] Square Kilometre Array South Africa, "Research and study opportunities," https://www.ska.ac.za/students/ (accessed September 9, 2018).

[79] University of the Western Cape, "Three SA Universities join forces to bolster SKA," 2013, https://www.uwc.ac.za/News/Pages/Three-SA-universities-join-forces-to-bolster-SKA.aspx (accessed September 12, 2018).

[80] Oyewole, "Space Research and Development in Africa," 199.

Annual ministerial meetings are held between the nine African partner countries, with the fifth, and most recent, being held in October 2018. There, all countries pointed to "financial constraints as a major obstacle to the full rollout of the AVN project [African Very Long Baseline Interferometry Network], [but] they were unanimous that progress was being made", and another initiative funded by South Africa and the United Kingdom "aimed at developing radio astronomy capacity in partner countries, namely the Development in Africa through Radio Astronomy (DARA) programme" was noted.[81] The importance of the Big Data Africa project was noted by the ministers, for "both astronomy as well as more general preparations for the fourth industrial revolution", and "[g]iven the significance of big data and cyber infrastructure in economic development at both national and regional level, it was agreed that South Africa and Namibia would explore ways of integrating the Big Data Africa activities in Southern Africa into the SADC Industrialisation Strategy, taking into account prior work within SADC, and liaising with the other members of SADC".[82] Thus, the SKA project presents spin-off benefits for the entire region.

### AfriGEOSS

AfriGEOSS represents the African Earth Observation community within the Global Earth Observation System of Systems (GEOSS).[83] AfriGEOSS is an initiative "developed within the GEO [Group on Earth Observations] framework, [which] will strengthen the link between the current GEO activities with existing capabilities and initiatives in Africa" in order to "provide the necessary framework for countries and organizations to access and leverage ongoing bilateral and multilateral EO-based initiatives across Africa, thereby creating synergies and minimizing duplication for the benefit of the entire continent".[84] It also serves "as the gateway into Africa for International partners and as a platform for Africa's participation in GEO".[85] More specifically, AfriGEOSS identifies the following vision and goal:

[81]Space in Africa, "Joint media statement on the outcomes of the 5th Ministerial Meeting of the Square Kilometre Array (SKA) African Partner Countries," *Africa Space News*, October 25, 2018, https://africanews.space/joint-media-statement-on-the-outcomes-of-the-5th-ministerial-meeting-of-the-square-kilometre-array-ska-african-partner-countries/?fbclid=IwAR0oKjmgRzEYsTsOnP5TNbRd4Z2_FrupnBh1pvFWyiTgvkTWp1s0-jMQ08A (accessed December 7, 2018).

[82]Ibid.

[83]AfriGEOSS, "About AfriGEOSS," *Group on Earth Observations*, http://www.earthobservations.org/afrigeoss.php (accessed September 9, 2018).

[84]Ibid.

[85]Ganiy I. Agbaje and Olusoji N. John, "Cooperation in Earth Observation Missions in Africa: A Role for AfriGEOSS," *GeoJournal*, 2017: 7.

> a continent where decisions on policy and implementation programs, involving the production, management and use of Earth observation, are taken with the involvement of all stakeholders, through a coordination framework enabling the linkage country-region-continent that AfriGEOSS wants to build. This is expected to be realized, in the medium-long term, by strengthening and enlarging the role of the existing national, regional and continental institutions.[86]

> AfriGEOSS aims to provide the necessary framework for African countries and organizations as well as international partners to access and leverage on-going local and international bilateral and multilateral EO-based initiatives across Africa, thereby creating synergies and minimizing duplication for the benefit of the continent.[87]

Seven objectives are stated, namely, to (i) coordinate and bring together relevant stakeholders, institutions, and agencies across Africa that are involved in GEO and other Earth observation activities; (ii) provide a platform for countries to participate in GEO and to contribute to GEOSS; (iii) assist in knowledge sharing and global collaboration; (iv) identify challenges, gaps, and opportunities for African contributions to GEO and GEOSS; (v) leverage existing capacities and planned assets and resources; (vi) develop an appropriate strategy and participatory model for achieving the above goals; and (vii) develop a strategy of communication of the Earth observation data in Africa.[88]

While the broader GEO initiative is comprised of over 100 national governments and over 100 participating organisations, focused on "a future where decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations", AfriGEOSS has 27 African states as members (Fig. 2.6).

The third AfriGEOSS Symposium was held in Libreville, Gabon, on June 26–28, 2018, focusing on the topic of building smarter Earth observations to support sustainable development policies.[89] Representatives from other African countries, such as Rwanda and Togo,[90] as well as organisations beyond Africa, such as the European Space Agency (ESA) and the National Aeronautics and Space Administration, were also present, with the latter agencies being involved in various training sessions.[91]

[86]AfriGEOSS, "Vision, Goal and Objectives," http://www.earthobservations.org/afrigeoss.php (accessed September 9, 2018).

[87]Ibid.

[88]Ibid.

[89]AfriGEOSS, "3rd AfriGEOSS Symposium," *Group on Earth Observations*, 2018, http://www.earthobservations.org/documents/me_201806_afrigeoss/me_201806_afrigeoss_final_agenda.pdf (accessed September 9, 2018).

[90]Ibid.

[91]AfriGEOSS, "Trainings sessions, 22–25 June 2018," Group on Earth Observations, 2018, http://www.earthobservations.org/documents/me_201806_afrigeoss/me_201806_afrigeoss_training_schedule.pdf (accessed September 9, 2018).

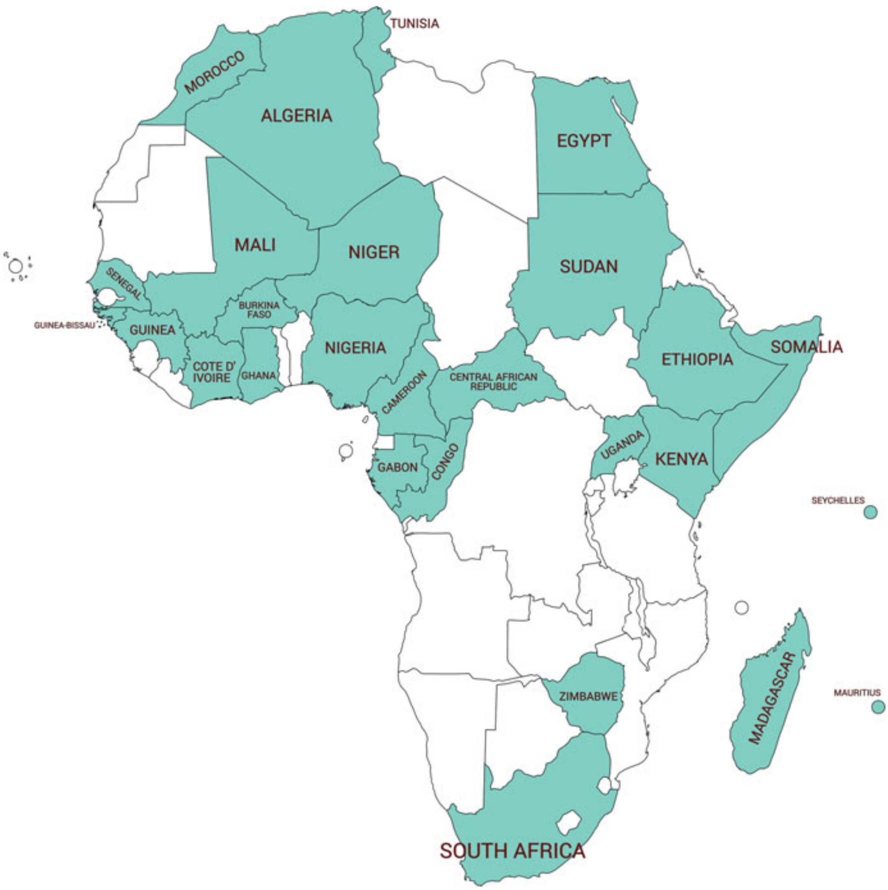


**Fig. 2.6** African member states of AfriGEOSS within the Group on Earth Observations. AfriGEOSS, "Member Countries," *Group on Earth Observations*, http://www.earthobservations.org/afrigeoss.php# (accessed September 9, 2018)

Accordingly, the broader GEO network has good African representation, as well as intra-African relationships in the form of AfriGEOSS. GEO itself is predicated on "creating a Global Earth Observation System of Systems (GEOSS) to better integrate observing systems and share data by connecting existing infrastructures using common standards",[92] and thus strong African participation is beneficial for the continent. This is especially the case given that there "are more than 400 million open data resources in GEOSS from more than 150 national and regional providers

[92]Group on Earth Observations, "About Us," http://www.earthobservations.org/geo_community.php (accessed September 9, 2018).

such as NASA and ESA; international organizations such as WMO and the commercial sector such as Digital Globe".[93]

African participation within the broader GEO network, and more specifically within the AfriGEOSS initiative, thus can once again directly link up with all aspects of the primary needs model. Earth Observation (EO) data supports all facets of climate, biodiversity, health, water, education, and capacity building, and by facilitating access and leveraging EO-based initiatives across Africa, as well as organising symposia and training sessions, AfriGEOSS is strengthening Africa's capabilities in this arena, and the "initiative has been recognized [as] essential to enhance Africa's capacity for producing, managing and using Earth observations, thus also enabling the Region's participation in, and contribution to, the Global Earth Observation System of Systems (GEOSS)".[94] Moreover, the importance of EO data cannot be underestimated since "Africa remains the least mapped continent in the world" with serious consequences—"if it can't map, surely it can't be managed".[95] Accordingly, all efforts in this field are critical given the power of remote sensing technology to change "the way we think and solve problems related to the environmental and sustainable stewardship of our planet".[96]

### The African Regional Institute for Geospatial Science and Technology (AFRIGIST)

The AFRIGIST (formerly known as the Regional Centre for Training in Aerospace Surveys—RECTAS) was founded under the auspices of the United Nations Economic Commission for Africa (UNECA) in 1972 to act as an "educational 'one-stop' solution institution that trains highly skilled manpower in geospatial information science and technology, and its applications".[97] It is based at the campus of Obafemi Awolowo University, Ile-Ife, Nigeria. While other educational institutions in Africa, such as UNOOSA's ARCSSTE, will be discussed in a later section due to their forming part of a broader international network, AFRIGIST is an "inter-governmental joint institution for Africa", operating on a bilingual (English and French) basis, with membership open to all African countries.[98] Currently, 11 African countries are members of AFRIGIST—Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Ghana, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, and Senegal (Fig. 2.7).

[93] Ibid.

[94] AfriGEOSS, "About AfriGEOSS."

[95] Agbaje and John, "Cooperation in Earth Observation Missions in Africa," 2.

[96] Pratistha Kansakar and Faisal Hossain, "A review of applications of satellite earth observation data for global societal benefit and stewardship of planet earth," *Space Policy* 36, (2016):53.

[97] African Regional Institute for Geospatial Science and Technology, "About Us," 2018, https://afrigist.org/about/# (accessed September 12, 2018).

[98] Ibid.

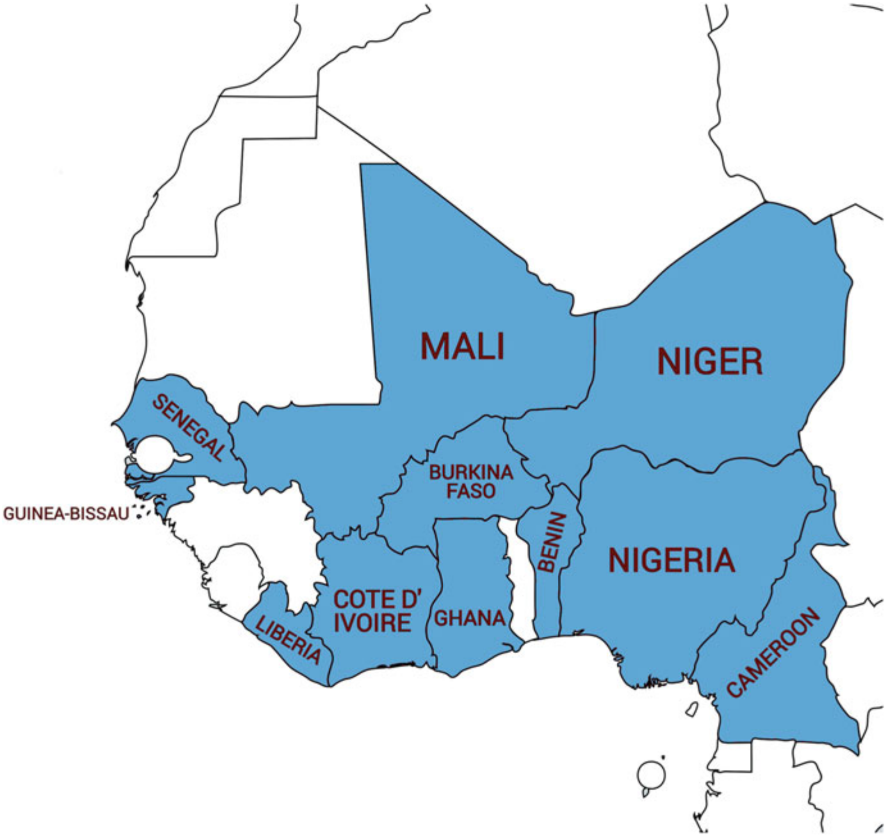


**Fig. 2.7** Members of the African Regional Institute for Geospatial Science and Technology. African Regional Institute for Geospatial Science and Technology, "About Us," 2018, https://afrigist.org/about/# (accessed September 12, 2018)

Training packages (including e-learning options) are offered in a range of subject areas of geospatial science technology, as are a range of courses—including Technologist Diploma (TD), Postgraduate Diploma (PGD), Professional Master (PM), and Master's of Science in Geo-Information Science (MGIS).[99] AFRIGIST also maintains a consultancy outfit named RECTAS Consult. Over 2200 trainees have attended AFRIGIST, making it an important contributor to education as part of the primary needs approach, since Geospatial Information Science and Technology is a critical component in making use of EO data (thus indirectly also supporting the full range of primary needs).

[99]Ibid.

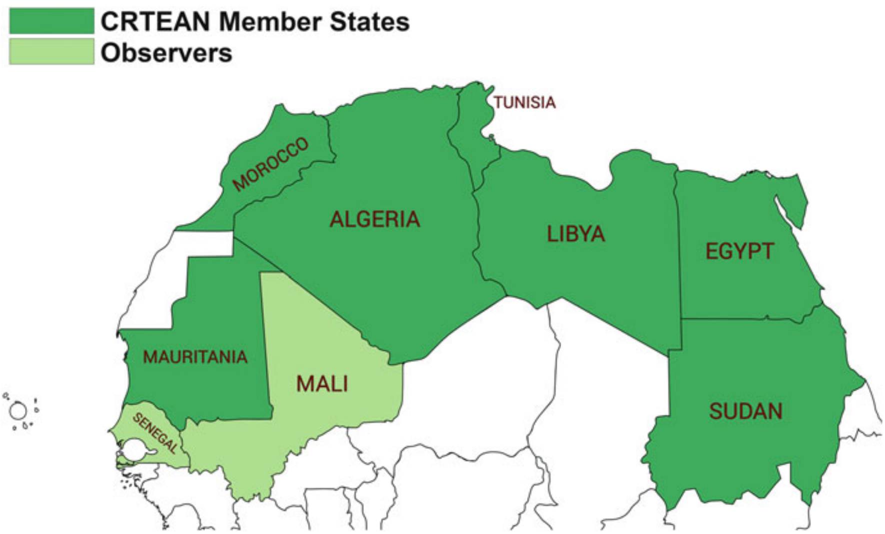


**Fig. 2.8** Member states and other African state observers of CRTEAN. Regional Centre for Remote Sensing of North Africa States, "The Centre: Composition"

## The Regional Centre for Remote Sensing of North Africa States (CRTEAN)

Headquartered in Tunis, Tunisia, is the CRTEAN (*Centre Régional de Télédétection des Etats de l'Afrique du Nord*), which is an international organisation with seven North African member states (Algeria, Egypt, Libya, Mauritania, Morocco, Sudan, and Tunisia—seen in Fig. 2.8).[100] CRTEAN was founded in 1990.[101] Organisations from the member countries which are part of CRTEAN are the National Centre for Mapping and Remote Sensing (CNCT), Tunisia; the Royal Centre for Remote Sensing (CRTS), Morocco; Survey Department (SDL), Libya; the Ministry of Housing and Urbanism and Reclamation Turabi, Mauritania; the National Authority for Remote Sensing and Space Sciences (NARSS), Egypt; and the Sudan National Survey Authority (SNSA), Sudan.[102] Observer members of CRTEAN include General Organisation for Remote Sensing (GORS) in Syria; General Authority for Remote Sensing in Sudan; Libyan Centre for Remote Sensing and Space Sciences (LCRSSS) in Libya; Yemen Centre for Remote Sensing and GIS (YRSC) in Yemen;

[100] Regional Centre for Remote Sensing of North Africa States, "Home," 2014, http://www.crtean.org.tn/en/ (accessed September 12, 2018).

[101] Regional Centre for Remote Sensing of North Africa States, "The Centre: Presentation," 2014, http://www.crtean.org.tn/en/index.php/the-center/presentation (accessed September 12, 2018).

[102] Regional Centre for Remote Sensing of North Africa States, "The Centre: Composition," 2014, http://www.crtean.org.tn/en/index.php/the-center/composition1 (accessed September 12, 2018).

**Table 2.3** Objectives stipulated in the constitutive act of CRTEAN

| |
|---|
| a. Promote the development of remote sensing activities in the member states and encourage them to set up specialised national facilities |
| b. Promote the setting up of regional projects related to remote sensing and coordinate remote sensing activities in the member state territories to improve the exploration, the inventory, and the development of national natural resources that are of common economic interest to more than one member state |
| c. Encourage multilateral and bilateral close relations between the member states in the field of remote sensing as well as promote staff and know-how exchanges |
| d. Be informed of the existing potentials in the region, of the new technics [techniques] introduced, and of the associated management methods. In addition, get the member states informed through magazines, directories, and other publications, and encourage the national and optimal use of the existing means based on self-reliance, according to the spirit of the Lagos Action Plan [this was an Organisation of African Unity-backed plan to increase Africa's self-sufficiency, drafted in Lagos, Nigeria, in April 1980] |
| e. Enhance the flourishing of sciences alongside the mastering of geographical information at the level of the member states |
| f. Enable member states to have access to remote sensing technics [techniques], and promote training |
| g. Encourage continuous training as well as high-level training for member states' nationals with the participation of the operative organisations. Promote the holding of conferences, seminars, exhibitions, and other scientific and technical events related to remote sensing at the national and regional levels |
| h. Operate within the African Organisation of cartography and remote sensing along with the international, regional, and operative organisations in order for the centre to be effectively involved in the coordination of actions and projects of common interest targeting the member states' territories |
| i. Support the African Organisation of cartography and remote sensing to coordinate projects and implement action plans related to the region and to the member states in the field of remote sensing, and seek the assistance of international, regional, and operative organisations to guarantee the success of these projects |

Regional Centre for Remote Sensing of North Africa States, "The Constitutive Act of the North African Center of Remote Sensing (CRTEAN)", http://www.crtean.org.tn/Nouveau/pdf/Texte_Jur.En.pdf (accessed September 12, 2018)

International Space University (ISU), France; Mali (representative); and Senegal (representative).[103] The Arab Maghreb Union REC is also a partner.[104] Its objectives revolve around encouraging institutions in member states to (i) use remote sensing techniques and upstream systems in the areas of sustainable development and scientific research, (ii) promote technology transfer, and (iii) build capacity in member states.[105] More specifically, the Constitutive Act of CRTEAN stipulates the objectives as listed in Table 2.3.

[103]Ibid.

[104]Ibid.

[105]Regional Centre for Remote Sensing of North Africa States, "Home."

As outlined in the organisation's 2013 General Strategy, there are ten identified "Accessible fields from a research point of view" for which remote sensing applications can be of benefit, namely, environment, natural resources, agriculture, periodic surveillance and security, geodesics and space, urbanisation and population census, disaster monitoring, space science, space culture and community awareness, and space legislation.[106] CRTEAN thus directly supports the full range of primary needs identified in Chap. 1, including education and capacity building, without which remote sensing data cannot be effectively utilised. CRTEAN thus forms an important North African hub for "international cooperation in the field of space technology … to benefit from them as much as possible through the creation of programs between Member States and these agencies".[107]

### SERVIR and the (Eastern and Southern African) Regional Centre for Mapping of Resources for Development (RCMRD)

SERVIR is a result of a joint partnership between the US Agency for International Development (USAID) and the US National Aeronautics and Space Administration (NASA) and regional institutions in East Africa in order to "improve environmental management and resilience to climate change".[108] The project was originally set up in Latin America but was extended to Africa in 2008 when NASA and USAID partnered with the Kenyan Regional Centre for Mapping of Resources for Development (RCMRD) in Nairobi.[109] SERVIR "integrates satellite observations and predictive models with other geographic information (sensor and field-based) to monitor and forecast ecological changes and respond to natural disasters"[110] and applies to "multiple sectors and supports the objectives of the Intergovernmental Group on Earth Observations (GEO) in the areas of agriculture, biodiversity, climate change, disasters, ecosystems, health, water, and weather".[111] The Eastern and Southern African hub caters primarily to:

> better hydrologic estimation in the region, delivering data to aid flood forecasting, flood relief and post-event flood mapping. It works to manage precious natural resources and to promote sustainable development through dissemination of satellite information and services among participating nations across the region—and throughout the continent as a

[106] Regional Centre for Remote Sensing of North Africa States, "General Strategy of the Regional Center for Remote Sensing of North African States," *Regional Centre Administration*, December, 2013, 19–22, http://www.crtean.org.tn/en/images/PDF/Strategy%20-%20english.pdf (accessed September 12, 2018).

[107] Ibid., 9.

[108] Regional Centre for Mapping of Resources for Development, "SERVIR Eastern & Southern Africa," http://www.rcmrd.org/projects/servir-esa (accessed September 13, 2018).

[109] Agbaje and John, "Cooperation in Earth Observation Missions in Africa," 3–4.

[110] Ibid., 4.

[111] Regional Centre for Mapping of Resources for Development, "SERVIR Eastern & Southern Africa."

> whole. The end result—reducing risks associated with famine and disease epidemics springing up in the wake of drought and flood cycles to devastate the population.[112]

SERVIR builds on the strengths of the RCMRD, which aims to "promote sustainable development in the member States through generation, application and dissemination of geo-information and allied ICT technologies, products and services" and which was founded in 1975 under UNECA auspices, followed by the Organisation of African Unity (OAU) and ultimately the African Union.[113] The RCMRD is an intergovernmental African hub of expertise and is "instrumental in capacity building in resource survey, mapping, remote sensing, GIS and natural resources assessment and management in Africa", assisting with the setting up of various national mapping agencies in Africa, and trains "more than 3000 technical officers from its member States and other African countries in the fields of surveying and mapping, remote sensing, GIS and natural resources assessment and Management" yearly.[114] It is comprised of 20 contracting member states and five noncontracting member states, as outlined in Fig. 2.9.

Together, SERVIR and the RCMRD address all aspects of the primary needs model. In its training capacity, the RCMRD plays a critical educational and capacity building role in relation to surveying and mapping, remote sensing, GIS, and natural resource assessment and management, while in its capacity of providing services on a demand-driven basis, including problem-solving applications in natural resource and environmental management, and together with SERVIR, environment, biodiversity, health, and water are all addressed. Its range of services cover "the fields of surveying and mapping including aerial photography, photogrammetry, photo-interpretation, first order geodesy, remote sensing, calibration and maintenance of surveying and mapping equipment"[115]—which can be used in relation to the primary needs areas mentioned above.

The 11th RCMRD Conference of Ministers (held every 2 years) was held in November 2018 in Kasane, Botswana, where over 100 senior government officials and ministers in charge of Lands and Mapping from Southern and Eastern Africa met to discuss their new strategic plan for the period 2019–2022 as well as "the role of mapping, remote sensing and GIS in the promotion of the economic development, poverty reduction, environmental conservation, land management and administration in the region".[116] The 52nd meeting of the Governing Council (GC) of the RCMRD and its committees was also held at the same venue to review and approve "implementation of the 2018 Annual Work plan, consider and approve the 2019

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[112]Jennifer Harbaugh, "SERVIR-Eastern and Southern Africa," *National Aeronautics and Space Administration*, August 4, 2017, https://www.nasa.gov/mission_pages/servir/africa.html (accessed September 13, 2018).

[113]Regional Centre for Mapping of Resources for Development, "About Us," http://www.rcmrd.org/about-us/organization (accessed September 13, 2018).

[114]Ibid.

[115]Ibid.

[116]Space in Africa, "11th RCMRD Conference of Ministers Held in Kasane, Botswana," *Africa Space News*, November 23, 2018, https://africanews.space/11th-rcmrd-conference-of-ministers-held-in-kasane-botswana/ (accessed December 7, 2018).

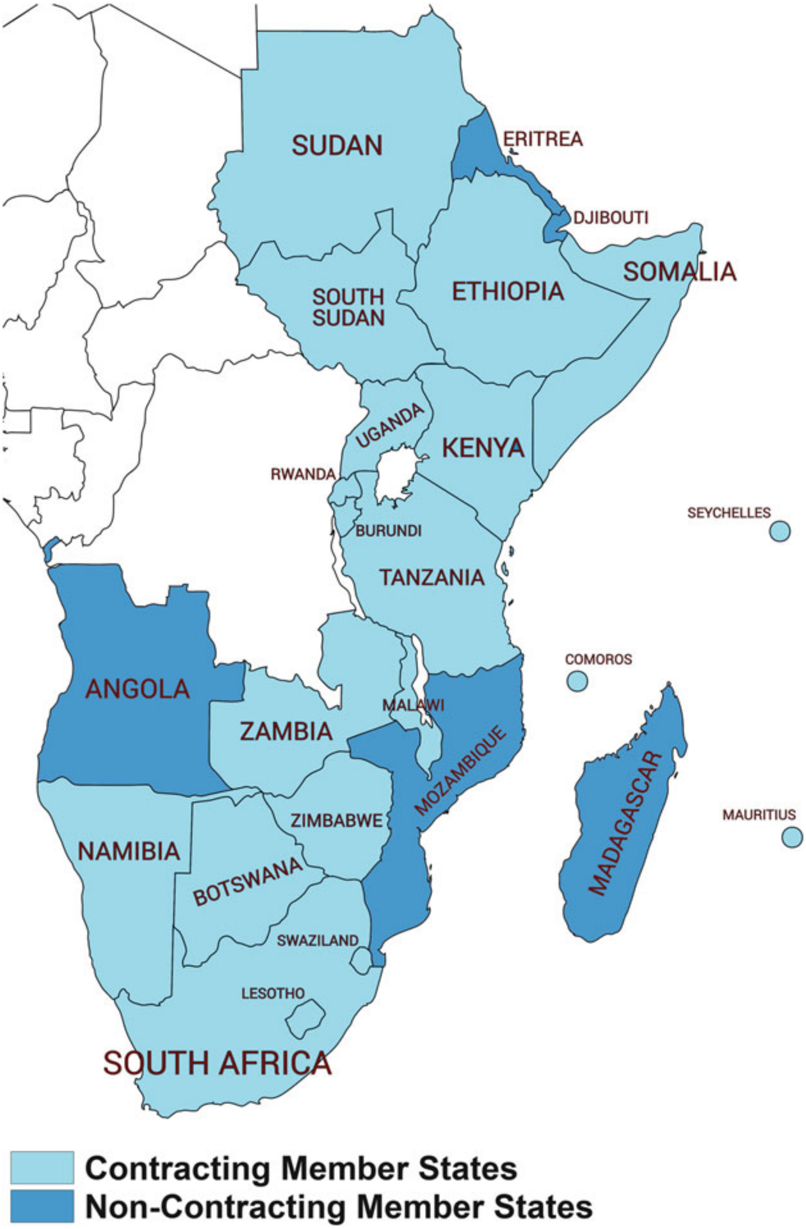


**Fig. 2.9** Member states of the RCMRD. Regional Centre for Mapping of Resources for Development, "About Us," http://www.rcmrd.org/about-us/organization (accessed September 13, 2018)

Work Plan, receive the 2017 financial audit report, appoint senior staff and appoint contractors for infrastructure projects at the Centre".[117]

### The African Centre of Meteorological Application for Development (ACMAD)

ACMAD was founded in 1987 by the Conference of Ministers of UNECA and the World Meteorological Organisation (WMO) and has been based in Niamey, Niger, since 1992.[118] All African states are members of the organisation.[119] ACMAD is a weather and climate centre that is operated by a "staff complement of 12 persons (experts and support personnel included)", but this number can grow to 30 depending on "personnel on attachment from National Meteorological Services and those on On-the-Job training programmes".[120] Besides its African member states, ACMAD also has a range of other partners, namely, foreign states (France, the United States, the United Kingdom, Spain, Germany, Canada, China, Australia), various subregional groupings including some RECs (SADC, ECOWAS, IGAD, CEMAC, CILSS,[121] COI), and a number of partner institutions (DMC, Harare, and IPCAC, Nairobi; NBA, AGRHYMET CERMES, CRESA, EAMAC, ICRISAT, METEO, France; IRD, MEDIAS, France; UKMO, INM, Espagne; NOAA, IRI CIMMS, EUMETSAT, CEPMMT, PNUD, PNUE, WorldSpace).[122]

ACMAD's mission is to provide weather and climate information and to promote sustainable development in the context of national poverty eradication strategies, in

[117]Space in Africa, "Excerpts from 52nd RCMRD Governing Council meeting in Kasane, Botswana," *Africa Space News*, November 19, 2018, https://africanews.space/52nd-rcmrd-governing-council-in-kasane-botswana/ (accessed December 7, 2018).

[118]African Center of Meteorological Application for Development, "About Us," 2018, http://www.acmad.net/new/?q=en/pages/about-us (accessed September 13, 2018).

[119]While ACMAD's website (Ibid.) states "ACMAD is composed of 53 Member States, the 53 countries of 'Africa' continent", a presentation by the centre's acting Director General indicates all countries are members: B.L. Lamptey, "Weather and Climate Services in Africa," African Center of Meteorological Application for Development, June, 2017, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=8&cad=rja&uact=8&ved=2ahUKEwiRorPMvLjdAhUpCcAKHWiYCRoQFjAHegQIAxAC&url=ftp%3A%2F%2Fftp.earthobservations.org%2FAfriGEOSS%2Fafrigeoss2017%2FFinal%2520Proceedings%2FSession09%2520Climate%2520adaptation%2FS09-2%2520Lamptey_ACMAD%2520AfriGEOSS2017.ppt&usg=AOvVaw17hWpzNcnL9uY2LWvmJwtT (accessed September 13, 2018).

[120]African Center of Meteorological Application for Development, "About Us."

[121]Permanent Interstate Committee for Drought Control in the Sahel, created in 1973 following severe drought in the Sahel region, with its secretariat based in Burkina Faso, and with 13 member states—Cape Verde, Burkina Faso, Mali, Niger, Chad, Benin, Côte d'Ivoire, Gambia, Guinea, Guinea-Bissau, Mauritania, Senegal, and Togo; Le Comité Permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel, "Présentation du CILSS," 2018, http://www.cilss.int/index.php/640-2/ (accessed September 13, 2018).

[122]African Center of Meteorological Application for Development, "About Us."

the fields of agriculture, water resources, health, public safety, and renewable energy.[123] The centre also engages in capacity building of the National Meteorological Services (NMS) of members, in terms of “weather prediction, climate monitoring (extreme events. . .), transfer of technology (telecommunications, computing and rural communication) and in research”.[124] It also undertakes activities related to (i) preparation and dissemination of products and services; (ii) development and transfer of tools and technology to NMSs; (iii) monitoring communications with users notably in rural communities; (iv) networking with NMSs and regional development aid institutions; (v) provision of a window to technology partners, under conditions which are typical of the African situation; (vi) supplementing member states and partner's contributions through a resource mobilisation policy; (vii) being a “nursery” for sustainable development of Africa; and (viii) utilising climate and the environment as resources for development.[125] Accordingly, ACMAD’s services and activities are indicative of all levels of the primary needs model.

**The African Union Space Working Group (SWG)**

The AU SWG originated from a recommendation by the Fourth African Ministerial Conference on Science and Technology (AMCOST IV) in March 2010.[126] The working group was responsible for the drafting of the African Space Policy and Strategy (ASPS), discussed in the previous chapter, and apart from organisations such as the AU Commission, the UNECA, and the NEPAD Agency, ten states make up the membership of the body, as indicated in Fig. 2.10.[127] Membership in the body thus indicates a level of recognised expertise in space affairs, a national interest in shaping space policy, and in coordinating inputs from a variety of user sectors and AU policy organs. Since the ASPS constitute key documents in relation to the African space arena, and they speak to the full range of space activities on the continent, the activities of the SWG can thus be argued to indirectly align with all aspects of the primary needs model.

### *2.2.2 Non-governmental Organisations (NGOs)*

This section will detail key African space-related NGOs and their alignment with the primary needs model. Seven NGOs have been selected, including well-known ones

[123] Ibid.

[124] Ibid.

[125] Ibid.

[126] African Union, “The African Union Working Group on Space Meeting,” *Press release No 137/2013*, August 26, 2013, https://au.int/sites/default/files/newsevents/pressreleases/27555-pr-pr_137-au_working_group_on_space_meeting.pdf (accessed September 13, 2018).

[127] Ibid.


**Fig. 2.10** Member states of the African Union Space Working Group. African Union, "The African Union Working Group on Space Meeting," *Press release No 137/2013*, August 26, 2013, https://au.int/sites/default/files/newsevents/pressreleases/27555-pr-pr_137-au_working_group_on_space_meeting.pdf (accessed September 13, 2018)

such as the African Association of Remote Sensing of the Environment (AARSE) and smaller, less well-known ones such as the Foundation for Space Development. Again, the goal is to demonstrate that African space activities extend to a diverse range of fields and do not solely depend on governmental initiatives.

### The African Association of Remote Sensing of the Environment (AARSE)

AARSE is a non-political scientific NGO founded in 1992, based in South Africa, and motivated by the primary aim to "increase the awareness of African governments and their institutions, the private sector and the society at large, about the empowering and enhancing benefits of developing, applying and utilizing

**Table 2.4** Objectives of the African association of remote sensing of the environment

| |
|---|
| a. To create an enabling environment for the continent of Africa to derive benefits from and contribute to international space science, technology, and application programmes |
| b. To assist its members as well as national, regional, and international user communities through timely dissemination of scientific, technical, policy, and programme information in all aspects of space science and technology |
| c. To provide a forum to address issues of common interest through the conduct of conferences, seminars, and workshops |
| d. To promote greater cooperation and coordination of efforts among African countries, institutions, and industries in the development of space technology and its application to natural resources and environmental issues |
| e. To promote greater appreciation of the benefit of the technology, especially remote sensing and geographic information system (GIS), in the pursuance of an African priority programme for economic recovery and sustainable development |
| f. To exchange views and ideas on technology, systems, policy, and services of earth observation systems and geoinformation science which are applicable to the betterment of Africa |
| g. To improve teaching and training in EO systems and geoinformation science and to collect, evaluate, and disseminate results and failures in remote sensing activities from all over the world |
| h. To bring together experts in remote sensing, GIS, and environmental problems and foster good understanding among the members |
| i. To promote or to organise public meetings and congresses with scientific reports |
| j. To conduct other remotely sensed and GIS activities consistent with its aims |

African Association of Remote Sensing of the Environment, "Overview," http://www.africanremotesensing.org/page-1611993 (accessed September 12, 2018)

responsibly, the products and services of Earth Observation Systems and Geo-information Technology".[128] Its specific objectives are outlined in Table 2.4.

AARSE has held biennial conferences across Africa since 1996, which constitute "the largest and premier forum in the continent for researchers on remote sensing technologies and geospatial information science, gathering leading scholars from the remote sensing and related communities" in order to present achievements, discuss challenges, and share experiences.[129] AARSE also consists of four technical committees, in the fields of Capacity Building and Outreach; Applications and Algorithm; Politics, Economics, and Entrepreneurship; and Sensors and Data.[130] Past AARSE conference locations are indicated in Fig. 2.11.

By stimulating research and discussions around remote sensing policies and remotely sensed data and GIS in environmental and natural resources assessment, and by providing an African forum for remote sensing professionals, as well as hosting workshops, symposia, and tutorials, AARSE relates to all aspects of the

[128] African Association of Remote Sensing of the Environment, "Overview," http://www.africanremotesensing.org/page-1611993 (accessed September 12, 2018).

[129] African Association of Remote Sensing of the Environment, "AARSE Conferences," http://www.africanremotesensing.org/page-1612007 (accessed September 12, 2018).

[130] African Association of Remote Sensing of the Environment, "Technical Committees," http://www.africanremotesensing.org/Technical-Committees (accessed September 12, 2018).

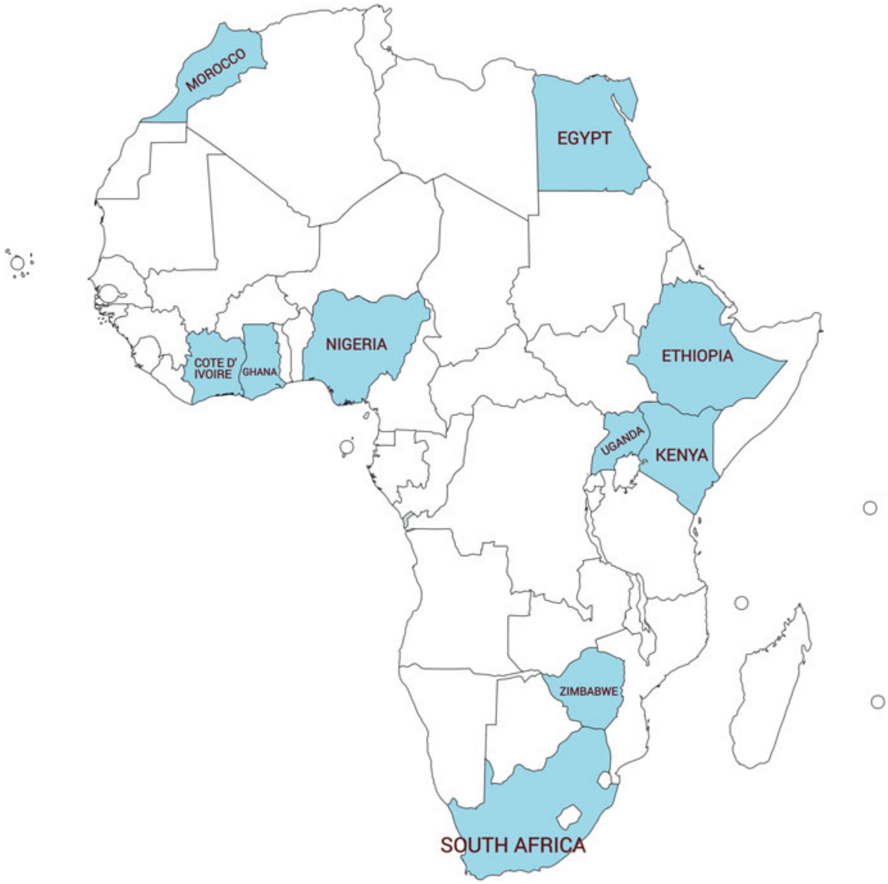


**Fig. 2.11** AARSE conference locations

primary needs model. The effective use of remote sensing data speaks to environmental, biodiversity, climate, water, and health issues, while workshops and tutorials promote education and capacity building. This is especially critical since "[r]emote sensing will play increasingly important roles in the solution to environmental problems, the study of global climate change and the monitoring of natural disasters".[131]

The most recent AARSE conference was held in October 2018, in Alexandria, Egypt, and was also attended by representatives of the African Union

[131] African Association of Remote Sensing of the Environment, "Why Join AARSE," http://www.africanremotesensing.org/Why-Join-AARSE (accessed September 12, 2018).

Commission.[132] At the conclusion of the successful conference, the AARSE Alexandria Declaration was accepted and called on the African Union and African governments to (i) "support the implementation of the Pan African Space Policy and Strategy and recognise the necessity for establishing the African Space Agency to manage and coordinate the implementation", (ii) "Urge African National Space Agencies and Remote Sensing Organisations to contribute to the implementation of the Pan African Space Policy and Strategy", (iii) "Encourage the development of national space policies and strategies flowing from and in line with the Pan African Space Policy", (iv) "Support the African Union Commission to strengthen Africa's space science and technology capabilities across the continent for the development of African nations", (v) "Ensure the realisation of the AU Agenda 2063 and the African Action Plan on the UN Global Geospatial Information Management (UN-GGIM)", (vi) "Stimulate African dialogue on space as a front-runner for innovation, technology development and job creation", (vii) "Build and invest in African capacity and capability, in both human resources and technology", (viii) "Encourage and support African universities and other institutions of higher education through adequate funding for fundamental and applied research and teaching in Earth Observation and geoinformation science and technology including the measuring of the indicators for the targets to be achieved by the SDGs", (ix) "Strengthen public-private partnership in space related activities and service delivery by private sector companies based on space-derived data", (x) "Recognise the role of specialised institutions at both the national and continental levels in geoinformation and Earth Observation and the role that they can play with AARSE to improve the knowledge and capacity in Africa", (xi) "Increase local investments to complement external investments to ensure sustainability of Earth Observation in Africa", and (xii) "Inspire Africa's youth through innovative space based education and outreach programs".[133] This declaration was unanimously accepted. The next AARSE conference will be held in Rwanda in 2020.

### The International Astronautical Federation (IAF) African Regional Group

The IAF is one of the best-known space advocacy NGOs, founded to promote dialogue on space research between its member organisations.[134] The IAF has an African regional group (along with an Asia-Pacific Regional Group and a Latin American and Caribbean Regional Group), and these regional groups "review and

[132]Space in Africa, "12th AARSE International Conference commences today in Alexandria, Egypt," *Africa Space News*, October 25, 2018, https://africanews.space/12th-aarse-international-conference-commences-today-in-alexandria-egypt/ (accessed December 7, 2018).

[133]African Association of Remote Sensing of the Environment, "AARSE Alexandria Declaration," October 29, 2018, presentation at 12th International AARSE Conference, Alexandria, Egypt.

[134]International Astronautical Federation, "History," http://www.iafastro.org/about/history/ (accessed September 13, 2018).

**Table 2.5** African member organisations of the IAF

| | |
|---|---|
| Algeria | • Agence Spatiale Algérienne (ASAL) |
| Kenya | • Kenya National Space Secretariat |
| Libya | • Association of Arab Remote Sensing Centres (AARSC) |
| Mauritius | • SpaceLand Africa |
| Morocco | • Centre Royal de Télédétection Spatiale |
| Nigeria | • The Federal University of Technology Akure (FUTA)<br>• Nigerian Meteorological Agency |
| South Africa | • Denel Spaceteq<br>• South African National Space Agency (SANSA)<br>• South African Space Association (SASA)<br>• Space Commercial Services Holdings (Pty) Ltd<br>• Stellenbosch University<br>• University of the Western Cape |
| Tunisia | • Centre National de la Cartographie et de la Télédétection (CNCT) |

International Astronautical Federation, "Our Members", http://www.iafastro.org/membership/ (accessed September 13, 2018)

report to the IAF via its Bureau on the status of the space activities and technologies in their region" while also submitting "recommendations to encourage and facilitate cooperation in their region in the uses of outer space".[135] Regional groups also undertake activities to "encourage institutions, corporations and individuals based in their region, especially those from the developing nations, to take interest and participate in the activities of the Regional Groups and in the wider framework of IAF".[136] Finally, regional groups also "coordinate representatives of the region in promoting space research and technology, formulating local demands in technology and applications, define regional interests, discuss membership matters, political priorities and stimulate proposals on potential venues for futures IACs".[137] It is not clear which African organisations are currently (voluntary) members of the African Regional Group, but Table 2.5 indicates the full list of IAF African members.

Due to the broad range of topics discussed at the IAF, it can be argued that it relates to all aspects of the primary needs model. As indicated by the activities of the regional groupings, the promotion of space research and technology, cooperation, formulating demands and refining interests, and stimulating proposals can thus apply to the full spectrum of space activities.

[135]International Astronautical Federation, "IAF Regional Groups (2015–2018)," http://www.iafastro.org/committees/iaf-regional-groups/ (accessed September 13, 2018).

[136]Ibid.

[137]Ibid.

### The Space Generation Advisory Council (SGAC) Africa

Also worthy of mention is the profit NGO SGAC which, in support of the United Nations Programme on Space Applications, "aims to represent university students and young space professionals ages 18–35 to the United Nations, space agencies, industry, and academia" and is headquartered in Vienna, Austria.[138] Conceived in 1999 at UNISPACE III, the SGAC "works diligently to raise awareness among the next generation of space professionals on a global scale working together with the United Nations Office for Outer Space Affairs (UNOOSA) in promoting UN workshops and activities, and in supporting SGAC members to attend UNOOSA workshops, events and High Level Fora".[139] The organisation has an African regional network with national points of contact in Algeria, Cameroon, Ethiopia, Ghana, Kenya, Lesotho, Libya, Mauritius, Morocco, Namibia, Nigeria, South Africa, Sudan, Uganda, Zambia, and Zimbabwe.[140] Given the importance of mobilising Africa's youth, the African regional block within the SGAC fulfils a vital role. The second African Space Generation Workshop (AF-SGW), organised by Space Generation Advisory Council and held in Port-Louis, Mauritius, on December 17 and 18, 2018, has the theme "Launching Africa: Space Exploration, Innovation and Business".[141] This is the largest gathering of young space professionals in Africa, with delegates from over 20 countries, bringing together "around 100 delegates, students (bachelor's, master's and doctoral degree candidates), young professionals and industry representatives to examine, consider and collaboratively stimulate interdisciplinary perspectives on space and scientific matters in the African region".[142]

### The Foundation for Space Development

The Foundation for Space Development, founded in 2009, is a South African NGO based in Cape Town, which aims to drive space awareness, outreach, and education.[143] It is currently focusing on four programmes, namely, Asteroid Mining,

[138]Space Generation Advisory Council, "About SGAC," 2018, https://spacegeneration.org/about (accessed December 7, 2018).

[139]Ibid.

[140]Space Generation Advisory Council, "Africa Region," 2018, https://spacegeneration.org/regions/africa (accessed December 7, 2018).

[141]Space in Africa, "5 reasons you should not miss the 2nd African Space Generation Workshop," *Africa Space News*, August 1, 2018, https://africanews.space/5-reasons-you-should-not-miss-the-2nd-african-space-generation-workshop/ (accessed December 7, 2018).

[142]Ibid.

[143]Foundation for Space Development, "Foundation for Space Development," *Twitter*, https://twitter.com/developspacesa (accessed September 12, 2018).

Space and Data, Disaster Management, and Africa 2 Moon.[144] The last is a project to raise funding for Africa's first moon mission, with the aim of "sending an African lander or orbiter to the Moon to stream live images back to classrooms on the continent" whereby "the project also hopes to inspire young Africans".[145] The project aims to achieve this by "transmit[ting] data from the surface of the moon to micro satellites in orbit around the moon, which can then be relayed back to Earth".[146] The activities of the Foundation for Space Development thus link up with the educational aspect of the primary needs model, since "[i]nspiration leads to education and in turn education leads to opportunity and economic empowerment".[147] Thus far, the foundation has raised over $25,000 via crowd funding.[148]

### The Environmental Information System (EIS) AFRICA

EIS-Africa is a network consisting of individual professionals and organisations, established in South Africa in 2000 to "improve the use of geospatial and environmental information in order to enrich policy debate and support decision-making for the well-being of Africa's people".[149] It originated out of the EIS Programme for sub-Saharan Africa (EIS-SSA) of the 1980s and 1990s, which saw experts developing what "was then called the National Environmental Action Plan (NEAPs) to gauge the state of the environment and to measure climate change".[150] EIS-Africa "evolved from an informal Advisory Group of experts into a World Bank funded initiative, based in the United States", but it proved "difficult to have an African organisation trying to work locally while being based out of the U.S.", which then saw it being relocated to South Africa in 2000.[151] Initially, the EIS Programme focused on the environment but expanded this focus "to the broader geospatial field and included Geographic Information Systems (GIS), Earth Observation, Remote Sensing, and Photogrammetry", meaning that EIS-Africa "focussed broadly on the

[144] Foundation for Space Development, "Programs," https://developspacesa.org/programs/ (accessed September 12, 2018).

[145] Gareth van Zyl, "African moon mission project seeks funding," *Fin24*, November 28, 2014, https://www.fin24.com/Tech/News/African-moon-mission-project-seeks-funding-20141128 (accessed September 12, 2018).

[146] Foundation for Space Development, "Africa 2 Moon," https://developspacesa.org/africa2moon/ (accessed September 12, 2018).

[147] Africa2Moon, "Africa's First Moon Mission," *Foundation for Space Development*, https://africa2moon.developspacesa.org/ (accessed September 13, 2018).

[148] Ibid.

[149] Sives Govender, "EIS Africa aims to improve use of geospatial and environmental information in Africa," *Geospatial World*, December 2, 2014, https://www.geospatialworld.net/article/eis-africa-aims-to-improve-use-of-geospatial-and-environmental-information-in-africa/ (accessed September 13, 2018).

[150] Ibid.

[151] Ibid.

use of Geospatial Science and Technology and the coordination thereof to support sustainable development in Africa".[152] Its efforts are to support "capacity building, networking, influencing policy strategy and project activities contributed to this broad role".[153]

EIS-Africa also hosts a biennial conference, AfricaGIS, first held in Tunis in 1993, which brings geospatial experts from around the globe to Africa, and includes a week of training, workshops, and demonstrations, as well as the exhibition of about 50 organisations.[154] Other initiatives have included (i) establishing of fully functional training units to meet the acute and perennial need for trained personnel (Madagascar, Tanzania, Ghana); (ii) creation of a complete series of environmental datasets (Madagascar and Ghana); (iii) environmental information system operations becoming an integral part of a State of Environment reporting process founded on national legislation (Uganda); (iv) development of a platform for sharing environmental and geospatial data on the internet (known as SISEI in French), as part of a virtual clearing-house mechanism in support of the implementation of its National Environmental Action Program (NEAP) (Benin); (v) extending applications to support national-level investment and tourism promotion, as well as tax collection at the local level (Côte d'Ivoire); and (vi) supporting the development of the Greater Banjul Master Plan to identify waste disposal sites for the city of Banjul (The Gambia).[155] Given its broad-ranging activities, including training efforts, EIS-Africa is thus fully aligned with all aspects of the primary needs model.

### The African Space Foundation (ASF)

The ASF was founded by Adigun Ade Abiodun who, among other achievements, was the Nigerian Chairman of UNCOPUOS between June 2004 and June 2006.[156] The ASF was founded to "support the aspirations of African countries to be active participants in the space enterprise, and to enrich Africa in its knowledge, contributions and use of space science and technology for its sustainable development".[157] Its mission is to encourage African states to build partnerships on the continent as well as with relevant global entities, while encouraging African states to "be active participants in the exploration and use of the space environment for the benefit of the African people".[158] The ASF focuses on three particular areas, namely, (i) awareness

[152] Ibid.

[153] Ibid.

[154] Ibid.

[155] EIS-Africa, "About Us," 2018, http://www.eis-africa.org/about/ (accessed September 13, 2018).

[156] African Space Foundation, "ASF Founder," https://www.africanspacefoundation.org/about-asf-founder (accessed September 12, 2018).

[157] African Space Foundation, "About African Space Foundation," https://www.africanspacefoundation.org/about-asf (accessed September 12, 2018).

[158] Ibid.

and knowledge generation and acquisition, so that African states can recognise the role of space science and technology in development and its potential to solve an array of human problems and generate knowledge related to the social, economic, and strategic development needs of Africa; (ii) public and private investment in infrastructure and organisation, to encourage African states to pursue public and private investments in relevant science and technology infrastructure, including the evolution of collaborative organisational arrangements open to all participants; and (iii) dissemination and application of knowledge, so as to facilitate the adoption and application of pertinent new and emerging space technologies that will rapidly connect and inform communities that are presently isolated in order to raise the living standards and unleash the creative potential and imagination of all Africans.[159]

### Women in Aerospace Africa (WIA Africa)

Women in Aerospace (WIA) was founded in 1985 in the United States with the goal to "connect women in aerospace-related professions, raise their visibility within the sector, promote their advancement, and attract other women to its ranks". Today it is comprised of about 2000 individual members representing 250 companies and more than 80 corporate members.[160] A broad range of aerospace issues are covered by WIA, including human space flight, aviation, remote sensing, satellite communications, robotic space exploration, and related policy issues.[161] WIA consists of a range of global networks, including Women in Aerospace Africa.

WIA Africa operates with the mission to expand the opportunities of women in aerospace in Africa and supports the following objectives: (i) increase undergraduate and postgraduate opportunities for African women in aerospace and engineering, (ii) implement graduate internship programme, (iii) work with industry and government to increase employment opportunities for women in aerospace and engineering, and (iv) implement school-level awareness programme for young women.[162] Chapters exist in Nigeria, South Africa, Ethiopia, Botswana, South Sudan, Kenya, Egypt, Ghana, Cameroon, and others, and WIA met at the sidelines of the ALC held in Nigeria in November 2018, to discuss "key issues to promote women participation in the Aerospace industry in Africa".[163]

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[159] Ibid.

[160] Women in Aerospace, "History," 2018, https://www.womeninaerospace.org/about/history.html (accessed September 12, 2018).

[161] Women in Aerospace, "Home," 2018, https://www.womeninaerospace.org/ (accessed September 12, 2018).

[162] Women in Aerospace Africa, "Overview," http://wia-africa.org/resources/Women-in-Aerospace-Africa_Overview.pdf (accessed September 12, 2018).

[163] Space in Africa, "Women in Aerospace Africa meets at ALC – to organize 1st regional workshop in 2019," *Africa Space News*, November 7, 2018, https://africanews.space/women-in-aerospace-africa-meets-at-alc-to-organize-1st-regional-workshop-in-2019/ (accessed December 7, 2018).

Attendance included "about 50 participants from 10 countries", with a goal to organise the first regional workshop in 2019.[164]

### 2.2.3 Intra-African Space Engagement (IASE) Matrix

The foregoing discussion aimed to provide an overview of the key IGOs and NGOs operating in the space arena within Africa. While some of them, like SERVIR, were instigated from outside the continent, the key criterion for the IGOs was that they bind African states together in some way and promote intra-African relations in the space arena, while for NGOs it was that they advance the cause of space in Africa in some way. All of them were shown to relate to the components of the primary needs model presented in Chap. 1, and, in fact, most of them promote all the components of climate, biodiversity, health, water, education, and space-related capacity building either directly or indirectly. In this section, the first goal will be to present the Intra-African Space Engagement (IASE) Matrix, derived from the above discussion of the IGOs and NGOs. This will facilitate the second goal, which is to link up to the concepts of *ubuntu* and space middle powers discussed in Chap. 1 and to identify the emerging space middle powers in Africa. This in turn will link up to the discussion of African relationships and participation in international fora in the next section.

Here, a matrix is understood as the cultural, social, or political environment in which something develops, in this case, specifically the use of space to meet primary needs in Africa. The environment in this case is made up of the various IGOs and NGOs discussed earlier, which all serve individually as vehicles for developing the use of space and collectively as a web or network of African space-related organisations, relationships, and activities. The next step is to explicate the methodology used in the creation of the IASE Matrix.

While all of these organisations play critical roles in promoting space technologies, data, or skills, for the purpose of producing the IASE Matrix, two points will be assigned to each African country for membership in an IGO or for hosting the activities or conferences of an IGO (such as the ALC), whereas involvement in the NGOs will be assigned one point. The reason for this distinction is because when a state joins an organisation such as ARMS-C, it signifies greater national involvement in promoting space activities than when their citizens found a space-related NGO (such as the African Space Foundation). Of course, not all organisations are equivalent in their status, membership, or activities, and so, for instance, AARSE, which is a regular attendee at UNCOPUOS, plays a greater role than the African Space Foundation. However, the aim is not to quantify the "value" of such organisations for Africa but to provide a general indication of which countries are more active players in intra-African space affairs and thus an image of patterns of intra-African

[164]Ibid.

relations and activities. The IASE Matrix thus simplifies a very complex field in order to facilitate comparison.

Moreover, while countries receive a score for participating in an organisation or project, such as the SKA, they receive an additional point if they are a host nation. This is because “experience with African continental organisations has shown that the host country winds up shouldering the lion’s share of the financial burden of sustaining such entities”.[165] For the sake of analysis here, the same will apply to NGOs, such as the AARSE, which is based in South Africa but has held conferences across the continent. In this case, South Africa gets the extra point as a measure of the vibrancy of the space sector in the country, while conference hosts also get one point since this is an indication of interest in space fora and exchanges in the country. In the case of EIS-Africa, points will also be awarded for the milestones achieved in various countries. Table 2.6 presents the IASE Matrix.

From the IASE Matrix, it becomes apparent that every country in Africa is involved in at least some capacity in the space sector, apart from being a user of space data. A very clear picture also emerges in terms of which countries are leaders in intra-African space engagement. This is a critical insight since the South African Department of Trade and Industry has argued that “[t]he key element to successful regional cooperation seems to be the emergence of one or more actors to take the lead” while “[t]he most mature form of regional cooperation is one where countries individually have significant space capabilities, but do not have the political will or economic means to ‘go it alone’”.[166] A potent example of this was the comment made by Nigeria’s Communication Minister in 2001 when the country signed the agreement ratifying the RASCOM Convention: “Nigeria played a major role in the RASCOM project, as we are aware that the problems encountered by Africa can only be overcome through a regional approach”.[167] In other words, regional leaders are critical in order to bind together the efforts of individual countries, precisely so that they do not have to go it alone.

This is where the concept of emerging space middle powers comes to the fore. To summarise from Chap. 1, a middle power is a country that is neither particularly great nor small on the international stage in terms of its power, capacity, or influence, which tends to uphold and support the international order or status quo. Thus middle powers do not challenge but legitimise and stabilise that word order (this therefore excludes states such as Iran, Venezuela, and North Korea). Middle powers also strongly favour multilateral initiatives in order to build consensus and legitimacy. However, there is a distinction between traditional (developed) and emerging (developing) middle powers, in that emerging middle powers do not typically have fully consolidated democracies; tend to place more emphasis on economic matters,

[165]Peter Martinez, “Is There a Need for an African Space Agency?,” *Space Policy* 28, (2012): 143.

[166]Department of Trade and Industry, Republic of South Africa, *The International Space Landscape*, 2009, Pretoria, South Africa: 8.

[167]Panafrican News Agency, “Nigeria Ratifies RASCOM Convention,” *AllAfrica Global Media*, February 2, 2001, https://allafrica.com/stories/200102020033.html (accessed September 4, 2018).

**Table 2.6** Intra-African Space Engagement (IASE) matrix

| | RASCOM | ARMS-C | ALC hosts | SKA | AfriGEOSS | AFRIGIST | CRTEAN[a] | RCMRD[b] | ACMAD | AU SWG | AARSE | WIA Africa | ASF | FSD | IAF | EIS-Africa |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Algeria | • | • | • | | • | | • | | • | • | | | | | • | |
| Angola | • | | | | | | | | • | | | | | | | |
| Benin | • | | | | | • | | | • | | | | | | | • |
| Botswana | | | | • | | | | • | • | | | | | | | |
| Burkina Faso | • | | | | • | • | | | • | | | | | | | |
| Burundi | • | | | | | | | • | • | | | | | | | |
| Cameroon | • | | | | • | • | | | • | • | | | | | | |
| Cape Verde | • | | | | | | | | • | | | | | | | |
| Central African Republic | • | | | | • | | | | • | | | | | | | |
| Chad | • | | | | | | | | • | | | | | | | |
| Comoros | • | | | | | | | • | • | | | | | | | |
| Democratic Republic of the Congo | • | | | | | | | | • | | | | | | | |
| Republic of the Congo | • | | | | • | | | | • | • | | | | | | |
| Côte d'Ivoire | • | | | | • | • | | | • | | • | | | | | • |
| Djibouti | • | | | | | | | | • | | | | | | | |
| Egypt | • | | • | | • | | • | | • | • | • | | | | | |
| Equatorial Guinea | | | | | | | | | • | | | | | | | |
| Eritrea | • | | | | | | | | • | | | | | | | |
| Ethiopia | • | | | | • | | | • | • | | • | | | | | |
| Gabon | • | | | | • | | | | • | | | | | | | |
| Gambia | • | | | | | | | | • | | | | | | | • |
| Ghana | • | | • | • | • | • | | | • | • | • | | | | | • |
| Guinea | • | | | | • | | | | • | | | | | | | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Guinea-Bissau | • | | | | • | • | | | • | | | | | | | |
| Kenya | • | • | • | • | • | | | •• | • | • | • | | | | • | |
| Lesotho | • | | | | | | | • | • | | | | | | | |
| Liberia | • | | | | | • | | | • | | | | | | | |
| Libya | • | | | | | | • | | • | | | | | | • | |
| Madagascar | | | | • | • | | | | • | | | | | | | • |
| Malawi | • | | | | | | | • | • | | | | | | | |
| Mali | • | | | | • | • | | | • | | | | | | | |
| Mauritania | • | | | | | | • | | • | | | | | | | |
| Mauritius | •• | | | • | • | | | • | • | | | | | | • | |
| Morocco | | | | | • | | • | | • | | • | | | | • | |
| Mozambique | • | | | • | | | | | • | | | | | | | |
| Namibia | • | | | • | | | | • | • | • | | | | | | |
| Niger | • | | | | • | • | | | •• | | | | | | | |
| Nigeria | • | • | •• | | • | •• | | | • | • | • | • | • | | • | |
| Rwanda | • | | | | | | | • | • | | | | | | | |
| São Tomé and Príncipe | | | | | | | | | • | | | | | | | |
| Senegal | • | | | | • | • | | | • | | | | | | | |
| Seychelles | | | | | • | | | • | • | | | | | | | |
| Sierra Leone | • | | | | | | | | • | | | | | | | |
| Somalia | | | | | • | | | • | • | | | | | | | |
| South Africa | • | • | • | •• | • | | | • | • | • | •• | • | | • | • | • |
| South Sudan | | | | | | | | • | • | | | | | | | |
| Sudan | • | | | | • | | • | • | • | | | | | | | |
| Swaziland | • | | | | | | | • | • | | | | | | | |
| Tanzania | • | | | | | | | • | • | • | | | | | | • |
| Togo | • | | | | | | | | • | | | | | | | |
| Tunisia | • | | | | • | | •• | | • | | | | | | • | |

(continued)

**Table 2.6** (continued)

| | RASCOM | ARMS-C | ALC hosts | SKA | AfriGEOSS | AFRIGIST | CRTEAN[a] | RCMRD[b] | ACMAD | AU SWG | AARSE | WIA Africa | ASF | FSD | IAF | EIS-Africa |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Uganda | • | | | | • | | | • | • | | • | | | | | • |
| Zambia | • | | | • | | | | • | • | | | | | | | |
| Zimbabwe | • | | | | • | | | • | • | | • | | | | | |

[a]Excluding observers
[b]Excluding noncontracting member states

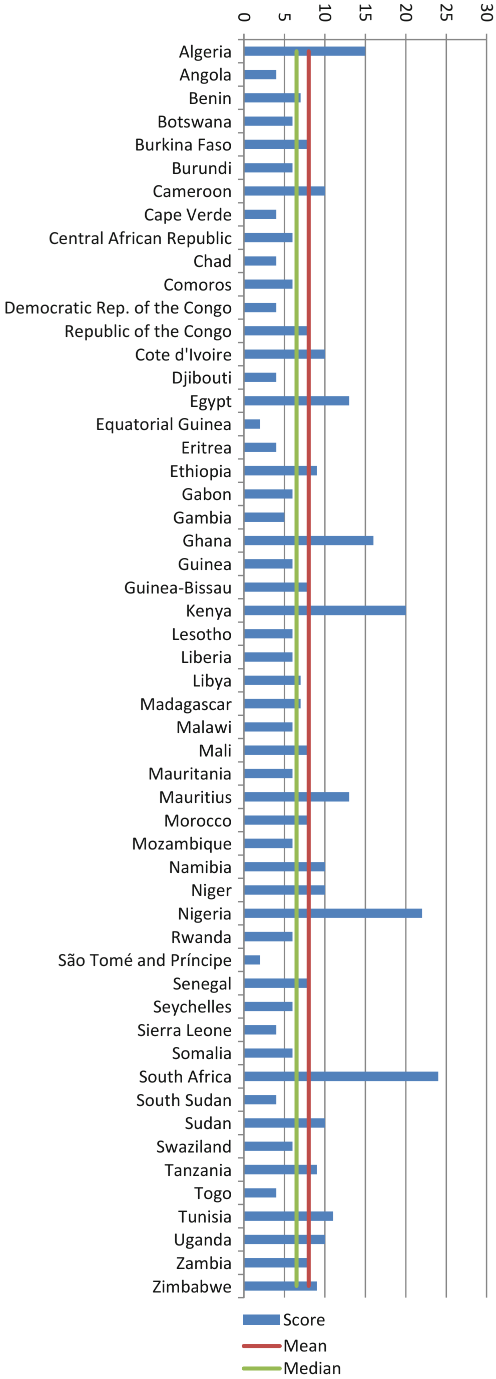
equity, and justice than on military or political ones; fall into the medium human development category; are regionally dominant and tend to be drivers of regional structures in which they are dominant; have a more neutral global posture; and are more active participants of international organisations dominated by the South.

Based on these features, it is possible to produce a framework to identify and classify the emerging space nations of Africa, based on the hypothesis that emerging middle powers of Africa will carry forth these principles in their space postures as well. Since this section focuses on intra-African relations, the posture of African countries vis-à-vis the international order will only be discussed in the next section, but the expectations on a regional level following from the hypothesis here is that African space middle powers will (i) place a strong emphasis on the socio-economic benefits of space technology as opposed to military or security objectives and (ii) strongly favour and drive regional and continental efforts to create space institutions and structures (including policy) in Africa while taking a leading or dominant position in these. Based on the IASE score assigned to each country in Table 2.6, it is possible to identify the "outliers" in intra-African space engagement, shown in Fig. 2.12.

Figure 2.12, which also indicates the mean (8) and median (6.5) values, enables the clear identification of those states that are engaged "above average" in the space arena. The median value evenly splits the states of the continent into two groups, the less engaged and the more engaged, while the mean further narrows the more engaged group and identifies those states that are clear leaders in intra-African space engagement. In descending order (or alphabetical in the case of similar score), these are South Africa, Nigeria, Kenya, Ghana, Algeria, Egypt, Mauritius, Tunisia, Cameroon, Côte d'Ivoire, Namibia, Niger, Sudan, Uganda, Ethiopia, Tanzania, Zimbabwe, Burkina Faso, Republic of the Congo, Guinea Bissau, Mali, Morocco, Senegal, and Zambia. Two important distinctions must be made here. First, this score does not account for national space activities or infrastructure such as satellites built, owned, or launched (encapsulated by Wood and Weigel's Space Technology Ladder—as applied in the next chapter—for instance), and second, it does not take into account the power, capacity, or influence of the states on the international stage.

In order to arrive at a conception of African emerging space middle powers, the concept of *power* also needs to be accounted for. However, power can be defined in many different ways and is highly subjective. For the purposes here, a study and model used to score and rank countries developed by Y&R's BAV Group and the Wharton School of the University of Pennsylvania will be utilised. Once again, it should be emphasised that this is not being used to assign "value" to countries but to gain a better understanding of emerging space middle powers in Africa. In that study, 80 countries were scored in a survey by over 21,000 respondents on 65 different attributes, including perceived power, understood as a country being or having "a

**Fig. 2.12** IASE scores



leader, economically influential, politically influential, strong international alliances, strong military".[168] While the study did not include all countries, by virtue of making the top 80, the countries on the list can already be seen as possessing some power to be recognised. The following African countries made the list, along with their rank out of 80: Egypt (25), South Africa (28), Nigeria (44), Algeria (54), Angola (57), Morocco (60), Kenya (61), Tanzania (62), Ghana (63), and Tunisia (66).[169] For the purposes of the discussion here, the individual ranks will not be important, since these 10 African countries can thus on some level all be perceived as relatively powerful in some way. For reference, Tunisia at 66 was considered more powerful than Chile (68), Czech Republic (69), or Slovenia (80). Figure 2.13 combines the results of the IASE scores and the power rankings to identify Africa's emerging space middle power candidates based on their intra-African relations.

Based on the findings presented in Fig. 2.13, nine African emerging space middle power candidates are identified according to their perceived international power and IASE score. These are Algeria, Egypt, Ghana, Kenya, Morocco, Nigeria, South Africa, Tanzania, and Tunisia. However, this does not yet reflect the international dimension of whether these countries actively support the international order or status quo in space, and thus the next section will delve into this dimension and complete the picture. Nevertheless, Fig. 2.13 does reveal six categories of African states—those which are (i) more powerful and leaders in space engagement, (ii) those which are more powerful and well-engaged, (iii) those which are more powerful and not well-engaged, (iv) those which are less powerful and leaders in space engagement, (v) those which are less powerful and well-engaged, and (vi) those which are less powerful and not well-engaged. This is depicted in Table 2.7.

Those states that are perceived as powerful and are leaders in their space engagement are the above-mentioned candidates for Africa's emerging space middle powers—situated at the inner core of the continent's network of space-related organisations, relationships, and activities speaking to primary needs. In the outer core are those 15 states that perform very well in their space engagement, but are not considered to be very powerful, and thus in a sense these states are "punching above their weight", showing a concerted effort to take part in the continent's space sector.

At the periphery lie those states that are less powerful and received an IASE score below the median. These represent the untapped potential of the intra-African space arena, since even though each state is engaged in some way as Table 2.6 showed, these particular 27 states are at the lower end of the space engagement spectrum. In this periphery, there is one very clear outlier however—Angola—which is perceived as more powerful than Morocco, Kenya, Tanzania, Ghana, and Tunisia, yet which

[168]Deidre McPhillips, "Methodology: How the 2018 Best Countries Were Ranked," *U.S. News & World Report L.P.*, January 23, 2018, https://www.usnews.com/news/best-countries/articles/methodology (accessed September 14, 2018).

[169]U.S. News & World Report L.P., "Power Rankings," 2018, https://www.usnews.com/news/best-countries/power-full-list# (accessed September 14, 2018).

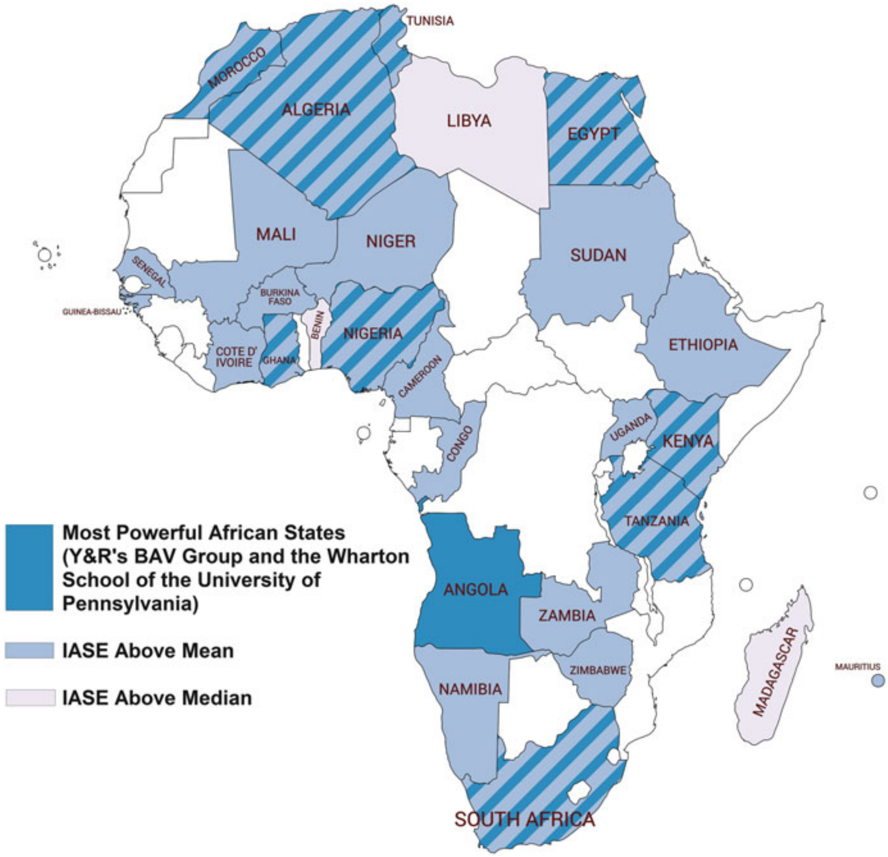



**Fig. 2.13** Emerging space middle power candidates based on power perception and IASE score

has remained relatively poorly engaged in the space sector. An argument can thus be made that Angola is the underperformer in space when measured against expectations of its power internationally. Between the core and periphery lies the semi-periphery, with three less powerful states performing better than the median but not better than the mean in their IASE scores. Benin, Libya, and Madagascar can thus be argued to be rising African space actors.

In terms of the African RECs, all are represented by at least one emerging space middle power candidate, with the notable exception of ECCAS. However, ECCAS

**Table 2.7** Six categories of African states based on power and space engagement

| | A. IASE above mean | B. IASE above median | C. IASE below median |
|---|---|---|---|
| 1. More powerful | Algeria, Egypt, Ghana, Kenya, Morocco, Nigeria, South Africa, Tanzania, Tunisia | | Angola |
| 2. Less powerful | Burkina Faso, Cameroon, Côte d'Ivoire, Ethiopia, Guinea-Bissau, Mali, Mauritius, Namibia, Niger, Republic of the Congo, Senegal, Sudan, Uganda, Zambia, Zimbabwe | Benin, Libya, Madagascar | Botswana, Burundi, Cape Verde, Central African Republic, Chad, Comoros, Democratic Republic of the Congo, Djibouti, Equatorial Guinea, Eritrea, Gabon, Guinea, Lesotho, Liberia, Malawi, Mauritania, Mozambique, Rwanda, São Tomé and Príncipe, Seychelles, Sierra Leone, Somalia, South Sudan, Swaziland, Gambia, Togo |

does have other outer core members (Table 2.8). The core states in each of the RECs are thus the regional leaders called for by the South African Department of Trade and Industry, and they are the drivers and promoters of infusing space into African societies to assist meeting primary needs. This will also be seen in the following two chapters when considering the individual national space infrastructures, activities, and policies.

Before considering the concept of *ubuntu*, as elucidated in Chap. 1, it is useful to summarise the main features. *Ubuntu* is characterised by (i) consensual decision-making, with an accompanying strong emphasis on respect for national sovereignty based on the continent's colonial experience, with a strong focus on multilateralism, (ii) groupthink with a premium on maintaining harmony and conformity, and (iii) pan-African solidarity. From the discussion of African IGOs and NGOs, this preference for multilateralism, collective decision-making, and harmony is evident, since all African states that have moved from "a spectator to a participant in space—from a consumer to a sponsor of space technology" (as will be seen in Chap. 3) have shown a willingness to engage in space-related networks, to share data (such as through ARMS-C) or otherwise be active promoters and drivers of continental space initiatives. Thus, in essence, African states are not "going it alone" when it comes to space efforts on the continent, and relationships are indeed a cornerstone of understanding Africa's relationship with space. However, this discussion cannot be completed without first considering the other major dimension of African involvement in international fora, particularly UNCOPUOS, which will round out the emerging space middle power concept.

**Table 2.8** IASE categories per regional economic community (REC)

| | Core | Semi-periphery | Periphery |
|---|---|---|---|
| Arab Maghreb Union (AMU) | *Algeria*, *Morocco*, *Tunisia* | Libya | Mauritania |
| Common Market for Eastern and Southern Africa (COMESA) | *Egypt*, *Kenya*, *Tunisia*, Sudan, Ethiopia, Uganda, Mauritius, Zambia, Zimbabwe | Libya, Madagascar | Djibouti, Eritrea, Somalia, Rwanda, Burundi, Comoros, Seychelles, Democratic Republic of the Congo, Malawi, Swaziland |
| Community of Sahel-Saharan States (CEN-SAD) | *Egypt*, *Ghana*, *Morocco*, *Nigeria*, *Kenya*, *Tunisia*, Sudan, Niger, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Senegal, Mali | Benin, Libya | Djibouti, Eritrea, Somalia, Central African Republic, Comoros, Cape Verde, São Tomé and Príncipe, Chad, Togo, Liberia, Sierra Leone, Guinea, Mauritania, Gambia |
| East African Community (EAC) | *Kenya*, *Tanzania*, Uganda | | South Sudan, Rwanda, Burundi |
| Economic Community of Central African States (ECCAS) | Cameroon, Republic of the Congo | | Rwanda, Burundi, Democratic Republic of the Congo, Angola, Gabon, Equatorial Guinea, São Tomé and Príncipe, Central African Republic, Chad |
| Economic Community of West African States (ECOWAS) | *Ghana*, *Nigeria*, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal | Benin | Guinea, Sierra Leone, Liberia, Togo, Cape Verde, Gambia |
| Intergovernmental Authority on Development (IGAD) | *Kenya*, Uganda, Sudan, Ethiopia | | South Sudan, Djibouti, Eritrea, Somalia |
| Southern African Development Community (SADC) | *South Africa*, *Tanzania*, Mauritius, Namibia, Zambia, Zimbabwe | Madagascar | Lesotho, Swaziland, Mozambique, Seychelles, Botswana, Angola, Democratic Republic of the Congo, Malawi |

## 2.3 African Relationships and Participation in International Space Fora

This section will consider the dimension of Africa's relationships and participation in international space fora. In terms of such fora, UNCOPUOS is by far the most significant, having been founded in 1959 by the UN General Assembly to govern the use of space and space exploration in line with the tenets of peace, security, and development.[170] It was also within UNCOPUOS that the core body of international space law was shaped by the five major treaties.[171] Alongside these treaties, five more declarations and legal principles were adopted by the General Assembly.[172,173] Two subcommittees, namely, the Scientific and Technical Subcommittee (STSC) and Legal Subcommittee (LSC), work alongside the main UNCOPUOS committee to address questions related to the scientific and technical aspects of space activities and the legal questions related to the exploration and use of outer space, respectively. The importance of UNCOPUOS as the "only committee of the General Assembly dealing exclusively with international cooperation in the peaceful uses of outer space" cannot be overstated, given its role "as a forum to monitor and discuss developments related to the exploration and use of outer space".[174] As such, this section will analyse Africa's involvement in this body, by way of the International Space Engagement (ISE) Matrix, which supplements the previously discussed Intra-African Space Engagement (IASE) Matrix by considering the international dimension of Africa's space engagement. UNCOPUOS is especially important here because middle powers are known by their global roles, not only their regional ones, and the international order in outer space (and other fields) is embodied by the UN. Moreover, since UNCOPUOS is the global governance forum for outer space, its activities are comprehensive and highly relevant to all basic needs.

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[170]United Nations Office for Outer Space Affairs, "Committee on the Peaceful Uses of Outer Space," 2018, http://www.unoosa.org/oosa/en/ourwork/copuos/index.html (accessed September 18, 2018).

[171](i) Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty, OST, entered into force 1967); (ii) Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (Rescue Agreement, ARRA, entered into force 1968); (iii) Convention on International Liability for Damage Caused by Space Objects (Liability Convention, LIAB, entered into force 1972); (iv) Convention on Registration of Objects Launched into Outer Space (Registration Convention, REG, entered into force 1976); (v) Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Treaty, MOON, entered into force 1984).

[172](i) Declaration of Legal Principles Governing the Activities of States in the Exploration and Uses of Outer Space (Declaration of Legal Principles, 1963); (ii) Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television Broadcasting (Broadcasting Principles, 1982); (iii) Principles Relating to Remote Sensing of the Earth from Outer Space (Remote Sensing Principles, 1986); (iv) Principles Relevant to the Use of Nuclear Power Sources in Outer Space (Nuclear Power Sources, 1992); (v) Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries (Benefits Declaration, 1996).

[173]United Nations Office for Outer Space Affairs, "Space Law Treaties and Principles," 2018, http://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties.html (accessed September 18, 2018).

[174]United Nations Office for Outer Space Affairs, "Committee on the Peaceful Uses of Outer Space and its Subcommittees," 2018, http://www.unoosa.org/oosa/en/ourwork/copuos/comm-subcomms.html (accessed September 18, 2018).

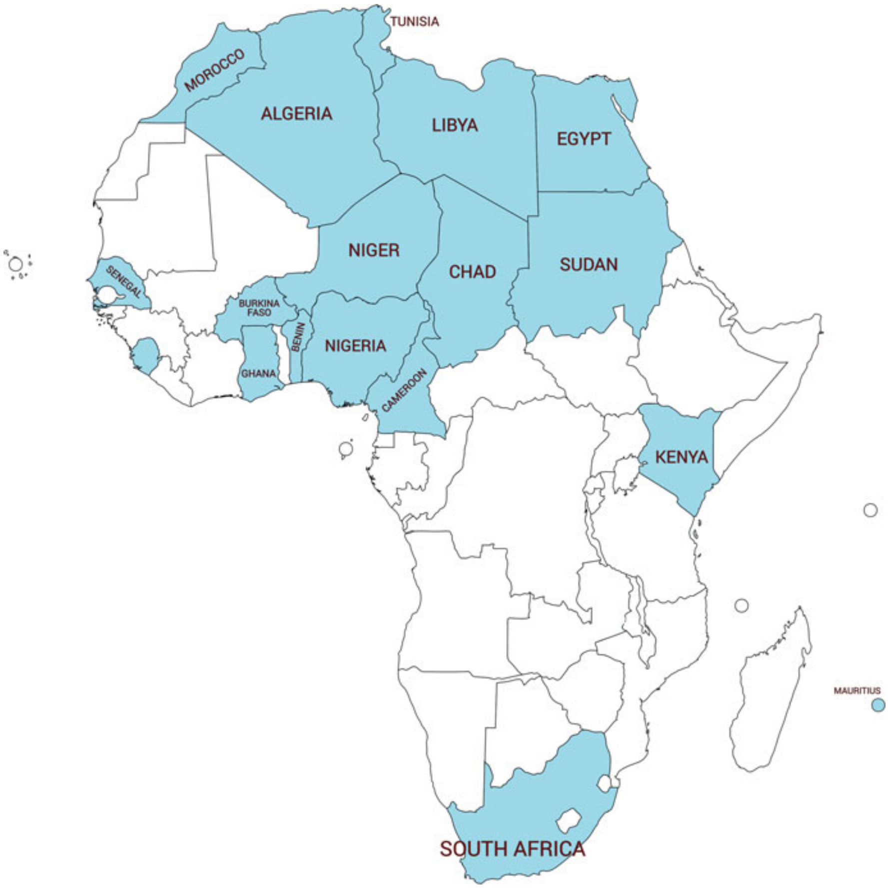


**Fig. 2.14** African member states of UNCOPUOS (September 2018)

### *2.3.1 Africa and UNCOPUOS*

Currently, as of March 2019, UNCOPUOS has 92 member states, 18 of which are African.[175] Therefore, one third (33.3%) of African states are members of UNCOPUOS, as seen in Fig. 2.14. However, the distribution of these members means that each of the RECs has at least one UNCOPUOS member, as highlighted in Table 2.9.

African membership of UNCOPUOS has steadily increased along with total membership as depicted in Fig. 2.15. The largest increases in African membership

175 United Nations Office for Outer Space Affairs, "Committee on the Peaceful Uses of Outer Space: Membership Evolution," 2018, http://www.unoosa.org/oosa/en/ourwork/copuos/members/evolution.html (accessed September 18, 2018).

**Table 2.9** UNCOPUOS member states by regional economic community

| | |
|---|---|
| Arab Maghreb Union (UMA) | Algeria, Libya, Tunisia, Morocco |
| Common Market for Eastern and Southern Africa (COMESA) | Egypt, Kenya, Libya, Mauritius, Sudan, Tunisia |
| Community of Sahel-Saharan States (CEN-SAD) | Benin, Burkina Faso, Chad, Egypt, Ghana, Kenya, Libya, Morocco, Niger, Nigeria, Senegal, Sierra Leone, Sudan, Tunisia |
| East African Community (EAC) | Kenya |
| Economic Community of Central African States (ECCAS) | Cameroon, Chad |
| Economic Community of West African States (ECOWAS) | Benin, Burkina Faso, Ghana, Niger, Nigeria, Senegal, Sierra Leone |
| Intergovernmental Authority on Development (IGAD) | Kenya, Sudan |
| Southern African Development Community (SADC) | Mauritius, South Africa |

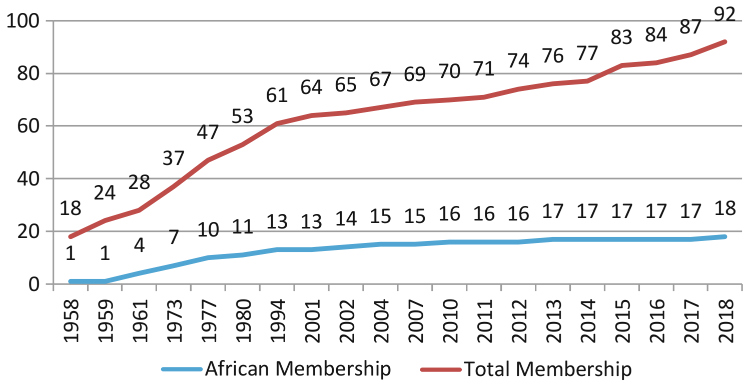


**Fig. 2.15** UNCOPUOS membership evolution. United Nations Office for Outer Space Affairs, "Committee on the Peaceful Uses of Outer Space: Membership Evolution," 2018, http://www.unoosa.org/oosa/en/ourwork/copuos/members/evolution.html (accessed September 18, 2018)

occurred in 1961, 1973, and 1977 with three new African states joining in each of those years. This can largely be attributed to the decolonisation of Africa and subsequent newly independent states joining the world stage. Another small jump occurred in 1994 with the joining of South Africa along with Senegal, with the former ending a period of international isolation due to apartheid. Apart from these increases, African states have been slow to join UNCOPUOS, with the occasional member increasing the number by one. Only one African state was a founding member of UNCOPUOS, namely, Egypt, since most of Africa was still under European colonial control at the time. From 1961 to 2019, African membership made up about 18–21% of total membership.

However, a more important consideration than mere membership is whether states are *active* members of UNCOPUOS. At the most basic level, active membership, or participation, is defined here as states that have attended at least half the UNCOPUOS sessions (including the subcommittees) in the last 4 years (2015–2018).[176] In that respect, only 9 out of 17 African member states can be considered as active members (Mauritius, the 18th member, joined recently and is thus excluded here).[177] Of these 17, four states have attended all meetings during the stated period, namely, Algeria, Burkina Faso, South Africa, and Tunisia. In contrast to these nine active states, three states have attended less than half of the UNCOPUOS sessions in the above mentioned period, namely, Ghana, Libya, and Cameroon. In the case of Libya, the civil war which erupted in 2014 no doubt made attendance difficult, but in the last 2 years, its attendance has improved with it being present at five of the six sessions (again including subcommittees). However, beyond these 12 states, 5 African member states have not attended even 1 UNCOPUOS session in the last 4 years, namely, Niger, Benin, Chad, Sierra Leone, and Senegal. One explanation for this is travel fund constraints, since these five states are all among the low-income economies as identified in Chap. 1. However, some doubt is cast upon this explanation since Burkina Faso is also in this category and yet has been present at every UNCOPUOS meeting (including subcommittees) in the last 4 years. Thus, political will and awareness of the importance of participating at UNCOPUOS sessions could also be lacking.

It could be argued that the principle of international space cooperation, as contained in the Benefits Declaration of 1996 (see footnote 172), which specifically spoke to the role of developing countries in the space arena, is a strong motivator for states to actively participate in international space affairs and cooperation.[178] As the Benefits Declaration of the General Assembly states, in paragraph two, while "States are free to determine all aspects of their participation in international cooperation in the exploration and use of outer space on an equitable and mutually acceptable basis", paragraph three argues that:

> All States, particularly those with relevant space capabilities and with programmes for the exploration and use of outer space, should contribute to promoting and fostering international cooperation on an equitable and mutually acceptable basis. In this context, particular attention should be given to the benefit for and the interests of developing countries and countries with incipient space programmes stemming from such international cooperation conducted with countries with more advanced space capabilities.[179]

[176]The most recent years were selected to give a good sense of engagement with current contemporary issues, and it reflects consistency in engagement.

[177]Analysis performed by identifying yearly participants from official COPUOS documentation.

[178]Joel A. Dennerley, "Emerging space nations and the development of international regulatory regimes," *Space Policy* 35, (2016): 28.

[179]United Nations, *United Nations Treaties and Principles on Outer Space: Text of treaties and principles governing the activities of States in the exploration and use of outer space, adopted by the United Nations General Assembly* (New York: United Nations, 2002), 56.

Thus, the principle of international space cooperation is "well established in space law".[180] Moreover, "[a]rguably, this cooperation [principle] regarding the exploration and use of space would extend to the cooperative multi-lateral development of laws, rules, regulations and standards applicable to spatial activities".[181]

The need for participation in major standard setting bodies related to space is clear since once those standards are set, especially in relation to international law, they become (with sufficient support) applicable to all states, even those that did not participate in setting those standards. In addition, the effect of this is even more pronounced for small developing countries such as Benin, Senegal, Niger, Chad, and Sierra Leone: "certain emerging space nations such as Iran, Pakistan, Mexico or South Africa would not be as adversely affected by the international standard setting process as compared to many other much smaller developing countries that may simply not participate, or do so in a limited way".[182] The reason for this is that small developing countries have much less leeway in "going it alone" or not complying with international standards. Thus, "an essential strategy for the inclusion of developing countries is their active participation in these groups, committees and meetings, because inevitably their competitors will be there", meaning that "[a]n attitude of apathy toward the development of international standards will simply leave certain States behind".[183] This concern is also echoed elsewhere: "Africa must move beyond mere scepticism at proposals that seek to make change, but be proactive about contributing ideas about what that change should look like"—a scepticism often based on the "misconception that space activities are not a third world concern"—because such "scepticism without action to increase knowledge, balance beliefs against criteria and criteria against beliefs, ensu[r]es that one remains at the periphery in a given situation".[184] This also includes issues such as space debris, because "even if few African countries are yet active in space, they are equally at risk from asteroid and space weather hazards, and also need to feel that, once they are in a position to build and launch their own satellites, these will still find room in crowded orbits".[185] In fact, African countries have already been affected by space debris, such as debris from an Ariane 3 booster that fell in Kasambaya, Uganda, in March 2002, during which a pressure sphere hit a home, and debris from an Ariane 4 booster which fell near the village of Manzau, Angola, in August 2002.[186] These are only a few examples, stretching back to October 1962 when

[180]Dennerley, "Emerging space nations and the development of international regulatory regimes," 28.

[181]Ibid.

[182]Ibid., 29.

[183]Ibid.

[184]Timiebi Aganaba-Jeanty, "Why Africa Must Move beyond Scepticism to Influence International Law," *Business Day*, August 26, 2014, https://www.businessdayonline.com/exclusives/analysis-sub/article/why-africa-must-move-beyond-scepticism-to-influence-international-law/ (accessed September 18, 2018).

[185]Abiodun, "Trends in the Global Space Arena – Impact on Africa and Africa's Response," 286.

[186]Ibid., 287.

debris from an Atlas booster from Mercury MA-8 fell in Côte d'Ivoire and Burkina Faso. A more recent example is that of Namibia, where a metallic ball fell near Onamatango village close to Outapi, 750 kilometres northwest of Windhoek in November 2011.[187] Two similar titanium spheres fell in South Africa one day apart outside Cape Town in 2000.[188]

In contrast to the lack of participation by some African states, a small minority has assumed leadership positions within UNCOPUOS or its subcommittees. Since 2002, three states have chaired a committee, a total of five times. These are Nigeria (2004–2005 main committee), Algeria (2014–2015 main committee), Algeria (2008–2009 STSC), South Africa (2018–2019 STSC), and Nigeria (2012–2013 LSC).[189] These three states thus stand out in their level of engagement and ability to provide recognised leadership in these international fora.

Apart from active participation in UNCOPUOS, another critical indicator of engagement in international space affairs is whether states have signed or ratified the five major space-related treaties referred to above (footnote 171). Doing so is not dependent on being an UNCOPUOS member, but African states in general have been slow to accede to these treaties. A total of 19 states have neither signed nor ratified any of the treaties.[190] Only one, Morocco, has ratified all five treaties, while only four others have ratified all treaties apart from the Moon Agreement. Africa's international engagement in this regard is thus lacklustre, possibly again due to the misconception that it is to a large extent irrelevant for developing countries with other priorities.

Finally, in order to gauge African engagement in the broader UNOOSA architecture, participation and hosting of (i) regional offices of the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER), (ii) appointing of a National Focal Point "who serves as a contact person for the application of space technologies to disasters and disaster risks"[191] as requested by UN-SPIDER of all member states, and (iii) hosting of a Regional Centre for Space Science and Technology Education are taken as indications of African states' willingness to bear the financial responsibility of hosting such an office or centre and their political will to take part in cooperation. This helps to provide a more complete picture of African engagement with UNCOPUOS and

[187] Discover Namibia, "Mysterious space ball landed in Namibia," *Gondwana Collection Namibia (Pty) Ltd*, December 14, 2018, https://www.gondwana-collection.com/news/article/2018/12/14/mysterious-space-ball-landed-in-namibia/ (accessed December 18, 2018).

[188] Ibid.

[189] Compiled from reports by United Nations Office for Outer Space Affairs, "Past Sessions of the Committee and its Subcommittees," 2018, http://www.unoosa.org/oosa/en/ourwork/copuos/past-sessions.html (accessed September 19, 2018).

[190] United Nations Office for Outer Space Affairs, "Status of International Agreements relating to Activities in Outer Space," 2018, http://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/status/index.html (accessed September 19, 2018).

[191] United Nations Office for Outer Space Affairs, "UN-SPIDER's Network," 2018, http://www.unoosa.org/oosa/en/ourwork/un-spider/network.html (accessed September 19, 2018).

UNOOSA. All of the factors discussed in this section are combined to create the International Space Engagement Matrix, discussed in the next section. In the next volume of this series, where African states have made use of UN-SPIDER in supporting their disaster management and emergency response efforts will be investigated.

### *2.3.2 International Space Engagement (ISE) Matrix*

By assigning a score to the factors discussed above, it becomes possible to gain a clearer understanding of the remaining dimensions of emerging space middle powers. Apart from those factors considered in Sect. 1.2.3, emerging space middle powers can be characterised (to summarise the discussion in Chap. 1) by the following: (i) they are strong proponents of the existing international order in relation to outer space and will be advocates of international law in this field (evidenced by their roles and actions in UNCOPUOS and other space organisations and ratification of UN treaties on outer space), (ii) they will strive to stabilise and legitimise this order through multilateral arrangements in international organisations, (iii) they will tend to mediate or foster relationships between global powers and other African states, and (iv) they prefer gradual reforms in international bodies to increase the profile of Africa rather than dramatic changes in the status quo.

By combining the factors of treaty signature or ratification, UNCOPUOS membership, active participation in UNCOPUOS, chairing or UNCOPUOS or its subcommittees, participating in UN-SPIDER, and hosting a Regional Centre for Space Science and Technology Education, it is possible to clearly identify those states that are strong proponents of the existing international order and its multilateral arrangements and which, by virtue of their strong engagement, become African “representatives” or mediators for the entire continent. The issue of gradual versus radical reform will be considered shortly after the discussion of the ISE Matrix by way of the Bogotá Declaration.

To make the ISE Matrix meaningful, higher scores are assigned for greater engagement. Thus, scores are assigned as follows: signing a treaty, 1 point (S); ratifying a treaty, 2 points (R); being an UNCOPUOS member, 3 points (Mem.); being an active participant (attending more than half of all sessions from 2015 to 2018), 4 points (Particip.); chairing any committee, 4 points (Ch.); participating in UNOOSA’s African institutions (UN-SPIDER National Focal Point), 3 points (Particip.); and hosting one of these institutions (UN-SPIDER Regional Office or Regional Centre for Space Science and Technology Education), 4 points (H.). The ISE Matrix is presented in Table 2.10.

As with the IASE Matrix, it is possible to identify the “outliers” in international space engagement based on the ISE score assigned to each country in Table 2.10. This is done in Fig. 2.16, and again the mean (8.15) and median (6) are provided.

While Fig. 2.12 identified clear emerging space middle power candidates in terms of the regional dimension of space engagement, Fig. 2.16 identifies equally clear

**Table 2.10** African international space engagement (ISE) matrix

| | UN treaties | | | | | | | | | | UNCOPUOS | | | UNOOSA | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OST | | ARRA | | LIAB | | REG | | MOON | | | | | African institutions | |
| *Country* | S | R | S | R | S | R | S | R | S | R | Mem. | Particip. | Ch. | Particip. | H. |
| Algeria | | • | | | | • | | • | | | • | • | •• | • | • |
| Angola | | | | | | | | | | | | | | | |
| Benin | | • | | | | • | | | | | • | | | | |
| Botswana | • | | | • | | • | | | | | | | | | |
| Burkina Faso | | • | | | | | | | | | • | • | | • | |
| Burundi | • | | | | • | | • | | | | | | | • | |
| Cameroon | • | | | • | | | | | | | • | | | | |
| Cape Verde | | | | | | | | | | | | | | | |
| Central African Republic | • | | | | • | | | | | | | | | | |
| Chad | | | | | | | | | | | • | | | | |
| Comoros | | | | | | | | | | | | | | | |
| Democratic Republic of the Congo | • | | • | | • | | | | | | | | | | |
| Republic of the Congo | | | | | | | | | | | | | | | |
| Côte d'Ivoire | | | | | | | | | | | | | | • | |
| Djibouti | | | | | | | | | | | | | | | |
| Egypt | | • | | • | • | | | | | | • | • | | • | |
| Equatorial Guinea | | • | | | | | | | | | | | | | |
| Eritrea | | | | | | | | | | | | | | | |
| Ethiopia | • | | | | | | | | | | | | | | |
| Gabon | | | | • | | • | | | | | | | | | |
| Gambia | • | | | • | • | | | | | | | | | | |
| Ghana | • | | • | | • | | | | | | • | | | | |
| Guinea | | | | | | | | | | | | | | | |
| Guinea-Bissau | | • | | • | | | | | | | | | | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kenya | | • | | | | • | | | | | • | • | | • | • |
| Lesotho | • | | • | | | | | | | | | | | | |
| Liberia | | | | | | | | | | | | | | | |
| Libya | | • | | • | | • | | • | | | • | | | | |
| Madagascar | | | | | | | | | | | | | | | |
| Malawi | | | | | | | | | | | | | | • | |
| Mali | | • | | | | • | | | | | | | | | |
| Mauritania | | | | | | | | | | | | | | • | |
| Mauritius | | • | | • | | | | | | | • | | | | |
| Morocco | | • | | • | | • | | • | | • | • | • | | • | • |
| Mozambique | | | | | | | | | | | | | | | |
| Namibia | | | | | | | | | | | | | | | |
| Niger | | • | | • | | • | | • | | | • | | | | |
| Nigeria | | • | | • | | • | | • | | | • | • | •• | •• | •• |
| Rwanda | • | | • | | • | | | | | | | | | | |
| São Tomé and Príncipe | | | | | | | | | | | | | | | |
| Senegal | | | • | | | • | | | | | • | | | • | |
| Seychelles | | • | | • | | • | | • | | | | | | | |
| Sierra Leone | | • | • | | • | | | | | | • | | | | |
| Somalia | • | | • | | | | | | | | | | | | |
| South Africa | | • | | • | | • | | • | | | • | • | • | | |
| South Sudan | | | | | | | | | | | | | | | |
| Sudan | | | | | | | | | | | • | • | | | |
| Swaziland | | | | • | | | | | | | | | | | |
| Tanzania | | | | | • | | | | | | | | | • | |
| Togo | | • | | | | • | | | | | | | | • | |
| Tunisia | | • | | • | | • | | | | | • | • | | • | |

(continued)

**Table 2.10** (continued)

| | UN treaties | | | | | | | | | | UNCOPUOS | | | UNOOSA | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OST | | ARRA | | LIAB | | REG | | MOON | | | | | African institutions | |
| *Country* | S | R | S | R | S | R | S | R | S | R | Mem. | Particip. | Ch. | Particip. | H. |
| Uganda | | • | | | | | | | | | | | | | |
| Zambia | | • | | • | | • | | | | | | | | • | |
| Zimbabwe | | | | | | | | | | | | | | | |

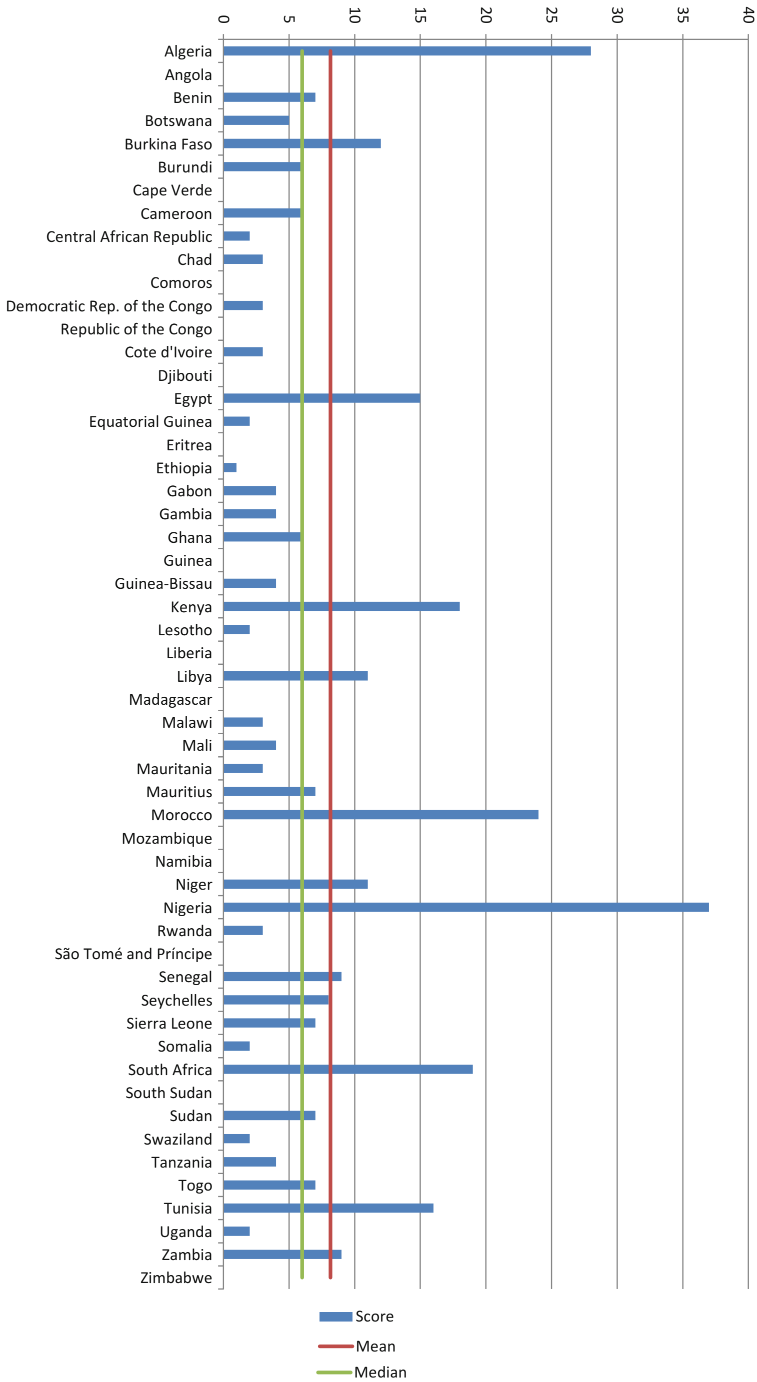


**Fig. 2.16** ISE scores

candidates based on the international dimension of space engagement. The leaders in this regard are (in descending order) Nigeria, Algeria, Morocco, South Africa, Kenya, Tunisia, Egypt, Burkina Faso, Libya, Niger, Senegal, Zambia, and Seychelles. A small number of states do not score at or above the mean but nevertheless score at or above the median, which divides the continent between 21 more internationally engaged and 33 less internationally engaged states. These are Sierra Leone, Sudan, Mauritius, Togo, Benin, Burundi, Cameroon, and Ghana. While the picture presented by the ISE (and IASE) scores do not necessarily provide an exhaustive account of all African engagement with space (e.g. Namibia attended five of the last 12 UNCOPUOS sessions, including subcommittees, as an observer, while Angola did so twice), a very clear trend emerges nevertheless, and again the purpose behind compiling these scores is not to "value" states or their engagement but to illuminate the main patterns thereof.

Similar to how the Intra-African Space Engagement Matrix was combined with the concept of power to narrow the emerging space middle power candidates, here, the economic dimension in terms of gross national income (GNI) per capita will be combined with the International Space Engagement Matrix. As was seen above, an argument regarding limited funds can be made to partially explain the absence within UNCOPUOS of Niger, Benin, Chad, Sierra Leone, and Senegal—all classified as low-income economies by the World Bank (as was seen in Chap. 1). While the exception of Burkina Faso does stand out in this regard, just as a less powerful state will have difficulty fulfilling the role of a middle power, so too will a low-income economy. This is again not a fixed rule but is a helpful heuristic device. Thus, Fig. 2.17 combines ISE scores and GNI per capita (World Bank country classifications for 2017).

Based on these findings, 12 categories of African states can be identified. Table 2.11 presents these categories, which are defined by the level of the economy and the ISE score of all 54 states. Again, a core, periphery, and semi-periphery are apparent. In the core, a pattern emerges that shows that countries with high levels of international space engagement are spread out throughout all economic categories. Thus, a key finding is that other factors such as political will must be the primary drivers of national space engagement and cannot be discounted, while awareness and outreach efforts must continue. In this low-income category, while both Niger and Senegal score above the mean despite not being active UNCOPUOS members, the true outlier is Burkina Faso given its dedication in attending each UNCOPUOS session in the last 4 years. It can thus be argued that Burkina Faso has shown a high level of political will to drive a concerted effort to take part and cooperate in the space arena, although the factor of maintaining an embassy in Vienna does make it easier for Burkina Faso to attend UNCOPUOS meetings. Conversely, it could be argued that the upper-middle-income countries of Botswana, Equatorial Guinea, Gabon, and Namibia are underperformers since none of them have joined UNCOPUOS despite Namibia's attendance as observer, and Namibia also maintains an embassy in Vienna.

In the case of the ISE scores, the entire core category can thus be considered as emerging space middle power candidates, since it has been shown that space

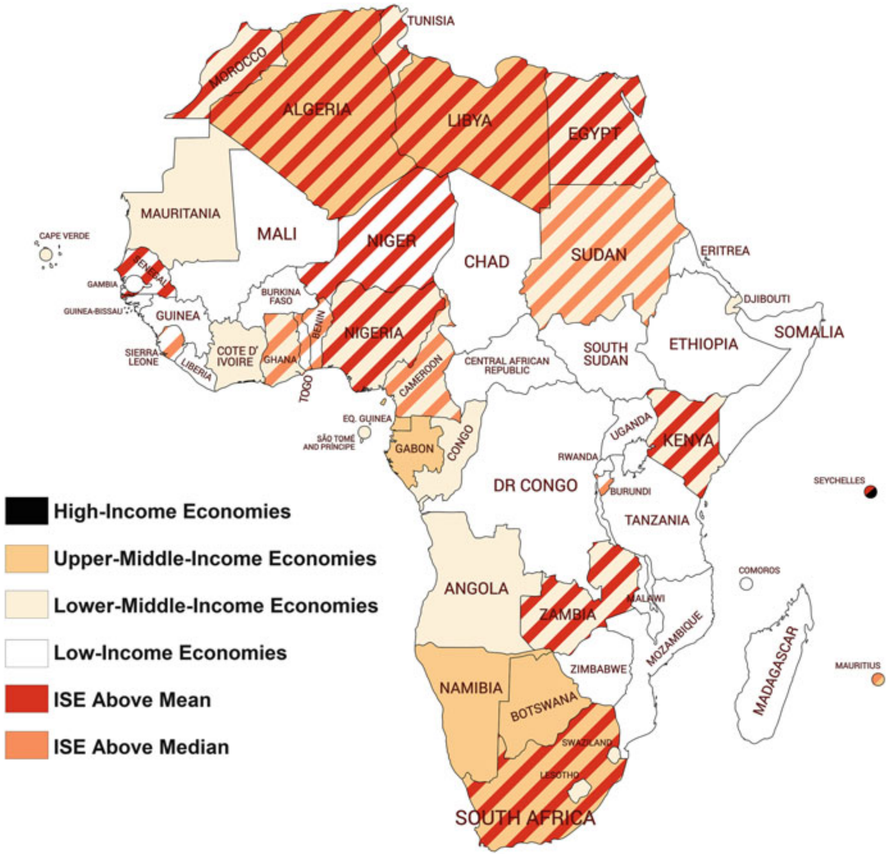


**Fig. 2.17** Emerging space middle power candidates based on economic classification (see Fig. 1.17) and ISE score

engagement does not depend on levels of economic development. Thus, the 13 high-scoring states will be compared to the list of candidates from the IASE Matrix (combined with power perception) discussed earlier, to find the African emerging space middle powers in the next section.

### *2.3.3 African Emerging Space Middle Powers*

Based on the most active participants in the major intra-African space efforts and activities discussed in Sect. 2.2, and the most active African states in terms of the key international space forum, treaties, and affiliated organisations such as UN-SPIDER,

**Table 2.11** Twelve categories of African states based on economy and space engagement

| | A. ISE above mean | B. ISE above median | C. ISE below median |
|---|---|---|---|
| 1. High-income | Seychelles | | |
| 2. Upper-middle-income | Algeria, Libya, South Africa | Mauritius | Botswana, Equatorial Guinea, Gabon, Namibia |
| 3. Lower-middle-income | Egypt, Kenya, Morocco, Nigeria, Tunisia, Zambia | Cameroon, Ghana, Sudan | Angola, Cape Verde, Republic of the Congo, Côte d'Ivoire, Djibouti, Lesotho, Mauritania, São Tomé and Príncipe, Swaziland |
| 4. Low-income | Burkina Faso, Niger, Senegal | Benin, Burundi, Sierra Leone, Togo | Central African Republic, Chad, Comoros, Democratic Republic of the Congo, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Liberia, Madagascar, Malawi, Mali, Mozambique, Rwanda, Somalia, South Sudan, Tanzania, Uganda, Zimbabwe |

it is now possible to identify the major African space actors in terms of their engagement and cooperation, and thus the emerging space middle powers, as done in Fig. 2.18. The major African space actors in terms of their national activities and capabilities will be explored in Chap. 3, but this dimension of cross-border engagement and cooperation is, as argued previously, a cornerstone of the global space sector. Given the importance of ubuntu and its aspects of group support, cooperation, and solidarity, these emerging space middle powers are called upon to provide the continental leadership, encouragement, and support needed to extend the African involvement in, and ownership of, the space sector and its regulations. As Nelson Mandela put it in a speech to the then-OAU in 1998, "we charge you with the responsibility to lead our peoples and Continent into the new world of the next century—which must be an African Century—during which all our people will be freed of the bitterness born of the marginalisation and degradation of our proud continent of Africa".[192] It is therefore up to the nations of Africa to stand by one another to advance the continent's interests in the space arena, without which this marginalisation and degradation will repeat itself.

The result of this analysis reveals the emerging space middle powers, and thus the continental leaders that meet the criteria set forth in Sect. 1.3.1 of Chap. 1, to be Algeria, Egypt, Kenya, Morocco, Nigeria, South Africa, and Tunisia. These seven countries must play the main leadership role for Africa to meet its goals and targets set out in the AU's Agenda 2063 first 10-year implementation plan, specifically those elements highlighted in bold in Table 2.12 below.

[192]Nelson Mandela, "Mandela Quotes and Interesting information," *South African History Online*, 2017, https://www.sahistory.org.za/archive/mandela-quotes-and-interesting-information (accessed September 20, 2018).

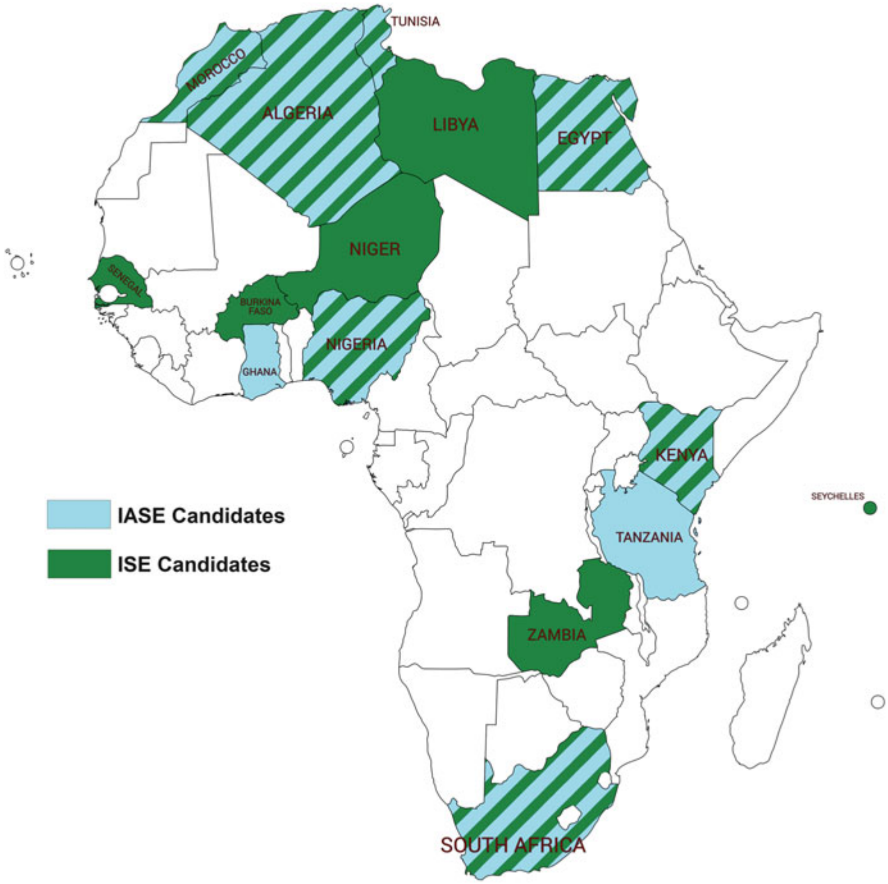


**Fig. 2.18** African emerging space middle powers revealed

While the indicative strategies accompanying the goals in Table 2.12 include setting up continental grant systems, strengthening interuniversity collaboration, and facilitating the adoption of curricula in space technology in member states universities/polytechniques (all important), there is no word on achieving a common African position on the international space agenda or even how Africa can speak with one voice on global affairs in general. In 2012 it was observed that the AU "does not have the capacity to develop common African positions on space-related matters",[193] and this goal is still severely hampered by the lack of engagement with the international space agenda, or even continental space initiatives, by far too many African states. This includes signing and ratifying the major space treaties. Without

[193]Martinez, "The African Leadership Conference on Space Science and Technology for Sustainable Development," 36.

**Table 2.12** Global affairs priority areas and targets for 2023 (AU Commission)

| | | |
|---|---|---|
| **Aspiration 7**. Africa as a strong, united, resilient, and influential global partner and player | **Goal 19**. Africa as a major partner in global affairs and peaceful co-existence | • **Priority area 1**. Africa's place in global affairs<br>*Regional/continental targets (2023):*<br>1. **Africa Speaks with One Voice on Global Affairs**<br>2. African Space Agency established and is fully operational<br>3. Strategic Freight Maritime Task Force is established<br>4. AU stand-alone department for Maritime Affairs to be responsible for AIMS implementation established<br>5. African island states are fairly represented in appointments to regional/continental and international bodies<br>6. All Colonies are free by 2020<br>*Key process actions/milestones towards 2023 on AU framework (s)*<br>1. **Science Technology and Innovation Strategy for Africa (STISA-2024)**<br>2. STISTA is adopted by AU Summit in 2014<br>3. Development/implementation of first set of flagship programmes under STISA takes place between 2015 and 2017<br>4. Development/implementation of second set of flagship programmes under STISA takes place between 2018 and 2020<br>5. Development/implementation of the third set of flagship programme under STISA takes place between 2021 and 2023<br>6. Final Evaluation of STISA takes place in 2023<br>7. African Space Policy<br>8. Development and Adoption of African Space Policy and Strategy is done in 2015<br>9. Preparation and Implementation of Action Plan on African Space Policy starts in 2016<br>10. **African Common Position on International Space Agenda is attained by 2018** |

African Union Commission, *Agenda 2063: The Africa We Want—First 10-Year Implementation Plan 2014–2023*, 2015, Addis Ababa, 91. https://au.int/sites/default/files/documents/33126-doc-ten_year_implementation_book.pdf (accessed June 22, 2018)

**Table 2.13** Emerging space middle powers by regional economic community

| | Emerging space middle powers |
|---|---|
| Arab Maghreb Union (UMA) | Algeria, Morocco, Tunisia |
| Common Market for Eastern and Southern Africa (COMESA) | Egypt, Kenya, Tunisia |
| Community of Sahel-Saharan States (CEN-SAD) | Egypt, Morocco, Nigeria, Kenya, Tunisia |
| East African Community (EAC) | Kenya |
| Economic Community of Central African States (ECCAS) | *Cameroon, Republic of the Congo* |
| Economic Community of West African States (ECOWAS) | Nigeria |
| Intergovernmental Authority on Development (IGAD) | Kenya |
| Southern African Development Community (SADC) | South Africa |

this engagement, meeting the primary needs of Africa through space is made unnecessarily difficult. While some efforts are under way to address this, such as the ALC, much more needs to be done, including within the RECs. Space data and activities are important for all economies; thus the Regional Economic Communities are a good platform for encouraging greater space engagement. Space must therefore be afforded a higher priority within these communities, and on the continent as a whole, and this is where the emerging space middle powers can play a powerful role. As Table 2.13 shows, all but one REC has one of these middle powers as a member, and, even for ECCAS, Cameroon and the Republic of the Congo can still play important leadership roles as Table 2.8 showed earlier.

It is encouraging to note, as a statement by the South African Ambassador on behalf of the African Group pointed out at the 49th STSC meeting in 2012, that the group "stresses the importance of dissemination of knowledge and technology transfer through bilateral channels as well as in reinforcing multilateral cooperation, with increased role for the Office of Outer Space Affairs (OOSA)" and reaffirmed its support for ARMS-C, UN-SPIDER, and the ALC.[194] The statement also reflected that the African Group considered that "the efforts of the UNCOPUOS, are paramount to promoting international cooperation in the peaceful uses of outer space" and highlighted two particular concerns, namely, that the "geostationary orbit is a limited resource at risk of becoming saturated . . . [and that] its use should be streamlined giving priority to activities with long term perspective, leading to achieve the Millennium Development Goals while taking into account the conditions of equality of all countries irrespective of their current space capacities" and that "[t]he Group attaches great importance to the preservation and sustainability of space activities, to ensure that they benefit all nations".[195]

[194]Xolisa Mfundiso Mabhongo, "Statement of the African Group during the forty-ninth session of the Scientific and Technical Subcommittee of Committee on the Peaceful uses of Outer Space," *South African Council for Space Affairs*, February, 2012, http://www.sacsa.gov.za/conferences/African_statement_STSC_Mabhongo.pdf (accessed September 20, 2018).

[195]Ibid.

This points to a noteworthy evolution in the position of some African states on outer space, especially geostationary orbit. In 1976, eight equatorial states (including four African ones) signed the Bogotá Declaration that represented a challenge to the legal status quo in relation to space. Along with Brazil, Colombia, Ecuador, and Indonesia, the states of the Republic of the Congo, then-Zaire (now Democratic Republic of the Congo), Uganda, and Kenya argued that "the segments of geostationary synchronous orbit are part of the territory over which Equatorial states exercise their national sovereignty" by virtue of this orbit being "a physical fact linked to the reality of our planet because its existence depends exclusively on its relation to gravitational phenomena generated by the earth, and that is why it must not be considered part of the outer space".[196] Therefore, these states argued that this particular orbit qualified as a natural resource and that "[t]he devices to be placed permanently on the segment of a geostationary orbit of an equatorial state shall require previous and expressed authorization on the part of the concerned state, and the operation of the device should conform with the national law of that territorial country over which it is placed" and that "[e]quatorial states do not condone the existing satellites or the position they occupy on their segments of the Geostationary Orbit nor does the existence of said satellites confer any rights of placement of satellites or use of the segment unless expressly authorized by the state exercising sovereignty over this segment".[197] Because these claims never received wider international support, they have faded away to the point that the African Group (which includes Kenya as a UNCOPUOS member) could make the above statement relating to the use of geostationary orbit on the basis of the equality of all countries.

As argued earlier, a middle power is defined by its support for the international order and by its favouring of gradual reform instead of radical change and confrontation. Thus, especially in the case of Kenya, there has been a marked shift in tone from appropriation to exploitation for mutual benefit of all states. One of the likely reasons for this shift in tone is the end of the Cold War, since "space policy was the protagonist of the Cold War for its high symbolic meaning and strong military significance" which "has changed profoundly in recent years, for political, economic, and technological reasons, after having long been the stage on which the two superpowers of the Cold War measured their ability to impress international opinion".[198] Additionally, since "traditional security concerns are no longer the only driver behind the adoption of space policies", there has been a shift towards investment "in space assets primarily as a vehicle to promote socioeconomic growth through better natural resource management and improved communications—or

[196] Declaration of the First Meeting of Equatorial Countries, "The Bogotá Declaration," 1976, https://bogotadeclaration.wordpress.com/declaration-of-1976/ (accessed September 20, 2018).

[197] Ibid.

[198] Giorgio Petroni and Davide Gianluca Bianchi, "New patterns of space policy in the post-Cold War world," *Space Policy* 37, (2016):12.

even to inspire their youth to study science".[199] This is very difficult to achieve in isolation, thus helping to explain the shift in tone. Nevertheless, as was evident in the statement on behalf of the African Group within the UN, the continent does still place heavy emphasis on respect for sovereignty, in line with the arguments presented in the last chapter regarding Africa's preference for consensus and self-determination.

## 2.4 International Space Activities, Agreements, and Initiatives in Africa

This section will examine the third dimension of the African international space ecosystem, namely, various international efforts related to space taking place on the continent, in contrast to Sect. 2.2, which considered efforts that were more intra-African in nature. This section will itself be divided into various subsections dedicated to exploring (i) international initiatives with a bearing on Africa, (ii) a range of African agreements with foreign space agencies and other actors, and (iii) foreign space infrastructure in Africa, with particular reference to the Italian Luigi Broglio Space Centre in Kenya and the Chinese satellite ground station in Namibia. Again, while it is not possible to include a full account of every initiative or agreement here, the focus will be placed on surveying those with particular bearing on the primary needs identified previously.

### *2.4.1 International Initiatives in Africa*

This first initiative to be discussed here is the Regional Centres for Space Science and Technology Education (ARCSSTE) effort of UNOOSA, which established two African centres—one in English and one in French—thus known by their acronyms ARCSSTE-E and CRASTE-LF, both inaugurated in 1998 in Nigeria and Morocco, respectively.[200]

ARCSSTE-E is housed at the Obafemi Awolowo University Campus, Ile-Ife, for the benefit of Anglophone African countries, and is supervised by the Nigerian National Space Research and Development Agency (NASRDA).[201] It has four broad

[199]Robert C. Harding, "Introduction: Space policy in developing countries," *Space Policy* 37, no. 1 (2016): 1.

[200]United Nations Office for Outer Space Affairs, "Regional Centres for Space Science and Technology Education (affiliated to the United Nations)," 2018, http://www.unoosa.org/oosa/en/ourwork/psa/regional-centres/index.html (accessed September 21, 2018).

[201]African Regional Centre for Space Science and Technology Education-English, "Brief on the Centre," http://arcsstee.org.ng/index.php/about-us (accessed September 21, 2018).

goals, namely, (i) the development of skills and knowledge of university educators and environmental research scientists in the four principal areas of remote sensing, satellite meteorology applications, satellite communication, and basic space and atmospheric science and technology, (ii) to engage educators in the development of environmental and atmospheric science curricula that can be used to advance the knowledge of the scholars, (iii) the development of research scientists and project personnel in preparing the space-derived information for presentation to the policy- and decision-makers in charge of national and regional development programs, and (iv) the coordination of regional and international cooperation in space science and technology programs.[202] Its expectations are (i) to contribute to sustainable development of natural resources (air/water/land); (ii) to provide an input for the conservation of all earth resources and natural environment through increased capacity building for educators, research, and application scientists in environmental information systems with emphasis on remote sensing, satellite meteorology, and other spin-off technologies at the local level; and (iii) to develop skills for satellite communication, including those associated with rural development and health services, long distance education, disaster mitigation, navigation, and regional networking/linkages with industries.[203] Its operations are thus directly applicable to the primary needs of climate, biodiversity, health (e.g. through meteorological services), water, education, and capacity building. With regard to the last, the centre's Master's Programme in Space Science and Technology focuses on the thematic areas of satellite communication, basic space physics, satellite meteorology, and remote sensing and geographic information systems (GIS).[204]

The establishment of the centre is also argued to have "either initiated or encouraged the establishment of space related courses in some tertiary institutions in Nigeria" such as programmes in remote sensing/GIS at Obafemi Awolowo University, Federal University of Technology Akure, and the Regional Centre for Training in Aerospace Surveys, as well as a Meteorology Department at the Federal University of Technology Akure.[205] It was also a catalyst that "led to the establishment of the Nigerian space agency" (NASRDA).[206] Apart from its postgraduate programme, the centre also runs "several outreach programmes" for students, the public, and policymakers while also organising workshops, conferences, and seminars, alongside a conference dedicated to "advance the use of space in the socio-economic development of Africa".[207] Beyond these functions it also "promotes awareness and knowledge in international space law", in particular by supporting the Nigerian participants in the Manfred Lachs Space Law Moot Court Competition

[202]Ibid.

[203]Ibid.

[204]Ibid.

[205]Olakunle Oladosu and Etim Offiong, "Improving space knowledge in Africa: The ARCSSTE-E," *Space Policy* 29, (2013): 155.

[206]Ibid.

[207]Ibid.

(more on this later in this section).[208] ARCSSTE-E thus fulfils a critical function as an incubator of space-related skills and outreach for Nigeria specifically and Anglophone African countries in general.

CRASTE-LF fulfils a very similar role to ARCSSTE-E for Francophone countries. It is a "high-level training and research institution", established at the Mohammadia School of Engineers of Mohammed V University in Rabat (EMI), and is supported by other Moroccan institutions such as the Royal Centre for Remote Sensing (CRTS), the Veterinary Agronomic Institute (IAV) HASSAN II, the National Institute of Posts and Telecommunications (INPT), and the Directorate of National Meteorology (DMN).[209] A total of 11 African states participated in the establishment of the CRASTE-LF, and current member states and their relevant organisations are Algeria (Algerian Space Agency, ASAL), Cameroon (Ministry of Scientific Research and Innovation), Cape Verde (Ministry of Higher Education Science and Innovation), Central African Republic (Ministry of National Education, Higher Education, and Research), Democratic Republic of the Congo (Ministry of Foreign Affairs), Côte d'Ivoire (Ministry of Higher Education and Scientific Research), Gabon (Ministry of Higher Education, Research, and Technological Innovation), Morocco (Ministry of Higher Education, Scientific Research, and Executive Training), Mauritania (Ministry of Higher Education and Scientific Research), Niger (Ministry of Secondary and Higher Education, Research, and Technology), Senegal (Ministry of Higher Education, Universities, and Regional University Centres and Scientific Research), Togo (Ministry of Technical Education and Vocational Training), and Tunisia (Ministry of Higher Education and Scientific Research).[210] Similar to ARCSSTE-E, CRASTE-LF offers "training courses for academics, researchers, engineering administrators and system planning" in areas of satellite communication, space sciences and atmospheric sciences, satellite meteorology and global climate, and remote sensing and geographic information systems, with a master's degree in Sciences and Technology of Space in the chosen specialty.[211] The ARCSSTE initiative is thus intimately tied to the primary needs of education and space-related capacity building.

Another UNOOSA initiative which is also found in Africa is the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER), which "develops solutions to address the limited access developing countries have to specialized technologies that can be essential in the

[208] Ibid., 156.

[209] Le Centre Régional Africain des Sciences et Technologies de l'Espace en langue Français, "Création," 2018, http://www.crastelf.org.ma/index.php/2016-02-29-09-08-40/historique (accessed September 21, 2018). Translated from French.

[210] Le Centre Régional Africain des Sciences et Technologies de l'Espace en langue Français, "Pays membres," 2018, http://www.crastelf.org.ma/index.php/2016-03-13-23-21-46/pays-membres (accessed September 21, 2018).

[211] Le Centre Régional Africain des Sciences et Technologies de l'Espace en langue Français, "Introduction," 2018, http://www.crastelf.org.ma/index.php/2016-02-29-09-10-06/formation (accessed September 21, 2018).

management of disasters and the reducing of disaster risks".[212] UN-SPIDER has a range of Regional Support Offices around the world, including national space agencies, geographic institutes, civil protection agencies, universities, and regional remote sensing centres, with which it sets up "international and regional workshops and conferences, provides technical advisory support, facilitates the access to space-based resources in case of disasters and elaborates relevant content for UN-SPIDER's Knowledge Management tools".[213] Three Regional Support Offices are based in Africa. The first is hosted by the Algerian Space Agency and was established during the third ALC in 2009 in Algiers.[214] It covers the North African and Sahel region, and "[i]n case of an emergency, it will liaise between the end-users of space-based information and the Algerian Space Agency, which will act as a value-adder to space-derived data".[215] A second Regional Support Office is hosted by the Nigerian NASRDA, and was established in 2008, to "promote and support the use of space technology within and outside of Nigeria in the management of the full disaster cycle including prevention and mitigation".[216] The third centre is hosted by the previously discussed RCMRD in Kenya.[217]

Closely related to UN-SPIDER is the Disaster Monitoring Constellation (DMC), which is an international programme proposed in 1996. The DMC consortium consists of a partnership between five states (Algeria, China, Nigeria, Turkey, and the United Kingdom) and their relevant organisations.[218] The African contributions to the first generation of satellites were, as earlier mentioned, AlSat-1 and NigeriaSat-1, while the second-generation contributions were NigeriaSat-2 and NigeriaSat-X, as well as AlSat-1B, AlSat-2, and AlSat-2B.[219] The constellation is

[212]United Nations Office for Outer Space Affairs, "United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER)," 2018, http://www.unoosa.org/oosa/en/ourwork/un-spider/index.html (accessed September 21, 2018).

[213]United Nations Office for Outer Space Affairs, "UN-SPIDER's Network," 2018, http://www.unoosa.org/oosa/en/ourwork/un-spider/network.html (accessed September 21, 2018).

[214]United Nations Office for Outer Space Affairs, "Algeria Regional Support Office," 2017, http://www.un-spider.org/network/regional-support-offices/algeria-regional-support-office (accessed September 21, 2018).

[215]Ibid.

[216]United Nations Office for Outer Space Affairs, "Nigeria Regional Support Office," 2017, http://www.un-spider.org/network/regional-support-offices/nigeria-regional-support-office (accessed September 21, 2018).

[217]United Nations Office for Outer Space Affairs, "Regional Center for Mapping of Resources for Development (RCMRD)," 2017, http://www.un-spider.org/network/regional-support-offices/regional-center-mapping-resources-development-rcmrd (accessed September 21, 2018).

[218]European Space Agency, "DMC-1G," eoPortal, 2018, https://directory.eoportal.org/web/eoportal/satellite-missions/d/dmc (accessed September 21, 2018).

[219]European Space Agency, "DMC-3," eoPortal, 2018, https://directory.eoportal.org/web/eoportal/satellite-missions/d/dmc-3 (accessed September 21, 2018); World Meteorological Organisation, "Satellite Programme: Algeria Satellite," *OSCAR: Observing Systems Capability Analysis and Review Tool*, 2018, https://www.wmo-sat.info/oscar/satelliteprogrammes/view/8 (accessed September 21, 2018).

coordinated by DMC International Imaging (DMCii), to "deliver high quality commercial earth imaging services", and apart from this commercial service, the DMC "works actively within the International Charter 'Space and Major Disasters' to provide free satellite imagery for humanitarian use in the event of major international disasters such as tsunamis, hurricanes, fires and flooding".[220] The satellites are all built in partnership with Surrey Satellite Technology Ltd (SSTL), and the UK Space Agency represents the DMC on the International Disasters Charter Board, and DMCii represents it in the Executive Secretariat.[221] Through the DMC African states are thus both contributors and potential users of data supporting primary needs related to climate, water, and health in the case of disasters, as well as biodiversity depending on commercial needs.

The next initiative is ArabSat, which is "one of the world's top satellite operators and by far the leading satellite services provider in the Arab world, it carries over 500 TV channels, 200 radio stations, pay-tv networks and wide variety of HD channels reaching tens of millions of homes in more than 80 countries across the Middle East, Africa and Europe".[222] Having been founded in 1976 by the 21 member states of the Arab League, nine African countries contributed to Arabsat's initial capital fund of $500 million, with Libya being the third-largest contributor (11.2785%), followed by Algeria in 11th place (1.7163%), Egypt in 13th place (1.5937%), Tunisia in 15th (0.7355%), Morocco in 16th (0.6129%), Mauritania in 17th (0.2758%), Sudan in 18th (0.2678%), Somalia in 20th (0.24465%), and Djibouti in 21st place (0.1225%).[223] Arabsat operates with the mission to "[c]onnect Arab societies and the world by providing reliable telecommunications services in harmony with Arab values and culture", and the vision "[t]o be the regional and global leader in the field of space telecommunications".[224] The organisation is headquartered in Saudi Arabia but has a satellite control station in Tunis, Tunisia. Accordingly, Arabsat can be argued to contribute some level of capacity building in North Africa.

The next initiative is the above-mentioned Manfred Lachs Space Law Moot Court Competition, founded by the International Institute of Space Law (IISL) in 1992 as an "unparalleled learning experience" with judges of the International Court of Justice (ICJ) presiding over and judging the contest.[225] The moot court consists of a "simulated hearing in the area of space law" and includes the Africa Regional Round, first introduced in 2011, alongside other regions (Asia-Pacific, Europe, and

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[220] DMC International Imaging, "DMC Constellation," *Airbus Defence and Space Limited*, http://www.dmcii.com/?page_id=9275 (accessed September 21, 2018).

[221] Ibid.

[222] Arabsat, "About," 2018, http://www.arabsat.com/english/about (accessed September 21, 2018).

[223] Ibid.

[224] Ibid.

[225] International Institute of Space Law, "Lachs Moot Competition," 2018, http://iislweb.org/lachs_moot/ (accessed September 21, 2018).

North America).[226] Regional winners go one to represent their regions in the World Finals, which are held in conjunction with the International Astronautical Congress. The runner-up in 2016 was from Obafemi Awolowo University, Ile-Ife, Nigeria.[227] The same institution produced semi-finalists in 2012, 2014, and 2015, while the University of Pretoria, South Africa, produced semi-finalists in 2013 and 2017 and World Finals winners in 2018—the first time an African team won the World Finals.[228] This initiative is directly related to the primary needs of education and capacity building and has drawn participants from countries including Nigeria, South Africa, and Kenya.

In 2009 the South African Astronomical Observatory (SAAO) in Cape Town managed to win the bid to host the International Astronomical Union's (IAU) Office of Astronomy for Development (OAD), which is a joint project of the IAU and the South African National Research Foundation (NRF), supported by the Department of Science and Technology (DST).[229] The OAD has 10 regional offices and language centres around the globe, including in Zambia (covering Southern Africa), Nigeria (for West Africa), Ethiopia (for East Africa), and Jordan (for the Arab world including North Africa).[230] The OAD's goal is to "help further the use of astronomy, including its practitioners, skills and infrastructures, as a tool for development by mobilizing the human and financial resources necessary in order to realize the field's scientific, technological and cultural benefits to society". It achieves this through funding and coordination of projects "using Astronomy as a tool to address issues related to sustainable development".[231] Over 120 projects have been funded since 2013, including about 31 projects in Africa such as an optical camera for a 14-inch telescope in Namibia, a West African International Summer School for Young Astronomers in Ghana, Astro-Science Ambassadors Outreach for Science Education in Tanzania, Madagascar Astronomy Python Workshop, and others.[232] The OAD also engages in its own activities such as Virtual Observatory workshops, World Wide Telescope workshops, AstroVARSITY, Astro4Dev Brainstorming Meetings,

[226]International Institute of Space Law, "African Region," 2018, http://iislweb.org/awards-and-competitions/manfred-lachs-space-law-moot-court-competition/participating-in-the-lachs-competition/africa/ (accessed September 21, 2018).

[227]International Institute of Space Law, "Category Archive: Lachs winners," 2018, http://iislweb.org/category/lachs-winners/ (accessed September 21, 2018).

[228]Ibid.; Space in Africa, "Africa wins the Manfred Lachs Space Law Moot World Finals 2018," *Africa Space News*, October 5, 2018, https://africanews.space/africa-wins-the-manfred-lachs-space-law-moot-world-finals-2018/ (accessed December 7, 2018).

[229]Office of Astronomy for Development, "Office of Astronomy for Development," *International Astronomical Union*, http://www.astro4dev.org/ (accessed September 21, 2018); Keith Gottschalk, "Astronaissance: Communicating Astronomy & Space to the African Imagination," *The Re-emergence of Astronomy in Africa: A Transdisciplinary Interface of Knowledge Systems Conference*, Maropeng, South Africa, September 10–11, 2012: 8.

[230]Office of Astronomy for Development, "Regions," *International Astronomical Union*, http://www.astro4dev.org/regions/ (accessed September 21, 2018).

[231]Office of Astronomy for Development, "Office of Astronomy for Development."

[232]Ibid.

and others.[233] The OAD thus fulfils a powerful role in education and space-related capacity building in Africa (where it is also headquartered) and elsewhere around the world.

A recent initiative is the African Regional Data Cube (ARDC), launched in 2018 and developed by the Committee on Earth Observation Satellites (CEOS), in partnership with the Group on Earth Observations (GEO), Amazon Web Services, Strathmore University in Kenya, Office of the Deputy President—Kenya—and the Global Partnership for Sustainable Development Data.[234] It is a "new tool that harnesses the latest Earth observation and satellite technology to help Kenya, Senegal, Sierra Leone, Ghana, and Tanzania address food security as well as issues relating to agriculture, deforestation, and water access"[235]—thus speaking to the primary needs of biodiversity, water, and health (through food security). The ARDC is based on the Open Data Cube (ODC) infrastructure, which "allows analysis-ready satellite data (e.g. Landsat, Sentinel) to be spatially and temporally aligned in 'cubes' of pixels".[236] It is aimed for the ARDC to "help governments, farmers and consumers manage the complex challenges they face in trying to navigate the economic, social and environmental systems on which they depend" by making available "[v]ast quantities of freely available satellite data [which] offer real opportunity to improve agricultural production, food security and access to water".[237] The Deputy President of Kenya has stated that "[t]his technology will help us understand month by month how our land is being used so that we can target interventions aimed at improving our actions against climate change, help smallholder farmers and secure sustainable food and water for our citizens".[238]

The Inter-Islamic Network on Space Sciences and Technology, hosted by the Pakistan Space and Upper Atmosphere Research Commission, is an "independent, autonomous and self governing institution" under the Organisation of the Islamic Conference's Standing Committee on Scientific and Technological Cooperation and has the mission to "[p]romote Space Sciences, Space Technology and their Applications for peaceful purposes in OIC member countries".[239] Member countries

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[233]Office of Astronomy for Development, "OAD activities," *International Astronomical Union*, http://www.astro4dev.org/oad-activities/ (accessed September 21, 2018).

[234]Global Partnership for Sustainable Development Data, "Africa Regional Data Cube," 2016, http://www.data4sdgs.org/initiatives/africa-regional-data-cube (accessed September 21, 2018).

[235]Ibid.

[236]Open Government Partnership, "Launch of the Africa Regional Data Cube (ARDC) – Kenya," 2018, https://www.opengovweek.org/event/launch-of-the-africa-regional-data-cube-ardc-kenya/ (accessed September 21, 2018).

[237]Global Humanitarian Assistance Programme (Development Initiatives), "New satellite technology tool transforms central Africa's ability to manage food security," *reliefweb*, March 21, 2018, https://reliefweb.int/report/kenya/new-satellite-technology-tool-transforms-central-africas-ability-manage-food-security (accessed September 21, 2018).

[238]Ibid.

[239]Inter Islamic Network on Space Sciences and Technology, "About ISNET," http://www.isnet.org.pk/ (accessed September 21, 2018).

include the African states of Egypt, Libya, Morocco, Niger, Senegal, Sudan, and Tunisia. The organisation works with its members "for the peaceful uses of outer space; exploiting the potential of the outer space for the development and benefit of these countries" and "provides a platform for space science experts of OIC [Organisation of Islamic Cooperation] member states to come forward and share their experiences, research studies and developments in space sciences and applications in their respective countries so that these activities may jointly benefit all OIC countries".[240] It relates directly to education and capacity building since it "forms a network of information exchange by assisting in training to develop the quality and capability of manpower of the OIC countries in the relevant fields", through annual training programmes, and sponsoring of member states citizens to attend.[241]

Another noteworthy initiative, by Japan, is known as the Joint Global Multi-Nation Birds Satellite project (Birds Project), with Ghana and Nigeria as African participating countries of the first phase (Birds-1) between 2015 and 2017.[242] Birds-1 was a "cross-border interdisciplinary satellite project for non-space faring countries" for students from the seven participating countries to "design, develop and operate 5 units of identical 1 U CubeSats (1 kg, 10 cm cubic)" which belong to the participating countries and are operated from seven ground stations—one in each participating country—thereby "to form first time in the world a constellation of 5 CubeSats operated in 7 networked ground stations".[243] This project is thus directly relevant to the education of African students and building of capacity in satellite manufacturing and design, and Nigeria and Ghana's satellites (GhanaSat-1 and Nigeria Edusat-1) were launched in 2017.[244] Training was provided by the Graduate School of Engineering of the Kyushu Institute of Technology, and students were enrolled in master's or doctoral degree programmes in a Space Engineering International Course. The Birds Project is continuing, now in its third phase, Birds-3.

Japan, together with the United Nations Office for Outer Space Affairs (UNOOSA), also runs the KiboCUBE initiative, and as will be seen in the next chapter, African countries are also taking part. The KiboCUBE initiative is a "dedicated collaboration between UNOOSA and JAXA in utilizing the ISS Kibo for the world" whereby "KiboCUBE aims to provide educational or research institutions from developing countries of United Nations membership with opportunities to deploy, from the ISS Kibo, cube satellites (CubeSats) which they develop and manufacture".[245] Three rounds of the initiative have been held, with the fourth

[240]Inter Islamic Network on Space Sciences and Technology, "ISNET Activities," http://www.isnet.org.pk/pages/isnet-activities.asp (accessed September 21, 2018).

[241]Ibid.

[242]Kyushu Institute of Technology, "Joint Global Multi Nation Birds 1," 2017, http://birds1.birds-project.com/index.html#about (accessed September 21, 2018).

[243]Ibid.

[244]Oyewole, "Space Research and Development in Africa," 189.

[245]United Nations Office for Outer Space Affairs, "The United Nations/Japan Cooperation Programme on CubeSat Deployment from the International Space Station (ISS) Japanese

now open, predicated on the notion that "KiboCUBE will lower the threshold of space activities and will contribute to build national capacity in spacecraft engineering, design and construction".[246]

Morocco has also taken part in the TUBSAT (Technical University of Berlin Satellite) programme, which is a "low-cost and fast-turnaround microsatellite program series defined, designed and built by the Institute of Aeronautics and Astronautics (ILR: Institut für Luft- und Raumfahrt) of the Technical University of Berlin (TUB), Germany", pursuing the goal to "explore technical capabilities in microsatellite design (in particular in the field of attitude determination) and space-related applications".[247] Thus far, Morocco has been the only African country to participate in the TUBSAT programme, which is "an educational program including the design, manufacture, testing, launching and operation of 'microsatellites' (<100 kg) that was initiated in 1985 for students at the Technical University of Berlin (TUB)".[248]

### *2.4.2 African Agreements with Foreign Space Agencies and Other Actors*

In recent years, as African space agencies have been established (more on these in the next chapter), international agreements between these agencies and their foreign counterparts have proliferated, even extending to countries without formal government space offices. In a 1992–2004 survey of cooperative agreements between 12 of the world's space agencies, Africa did not feature as an actor at all, instead only being blocked with the Middle East as partners for these 12 major space agencies.[249] Thus, given this grouping with the Middle East, it was not even possible to identify specifically African agreements. In recent years, this picture has changed drastically however, and a range of agreements are examined here.

First, South Africa's National Space Agency (SANSA) recently signed its first memorandum of understanding (MoU) with the United Arab Emirates Space Agency, which outlines a "framework for cooperation in the peaceful exploration and use of outer space".[250] It was signed at UNISPACE+50 in Vienna, and specific goals include "organisation and exchange of information, data, expertise, laws and

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Experiment Module (Kibo) 'KiboCUBE'," October, 2018, http://www.unoosa.org/oosa/en/ourwork/psa/hsti/kibocube.html (accessed December 7, 2018).

[246]Ibid.

[247]eoPortal Directory, "TUBSAT," *European Space Agency*, 2018, https://directory.eoportal.org/web/eoportal/satellite-missions/t/tubsat (accessed December 7, 2018).

[248]Ibid.

[249]Nicolas Peter, "The changing geopolitics of space activities," *Space Policy* 37, (2016): 148.

[250]Space in Africa, "SANSA signs MoU with UAE Space Agency," *Africa Space News*, June 22, 2018, https://africanews.space/sansa-signs-mou-with-uae-space-agency/ (accessed September 21, 2018).

regulations", together with human capital development plans, including exchange of engineers, experts, and academics.[251] The two states will also cooperate to "identify projects of common interest that can be supported and developed in both countries" and will "hold joint conference and symposiums, promote educational activities in space science and technology, and enhance collaboration between their space sector and industry bodies".[252]

South Africa also held talks with France in 2017 on the sidelines of the meeting of the Committee on Earth Observation Satellites (CEOS), with the French Space Agency CNES (Centre national d'études spatiales) "ready to step up their partnership".[253] Existing South African-French cooperation revolves around operation of the control station in Hartebeesthoek (more on this in the next chapter), while also covering "coordination with CNES's subsidiary CLS on tracking of wildlife and could be extended to tele-epidemiology". It is also reported that the Institute for Sustainable Malaria Control at the University of Pretoria is working on an instrument to help predict the spread of the disease in infested areas, and "CNES could contribute its recognized expertise in this domain to planned studies", and "[t]raining could also be pursued at the French-South African Institute of Technology with support from the French Embassy".[254]

In 2017, SANSA also joined a space initiative through its BRICS (Brazil, Russia, India, China, South Africa) partnership, which will establish the BRICS Remote Sensing Satellite Constellation.[255] This will occur in two phases, with "phase one comprising of a virtual constellation of existing satellites, and phase two compromises of a new satellite constellation", as a "practical step towards high-tech cooperation between these countries that will assist in attaining the sustainable development goals and challenges pertaining to our respective economies and societies".[256] In 2018, SANSA also signed an MoU specifically with the Indian Space Research Organisation (ISRO) to formalise their relationship, on the sidelines of the BRICS summit in Johannesburg.[257] The MoU provides "for the two agencies to engage in mutually beneficial joint projects and joint research" in areas of applications for space technologies, Earth remote sensing, satellite navigation and

[251] Ibid.

[252] Ibid.

[253] African Aerospace Online News Service, "France-South Africa space cooperation," May 2, 2017, https://www.africanaerospace.aero/france-south-africa-space-cooperation.html (accessed September 21, 2018).

[254] Ibid.

[255] Tabisa Raziya, "SA joins BRICS space programme," *Independent Media*, July 4, 2017, https://www.iol.co.za/news/politics/sa-joins-brics-space-programme-10127283 (accessed September 21, 2018).

[256] Ibid.

[257] Rebecca Campbell, "South African, Indian space agencies strengthen their mutual cooperation," *Creamer Media*, July 30, 2018, http://www.engineeringnews.co.za/article/south-african-and-indian-space-agencies-strengthen-their-mutual-cooperation-2018-07-30/rep_id:4136 (accessed September 21, 2018).

communication, space infrastructure, and space science and planetary exploration.[258] Also in 2018, SANSA and Algeria's ASAL signed an MoU "on cooperation in the field of space science and technology", also in Vienna.[259]

In turn, Algeria also signed an MoU with the UAE Space Agency in 2017 to promote "collaboration in the fields of policy-making, regulations, space science, technology, and human capital development in the space sector".[260] ASAL also has other agreements such as with Surrey Satellite Technology Ltd (SSTL) to build satellites and provide training. More general agreements were concluded by ASAL with British firm Wisscom Aerospace Ltd. and Spanish company Zero 2 Infinity to "boost the national space technology capacities of the North African nation".[261] Algeria had also signed an MoU on cooperation and training with India in 2006 which "enabled 20 Algerian engineers to attend Master's degree courses in space applications and advanced training in space telecommunications and geo-information", and a new cooperative agreement was signed on 19 September 2018 in Bangalore covering areas of science, technology, and space applications.[262]

Other agreements involving African states include a framework space cooperation agreement between Morocco and France, signed in 2015, which meant that "discussions and exchanges between the two nations have stepped up a gear", while the themes underpinning the cooperation between the two states include "areas such as agriculture, water resource management, oceanography, crisis management and climate change, which are integral to sustainable development".[263] The President of CNES also highlighted at a more recent event (in 2017) that Morocco was a "relay for the rest of Africa, notably in developing and disseminating new applications",[264] neatly tying in with Morocco's role as an emerging space middle power. There was also a recent MoU signed between Egypt and China at the 2017 BRICS summit in China, whereby China will partly fund MisrSat-2, which is expected to be "Egypt's first indigenously made satellite in 2020", and Space City, which is a planned

[258]Ibid.

[259]Embassy of Algeria in South Africa, "Algeria, South Africa sign MoU on space technology cooperation," June 23, 2018, http://www.embassyofalgeria-rsa.org/index.php/en-gb/algeria-south-africa-relations/news-alg-sa-relations/1303-algeria-south-africa-sign-mou-on-space-technology-cooperation (accessed September 21, 2018).

[260]African Aerospace Online News Service, "UAE Space Agency and Algerian Space Agency strengthen ties," April 27, 2017, https://www.africanaerospace.aero/uae-space-agency-and-algerian-space-agency-strengthen-ties.html (accessed September 21, 2018).

[261]North Africa Post, "Algeria inks agreement with British and Spanish firms to boost Space program," August 8, 2018, http://northafricapost.com/24871-algeria-inks-agreement-with-british-and-spanish-firms-to-boost-space-program.html (accessed September 21, 2018).

[262]Hana Saada, "Algeria, India ink cooperation agreement in space field," *DZ Breaking*, September 20, 2018, https://www.dzbreaking.com/2018/09/20/algeria-india-ink-cooperation-agreement-space-field/ (accessed September 21, 2018).

[263]African Aerospace Online News Service, "France-Morocco space cooperation," April 26, 2017, https://www.africanaerospace.aero/france-morocco-space-cooperation.html (accessed September 21, 2018).

[264]Ibid.

100 acre plot of land in New Cairo where "satellite manufacturing and other space facilities are being built".[265] China already provided U.S.$23 million by 2017 and will contribute a further U.S.$45 million "as part of an overall aid package worth over U.S.$65 million for Egypt's space programme".[266] Intergovernmental agreements between Kenya and Italy, and China and Namibia, will be discussed in the next section, since they have a direct bearing on foreign space-related infrastructure in Africa.

### *2.4.3 Foreign Space Infrastructure in Africa*

Two particular international projects based in Africa will be discussed here—the longstanding Luigi Broglio Space Centre (LBSC) in Kenya and the newer China Telemetry, Tracking, and Command Station at Swakopmund, Namibia. The LBSC has been operated by Italy (originally through the San Marco Project Research Centre, CRSPM, and was managed by the University of Rome La Sapienza until the end of 2003, thereafter by the Italian Space Agency, ASI) in accordance with renewable intergovernmental agreements with Kenya since the early 1960s.[267] These agreements allow for the "possibility to carry out launch activities, data acquisition from satellites, remote sensing and training activities both in Kenya and in Italy", and while Italy delineates the programs, supplies equipment, and hires local Kenyan employees, Kenya rents out the territory used by the LBSC to Italy. Kenya must also "be informed about programmes making use of the Centre and asks, for commercial programmes, a royalty depending on the terms of the commercial agreement", while equipment becomes the property of Kenya after 15 years.[268]

LBSC consists of three main components. The first, the Santa Rita Oil Rig, was towed from Italy to Kenya within days of Kenyan independence, due to the advantages of launching rockets from the equator, while the second component, a larger steel barge named San Marco (used as the main launch site), was purchased from the United States, and both were then anchored after environmental studies on the seabed of Ungwana Bay, "right on the end of Kenya's territorial waters" (then three nautical miles) so that the "platforms could be supported in international

[265] Spacewatch Middle East, "Cairo Approves Establishment of Egyptian Space Agency and Receives Further Chinese Funding For Its Space Programme," *ThorGroup GmbH*, September, 2017, https://spacewatchme.com/2017/09/cairo-approves-establishment-egyptian-space-agency-receives-chinese-funding-space-programme/ (accessed September 21, 2018).

[266] Ibid.

[267] Agenzia Spaziale Italiana, "'Luigi Broglio' Space Center," 2009, https://www.asi.it/en/agency/bases/broglio (accessed September 21, 2018).

[268] Ibid.

waters, not having to pay Kenya anything for the main platform".[269] Apart from these two components, the project required a ground station, which was built in Ras Ngomeni near Malindi in Kenya, and today this Earth segment "involves many buildings made of masonry and wood used as accommodations and services, a small seaport for docking the ships serving as a link with the platforms as well as three Earth Stations (antenna systems) for the in-orbit control as well as the telemetry receipt from satellites and vectors".[270] The three stations have the following specifications: (i) S-Band station, equipped with a 10-m-long parabola used for the agency programs; (ii) S-/X-/L-band station, equipped with a 10-m-long parabola used for the control of launch vehicles (Arianespace, Titan) and to give support to the first phases of commercial satellites flight (LEOP); and (iii) X-band station equipped with a 6-m-long parabola used to receive remote sensing data (ERS2, Spot, Landsat).[271] In 1969 Kenya's territorial waters increased to 12 nautical miles, and the platforms "survived past 1969 through sheer goodwill and a loose treaty signed in 1964" since Italy and Kenya would only reach an agreement on rent about 15 years later.[272]

Twenty-seven launches, most of which were sounding rockets but nine of which were for satellites, were made between 1964 and 1988, with a 100% success rate for the nine satellites (four Italian, four American, and one British), including the notable NASA satellite named Uhuru, launched on Kenya's independence anniversary in 1970.[273] It is reported that the platforms are in disrepair but that the ground station "thrived" with the addition of a remote sensing centre in 1997 and new equipment.[274] The latest agreement was signed between Italy and Kenya in 2016, renewing the Luigi Broglio Space Centre Agreement, with the inclusion of five implementation protocols: "Support to the Kenyan National Space Agency", "Establishing a Regional Centre for the Observation of the Earth", "Access to Earth Observation Data and Scientific Data", "Training and Educational Activities", and "Telemedicine".[275] There is thus an increased scope for the LBSC to play a larger supporting role for Kenya's primary needs, especially education and capacity building, and (indirectly) other needs via EO data and support of the Kenya National Space Agency.

The International Centre for Space Education in Africa is a recent initiative by the International Astronautical Federation, Kenya Ministry of Defence, and Italian

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[269] Owaahh, "The Space Center Kenya Doesn't Own," March 31, 2016, https://owaahh.com/space-center-kenya-doesnt/#disqus_thread (accessed September 21, 2018).

[270] Agenzia Spaziale Italiana, "'Luigi Broglio' Space Center."

[271] Ibid.

[272] Owaahh, "The Space Center Kenya Doesn't Own."

[273] Ibid.

[274] Ibid.

[275] Ministry of Foreign Affairs and International Cooperation, "Italy and Kenya renew the 'Luigi Broglio' Space Centre Agreement (Trento, 24 October 2016)," *Governo Italiano*, October 25, 2016, https://www.esteri.it/mae/en/sala_stampa/archivionotizie/approfondimenti/2016/10/diplomazia-e-hi-tech-italia-e-kenya.html (accessed September 21, 2018).

Space Agency to "[p]repare African students and trainees to become Africa's space leaders and foster regional and international cooperation". It is open to all African countries and aims to have its first space course by the end of 2018 and is based at Luigi Broglio Space Centre (LBSC) in Malindi.[276] This is a very positive development and is a strong step to increasing capacity building in Eastern Africa in particular and all of Africa more generally. Disciplines and areas of research include Earth observation, including services and applications; space communications; satellite data acquisition, processing, archiving, and dissemination; control and telemetry services; and launching and control of satellites, suborbital platforms, and stratospheric balloons.[277] Activities and programs include training courses, workshops, seminars, internships, research projects, and spin-off activities. The International Centre for Space Education in Africa operates with the mission: "Prepare African students and trainees to become the Space leaders of future Africa and promote regional, international and inter—continental cooperation, for a peaceful and sustainable development of the African continent".[278]

The Chinese Telemetry, Tracking, and Command Station in Namibia is the result of an agreement signed between the two countries in 2000. The purpose of the station is to "manage and control the re-entry or landing procedure of China's Manned Spacecraft".[279] The station has "successfully participated" in at least six manned Chinese missions. A further Employment Agreement was signed in 2012 for the employment of Namibians at the station, and the original agreement makes provision for China to help Namibia to develop local space science and technology capacity. China also agreed to train Namibian citizens in this area through skills transfer, and at least 11 have been trained with five receiving master's degrees. The China Aerospace Science and Technology Exhibition Centre was also opened in 2010, during which degrees and certificates were handed over to recent Namibian graduates who studied in China and would be employed at the station. This cooperation thus serves Namibia in terms of education and capacity building in the context of the primary needs model.

As discussed in the next chapter, São Tomé and Príncipe also signed an MoU with India in September 2018 for ISRO (the Indian Space Research Organisation) to set up "a Space Centre" in the country.[280]

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[276]Roberto Battiston, "ASI initiatives and projects in support of education in emerging countries," *Italian Space Agency (ASI)*, October 2, 2018, presentation at 69th International Astronautical Congress, Bremen, Germany.

[277]Gabriella Arrigo, "Italian engagement in capacity – building activities in Africa," *Italian Space Agency (ASI)*, January–February, 2018, http://www.unoosa.org/documents/pdf/copuos/stsc/2018/tech-10E.pdf (accessed December 7, 2018).

[278]Ibid.

[279]GlobalSecurity.org, "Swakopmund, Namibia," August 26, 2018, https://www.globalsecurity.org/space/world/china/swakopmund.htm (accessed September 21, 2018).

[280]Space in Africa, "India and Republic of Sao Tome and Principe sign MoU to set up Space centre," *Africa Space News*, September 9, 2018, https://africanews.space/india-and-republic-of-sao-tomi-and-principe-sign-mou-to-set-up-space-centre/ (accessed December 10, 2018).

## 2.5 Conclusion

This chapter has shown that Africa is integrated into the international space ecosystem on three dimensions with direct bearing on primary needs. Two of these—the intra-African dimension of continental space-related IGOs and NGOs and the international dimension of Africa's participation in UNCOPUOS—were used to identify the levels of Africa's space engagement through the Intra-African Space Engagement and the International Space Engagement Matrices. It was found that a range of African states are engaged in the space arena, but seven in particular stood out as the emerging space middle powers of the continent, namely, Algeria, Egypt, Kenya, Morocco, Nigeria, South Africa, and Tunisia. The third dimension also served to illustrate that Africa is an increasingly attractive destination for space-related projects and partnerships, and international agreements have been proliferating in recent years.

That is, however, not to say that there is not a range of challenges that remain in terms of expanding space engagement across much of Africa. Some of these include involvement of key stakeholders, sensitisation and awareness, further capacity building programmes, and ICT infrastructure.[281] In terms of the first factor, it has been argued that most regional projects fail precisely because all key stakeholders, defined as "the right expert with the necessary experience and political clout", have not been involved to adequate degrees, with the result that there is little ownership by the people and the fruits of such projects are accordingly underutilised.[282] Strict and clear requirements in terms of knowledge, status, availability, and the contributions required from participating countries, plus involvement through all stages of projects (planning, design, implementation), are thus critical factors for success, especially if projects are to survive past pilot stage.

The second factor was mentioned earlier in the chapter, namely, sensitisation and awareness, and often a problem emerges with African decision-makers being unaware of the full range of initiatives or projects on the continent.[283] Key technical personnel are also absent from participation awareness meetings at times due to lack of travel funds, while "communications amongst African governments are generally poor".[284] The third factor of additional "robust and enduring" capacity building programmes is also critical if there is to be domestication of, and identification with, projects, and greater emphasis on open system and open-source software is "of the utmost importance".[285] Particular skills in demand are related to interoperability, standardisation, metadata and data publication, data management, governance, and fostering cooperating and collaboration.[286] Finally, as discussed in Chap. 1, ICT

[281] Agbaje and John, "Cooperating in earth observation missions in Africa," 9–10.

[282] Ibid.

[283] Ibid.

[284] Ibid.

[285] Ibid.

[286] Ibid., 11.

infrastructure on the continent is often a barrier to the uptake of space data utilisation in Africa, and more "deliberate decision" making must be done to improve this. Beyond these four factors, some argue that existing collaborative projects, including the ARMS-C, "must not be allowed to die",[287] and thus the initiatives discussed throughout this chapter cannot, and must not, be taken for granted but must be fought for and defended. They provide the kernel around which further collaboration can be promoted (the IASE and ISE Matrices suggest good candidates for such collaboration), and they have a clear advantage in that "it is easier to collaborate when there are central institutions that unite smaller actors" since "networks can produce maximization of space benefits".[288] Needless to say, but worth repeating here, a "society that fails to invest in the future may have no future at all".[289]

One promising proposal for the African space sector is that Africa should emulate the European model of establishing an African Space Policy Institute (ASPI), since "[t]oday, there is no institution in Africa, that offers evidence-based space policy advice to a national government nor the African Union", and thus, like the European Space Policy Institute (ESPI) in Austria, ASPI could fill this gap in policy formulation, capacity building, analysis, and training.[290] Another function of ASPI could be to promote awareness around the African Space Policy and Strategy, while addressing the "dearth of such skills [in space law and governance, which are] largely due to the nascent state of the African space sector and limited career opportunities for professionals".[291] The urgent need for such an institute is emphasised by the fact that "only South Africa has national space legislation and a regulatory body to oversee its implementation".[292] ASPI could also promote Africa's participation in discourse around issues such as space debris and other potential challenges to the sustainability of space and help work towards forming the single voice with which Africa is hoping to speak on the global stage, especially on the international space agenda. Indeed, current regulatory complexity means that simply investing in technology is not enough, and "[o]ne must also have the capacity to understand and shape regulatory agendas around technologies".[293] It is also necessary to have a full understanding and appreciation of the role of UNCOPUOS, for example, and a clearing away of misconceptions so that—given Africa's preference for consensus in decision-making among equal and sovereign partners—more states will recognise the value of fuller participation in that organisation. It is thus critical

[287]Ibid., 10.

[288]Timiebi Aganaba-Jeanty, "Space Sustainability and the Freedom of Outer Space," *Astropolitics* 14, no. 1 (2016): 6–7.

[289]Ibid., 11.

[290]Etim Offiong and Valanathan Munsami, "Towards a space policy institute for Africa," *Space Policy* 46, (2018): 4–5.

[291]Ibid., 6.

[292]Ibid.

[293]Dennerley, "Emerging space nations and the development of international regulatory regimes," 30.

for Africa's decision-makers to avoid a lack of long-term vision in this regard. Fostering commercial enterprises and public-private partnerships is also critical to reducing the length of time it takes to implement space projects in Africa and to ensuring sustainability.

To conclude, while it is true that not all countries are, or need to be, active in space in terms of owning satellites, the need for all to take seriously their involvement in space, and its regulatory aspects, is clear. In Africa, as in the rest of the world, cooperation and partnerships are the cornerstones of the space sector, and in this regard, Africa can benefit from more "space *ubuntu*" in the sense of better integrating and supporting the entire African family and community within the international space ecosystem, to unlock the benefits thereof for primary needs, through what the UN Secretary General called in 1977 a step of humility and hope. The next chapter will examine African space infrastructure, assets, national space-related authorities, initiatives, capabilities, and activities.

# Chapter 3
# African Union Member States: National Space Infrastructure, Activities, and Capabilities

**Abstract** Having examined the space-related engagements of African states and the context framing the primary needs approach in earlier chapters, this chapter examines the national space capabilities and initiatives of African states through the main lenses of the modified Space Technology Ladder and the emerging space actor (EMSA) framework, which are discussed first. The examination then proceeds according to Africa's Regional Economic Communities, identifying national space agencies, and current as well as upcoming infrastructure and satellite projects. This is followed by a summary of Africa's key ground segment infrastructure, as well as scientific research output across the continent in the areas of Space and Planetary Science, Astronomy and Astrophysics, and Aerospace Engineering. African space-related spending is also considered. In line with findings from the previous chapter, the current African space growth poles are identified, as are a host of promising rising stars in the sector. These findings, combined with those of previous chapters, powerfully counter the views that Africa remains behind in the space sector of the twenty-first century, that space activities are not relevant to developing nations with many other pressing concerns, and that space is not relevant to, or used to support, the daily lives of Africans—themes that are further examined in an upcoming work on Space Supporting Africa.

## 3.1 Introduction

> There are some who question the relevance of space activities in a developing nation. To us, there is no ambiguity of purpose. We do not have the fantasy of competing with the economically advanced nations in the exploration of the moon or the planets or manned space-flight. But we are convinced that if we are to play a meaningful role nationally, and in the community of nations, we must be second to none in the application of advanced technologies to the real problems of man and society.
>
> Vikram Ambalal Sarabhai[1]

[1] Indian Space Research Organisation (ISRO), "Dr. Vikram Ambalal Sarabhai (1963–1971)," 2017, https://www.isro.gov.in/about-isro/dr-vikram-ambalal-sarabhai-1963-1971 (accessed November 12, 2018).



A. Froehlich, A. Siebrits, *Space Supporting Africa*, Studies in Space Policy 20,
https://doi.org/10.1007/978-3-030-12173-0_3

Dr. Sarabhai, known as the father of the Indian space programme, had a clear appreciation of the role of space and advanced technology in addressing societal needs. Due to his vision, India's first satellite, Aryabhata, was launched in 1975, a feat he did not live to see.[2] This example serves to illustrate two critical points in relation to national investments in space technology and space-related activities. First, developing countries must be driven in their actions by the overriding need to address the "real problems" facing their societies, not by motives of prestige by competing with the more developed countries. Related to this, the challenge highlighted in earlier chapters—of needing to justify space expenditure in the face of many other pressing socio-economic needs—must continue to be faced through public outreach efforts and publicising and sharing the benefits derived from space activities, precisely so that the public and policymakers can fully appreciate the value of space for the well-being of Africa's people. Second, Dr. Sarabhai's example shows that narrow, short-term, and short-sighted thinking and planning must be avoided if investments in space are to bear fruit. Long-term vision, commitment, and clarity of purpose are the keys to success, and, today, India's "space program is thriving as one of the fastest-growing in the world". The key reason it "has become such a success is the belief in and acknowledgement of space as an avenue for a variety of practical applications, from scientific exploration to military applications and economic gain", supported by "a national narrative explaining the need for a robust and sustainable space program".[3]

The reality is that Africa cannot afford to ignore the space sector. The recent white paper issued by Airbus, entitled *The Great Enabler: Aerospace in Africa*, has made it clear that:

> The aerospace industry offers solutions to many of the socio-economic challenges Africa is facing on the path to sustainable development. A paradigm shift from thinking about aerospace as an isolated industry to a key enabler of socio-economic change is necessary to realise its benefits for a prosperous future.[4]

The white paper further stipulates that "[b]uilding a robust commercial aerospace industry in Africa is no longer a question of *if* but *how*"[5] and sets out the challenge for Africa in relation to critical success factors:

> For those countries that are already part of the global aerospace value chain as well as those in the process of becoming so, the critical success factors are human capital development and creation of a business-friendly environment in order to become competitive. In order to pursue these approaches in aerospace, government officials and policymakers must

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[2]Ibid.

[3]Raja Mansoor, "Pakistan Is Losing the Space Race," *The Diplomat*, February 1, 2018, https://thediplomat.com/2018/02/pakistan-is-losing-the-space-race/ (accessed November 13, 2018).

[4]Airbus, "Airbus launches landmark report on the impact and future of aerospace technologies in Africa," October 30, 2018, https://www.airbus.com/newsroom/press-releases/en/2018/10/airbus-launches-landmark-report-on-the-impact-and-future-of-aero.html (accessed November 13, 2018).

[5]Samsana Ismail and Ilunga Mpyana, *The Great Enabler: Aerospace in Africa* (Airbus, 2018), 9. https://www.airbus.com/content/dam/corporate-topics/publications/brochures/TheGreatEnable_AerospaceinAfrica.pdf (accessed November 13, 2018).

implement clear and realistic strategies to enable countries to reap the benefits of this robust and impactful industry.

In Chap. 1 it was argued that while not all countries are producers in the global aerospace value chain, all are consumers and are thus in some way involved in the sector. This is also echoed by the Airbus white paper, which put forth the argument that:

On manufacturing and industrialization, many African countries are final consumers in the global aerospace value chain. Joining the rank of producers in this value chain is challenging for many but not impossible. The examples of Africa's current leaders in aerospace—South Africa, Tunisia and Morocco—demonstrate the complexities but also the opportunities for African countries to develop aerospace manufacturing and industrialization capacity.[6]

Many African countries are already taking up this challenge of joining the ranks of the producers, as illustrated through the example that a stunning 40% of all African satellites have been launched in the last 2 years (2016–2018).[7] Since the first African satellite was launched by Egypt in 1998 (NileSat-101), over $3 billion has been spent on space projects on the continent, and the space sector is set to be one of the most dynamic in the coming years as more countries join in.[8] Therefore, an analysis of African space activities, capabilities, and infrastructure is a timely endeavour. In addition, entry barriers have been greatly reduced through miniaturisation and technological innovation, meaning that it:

is becoming increasingly more viable for low income countries thanks to the recent proliferation of small satellites, such as CubeSats. CubeSats and other nanosatellites are relatively cheaper that can even be built locally—indeed they can be. They thus provide a unique avenue where by even low-income nations can, within a short time and with few resources, acquire invaluable pertinent data that contributes toward judicious policies regarding natural disaster management, climate change mitigation, and agribusiness decision-making in general.[9]

In the previous chapter, Africa's relations in the space arena and participation and engagement on the continent and beyond were investigated. A very clear picture emerged of Africa's emerging space middle powers, and seven countries[10] were identified in this regard (the three identified by Airbus, above, as aerospace leaders

[6] Ibid., 8.

[7] Space in Africa, "Four (4) more satellites from Africa before the end of 2018," *Africa Space News*, October 13, 2018, https://africanews.space/four-4-more-satellites-from-africa-before-the-end-of-2018/?fbclid=IwAR3TQXUHB6LamE2YLg-PL4uR7wNS42uLV1Xut_1L13_FK3aZWE0JgSMSfso (accessed November 13, 2018).

[8] Space in Africa, "Over $3 billion have been spent on space projects in Africa since 1998," *Africa Space News*, May 11, 2018, https://africanews.space/over-3-billion-have-been-spent-on-space-projects-in-africa-since-1998/ (accessed November 13, 2018).

[9] Christon Maganga and Christopher Luwanga, "How Investing in Space Could Help Malawi," *Africa Space News*, June 2, 2018, https://africanews.space/how-investing-in-space-could-help-malawi/ (accessed December 9, 2018).

[10] Algeria, Egypt, Kenya, Morocco, Nigeria, South Africa and Tunisia.

were included), with a number of other promising rising stars[11]. In this chapter, the capabilities of African states with regard to space-related infrastructure and national space activities will thus be investigated to complement these findings. This will be done via the framework of the Space Technology Ladder (STL) of Wood and Weigel[12] and Harding's[13] framework of emerging space actors (EMSAs), supplemented in places with concepts from the European Space Agency's Technology Readiness Levels[14] (TRL). These were all introduced in Chap. 1 (Sect. 1.3.2). A regional approach will be taken, based on the Regional Economic Communities (RECs) discussed in Chap. 1, and this will be coupled with the findings of Chap. 2 in relation to the emerging space middle powers to structure the discussion (in particular Table 2.13 of Chap. 2). The interlinked nature of the analysis is presented in Fig. 3.1, identifying African space growth poles (as called for by Nhamo in Chap. 1), with "every subcontinental region needing strong drivers of growth"[15]—including in the space arena. Once again, the need to embed space

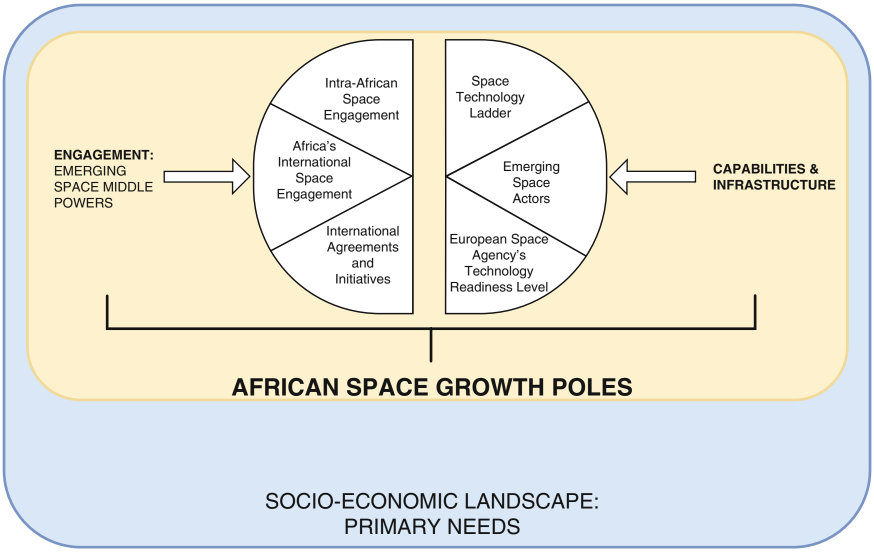


**Fig. 3.1** Identifying African space growth poles

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[11]Burkina Faso, Cameroon, Cote D'Ivoire, Ethiopia, Ghana, Guinea-Bissau, Libya, Mali, Mauritius, Namibia, Niger, Republic of Congo, Senegal, Seychelles, Sudan, Tanzania, Uganda, Zambia, and Zimbabwe, with a range of others also showing promise.

[12]Danielle Wood and Annalisa Weigel, "Charting the Evolution of Satellite Programs in Developing Countries – The Space Technology Ladder," *Space Policy*, 2012, no. 28.

[13]Robert C. Harding, *Space Policy in Developing Countries: The Search for Security and Development on the Final Frontier* (London: Routledge, 2013).

[14]European Space Agency, "Technology Readiness Level (TRL)," 2017, http://sci.esa.int/sci-ft/50124-technology-readiness-level/ (accessed July 8, 2018).

[15]Godwell Nhamo, "New Global Sustainable Development Agenda: A Focus on Africa," *Sustainable Development*, 2016: 1.

activities in the socio-economic landscape (and primary needs in particular) to meet the urgent needs of Africa is also emphasised.

The ultimate aim of this book is thus to present, at the end of this chapter, an overview of Africa's most notable space actors and space sector growth poles by combining the findings of this chapter with those of Chap. 2. As such, the structure of this chapter will be as follows—first, Wood and Weigel's STL will be used as a framework for analysing African space-related technological capabilities, including areas of national space agencies, satellites, and launch capability, as will the framework of Harding's emerging space actors. This will be approached regionally to provide a better picture of the nuances in the African space landscape. Second, since the STL does not include aspects of space budgets or scientific and research output in the space sector, these will be considered in the following section, alongside an overview of Africa's ground-based space infrastructure, such as in the astronomy field. Finally, the chapter, and the volume as a whole, will be concluded, laying the groundwork for the next volume considering aspects of space applications, policies, and African-European relations.

## 3.2 Application of the Space Technology Ladder

In this section, the Space Technology Ladder, developed by Wood and Weigel, will be used as a conceptual framework for the analysis of major space technology achievements in Africa. Before delving further into this framework, it is useful to consider the possible orbits that satellites can occupy around the Earth, in order to identify trends in African efforts, since these concepts are key to the Space Technology Ladder. Figure 3.2 depicts the main orbital zones of relevance, namely, low Earth orbit (LEO), medium Earth orbit (MEO), and geostationary and geosynchronous orbits (GEO). Satellites in LEO and MEO can vary in their orbits from equatorial to polar, with all possible inclinations in between. Equatorial orbits are usually favoured for observation of tropical weather patterns, and it is possible to monitor cloud conditions around the globe from this orbit.[16] In reality, many LEO satellites are in inclined orbits as an object's orbit generally reflects the latitude of the launch site, since orbital inclination changes are expensive to make in terms of fuel. For this reason, the International Space Station is in a 51.6-degree inclined orbit, since this is the "lowest inclination orbit into which the Russians can directly launch their Soyuz and Progress spacecraft".[17] Polar orbits are useful for mapping or surveillance since they can observe virtually every part of the Earth as the planet rotates underneath.[18] A special class of polar orbit is a sun-synchronous orbit, which

[16]Iasmania, "Types of Satellite Orbits: How satellites move in space," *Iasmania.com*, 2015, https://iasmania.com/types-of-satellite-orbits/ (accessed November 14, 2018).

[17]Patrick Donovan, "Mission Control Answers Your Questions," *National Aeronautics and Space Administration*, August 10, 2002, https://spaceflight.nasa.gov/feedback/expert/answer/mcc/sts-112/09_04_12_54_17.html (accessed November 14, 2018).

[18]Iasmania, "Types of Satellite Orbits."

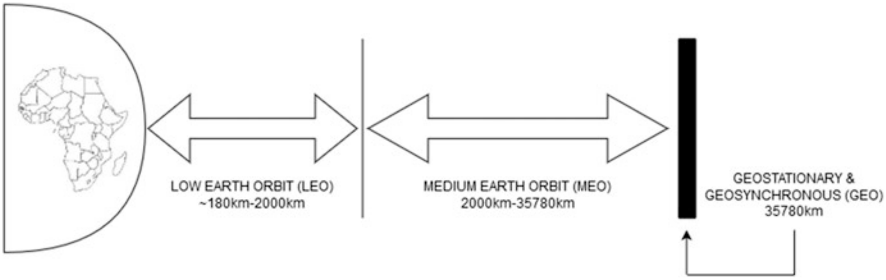


**Fig. 3.2** Orbital zones around the Earth (not to scale)

uses the Earth's nonspherical shape, and resultant gravity, to alter its path by about 1 degree per day (for 360 degrees, thus a full orbit of the Earth around the sun), meaning that a satellite maintains its angle to the sun and passes over a section of the Earth at the same time every day.[19] Highly elliptical orbits are also possible, as is the case of Russian Molniya satellites (after which a particular type of elliptical orbit was named).

Finally, geostationary orbit is a very specific type of equatorial orbit which is located at an altitude of 35,780 km above the surface of the Earth, in which satellites orbit at the same speed as the Earth's rotation, thus allowing them to appear motionless from the ground, occupying a fixed position in the sky.[20] This orbit is vital for communications and weather satellites, and their "footprint" constitutes the areas they cover. Geosynchronous orbits are very similar to geostationary orbits but are inclined, with satellites' angular velocity matching that of the Earth, again maintaining a nearly fixed position (although it will shift somewhat during the day it will return to the same position every 24 h), and are useful for covering areas of higher latitude on Earth.[21] GEO is thus considered to fall within the category of high Earth orbits (HEO). Beyond these, lunar and other orbits are possible, but not relevant to this study. Figure 3.3 illustrates some of the different orbits discussed.

To return to the Space Technology Ladder, its four categories, which are ranked to highlight increasing technical and managerial autonomy and complexity, are useful because "historically, they reflect the initial efforts of both developed and developing countries in space", and while African investments in space have been increasing, particularly in the last few years, the continent's efforts are predominantly in the initial phase of establishment. As was summarised in Chap. 1, these 4 categories contain 13 distinct actions, and while their levels of complexity and autonomy are not consistent *across* categories, they are *within* categories. For example, purchasing a geostationary satellite is less complex than building a satellite meant for low Earth orbit. Table 3.1 summarises these categories and their actions.

[19]Ibid.

[20]Ibid.

[21]Ibid.

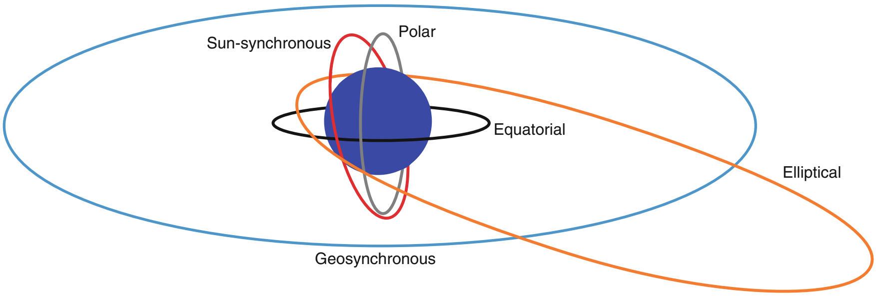


**Fig. 3.3** Types of orbits

**Table 3.1** The Space Technology Ladder (Wood and Weigel)

| | |
|---|---|
| 4. Launch capability | 13. Satellite to GEO |
| | 12. Satellite to LEO |
| 3. GEO satellite | 11. Build locally |
| | 10. Build through mutual international collaboration |
| | 9. Build locally with outside assistance |
| | 8. Procure |
| 2. LEO satellite | 7. Build locally |
| | 6. Build through mutual international collaboration |
| | 5. Build locally with outside assistance |
| | 4. Build with support in partner's facility |
| | 3. Procure with training services |
| 1. National space agency | 2. Establish current national space agency |
| | 1. Establish first government space office |

Wood and Weigel, "Charting the Evolution of Satellite Programs in Developing Countries," 17

As Wood and Weigel argue, the STL "provides a basis by which to compare the actual choices made by countries as they pursue new space technology", and it is possible to depict this through visual mapping in graph form.[22] This will be done here as well, depicting the first time a country achieves one of the milestones and thereby taking a "major step forward in their level of technical autonomy in the area of space or build new technological capability".[23] While the discussion here will highlight developments currently underway, each of the milestones will only be counted if the country in question has completed it, and thus new developments will, as Wood and Weigel suggest, be mapped to "future".

A discussion of the STL is not complete without noting the gaps in the framework. In this regard, six were noted in a study of Argentina's space activities by López, Pascuini, and Ramos.[24] First, the Space Technology Ladder does not account

[22]Wood and Weigel, "Charting the Evolution of Satellite Programs in Developing Countries," 18.

[23]Ibid., 17.

[24]Andrés López, Paulo Pascuinia, and Adrián Ramosa, "Climbing the Space Technology Ladder in the South: the case of Argentina," *Space Policy*, 2018.

for technical complexity within individual milestones—for instance, using more sophisticated technology or components to build a satellite as opposed to a small CubeSat—and it does not make a distinction for constellations.[25] However, since most of Africa's satellites tend to be smaller "entry-level" satellites, not part of massive constellations, this concern is reduced. Second, because the four different categories are based on different sets of scientific and technological abilities, there is no need for countries to follow any particular set of milestones. For instance, a country may skip establishing a national space agency in favour of launching a GEO satellite. Indeed, the purpose of the STL is not to depict a strict linear pathway all countries necessarily follow but, as stated, to show a general progression in complexity and autonomy, thus providing a basis for a comparative discussion of policy choices, being "very useful for analysing national trajectories in the space sector and as a way to bring together all the steps involved in mastering the technology cycle in the space industry".[26]

Moreover, the work by Al-Rumhi et al. provides an additional nuance to refine the STL framework and partially account for this.[27] They propose adding three categories or lenses through which to consider the STL: (i) High Space Technology Countries, namely, countries with space agencies; (ii) Medium Space Technology Countries, namely, countries with space involvement or capabilities, but no space agency; and (iii) Low Space Technology Countries, namely, countries with scarce or no space involvement or capabilities.[28] In this case, the factor of having a space agency represents a more concerted effort by the particular countries which have them to drive space efforts forward, to secure funding, be able to negotiate with similar agencies elsewhere, and develop a cadre of space experts domestically. This is an important consideration, and these categories will thus be applied alongside the STL, which does include a specific category for space agency, as a useful heuristic device.

Ercan and Kale also argue in their work on Turkey that it is necessary to add two more subcategories within Wood and Weigel's "National Space Agency" category, namely, Establish First Government Space Policy and Establish Space Infrastructure/Assembly, Integration, and Test (AIT) Centre, thus renaming this first category to "Establishing Space Policy, Agency and Infrastructure".[29] This is an excellent suggestion and will be taken up here as well, and thus aspects of both space and ground segments of space systems will be highlighted. Finally, Ercan and Kale propose modifying the category of GEO satellite to include MEO satellites as well

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[25]Ibid., 2.

[26]Ibid., 2.

[27]Ahmed Al-Rumhi, Bin Chen, Chee Wee Choo, et al., "Identifying and Developing Effective Applications of Space for Africa (IDEAS for Africa): Final Report," *IDEAS For Africa*, April 15, 2012, http://africa.isunet.edu/w/Final_Report_FINAL_OUTPUT#Title_Page (accessed November 15, 2018).

[28]Ibid., "Selection Methodology" section.

[29]Cihan Ercan and İzzet Kale, "Historical space steps of Turkey: It is high time to establish the Turkish space agency," *Acta Astronautica*, 2017, no. 130: 71–72.

since "their radiation environments are more similar to those of GEO's rather than LEO's".[30] This suggestion will thus also be adopted here.

The third gap noted by López, Pascuini, and Ramos is that the "build locally" milestone does not make allowance for nuances, such as certain parts being procured from abroad—important in the "current context of global fragmentation of technical and production capabilities".[31] One suggestion is to account for "integrating at least some locally produced key components and instruments".[32] This is captured to some extent by the modification proposed by Ercan and Kale, namely, the inclusion of AIT infrastructure. Fourth, the Space Technology Ladder does not include any aspects of national "capacity of building the ground stations" or other infrastructure.[33] This also includes other aspects such as national space-related research output, and thus, following this section utilising the STL, the next section will focus on factors such as research output, space budgets, astronomy, and other infrastructure.

Fifth, the milestone of "build through mutual international collaboration" is criticised for being very loosely defined since most projects "involve collaboration among different countries even in the developed world", and "collaboration also exists when a satellite completely designed and built in a certain country integrates into its payload instruments manufactured by a foreign country".[34] Moreover, López, Pascuini, and Ramos argue that ranking this milestone beneath "build locally" is problematic since "a country can manufacture a satellite integrating mostly imported components, while a mutual collaboration project may imply contributing with highly sophisticated technology developments to a bilateral project".[35] These points are not disputed here, but the original definition proffered by Wood and Weigel—stating that mutual collaboration "is used here to refer to collaboration projects in which the financial and technical contributions of each partner are similar"[36]—remains useful in the context of this study.

Finally, the sixth gap identified is that the STL does "not capture the emergence of a relatively new phenomenon in the space industry", namely:

> (i) The growing diffusion of small satellites: small satellites are more affordable but given their small size they can carry fewer instruments. However, technological advances (e.g. miniaturization) may help to bypass that restriction. Fractionated mission architectures are also a way to take advantage of small satellites working in networks/constellations; (ii) the introduction of new processes aimed at applying mass production techniques to manufacture spacecraft and launchers; (iii) the increasing use of advanced manufacturing technologies in the space industry; (iv) the expansion of electric propulsion satellites which, thanks to their lower weight, may embark more payload (e.g. more transponders in the case of telecommunication satellites).[37]

[30] Ibid.

[31] López, Pascuinia, and Ramosa, "Climbing the Space Technology Ladder in the South," 2.

[32] Ibid.

[33] Ibid., 3.

[34] Ibid.

[35] Ibid.

[36] Wood and Weigel, "Charting the Evolution of Satellite Programs in Developing Countries," 17.

[37] López, Pascuinia, and Ramosa, "Climbing the Space Technology Ladder in the South," 3.

For the purposes of this study, this concern is noted, but achievements in small satellites will still be considered as completing the relevant milestones. There is no question that Africa's achievements in space, even in small satellites, represent critical milestones in the continent's efforts to advance its aerospace industry, and thus affordability and size do not diminish these achievements—often great sources of national pride—or their importance for the people of Africa. A final point can be raised here regarding an omission in the STL not mentioned by López, Pascuini, and Ramos, namely, launching an astronaut into space. While no African country has done so, there are plans for this, and this achievement represents the ultimate expression of technical and managerial autonomy and complexity, and thus a category for this will be added under "launch capability"[38].

Having thus considered the concerns and debates around the STL, a modified version that includes 16 milestones is presented in Table 3.2.

At this point, a summary of Harding's model of emerging space actors (EMSAs)[39] is useful. This model provides very broad categories for organizing the capabilities of space actors and is thus useful to see which larger, structural shifts have taken place in the African space arena. Harding's first category of developed space actors (DVSAs) will be ignored here since it applies to developed states with a full range of capabilities, such as the United States, Russia, Japan, and the European Union. Within the EMSAs the first tier consists of the largest and most capable developing states, such as China, India, and Brazil. Thus, second- and third-tier subcategories are important here, and the goal is to identify whether any African states have moved from the third tier to the second tier or are about to do so. As stated in Chap. 1, the difference between these two subcategories is as follows (Harding identifies South Africa as the only second-tier African EMSA):

> The "second tier" states are those that produce some of their own space technology, have basic launch capacity (typically sounding rockets), have national space agencies, and frequently, out of necessity, collaborate with more advanced states' programs in the production of space technology. The "third tier" states occasionally make contributions in space-related technology, almost always purchase space-related technology from more advanced producers, and almost always collaborate with other more developed space actors to achieve their space policy goals. Rather than being space-faring, third tier space actors have made the policy decision to invest in space technology to accomplish what could not be done otherwise.[40]

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[38]The first African citizen in space ("Afronaut") was South African billionaire Mark Shuttleworth who, at own expense and in personal capacity, paid for a trip to the International Space Station in 2002 through Russian partnership. [First African in Space, "About the First African in Space Project," *Here Be Dragons*, http://www.africaninspace.com/ (accessed November 15, 2018).] Mike Melvill, born in South Africa and test pilot of SpaceShipOne, also crossed over into space above the 100 km altitude line, thus technically becoming an astronaut but was doing so in capacity of US citizen at the time [Dave Hirschman, "The Unlikeliest Astronaut: Mike Melvill's journey into space," *Aircraft Owners and Pilots Association*, June 5, 2013, https://www.aopa.org/news-and-media/all-news/2013/june/pilot/the-unlikeliest-astronaut (accessed November 15, 2018).]

[39]Robert C. Harding, *Space Policy in Developing Countries: The Search for Security and Development on the Final Frontier* (London: Routledge, 2013), 250.

[40]Ibid., 79.

**Table 3.2** Modified space technology ladder

| | |
|---|---|
| 4. Launch capability | 16. Astronaut to space |
| | 15. Satellite to GEO |
| | 14. Satellite to LEO |
| 3. MEO/GEO satellite | 13. Build locally |
| | 12. Build through mutual international collaboration |
| | 11. Build locally with outside assistance |
| | 10. Procure |
| 2. LEO satellite | 9. Build locally |
| | 8. Build through mutual international collaboration |
| | 7. Build locally with outside assistance |
| | 6. Build with support in partner's facility |
| | 5. Procure with training services |
| 1. Establishing space policy, agency, and infrastructure | 4. Establish space AIT centre/space industry |
| | 3. Establish current national space agency [critical factor for High/Medium/Low Space Technology Countries] |
| | 2. Establish first government space office |
| | 1. Establish first government space policy |

Thus, the emphasis is on the development of national space technology (much like Ercan and Kale argued in terms of including AIT infrastructure in the STL) and on possessing at least basic sounding rockets.

In agreement with Al-Rumhi et al., "[i]n the Low (or non-existing) Space Technology category, there are no benefits from applying a technology framework to countries which hardly produce spaceborne technology", and thus countries that are not very active in space in terms of the STL will be excluded from the discussion in this chapter. The following sections will follow the structure of the RECs as discussed in Chap. 1, starting with the Arab Maghreb Union, and will use the findings of African emerging space middle powers as structure, thus beginning with the most prominent space actors in each region. Where countries are members of more than one REC, the relevant analysis will be presented at the first appearance and then noted in subsequent RECS.

### *3.2.1 Arab Maghreb Union (UMA)*

While the UMA has only five members, three were featured prominently in the discussion in Chap. 2 and were subsequently identified as emerging space middle powers. The discussion will thus begin with them.

*Algeria* arguably established its first space office in 1987, "with the creation of the National Centre for Space Technology (Centre National des Techniques Spatiales—CNTS), the result of a merger between the National School of Geodetic Sciences (Ministry of Defence) and the Laboratory for Space Studies of Radiation (High

Commissioner for Research)".[41] The Algerian Space Agency (ASAL) (L'Agence Spatiale Algérienne) was established in 2002 following a presidential decree, incorporating the CNTS.[42] The country's first satellite, AlSat-1, was launched the same year and was designed and constructed by Surrey Satellite Technology Ltd (SSTL) as part of a "wider international collaboration to launch the first constellation of Earth observation satellites specifically designed for disaster monitoring".[43] As such, AlSat-1 was the first satellite in the Disaster Monitoring Constellation (DMC) led by SSTL.

However, rather than just having the satellite built by SSTL, Algerian personnel from the Centre National des Techniques Spatiales (CNTS) were involved, and training for 11 Algerian scientists and engineers was included.[44] SSTL also installed a mission control ground station in Algeria at the CNTS. Weighing 90 kg and placed in a sun-synchronous orbit by Russia[45], AlSat-1 had specifications including "specially-designed Earth imaging cameras which provide 32-m resolution imaging in 3 spectral bands (NIR, red, green) with an extremely wide imaging swath of 600 km on the ground that enables a revisit of the same area anywhere in the world at least every 4 days with just a single satellite"[46]. Since AlSat-1, five further Algerian satellites have been placed in sun-synchronous orbits, as detailed in Table 3.3, with one—AlComSat-1—built and launched by China in 2017, being placed in geosynchronous orbit.[47]

Algeria's space policy, known as the Programme Spatial National (PSN) Horizon 2020, was adopted by the government in 2006 and runs until 2020.[48] The three strategic targets include industrial capacity development, satisfaction of national needs, and mastery of knowledge and know-how. Under the PSN Application Action Program, 86 projects were selected, involving "the use of satellite remote sensing, satellite tracking (GPS, GLONASS, GALILEO in perspective), space telecommunication services, and Geographic Information Systems (GIS), offering to the different national sectors powerful tools for decision support".[49] In December

[41]GlobalSecurity.org, "Algerian Space Agency (ASAL)," July 27, 2016, https://www.globalsecurity.org/space/world/algeria/agency.htm (accessed November 17, 2018).

[42]Agence Spatiale Algérienne, "Mission," 2009, http://www.asal.dz/mission.php (accessed November 16, 2018)

[43]Gunter Dirk Krebs, "AlSat 1," *Gunter's Space Page*, June 22, 2018, https://space.skyrocket.de/doc_sdat/alsat-1.htm (accessed November 16, 2018).

[44]Ibid.

[45]Observing Systems Capability Analysis and Review Tool (OSCAR), "AlSat-1," *World Meteorological Organisation*, July 27, 2015, https://www.wmo-sat.info/oscar/satellites/view/8 (accessed November 16, 2018).

[46]Krebs, "AlSat 1."

[47]Aerospace Technology, "Alcomsat-1 Communications Satellite," *Verdict Media Limited*, 2018, https://www.aerospace-technology.com/projects/alcomsat-1-communications-satellite/ (accessed November 16, 2018).

[48]Agence Spatiale Algérienne, "Programme spatial national (PSN)," 2015, http://www.asal.dz/psn.php (accessed November 16, 2018).

[49]Ibid. Translated from French.

**Table 3.3** Algerian satellites

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| AlSat-1[a,b] | 2002 | Sun-synchronous | • Earth imaging cameras—32 m resolution imaging in three spectral bands (NIR, red, green) with an imaging swath of 600 km<br>• Launch site: Plesetsk Cosmodrome, Russia | • Designed and constructed by SSTL in a collaborative programme with the Algerian Centre National des Techniques Spatiales (CNTS)<br>• Data openly available through the DMC agreement<br>• Key areas: Earth observation for disaster monitoring, capacity building |
| AlSat-2A[c,d,e] | 2010 | Sun-synchronous | • "Equipped with NAOMI (New AstroSat Optical Modular Instrument), a latest-generation payload capable of supplying images with a resolution of 2.5 m in panchromatic mode and 10 m in each of 4 colour bands in multispectral mode"<br>• "Acquires high resolution images with a repeatability of 3 days and a field of observation of 17.5 km"<br>• Launch site: Satish Dhawan Space Centre (SDSC), India | • In February 2006, EADS Astrium signed a contract with the Algerian National Space Technology Centre (CNTS) for the development of the AlSat-2 system<br>• AlSat-2A was integrated and tested in France at EADS Astrium<br>• CTNS responsible for managing the AlSat-2 programme and operating the satellite system<br>• Data acquired at the Arzew station complex in western Algeria (Oran region), where imagery is analysed and from where spacecraft is controlled<br>• Key areas: Earth observation (cartography, management of agriculture, forestry, water, mineral and oil resources, crop protection, management of natural disasters, and land planning) |
| AlSat-1B[f,g,h] | 2016 | Sun-synchronous | • Based on the SSTL-100 platform, hosting a 24 m multispectral imager and a 12 m panchromatic imager | • Built jointly by the Algerian Space Agency (ASAL) and Surrey Satellite Technology Ltd (SSTL) |

(continued)

**Table 3.3** (continued)

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| | | | • "Time to revisit within 7 days of any point of National territory"<br>• Launch site: Satish Dhawan Space Centre (SDSC), India | • "Eighteen ASAL engineers will undertake the Assembly, Integration and Test phase of the satellite in Algeria, offering further opportunities for the transfer of skills and the development of local capabilities. Eighteen Algerian students will also study for Higher Degrees at the University of Surrey based in Guildford"<br>• "Ground segment is located at the Satellite Development Centre in Oran with a primary and a redundant chain composed of: (1) GCS: Ground Control Segment (SOC), (2) GIS: Ground Imaging Segment (MOC), (3) GS: Ground Station"<br>• Data openly available through the DMC agreement<br>• Key areas: main mission—land observation for disaster monitoring, capacity building |
| AlSat-2B[i,j] | 2016 | Sun-synchronous | • "Equipped with NAOMI (New AstroSat Optical Modular Instrument), a latest-generation payload capable of supplying images with a resolution of 2.5 m in panchromatic mode and 10 m in each of 4 colour bands in multispectral mode"<br>• Launch site: Satish Dhawan Space Centre (SDSC), India | • Designed and developed by EADS Astrium<br>• Integrated in Algeria within the small satellite development centre (UDPS) in Oran<br>• CNTS responsible for managing the AlSat-2 programme and operating the satellite system<br>• "AlSat-2A and AlSat-2B form a mini-constellation offering high- |

(continued)

**Table 3.3** (continued)

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| | | | | resolution images, with greater responsiveness in programming and a much higher volume of images taken daily (in monoscopic and stereoscopic mode). The images collected are used, among other things, in the areas of urban and agricultural planning and development of the territories and coastline, the mapping and monitoring of infrastructures and structures, the establishment and updating of steppe and Saharan cadastre and the prevention and management of natural hazards (floods, forest fires, . . .)"<br>• Key areas: Earth observation (wide variety of applications: cartography, management of agriculture, forestry, water, mineral and oil resources, crop protection, management of natural disasters, and land planning), capacity building |
| AlSat-1N (Nano)[k,l] | 2016 | Sun-synchronous | • 3U CubeSat<br>• Launch site: Satish Dhawan Space Centre, India | • Delivered by the SSC (Surrey Space Centre) of the University of Surrey, funded and steered by the UKSA (UK Space Agency)<br>• "Jointly developed by the Algerian Space Agency ASAL and the UK Space Agency"<br>• "Involves a number of Algerian graduate students hosted at |

(continued)

**Table 3.3** (continued)

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| | | | | SSC and focused on the development and operation of a nanosatellite as a hands-on learning exercise for the students and ASAL staff, to demonstrate the practical implementation of this type of low cost space technology. Graduate students are enrolled on courses related to key areas of satellite technology. Additional focused training programs were delivered to ASAL staff in the areas definition, implementation and testing of a full nanosatellite"<br>• Key areas: capacity building, collaboration |
| AlComSat-1[m] | 2017 | Geosynchronous | • Communications satellite<br>• "Total of 33 transponders, including 19 Ku-band, 12 Ka-band, and two L-band transponders"<br>• "X-band, UHF and EHF transponders as well as two transmission and three receiver antennas"<br>• Launch site: Xichang Satellite Launch Center in Sichuan province, China | • Built by China Academy of Space Technology (CAST) under a subcontract with China Great Wall Industry Corporation (CGWIC)<br>• "The contract also covers the supply of two ground control stations for use by the ASAL to control the satellite"<br>• "Services, including telecommunications, broadband internet, audio transmission, broadcast and television, satellite-based navigation, remote education, as well as enterprise and emergency communications"<br>• "Nine of the 19 Ku-band transponders are used to broadcast TV and |

(continued)

**Table 3.3** (continued)

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| | | | | digital radio channels, while the remaining are used to provide communications in North African regions, including Tunisia, Northern Chad, and Northern Sudan at speeds of 2 Mbps"<br>• "The Ka-band transponders are used to deliver high-speed broadband internet to the Algerian territory at speeds of 20 Mbps"<br>• Key areas: communication |

[a]Surrey Satellite Technology US LLC, "AlSat-1," 2018, http://www.sst-us.com/missions/alsat-1%2D%2Dlaunched-2002/alsat-1/alsat-1%2D%2Dthe-mission (accessed November 16, 2018)
[b]Observing Systems Capability Analysis and Review Tool (OSCAR), "Satellite: AlSat-1," *World Meteorological Organisation*, July 27, 2015, https://www.wmo-sat.info/oscar/satellites/view/8 (accessed November 17, 2018)
[c]Gunter Dirk Krebs, "AlSat 2A, 2B," *Gunter's Space Page*, December 11, 2017, https://space.skyrocket.de/doc_sdat/alsat-2.htm (accessed November 17, 2018)
[d]eoPortal Directory, "AlSat-2 (Algeria Satellite-2)," European Space Agency, 2018, https://directory.eoportal.org/web/eoportal/satellite-missions/a/aisat (accessed November 17, 2018)
[e]Agence Spatiale Algérienne, "Alsat-2A, deuxième satellite d'observation de la terre," 2015, http://www.asal.dz/Alsat-2A.php (accessed November 17, 2018)
[f]Gunter Dirk Krebs, "AlSat 1B," *Gunter's Space Page*, December 11, 2017, https://space.skyrocket.de/doc_sdat/alsat-1b.htm (accessed November 17, 2018)
[g]Observing Systems Capability Analysis and Review Tool (OSCAR), "Satellite: AlSat-1B," *World Meteorological Organisation*, August 3, 2017, https://www.wmo-sat.info/oscar/satellites/view/708 (accessed November 17, 2018)
[h]Agence Spatiale Algérienne, "ALSAT-1B, le quatrième satellite d'observation de la terre," 2015, http://www.asal.dz/Alsat-1B.php (accessed November 17, 2018)
[i]Gunter Dirk Krebs, "AlSat 2A, 2B"
[j]Agence Spatiale Algérienne, "Le satellite Alsat-2B, troisième satellite d'observation de la terre," 2015, http://www.asal.dz/Alsat-2B.php (accessed November 17, 2018)
[k]eoPortal Directory, "AlSat Nano/AlSat-1N," *European Space Agency*, 2018, https://directory.eoportal.org/web/eoportal/satellite-missions/a/alsat-nano (accessed November 16, 2018)
[l]Gunter Dirk Krebs, "AlSat-Nano (AlSat 1N)," *Gunter's Space Page*, December 11, 2017, https://space.skyrocket.de/doc_sdat/alsat-nano.htm (accessed November 17, 2018)
[m]Aerospace Technology, "Alcomsat-1 Communications Satellite"

2017, ASAL announced Algeria's 2020–2040 space programme, which is currently "under study" but includes plans to "send several state-of-the-art satellites" into space.[50] As Table 3.3 depicts, there has been a progression in Algeria's capabilities, with AlSat-1B being integrated and tested in Algeria and with Algeria operating the satellites from its own territory. The CDS (Centre for Satellite Design) was inaugurated by President Bouteflika in 2012, in Oran, and hosts "modern infrastructures (workshops and laboratories) dedicated to the design, assembly of satellites as well as means of testing and environmental testing".[51] Alongside CDS, ASAL operates three units, namely, the Space Technology Centre (STC), the Space Applications Centre (SAC), and the Telecommunication Systems Operating Centre (CEST).

Based on Al-Rumhi et al., Algeria thus qualifies as a High Space Technology Country. While two launch facilities exist within Algeria (built during colonial times by the French)—namely, a sounding rocket launch site in Béchar and Reggane[52] and a full rocket launch site in Hammaguir[53]—Algeria does not appear to be actively developing launch capacity, even of sounding rockets. Nevertheless, because the country is such an active player in space, possesses a growing space technology sector, has a well-developed national space agency, and collaborates with more advanced states as well as other African states (as seen in Chap. 2), on balance it qualifies as a second-tier EMSA.

*Morocco's* Royal Centre for Remote Sensing (CRTS), established in 1989, is the "national institution responsible for the promotion, use and development of remote sensing applications in Morocco" and is responsible for the "acquisition, archiving and dissemination of data and images, the observation of the Earth, the realization of projects and the development of methodologies in Remote Sensing and Geographic Information Systems and related fields" as well as providing training and collaboration with foreign institutions and partners.[54] Three Moroccan satellites have been placed in orbit. The first was launched in 2001, named Maroc-Tubsat (Zarkae Al Yamama), in cooperation between the CRTS and the German *Institute für Luft- und Raumfahrttechnik* of the Technical University of Berlin (TUB).[55] Maroc-TUBSAT was thus one of a series of TUBSATs launched over the years, and the University of

[50] Algeria Press Service, "Several Algerian satellites to be launched under space programme 2020–2040," December 18, 2017, http://www.aps.dz/en/health-science-technology/21871-several-algerian-satellites-to-be-launched-under-space-programme-2020-2040 (accessed November 16, 2018).

[51] Agence Spatiale Algérienne, "Son excellence le Président de la République Abdelaziz Bouteflika inaugure le Centre de Développement des Satellites (CDS)," http://www.asal.dz/inauguration-CDS.php (accessed November 17, 2018).

[52] Mark Wade, "Reganne," *Astronautix*, 2017, http://www.astronautix.com/r/reggane.html (accessed November 20, 2018).

[53] Luncedo Ngcofe and Keith Gottschalk, "The growth of space science in African countries for Earth observation in the twenty-first century," *South African Journal of Science* 109, no. 1/2 (2013): 4.

[54] Centre Royal de Télédétection Spatiale, "The CRTS," "Qui Sommes Nous," 2018, https://www.crts.gov.ma/Royal%20Centre%20for%20Remote%20Sensing and https://www.crts.gov.ma/le-crts/qui-sommes-nous (accessed November 17, 2018). Translated from French.

[55] eoPortal Directory, "TUBSAT (Technical University of Berlin Satellite) Program," *European Space Agency*, 2018, https://directory.eoportal.org/web/eoportal/satellite-missions/t/tubsat (accessed November 17, 2018).

Berlin's project is described as an "educational program including the design, manufacture, testing, launching and operation of 'microsatellites' (<100 kg)".[56] Maroc-TUBSAT's satellite bus was provided by the German partner, while the payload and launch were the responsibility of Morocco. Launched from Russia and with spacecraft operations controlled from TUB and CRTS (with ground stations at TUB and at CRTS), Maroc-TUBSAT focused on Earth observations.

Mohammed VI A is the second Moroccan satellite in orbit and was built by Astrium Satellites and Thales Alenia Space of France as a "high-resolution optical reconnaissance system".[57] As the first of a pair of satellites, it is "used for mapping and land surveying activities, regional development, agricultural monitoring, the prevention and management of natural disasters, monitoring changes in the environment and desertification, as well as border and coastal surveillance".[58] It was reported that "Moroccan security forces will use the satellites to help combat insurgent militants in the Sahel, such as al-Qaeda in the Islamic Maghreb, piracy in the Gulf of Guinea, and for border enforcement".[59] Mohammed VI B was launched in November 2018.[60] These surveillance satellites present "considerable and unprecedented advances to Morocco in its deep-rooted regional rivalry with Algiers".[61] It is however reported that civilian benefits also accrue since "space imagery operated from Morocco is playing a key role in the implementation of national strategies for the socio-economic development of the country especially on those relating to the agricultural sector—an important part of the Moroccan economy".[62] Overall, Morocco's space industry appears to be in the nascent stage, and since it does not have a national space agency (only a remote sensing-focused space office in the form of the CRTS) or active launch capacity, it qualifies as a Medium Space Technology Country and third-tier EMSA (Table 3.4). While the two Mohammed IV satellites are designed to be a dual civil/military system, Morocco's space efforts appear to be heavily focused on military aspects, and it is reported that:

[56] Ibid.

[57] Gunter Dirk Krebs, "Mohammed VI A, B (MN35-13)," *Gunter's Space Page*, December 11, 2017, https://space.skyrocket.de/doc_sdat/mohammed-6.htm (accessed November 20, 2018).

[58] Ibid.

[59] Stephen Clark, "Morocco's first high-resolution surveillance satellite launched aboard Vega rocket," *Spaceflight Now/Pole Star Publications Ltd*, November 8, 2017, https://spaceflightnow.com/2017/11/08/moroccos-first-high-resolution-surveillance-satellite-launched-aboard-vega-rocket/ (accessed November 20, 2018).

[60] Chris Bergin, "Arianespace's Vega rocket conducts Mohammed VI-B launch," *NASAspaceflight.com*, November 20, 2018, https://www.nasaspaceflight.com/2018/11/arianespace-vega-mohammed-vi-b-launch/ (accessed December 13, 2018).

[61] Space in Africa, "Morocco's Satellite Mohammed VI-A is Changing North African Regional Power Balance," *Africa Space News*, May 10, 2018, https://africanews.space/moroccos-satellite-mohammed-vi-a-is-changing-north-african-regional-power-balance/ (accessed November 20. 2018).

[62] Space in Africa, "Overview of the Morocco Space Industry," *Africa Space News*, May 6, 2018, https://africanews.space/overview-of-the-morocco-space-industry/ (accessed November 20, 2018).

**Table 3.4** Moroccan satellites

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| Maroc-TUBSAT (Zarkae Al Yamama)[a] | 2001 | Sun-synchronous | • Microsatellite<br>• "EIC (Earth Imaging Camera), developed at RAL (Rutherford Appleton Laboratory), UK [same camera design as flown on BADR-B of SUPARCO (Pakistan Space and Upper Atmosphere Research Commission)]. The instrument optics have a focal length of 72 mm with *f*/6 number. Observations are performed in the visible/near-infrared range. A filter is used for the near-infrared range. The FOV is $\pm 8.5°$ $\times \pm 8°$, providing an image size of about 190 km $\times$ 144 km at a resolution of 250 m"<br>• Launch site: Baikonur Cosmodrome | • Joint venture, the Moroccan side is responsible for the development of the payload and launch of the satellite, while the German side provides the satellite bus<br>• "Objectives of the mission are in earth remote sensing (in particular with regard to vegetation detection at medium-scale resolutions), and in the field of store-and-forward communications for mobile localization. A further goal is to develop attitude control strategies for high-resolution Earth observations"<br>• Key areas: Earth observation, capacity building |
| Mohammed VI A (MN35-13)[b,c] | 2017 | Sun-synchronous | • "Instrument description not yet available. It should be similar to the High-Resolution Imager (HiRI) of the Pléiades satellites, i.e. VNIR channel with resolution around 0.7 m (panchromatic) and 2.8 m (multispectral)"<br>• "Can capture over 500 images on a daily basis and update its data every 6 h"<br>• Launch site: Kourou, French Guiana | • "Although the satellite project received sizable support from France in its early phases, the satellite has been totally monitored by more than 100 Moroccan national engineers since its launch in November 2017. The specialist further explained that these top-performing engineers studied at two of the country's best information and documentation agencies and received '3 years of solid training in total discretion'"<br>• Substantial contribution to disaster monitoring<br>• Key areas: high-resolution land observation, capacity building |

(continued)

**Table 3.4** (continued)

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| Mohammed VI B (MN35-13)[d,e] | 2018 | Sun-synchronous | • "Instrument description not yet available. It should be similar to the High-Resolution Imager (HiRI) of the Pléiades satellites, i.e. VNIR channel with resolution around 0.7 m (panchromatic) and 2.8 m (multi-spectral)"<br>• "Capable of taking up to 1000 images per day with a resolution of up to 70 cm and will be circulating in the same orbit as the first satellite, 620 km above the earth"<br>• Will weigh about 1108 kg at launch<br>• Launch site: Kourou, French Guiana | • Second flight model of the Mohammed VI programme<br>• Substantial contribution to disaster monitoring<br>• Key areas: high-resolution land observation, capacity building |

[a]eoPortal Directory, "TUBSAT (Technical University of Berlin Satellite) Program"
[b]Observing Systems Capability Analysis and Review Tool (OSCAR), "Satellite: Mohammed VI-A," *World Meteorological Organisation*, February 22, 2018, https://www.wmo-sat.info/oscar/satellites/view/736 (accessed November 20, 2018)
[c]Space in Africa, "Morocco's Satellite Mohammed VI-A is Changing North African Regional Power Balance"
[d]Observing Systems Capability Analysis and Review Tool (OSCAR), "Satellite: Mohammed VI-B," *World Meteorological Organisation*, November 9, 2018, https://www.wmo-sat.info/oscar/satellites/view/737 (accessed November 20, 2018)
[e]Ahlam Ben Saga, "First Photos of Mohammed VI-B Satellite Installation Emerge Before Launch," *Morocco World News*, November 19, 2018, https://www.moroccoworldnews.com/2018/11/258154/photos-mohammed-vi-b-satellite-installation/ (accessed November 20, 2018)

> Morocco's first spy satellite fuels regional tension and regional space race with neighbouring Algeria and Spain. The satellite system allows Morocco to obtain detailed information on military installations and troop movements in Spain and Algeria, as well as spy on the Western Sahara separatist group Polisario Front, with which Morocco maintains a precarious ceasefire.[63]

*Tunisia*'s national space sector is in its fledgling stages, although the country did create the Tunisian National Commission for Outer Space Affairs (NCOSA) in 1984 and followed this up with the establishment of the National Centre for Cartography and Remote Sensing of Tunisia (Centre National de la Cartographie et de la Télédétection) in 1988.[64] The CNCT "is a non-administrative public enterprise

[63]Shaul Shay, "Morocco Seeks Space Edge over Algeria and Spain," *Israel Defense*, February 7, 2018, https://www.israeldefense.co.il/en/node/32980 (accessed November 20, 2018).
[64]Space in Africa, "Overview of the Tunisian Space Industry," *Africa Space News*, April 19, 2018, https://africanews.space/overview-of-the-tunisian-space-industry/ (accessed November 20, 2018).

under the supervision of the Ministry of National Defense, responsible for promoting remote sensing, research and training in its fields", and its mission was expanded in 2004 to "cover the areas of cartography, geodesy, topography and photogrammetry and gravimetry".[65] The centre's other missions include "multi-scale cartographic production, aerial photography activities, validation of GIS specifications, and technical control of GIS products".[66] In March 2018, a conference was held on the topic "Towards a Tunisian National Space Strategy" and was coordinated by the Ministry of Higher Education and Scientific Research.[67]

While Tunisia possesses no satellite at present, it was reported that "Brigadier Zuhair Al-Jandali hinted that the Centre is currently in the process of joining the National Committee for Outer Space [Tunisian National Commission for Outer Space Affairs (NCOSA)] on the completion of a satellite for Tunisia; emphasizing that the new satellite will be focused on socio-economic areas, especially communications".[68] It has also been reported that "[w]ork is currently ongoing on the development of the first Tunisian Satellite, the result of cooperation with Japanese and French companies", with this satellite named Challenge-1 to be launched by 2020.[69]

Tunisia's space technology growth and expansion has been described as "deliberate and intentional",[70] and the country is active in a variety of collaborative projects, such as "cooperation with fellow Maghreb states to establish a communication network that was envisioned to utilize satellite communication and data-sharing to further develop the region's educational system"[71] in 2001 and is "playing a significant role in launching of the ArabSat satellite enjoying the lattice space telecommunications".[72] Nevertheless, recent developments suggest Tunisia's space sector is set to expand rapidly, with "a company named Sfax Technopole [having] signed a partnership deal with Telnet and Aerospace Valley Toulouse [in 2017] with the aim of making the Sfax Technopole a centre of space, courtesy of the partnership between the Telnet Group and the European leader Airbus Safran Launchers".[73] This is reported to be the "first major private space investment" in the country and has led to the initiation of the development of Tunisia's first satellite.[74] There are also

[65]Centre National de la Cartographie et de la Télédétection, "Présentation," 2014, http://www.cnct.defense.tn/index.php/fr/site-map/presentation (accessed November 20, 2018). Translated from French.

[66]Ibid.

[67]Space in Africa, "Overview of the Tunisian Space Industry."

[68]Ibid.

[69]Space in Africa, "Is Tunisia the next space giant from Africa?," *Africa Space News*, December 11, 2018, https://africanews.space/is-tunisia-the-next-space-giant-from-africa/ (accessed December 12, 2018).

[70]Space in Africa, "Towards a Tunisian National Space Strategy," *Africa Space News*, March 22, 2018, https://africanews.space/towards-a-tunisian-national-space-strategy/ (accessed November 20, 2018).

[71]Ibid.

[72]Ibid.

[73]Space in Africa, "Is Tunisia the next space giant from Africa?."

[74]Ibid.

**Table 3.5** Tunisian satellite

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| Challenge-1 | Future 2020? | | • Centre National de la Cartographie et de la Télédétection and the Tunisian National Commission for Outer Space Affairs satellite collaboration?<br>• Sfax Technopole/Telnet/Airbus Safran Launchers collaboration? | • Key areas: socio-economic areas, especially communications |

indications that the development of a new "assembly, integration and microsatellite testing facility and the implementation of an engineering centre for microsatellites" is included in the Sfax Technopole project.[75] The engineering centre is set to have three main missions, namely, engineering and satellite design, research and patents in the field of space, and the development of innovative services in space.[76]

Accordingly, Tunisia can be classified as an emerging second-tier EMSA and Medium Space Technology Country. Although Tunisia has a "movement for the official establishment of the Tunisian Space Agency"[77], the organisation has not yet succeeded the CNCT, and this remains "a scientific association in Tunisia created in June 2012 to promote aerospace field in Tunisia"[78]. Such a development would make Tunisia a High Space Technology Country. At present, its upward trajectory appears strong (Table 3.5).

The *Libyan* Centre for Remote Sensing and Space Sciences is "a governmental research organization specialized in remote sensing, space, seismology, and astronomy research, headquartered in Tripoli and with branches in different regions of Libya". It was founded in 1989[79] as a response to "demands of the Libyan society in achieving sustainable development using modern technologies". Accordingly, it acts as a "specialized reference and advisory body at the local, regional and international levels, enabling it to play a pivotal role in comprehensive development programs".[80] The centre operates three scientific programmes, namely, in the fields of remote sensing science, seismology, astronomy and observatories, and maintains the following priorities:

- Build specialised capacities and enable them to contribute to sustainable development programmes through the transfer and resettlement of space technologies in Libya.

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75Ibid.

76Ibid.

77Space in Africa, "List of Space Agencies in Africa," *Africa Space News*, June 22, 2018, https://africanews.space/list-of-space-agencies-in-africa/ (accessed November 20, 2018).

78Tunisian Space Agency, "Association," http://tunispacedays.com/association/ (accessed November 20, 2018).

79Libyan Center for Remote Sensing and Space Sciences, "About the Center," 2008, http://www.lcrsss.ly/about-center.html (accessed November 20, 2018). Translated from Arabic.

80Ibid.

- Preparation of research and scientific plans and follow-up implementation and provide scientific advice in the areas of specialisation.
- Cooperation with the corresponding research centres and specialised international organisations and federations.
- Preparation and participation in awareness programmes and organisation of seminars and scientific conferences and workshops in the fields of specialisation.[81]

Despite the activities of the centre, Libya's space activities are at an early phase of development and have no doubt been harmed by the political turmoil of recent years. In the past, the West German *Orbital Transport und Raketen Aktiengesellschaft* (OTRAG) operated in Libya between 1979 and 1983 (after leaving the then Zaire).[82] OTRAG was the world's first commercial launcher development, production, and launch company, founded in the mid-1970s by Lutz Kayser to "develop a low-cost satellite launcher using clusters of mass-produced pressure-fed liquid propellant modules".[83,84] OTRAG's activities were, however, mired in controversy, including claims "that the company was using its ostensibly peaceful rocket program to mask efforts to sell military technology, including short-range military rockets, to Libya, Pakistan, Iraq, and other countries".[85] OTRAG Libyan suborbital test launches took place at the sounding rocket launch site in Tawiwa, but in 1983:

> the Libyan Government unlawfully confiscated all of OTRAG's rocket manufacturing and test equipment in the country (as it had done earlier with petroleum production facilities of Western companies). All of Kayser's attempts to obtain return of the property or to receive damages were unsuccessful (despite personal promises by Gaddafi to settle the matter lawfully). Without Kayser's know-how the Libyans were able to conduct only a few test launches with the stolen equipment. After ten years of desultory testing the Libyan program came to an end. The Libyans were apparently unsuccessful because the essential know-how and blueprints were retained by Kayser.[86]

Libya maintains no rocket launch capability, and without a space agency, the country can be classified as a Low Space Technology Country and due to its nascent space industry a third-tier EMSA.

Figure 3.4 depicts the STL milestones achieved by Arab Maghreb Union member states (Mauritania does not feature as it has not achieved a milestone yet). Based on this figure, the clear leader is Algeria with a succession of milestones, particularly visible after the adoption of the Horizon 2020 policy in 2006. As such, the country achieved three milestones in 2016 with its three satellites launched that year.

[81]Ibid.

[82]Mark Wade, "OTRAG," *Astronautix*, 2017, http://www.astronautix.com/o/otrag.html (accessed November 21, 2018).

[83]Ibid.

[84]Judith Miller, "West German Rocket Company pulls out of Libya," *New York Times*, December 27, 1981, https://www.nytimes.com/1981/12/27/world/west-german-rocket-company-pulls-out-of-libya.html (accessed November 21, 2018).

[85]Ibid.

[86]Mark Wade, "OTRAG."

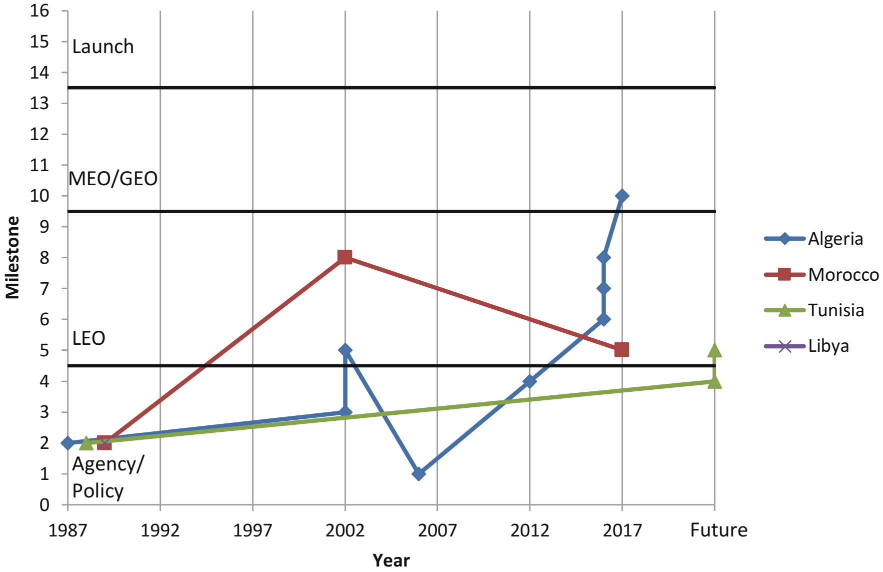


**Fig. 3.4** Milestone timeline—Arab Maghreb Union

### *3.2.2 The Common Market for Eastern and Southern Africa (COMESA)*

While Tunisia and Libya are members of COMESA, they will not be discussed again here. Two emerging space middle powers were identified in this REC (apart from Tunisia), namely, Kenya and Egypt. This discussion will thus start with them.

*Kenya* is a rapidly rising space actor and has been making strides in recent years. As mentioned in the previous chapter, Kenya is the site of the Italian-owned Luigi Broglio Space Centre, from which several orbital and suborbital launches have taken place. However, Kenya's own space efforts are more recent, although the country established its National Space Secretariat under the Ministry of Defence in 1993.[87] The "National Space Secretariat, under the Chairmanship of the Principal Secretary, coordinate[d] all space related activities in the Country" with the goal "to promote and enhance social and economic development through the utilization of space technology".[88] The Kenyan Space Agency, also falling under the Minister of Defence,

[87]National Commission for Science, Technology and Innovation, "Achievements," 2018, https://webcache.googleusercontent.com/search?q=cache:gyryD9XU2fwJ:https://www.nacosti.go.ke/component/content/article%3Fid%3D85:achievements%26start%3D2+&cd=1&hl=en&ct=clnk&gl=za (accessed November 22, 2018).

[88]Ministry of Defence – Kenya, "National Space Secretariat," http://www.mod.go.ke/?p=1932 (accessed November 22, 2018).

was founded in 2017.[89] The agency's responsibilities include "co-ordinating space-related activities, recommending national space policies and establishing centres of excellence in space science".[90] The board of the agency was appointed in 2018 and includes "principal secretaries for State Ministries and Departments, these are; Defence, National Treasury, University Education and Research, Environment and Forestry, Information, Communications and Technology".[91] Apart from the law establishing the Kenyan Space Agency (The Kenya Space Agency Order, 2017)[92], the country also issued the Kenya Space Policy and Kenya Space Strategy in 2016.[93] Information about this policy and strategy is scarce however.

The country's first satellite, a 10 cubic centimetre nanosatellite named First Kenyan University Nano Satellite-Precursor Flight (1KUNS-PF)[94], was developed by a team at the University of Nairobi[95] after they were "selected in 2016 by [the United Nations Office for Outer Space Affairs] UNOOSA, in collaboration with [Japan's Aerospace Exploration Agency] JAXA, for the first round of the KiboCUBE programme"[96]. The satellite was deployed in 2018 by JAXA from the International Space Station (ISS).[97] Technical support was offered by La Sapienza University of Rome and "the Italian Space Agency (ASI), in the framework of an Agreement fostering cooperation between La Sapienza University of Rome and Kenya Universities," while "[m]ost of the on-board hardware was donated by the Italian companies NPC-New Production Concept and Roboptics, which provided technical support for the program development".[98] Nevertheless, the satellite was developed by the University of Nairobi, demonstrating how countries are able to leap ahead in the Space Technology Ladder, thanks to miniaturised technology and components. The 1KUNS-PF satellite is a precursor for "the Kenyan-Italian IKUNS

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[89]Elvis Ondieki and Silas Apollo, "Kenya yet to activate its rich space agenda," *Daily Nation*, February 17, 2018, https://www.nation.co.ke/news/Why-work-at-Kenya-Space-Agency-is-yet-to-begin/1056-4309212-10s6deu/index.html (accessed November 21, 2018).

[90]Ibid.

[91]Ministry of Defence – Kenya, "Kenya Space Agency Board Appointed and Inaugurated," http://www.mod.go.ke/?p=10219 (accessed November 21, 2018).

[92]National Council for Law Reporting (Kenya Law), "The Kenya Space Agency Order, 2017," March 7, 2017, http://kenyalaw.org/kl/fileadmin/pdfdownloads/LegalNotices/2017/LN22_2017.pdf (accessed November 22, 2018).

[93]Nicholas Kimani, "Space Policy," February 28, 2016, https://nicholaskimani2011.wordpress.com/tag/space-policy/ (accessed November 22, 2018).

[94]Elvis Mboya, "Report on Kenya's first satellite," Africa Space News, September 20, 2018, https://africanews.space/report-on-kenyas-first-satellite/ (accessed November 21, 2018).

[95]AMSAT-UK, "Linear transponder CubeSat to deploy from ISS," May 10, 2018, https://amsat-uk.org/tag/1kuns-pf/ (accessed November 21, 2018).

[96]Space in Africa, "First KiboCUBE Satellite owned by Kenya deployed from the International Space Station," *Africa Space News*, May 13, 2018, https://africanews.space/first-kibocube-satellite-owned-by-kenya-deployed-from-the-international-space-station/ (accessed November 21, 2018).

[97]Ibid.

[98]1KUNS-PF Team, "1KUNS-PF," *University of Nairobi & La Sapienza – University of Rome*, 2018, https://1kuns-pf.ns0.it/ (accessed November 21, 2018).

earth observation CubeSat", which is "an extension of IKUNS (Italian-Kenyan University NanoSatellite), [and which] is a project run by the University of Nairobi in collaboration with 'La Sapienza' University of Rome and the Italian Space Agency, and is part of the projects initiated in 2015 between ASI and 'La Sapienza' under the Convention for managing activities at the Broglio Space Centre in Malindi (Kenya)".[99] IKUNS "will involve developing a CubeSat for Earth Observation and technological testing".[100]

Table 3.6 outlines information about Kenya's satellites. While the University of Nairobi played a key role in developing the 1KUNS-PF satellite, the country's space industry is at an emerging level, and the country can broadly be classified as a third-tier EMSA, although it has the potential to move into the second tier soon if the promise of its space agency and policy bear fruit. It can also be considered as a borderline High Space Technology Country given its space agency, but much more work is needed to actualise on this agency, especially since it took a year for the agency's board to be assembled[101].

*Egypt*'s efforts in the space arena date from the 1970s, when an "[e]arlier remote sensing initiative has [*sic*] started in Egypt in 1971 within the frame of the Egyptian Academy of the Scientific Research and Technology (ASRT) through an American-Egyptian joint project", which in turn "enabled for [sic] the establishment of the Remote Sensing Centre (in 1972) under ASRT".[102] In turn, the National Authority for Remote Sensing and Space Sciences (NARSS) was established in 1991, as a "General Authority for Remote Sensing" under the Ministry of Scientific Research since 1992.[103] NARSS has "two large sectors for remote sensing applications and space science and technology":

> The sector of remote sensing application works on the use of data provided by earth observation satellites and various airborne sensors to produce maps and spatial data for various applications such as the evaluation and monitoring of natural resources, natural hazards and environmental management. The sector of space science and technology is concerned with the development of sensors to be mounted on the earth observation satellites, satellite subsystems and space research. The sector is also concerned with the control and communication with the satellites as well as receiving the data for archiving and dissemination.[104]

[99]Gunter Dirk Krebs, "1KUNS-PF," *Gunter's Space Page*, October 24, 2018, https://space.skyrocket.de/doc_sdat/1kuns-pf.htm (accessed November 21, 2018).

[100]Ibid.

[101]Daily Nation, "Kenya yet to activate its rich space agenda," February 17, 2018, https://www.nation.co.ke/news/Why-work-at-Kenya-Space-Agency-is-yet-to-begin/1056-4309212-10s6deu/index.html (accessed November 22, 2018).

[102]Mohammed Rajaei, "Egypt Space Agency (NARSS)," *Geoinformation Online*, May 25, 2015, https://geoinformation.com/GeoInformation-dir/egypt-space-agency-narss/ (accessed November 22, 2018).

[103]Ibid.

[104]National Authority for Remote Sensing & Space Sciences, "About NARSS," 2015, http://www.narss.sci.eg/about (accessed November 24, 2018).

**Table 3.6** Kenyan satellites

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| 1KUNS-PF (First Kenyan University Nano Satellite-Precursor Flight)[a,b] | 2018 | LEO | • Nanosatellite<br>• "Testing in orbit and prove functionality of several components, either commercial or developed in house, intended for use in the IKUNS mission. In detail, the in-house developed systems are: Silicon cell solar panel; Telemetry Electronic Board; 3-DOF attitude control system, using a momentum wheel"<br>• Launch site: International Space Station (ISS) | • "To test technologies it has developed for the future launch of a larger earth observation satellite"<br>• "Run by the University of Nairobi in collaboration with 'La Sapienza' University of Rome and the Italian Space Agency, and is part of the projects initiated in 2015 between ASI and 'La Sapienza' under the convention for managing activities at the Broglio Space Centre in Malindi (Kenya)"<br>• Key areas: capacity building |
| IKUNS | Future | | | • CubeSat for Earth observation and technological testing |

[a]Space in Africa, "First KiboCUBE Satellite owned by Kenya deployed from the International Space Station"
[b]Gunter Dirk Krebs, "1KUNS-PF"

NARSS has three main premises, namely, the El-Nozha building (Cairo), which is "the main building (Headquarter)", the New Cairo space control station (Cairo), and the Aswan building receiving station (Aswan).[105]

In 2018, the Egyptian President passed Law no. 3 of 2018, thereby establishing the Egyptian Space Agency, to be headquartered in Cairo.[106] It is also reported that "the agency aims to develop and transfer space science and technology into Egypt to build satellites and launch them from Egyptian territories".[107] In this regard, "China and Egypt have signed an agreement that will see Beijing provide a U.S.$23 million grant for an Egyptian satellite test, integration, and assembly facility", which is "in line with the Egyptian policy intent to be self-sufficient and strategically autonomous in the manufacture of satellites and satellite components".[108] In line with this Chinese

[105]Ibid.

[106]Al-Masry Al-Youm, "Sisi passes law establishing Egyptian Space Agency," *Egypt Independent*, January 18, 2018, https://egyptindependent.com/sisi-passes-law-establishing-egyptian-space-agency/ (accessed November 22, 2018).

[107]Ibid.

[108]Space Watch Middle East, "China to Contribute Funds to Egypt's Space Programme," *ThorGroup GmbH*, 2018, https://spacewatchme.com/2017/03/china-contribute-funds-egypts-space-programme/ (accessed November 24, 2018).

support, Egypt "intends to create a satellite manufacturing centre in 2019".[109] The space agency will also "be given the responsibility of devising and implementing a national space policy and programme for the short, medium, and long-term".[110] There is however an "Initiative for Egyptian Space Policy", which outlines the following steps: "(1) Optimization of domestic resources, (2) Building Infrastructure for space science and technology, (3) Human resources capacity building, (4) Domestic Data and knowledge sharing, (5) Space awareness, (6) User needs and database integration, (7) International collaboration".[111] Herein, an Egyptian Space Strategy is outlined as well, "(1) Installation of Space city, (2) Foster and improve feeding industry for space technology and satellite building, (3) Partnership and international collaboration for the purpose of technology transfer, (4) Launching series of satellite with necessary facilities for operation testing serving strategic objectives, (5) Building required laboratories, (6) Building an integrated in situ measurement systems, (7) Improvement of space science and astronomy domestic network. (8) Completion of Space law and regulation".[112] However, there is a lack of "any indication as to the role of the Egyptian National Authority for Remote Sensing and Space Sciences (NARSS)" in the new space agency.[113]

In relation to the space segment of Egypt's space sector, the country was "the first Arab and African country to own a satellite in 1998 with the launch of 'NileSat-101', which was manufactured by the British-French company Matra Marconi space".[114] A further four satellites launched (and one planned) are detailed in Table 3.7. It is noteworthy that Egypt's first satellites were dedicated to communications, and NileSat-101 delivered "more than 100 digital TV channels as well as radio and multimedia services to more than five million homes over the whole of North Africa from Morocco to the Persian Gulf, [and thus] Egypt became the first African country to have its own direct TV broadcast satellite".[115] Egypt's second satellite was NileSat-102, and its fourth satellite was NileSat-201, and today "the NileSat system now broadcasts more than 150 digital TV channels and provides additional services such as data transmission, turbo internet and multicasting applications".[116]

[109] Space in Africa, "Over $3 billion have been spent on space projects in Africa since 1998."

[110] Space Generation Advisory Council, "SGAC Egypt," 2018, https://spacegeneration.org/regions/middle-east/egypt (accessed November 24, 2018).

[111] Ayman El-Dessouki, "Egyptian Space Program: Road-Map," *National Authority for Remote Sensing & Space Sciences*, 2015, http://www.alc.narss.sci.eg/webroot/attachments/alc2015/Day%203/Session%202/ESP%20Road%20Map.pdf (accessed November 24, 2018).

[112] Ibid.

[113] Spacewatch Middle East, "Egypt on the road to establishing national space agency amidst controversy," *ThorGroup GmbH*, August 2016, https://spacewatchme.com/2016/08/egypt-road-establish-national-space-agency-amidst-controversy/ (accessed November 24, 2018).

[114] Space in Africa, "Egypt close in on launching Misr Sat 2," *Africa Space News*, August 27, 2018, https://africanews.space/egypt-close-in-on-launching-misr-sat-2/ (accessed November 24, 2018).

[115] Gunter Dirk Krebs, "Nilesat 101, 102," *Gunter's Space Page*, July 18, 2018, https://space.skyrocket.de/doc_sdat/nilesat-101.htm (accessed November 24, 2018).

[116] Ibid.

**Table 3.7** Egyptian satellites

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| NileSat-101[a] | 1998 | Geostationary | • "Astrium supplied the two direct-broadcast satellites (based on the Eurostar-2000 version of the company's Eurostar series) and the two control centres (in Cairo and Alexandria), together with comprehensive operator training for the Egyptian engineers for control of the satellite once in orbit" • 12 Ku-band transponders • Launch site: Kourou, French Guiana | • "Delivering more than 100 digital TV channels as well as radio and multimedia services to more than 5 million homes over the whole of North Africa from Morocco to the Persian Gulf" • Key areas: communication, capacity building |
| NileSat-102[a,b] | 2000 | Geostationary | • Prime contractor: Matra Marconi Space • 12 Ku-band transponders • Launch site: Kourou, French Guiana | • Key areas: communication, capacity building |
| EgyptSat-1 (MisrSat-1)[c,d] | 2007 | Sun-synchronous orbit | • "International collaborative minisatellite project of NARSS (National Authority for Remote Sensing and Space Science) of Egypt and the Yuzhnoye State Design Office (YSDO), Dnepropetrosvk, Ukraine" • Two instruments: a multispectral imager and an infrared imager • Equipment: infrared imager, high-resolution multispectral imager, store and forward | • "Providing also technical expertise and on-the-job training to 60 Egyptian engineers and experts as well as technology transfer" • "Total of 5000 scenes were imaged by the satellite from 2008 to 2010" • Key areas: Earth observation, capacity building |

(continued)

**Table 3.7** (continued)

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| | | | communications payload<br>• Launch site: Baikonur | |
| NileSat-201[e] | 2010 | Geostationary | • NileSat's second-generation satellite<br>• Manufactured by Thales Alenia Space<br>• 24 Ku-band and 4 Ka-band transponders<br>• Coverage includes MENA region, including the GULF region, and full coverage of Sudan and East of Africa<br>• Launch site: Kourou, French Guiana | • Key areas: communication |
| EgyptSat-2 (MisrSat-2)[f,g] | 2014 | "Non-sun-synchronous orbit of 685 km × 710 km, inclination = 51.6°. The lower inclination allows the satellite to pass over Egypt more often than a satellite in a polar orbit" | • Built by RSC Energia for operation by the NARSS (National Authority for Remote Sensing and Space Sciences)<br>• "Resolution of 1 m in panchromatic mode and 4 m in multispectral mode. The camera can take both single frame images or stereoscopic images and can operate in pushbroom continuous imaging mode or in a cartographic mode"<br>• Launch site: Baikonur | • The "goal of the mission is to collect high-resolution imagery of the Egyptian territory and surrounding regions for digital mapping, assessments of mineral, water and other resources, environmental monitoring, vegetation monitoring, studies of the headwaters of the Nile, and disaster management"<br>• "In January 2015, control over the satellite was handed over to Egyptian specialists at NARSS"<br>• Key areas: Earth observation, capacity building |

(continued)

**Table 3.7** (continued)

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| EgyptSat-A (MisrSat-A)[h, i,j,k] | 2019 | Sun-synchronous orbit | • "China has agreed to contribute U.S. $64 million to the Egyptian earth observation satellite programme, EgyptSat, as part of a new cooperation agreement between the two counties signed on March 21, 2017" • "EgyptSat-A is being built as a replacement for EgyptSat-2 that failed in orbit in April 2015 less than a year after its launch" • "EgyptSat-A is being built using the funds recouped from the insurance claim against the EgyptSat-2 loss, said to be U.S. $100 million" • "A delegation of about 20 engineers have been sent for training on how to build satellites in China over the past few months," El Koussy said, "the mission came back about 2 months ago, and satellite building will proceed for the next 24 months" • Launch site: Baikonur | • "The satellite, built by the Russian national rocket and space corporation Energia" • "Will provide important images and data about border areas" • "Egypt has been trying to better monitor its borders with Libya and Sudan to respond to infiltrations. The Egyptian Army has a particular challenge in controlling the 1200 km border with Libya because of unrest in the country" |

[a]Revolvy, "Jabal Hamzah ballistic missile test and launch facility," https://www.revolvy.com/page/Jabal-Hamzah-ballistic-missile-test-and-launch-facility? (accessed November 26, 2018)
[b]The Satellite Encyclopedia, "Nilesat 102," *Tag's Broadcasting Services*, September 2, 2018, https://www.tbs-satellite.com/tse/online/sat_nilesat_102.html (accessed November 26, 2018)
[c]eoPortal Directory, "EgyptSat-1," *European Space Agency*, 2018, https://earth.esa.int/web/eoportal/satellite-missions/e/egyptsat-1 (accessed November 26, 2018)
[d]Gunter Dirk Krebs, "EgyptSat 1 (MisrSat 1)," *Gunter's Space Page*, December 11, 2017, https://space.skyrocket.de/doc_sdat/egyptsat-1.htm (accessed November 26, 2018)
[e]NileSat, "Nilesat 201," 2018, http://www.nilesat.com.eg/en/Pages/Index/6?type=1 (accessed November 26, 2018)

(continued)

[f]eoPortal Directory, “EgyptSat-2,” *European Space Agency*, 2018, https://directory.eoportal.org/web/eoportal/satellite-missions/e/egyptsat-2 (accessed November 26, 2018)
[g]Gunter Dirk Krebs, “EgyptSat 2 (MisrSat 2),” *Gunter's Space Page*, December 11, 2017, https://space.skyrocket.de/doc_sdat/egyptsat-2.htm (accessed November 26, 2018)
[h]Space Watch Middle East, “China to Contribute Funds to Egypt's Space Programme”
[i]Space in Africa, “Egypt close in on launching MisrSat 2,” *Africa Space News*, August 27, 2018, https://africanews.space/egypt-close-in-on-launching-misr-sat-2/ (accessed November 26, 2018)
[j]Ahmed Megahid, “Egypt is launching a new reconnaissance satellite to help military with border controls,” *Africa Space News*, September 2, 2018, https://africanews.space/egypt-is-launching-a-new-reconnaissance-satellite-to-help-military-with-border-controls/ (accessed November 26, 2018)
[k]Russian Aviation, “Russia to launch EgyptSat-A earth remote sensing satellite on December 27,” October 2, 2018, https://www.ruaviation.com/news/2018/10/2/12067/?h (accessed December 13, 2018)

Egypt can be considered a High Space Technology Country given the founding of its new space agency and, like Algeria, given that it is an active player in space, is growing its space technology sector and collaborates actively with other space actors. On balance, it can be considered as a second-tier EMSA. Also, an Egyptian Military Technical College and Institute of Aviation Engineering and Technology Joint Rocket Team took part in the Intercollegiate Rocket Engineering Competition (IREC) in 2017, and the KEMET-2 Rocket Team worked to “design, build, and launch a rocket carrying no less than ten pounds of payload to a target apogee of 10,000 feet AGL”.[117] The country also maintains the Jabal Hamzah ballistic missile test and launch facility that was built in the 1950s, but it is unclear what recent activities are taking place at the military facility or if they have any relation to space.[118]

*Sudan* established its National Remote Sensing Centre (NRSC) in 1977 within the auspices of the National Council for Research, Ministry of Higher Education and Scientific Research, later renamed in 1996 to the Remote Sensing Authority (RSA) in affiliation with the National Centre for Research, Ministry of Science and Technology.[119] In 1995 the Seismological Research Unit was established and later upgraded into the Seismological Research Institute, merged in 2013 with the RSA into the current Remote Sensing and Seismology Authority (RSSA).[120] According to the RSSA, the “RSA is doing research in the field of remote sensing, geo-informatics and GPS technology applications for natural resources, environment and disasters”, while the “Institute provides value-added services in natural resources management, remote sensing, GIS, GPS and technology transfer”.[121] The vision of the

[117]Military Technical College, “Egyptian KEMET-2 Rocket Team 2017 returns from the IREC with new perspectives,” *Armed Forces Main Information Center (AFMIC)*, January 8, 2018, http://www.mtc.edu.eg/mtcwebsite/ReadMore.aspx?id=10 (accessed November 26, 2018).

[118]Revolvy, “Jabal Hamzah ballistic missile test and launch facility,” https://www.revolvy.com/page/Jabal-Hamzah-ballistic-missile-test-and-launch-facility? (accessed November 26, 2018).

[119]Remote Sensing & Seismology Authority, “About Us,” 2018, https://rssa.gov.sd/about/ (accessed November 26, 2018).

[120]Ibid.

[121]Ibid.

organisation is "[t]owards optimized peaceful use of space technologies and seismology research in Sudan", while the mission is "[t]o ensure that space science, technology and seismological studies promote for [*sic*] socio-economic uplift of the country".[122] Its mandate is to "[c]onduct applied research in remote sensing in natural resources and environment and seismological studies" and to "[a]ssist government agencies, universities and research institutes in involving remote sensing and GIS for research, studies, and capacity building".[123]

Three space technology projects are said to be ongoing in the country. These are (i) the "University of Khartoum's Cubesat Project, which was established in 2010 and still going on, with 2 CubeSat prototypes developed and no launch yet", (ii) "National Centre of Research's Institute of Space Research and Aerospace (ISRA) which recently completed developing their first CubeSat Prototype", and (iii) "Future University established their Kush Institute of Space Technology in 2000. Although they have been working mostly on remote sensing, but they recently started a CubeSat project".[124] As such, Sudan is yet to place its first satellite in orbit. At present it can be classified as a third-tier EMSA and a borderline Medium Space Technology Country although its space capabilities are in the nascent stage (Table 3.8).

*Ethiopia* is making rapid strides in the space sector following the establishment of the non-profit Ethiopian Space Science Society (ESSS) in 2004, which now has "more than 10,000 members, 19 branches and 100 school space clubs".[125] The vision of the organisation is "[t]o make Ethiopia effective and extensive user of space science and technology, especially satellite science and technology applications in all aspects of the development of the country and become contributor to the development of astronomy, space science and related sciences within ten years". Its mission is to (i) "[s]atisfy all space science and technology, especially satellite

**Table 3.8** Sudanese satellites

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| | Future | | • University of Khartoum's CubeSat Project | • Key areas: capacity building |
| | Future | | • National Centre of Research's Institute of Space Research and Aerospace (ISRA) CubeSat | • Key areas: capacity building |
| | Future | | • Future University CubeSat | • Key areas: capacity building |

[122]Ibid.

[123]Ibid.

[124]Space Generation Advisory Council, "Sudan," 2018, https://spacegeneration.org/regions/africa/sudan (accessed November 26, 2018).

[125]Ethiopian Space Science Society, "About ESSS," 2018, https://webcache.googleusercontent.com/search?q=cache:YKmKo7dJDbAJ:https://www.ethiosss.org.et/about-esss/+&cd=2&hl=en&ct=clnk&gl=za (accessed November 26, 2018).

science and technology needs of the country fully by 2025"; (ii) "[d]evelop the necessary Capacity and research to be contributor to the development of science and Technology of the field"; (iii) "[b]uild regional, continental and international network to be fast learning country in space science, astronomy and related sciences and technologies"; and (iv) "[p]romote space science, astronomy and related sciences and technologies, by establishing different outreach programs".[126]

Following the establishment and advocacy work of ESSS, the Ethiopian government stated that it "seeks to develop and build satellites for the purposes of national security, disaster management and response, and land management", and the Ethiopian Space Science and Technology Institute and Council were founded under the Ministry of Science and Technology (MoST) after the approval of the Council of Ministers was granted in 2016.[127] Consequently, the first ordinary meeting of the Space Science Council was held in 2017, and "[t]he Ethiopian government (MoST) announced on January 2017 that it intends to build its own medium-sized space launch vehicle (SLV) and develop the capabilities to domestically build satellites".[128] In future, "[s]pace policy is to be developed by the Ethiopian Space Science institute", while plans for the development of a space industry exist.[129] The Ethiopian Space Science Institute has the following objectives:

> to enable the country to fully exploit multidimensional uses of space science and technologies; to produce demand based knowledgeable, skilled and attitudinally matured professionals in the field of aerospace science that enable the country to become internationally competitive in the sector; to develop and strengthen space science and technology infrastructures to speed up space science and technology development in the country; and enable the country to be robust contributor for the development of aerospace science and technology.[130]

The country is planning to place its first satellite in orbit by 2019, in collaboration with China, and the "design, development and manufacturing of the satellite are done in collaboration with the Chinese at $8 million cost", while "China has provided training and $6 million for the project".[131] It is reported that "[t]he satellite will be launched from China while the control and command station will be in Ethiopia". It is planned to be "an earth observatory satellite ... to improve its weather-monitoring capabilities".[132] Training and capacity building are key tenets

[126]Ibid.

[127]Aster Denekew Yilma, "Space Capability in Ethiopia," *African Centre for Statistics*, September, 2017, http://www.unoosa.org/documents/pdf/psa/activities/2017/GrazSymposium/presentations/Tuesday/Presentation16.pdf (accessed November 26, 2018).

[128]Ibid., 9.

[129]Ibid., 14.

[130]Ethiopian Space Science and Technology Institute, "Establishment of ESSTI," 2018, http://webcache.googleusercontent.com/search?q=cache:I6u_rWEXOEsJ:etssti.org/about-us1/+&cd=1&hl=en&ct=clnk&gl=za (accessed November 26, 2018).

[131]Space in Africa, "Ethiopia Set To Launch Its First Satellite Next Year," *Africa Space News*, November 3, 2018, https://africanews.space/ethiopia-to-launch-first-satellite-next-year/ (accessed November 26, 2018).

[132]Ibid.

**Table 3.9** Ethiopian satellite

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| | Future | | • Planned for 2019<br>• Partnership with China<br>• Launch site: China's Xichang Satellite Launch Centre? | • Key areas: Earth observation, meteorology, capacity building |
| | | | | • Design, build, and launch the second satellite independently |

of this project, and "the most preliminary and critical design is done by Ethiopian scientists" with "20 Ethiopian aerospace engineers involved in the satellite project", and a further "60 masters and PhD students are also taking part in research and training at the space institute as well as the country's multibillion-dollar Entoto Observatory and Research Centre" with the ultimate goal being to enable Ethiopia to "design, build and launch the second satellite independently".[133]

Ethiopia is as yet a third-tier EMSA and a Medium Space Technology Country, although this is set to change in the near future if the above-mentioned plans bear fruit (Table 3.9).

*Mauritius* is set to have its first satellite launched from the International Space Station in 2019, as part of the same programme that saw Kenya's first satellite placed in orbit. The Mauritius Research Council was selected in the third round of the KiboCUBE programme of JAXA (Japan Aerospace Exploration Agency) and UNOOSA (United Nations Office for Outer Space Affairs), and the planned satellite MirSat-1 "will include a longwave infrared thermal camera that will allow it to collect thermal infrared images of Mauritius and its surrounding areas" and will "test the onboard communication capabilities of the CubeSat by studying the satellite's capacity to transfer information via satellite radio wave frequency".[134] The launch date is planned for October 2019.[135] The satellite is planned to contribute to three major challenges facing Mauritius: "(1) Ocean surveillance and optimal management of ocean resources (e.g. tackling fish depletion) in the Mauritian Exclusive Economic Zone (EEZ) which is about 2.3 million kilometre square; (2) Road traffic congestion and (3) Natural disaster mitigation (i.e. frequent flooding)".[136] Mauritius

[133]Ibid.

[134]Space in Africa, "Team from the Mauritius Research Council selected for third round of KiboCUBE," *Africa Space News*, June 18, 2018, https://africanews.space/team-from-the-mauritius-research-council-selected-for-third-round-of-kibocube/ (accessed November 26, 2018).

[135]Space in Africa, "Towards Mauritius first Satellite – Excerpts from Infotech/Innovtech 2018," Africa Space News, September 2, 2018, https://africanews.space/towards-mauritius-first-satellite-excerpts-from-infotech-innovtech-2018/ (accessed November 26, 2018).

[136]Mauritius Research Council, "MIR-SAT1-First Mauritian Infrared Satellite selected under the UNOOSA/JAXA KiboCUBE 2018 Program," June 20, 2018, http://www.mrc.org.mu/English/News/Pages/Mauritian-Infrared-Satellite.aspx (accessed November 26, 2018).

**Table 3.10** Mauritian satellite

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| MirSat-1 | Future | Low Earth orbit | • Planned for October 2019<br>• CubeSat<br>• KiboCUBE programme<br>• Launch site: International Space Station | • Key areas: Earth observation |

can be classified as a third-tier EMSA and as yet a Low Space Technology Country, although this is set to change soon (Table 3.10).

*Rwanda* is another COMESA member with ambitious plans regarding the space sector. The country recently "began work to train aerospace engineers and launch a nano-satellite in the next few years", and specifically, the "Rwandan government announced they are working on building a Rwandan satellite to monitor progress in sustainable development goals".[137] In 2018 Rwanda's Utilities Regulatory Authority signed a "Space Inclusion in Africa agreement with Japanese government to start training Rwandan engineers in fabricating local satellites in big data, weather and space technology" as "part of Japanese African program to train satellite engineers, to provide required information and date in different areas".[138] Six Rwandan engineers are benefitting from training in 2018, and six annually after that, "with a high possibility of sending Japan's trainers to Rwanda as our starting point of expanding systems engineering technology in Africa".[139] Infrastructure is also being built, and the "first satellite data transmission on Rwanda was tested in March and the plan is to build a satellite station in Rwanda, which has already started in Kicukiro district alongside train[ing] Rwandans to develop smaller satellite to feed in various data".[140] The satellite is planned to be the country's "first telecoms satellite by 2020" with the goal "to achieve total telecoms autonomy with the launch of the satellite".[141] As such, "the government is putting together the Rwanda Space Project in partnership with the Japan International Cooperation Agency (JICA), Rwanda Regulatory Agency Utilities (RURA) and the Japan Space Agency (JAXA)".[142] Rwanda remains for now a third-tier EMSA and a Low Space Technology Country (Table 3.11).

[137]Space in Africa, "Towards the development of Rwanda's first Satellite; training of Engineers commences," *Africa Space News*, May 10, 2018, https://africanews.space/towards-the-development-of-rwandas-first-satellite-training-of-engineers-commences/ (accessed November 26, 2018).

[138]Ibid.

[139]Ibid.

[140]Ibid.

[141]Paul Adepoju, "Rwanda looks to satellite tech for total telecoms autonomy," *ITWebAfrica*, January 9, 2018, http://www.itwebafrica.com/telecommunications/satellite/826-rwanda/242247-rwanda-looks-to-satellite-tech-for-total-telecoms-autonomy (accessed November 26, 2018).

[142]Ibid.

**Table 3.11** Rwandese satellite

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| | Future | Geostationary? | • Partnership between RURA, JAXA, and JICA | • Key areas: communications |

*Democratic Republic of the Congo* was the first country used by OTRAG to establish its rocket range, and in 1977 flight tests were initiated in Shaba (Katanga), where a pad and gantry were set up.[143] After the country (then known as Zaire) was pressured by the USSR in particular to withdraw OTRAG's permission to use the Shaba site (also known as Kapani Tonneo[144]), OTRAG left for Libya. In more recent times, the Democratic Republic of Congo announced that it has "contracted with China Academy of Space Technology (CAST) to manufacture and launch a communication satellite named CongoSat-1".[145] It was reported that the Democratic Republic of the Congo's National Network of Satellite Telecommunications (Renatelsat) had signed a deal worth US$320 million with China's Great Wall Industry Corporation, to build and place the communication satellite in geosynchronous orbit.[146] However, it currently appears that "the launch of the satellite seems like an unrealistic dream due to financial constraints" since the deal was "put on hold" in May of 2016 for financial reasons, and as such, "[f]rom many indications, the deal may not be feasible in the near future".[147] Given this ambition, however, it does seem likely that the country will complete this goal at some point.

Renatelsat is the country's "public agency responsible for managing the ... domestic telecommunication network and geostationary communication satellites" and will be responsible for the operation of CongoSat-1.[148] Recent developments for Renatelsat include a public-private sector deal signed with the Africa Union Financial Services (AUFS) to "overhaul satellite connectivity" in the country and to "finance Renatelsat's capacity to exploit the Belarusian ... satellite Belintersat-1 to improve connectivity and telecommunication infrastructure in DR Congo", with the deal "structured to resuscitate the moribund Renatelsat and pull the agency to self-sustainability".[149]

Jean-Patrice Keka Ohemba Okese is a "self-made" Congolese "rocket expert [who] has been launching projectiles from yam farms ... near the village of

[143]Mark Wade, "OTRAG," *Astronautix*, 2017, http://www.astronautix.com/o/otrag.html (accessed December 9, 2018).

[144]The highest apogee reached by OTRAG at Kapani Tonneo is 30 km, as opposed to 150 km at Tawiwa, Libya. Ibid.

[145]Joseph Ibeh, "DR Congo's planned launch of CongoSat-1 still a mirage," *Africa Space News*, October 27, 2018, https://africanews.space/dr-congos-planned-launch-of-congosat-1-still-a-mirage/ (accessed December 9, 2018).

[146]Ibid.

[147]Ibid.

[148]Ibid.

[149]Ibid.

Menkao" in his Troposphere programme.[150] Five sounding rockets have been constructed, of which three launches have taken place from his eastern Congo location. Troposphere II "shot a mile up", and Troposphere IV "rose 10 miles … a sixth of the way to space, gracing the stratosphere", while Troposphere V, which "turned sideways" hitting a mountain, was "a 1576-pound, two-stage solid-fuel rocket designed to climb 23 miles" with "[o]n board … computers to send back video, GPS data and flight readings—and a rat, caught from the wild, in the Ovaltine-can passenger pod".[151] Troposphere VI is being built as a "three-stage-engine rocket, nicknaming it Soso Pembe or 'white rooster,' to power 120 miles up, 60 miles beyond what is considered the inner boundary of outer space".[152] While receiving no government support—"Every time I went to see the government … they told me that rocket science is too complicated and they don't want a part of it"—the launches are broadcast on television.[153] In effect, the Democratic Republic of the "Congo's space program is more or less synonymous with Jean-Patrice's Troposphere space program".[154] Despite these efforts, the Democratic Republic of the Congo is a third-tier EMSA and Low Space Technology Country. Since the ambition to develop a launch vehicle has no government support, the Space Technology Ladder will not reflect this ambition (Table 3.12).

*Malawi*'s National Commission for Science and Technology has recently held talks with the Kyushu Institute of Technology (KYUTECH)—which operates the Birds programme discussed in the previous chapter—and while "Malawi will not join KYUTECH's upcoming Birds project, this very discussion was a significant step in getting the government involved and aware of the benefits of space" with the ultimate aim "to build Malawi's first satellite".[155] While Malawi remains a third-tier EMSA and Low Space Technology Country, there are thus prospects for future space-related developments given the government's interest.

*Zimbabwe* has very recently established the Zimbabwe National Geospatial and Space Agency (ZINGSA), which launched in July 2018.[156] ZINGSA is run by the

**Table 3.12** Democratic Republic of the Congo satellite

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| CongoSat-1 | Future? | Geostationary | | • Key areas: communications |

[150]Drew Hinshaw, "One African's Personal Space Race Turns Vermin Into Astronauts," *The Wall Street Journal*, October 30, 2015, https://www.wsj.com/articles/one-africans-personal-space-race-turns-vermin-into-astronauts-1446239060 (accessed December 9, 2018).

[151]Ibid.

[152]Ibid.

[153]Ibid.

[154]Ibeh, "DR Congo's planned launch of CongoSat-1 still a mirage."

[155]Maganga and Luwanga, "How Investing in Space Could Help Malawi."

[156]Space in Africa, "Zimbabwe Space Agency is launching tomorrow – all you need to know," *Africa Space News*, July 9, 2018, https://africanews.space/zimbabwe-space-agency-is-launching-tomorrow-all-you-need-to-know/ (accessed December 9, 2018).

Ministry of Higher and Tertiary Education, Science and Technology Development, with five departments. The first is the Space Operations and Launch Services Department, with the following responsibilities: preparation and implementation of Earth observation missions; satellite command and control; managing communication between spacecraft, ground stations, and control centres; linking various complex operating processes; incorporating new technologies to space operations as the technologies become available; strategic planning of space operations; specifically developing future plans for ZINGSA systems, facilities, and personnel; launch services facilitating access to space for ZINGSA missions; and ensuring that critical infrastructure to access and use space meets expectations of ZINGSA.[157] The second is the Space Science Department, which researches key areas of space physics, astrophysics, and space weather and planetary science. The third is the Space Engineering Department, tasked with offering engineering advice to ZINGSA programmes and projects and ZINGSA innovations for space, from concept to applications, and to "educate scientists and engineers as well as inspire Space Research to better understand the Earth, our solar system and beyond".[158] The fourth is the Geospatial and Earth Observation Department, tasked with geoinformation Science and Earth observation; geospatial analytics and remote sensing; mining and mineral exploration; disaster management; weather and climate; and geospatial intelligence.[159] The fifth is the Finance and Administration Department, responsible for developing business plans, timelines, and budgets to perform financial projects; developing and maintaining standard financial and administrative procedures; monitoring and managing expenditures within allotted budget; ensuring the preparation and maintenance of all financial records; identification and resolution of financial and administrative issues; agriculture intelligence; and water, energy, health, and any other nationally strategic applications.[160] Key projects outlined for ZINGSA are renewable energy mapping, geological mineral mapping, wildlife surveillance, and malaria and bilharzia mapping.[161]

While the country has no satellites yet, talks are under way with "Geoscan, a Russian space company, for a joint venture in drones manufacturing. Belgian investors are also in talks with the ministry", while "President Emmerson Mnangagwa recently met China Space to discuss the possibility of accessing detailed imagery from Chinese satellites".[162] ZINGSA has also signed an agreement with "South Africa's Space Advisory Group to assist the Government arm start operations".[163] The government is reported to have "released $1.6 million for the Zingsa

[157]Ibid.

[158]Ibid.

[159]Ibid.

[160]Ibid.

[161]Ibid.

[162]Space in Africa, "ZINGSA signs MoU with Space Advisory Group," *Africa Space News*, November 18, 2018, https://africanews.space/zingsa-signs-mou-with-space-advisory-group/ (accessed December 9, 2018).

[163]Ibid.

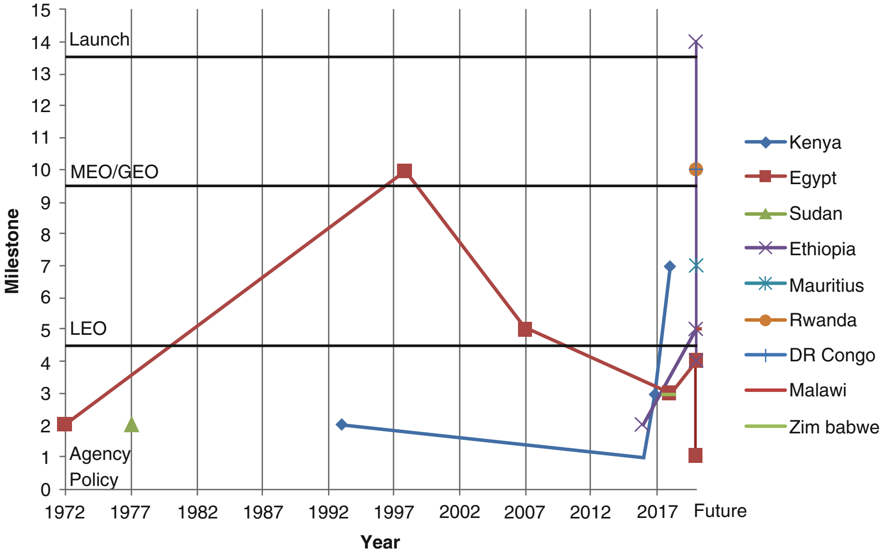


**Fig. 3.5** Milestone timeline—Common Market for Eastern and Southern Africa (COMESA)

pilot project".[164] While Zimbabwe thus has ambitious plans for space, for now it remains a third-tier EMSA and Low Space Technology Country.

In the COMESA region, a large number of promising space actors have thus been identified, as seen in Fig. 3.5. Egypt is the clear leader, with Kenya and Ethiopia new and rising entrants. Smaller actors like Rwanda, Mauritius, and Zimbabwe are also noteworthy.

### *3.2.3 The Community of Sahel-Saharan States (CEN-SAD)*

CEN-SAD, with its large membership, includes the already discussed Morocco, Tunisia, Libya, Egypt, Sudan, and Kenya, and as before, these will accordingly be excluded here. Beyond these, one emerging space middle power was identified, namely, Nigeria, and thus it will be the first CEN-SAD member looked at here.

*Nigeria* is, as seen in the preceding chapter, one of the most active African space actors and a leader on the continent. The country expressed the ambition to establish a space programme as early as 1976 during a joint session of the United Nations Economic Commission for Africa and the Organisation of African Unity.[165] The establishment of a National Centre for Remote Sensing was approved by the

[164]Ibid.

[165]Joseph Ibeh, "A Deep Dive into Nigeria's Space Sector," *Africa Space News*, October 2, 2018, https://africanews.space/a-deep-dive-into-nigerias-space-sector/ (accessed December 10, 2018).

National Council of Ministers,[166] and subsequently the National Remote Sensing Centre became operational by October 1995.[167] This was followed in 1999 by the establishment of the National Space Research and Development Agency (NASRDA), with the goal to "develop and promote the use of space technology as a key driver for socio-economic development". In 2001 the adoption of the Nigeria Space Policy set out the key responsibilities of NASRDA, in the areas of the development of human resources and capacity; natural resources management; defence, security, and law enforcement; study of the Earth and its environment; space communication and applications; education and training; and promotion of international cooperation.[168]

Nigeria's National Space Council is chaired by the president, and NASRDA has seven main centres, namely, Centre for Basic Space Science, Nsukka; Centre for Remote Sensing, Jos; Centre for Satellite Technology Development, Abuja; Centre for Space Transport and Propulsion, Epe; Centre for Space Science and Technology Education, Ile-Ife; Centre for Geodesy and Geodynamics, Toro; and Centre for Lower Atmospheric Research, Kogi State University.[169] It also operates one company, named GEOAPPS Plus Nig. Ltd. The country also maintains a Defence Space Administration (DSA), established by the National Assembly of the Federal Republic of Nigeria with the mandate to develop and operate military space technologies; support Nigerian military operations both within and outside the country as well as security agencies responsible for internal security, through the use of satellites; and provide resilient, affordable space and cyberspace capabilities for the Nigerian military as well as other security and law enforcement agencies.[170] Currently, the main legislative framework regulating the Nigerian space sector is the National Space Research and Development Act (2010).[171]

Nigeria initiated a 25-year space programme roadmap in 2005, divided into three phases. Phase one covered 2005–2013, phase two covers 2014–2022, and phase three will cover 2023–2030.[172] This roadmap has three overarching goals, namely,

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[166] Francis D. Chizea, "Space Technology Development in Nigeria," *National Space Research & Development Agency (NASRDA)*, Presentation at the United Nations/South Africa Symposium on Basic Space Technology, Stellenbosch, South Africa, December 2017, http://www.unoosa.org/documents/pdf/psa/activities/2017/SouthAfrica/slides/Presentation11.pdf (accessed December 10, 2018).

[167] Ibid.

[168] Ibeh, "A Deep Dive into Nigeria's Space Sector."

[169] Chizea, "Space Technology Development in Nigeria."

[170] Space in Africa, "Nigerian Defense Space Agency is recruiting," *Africa Space News*, April 25, 2018, https://africanews.space/nigerian-defense-space-agency-is-recruiting/ (accessed December 10, 2018).

[171] George Etomi and Partners, "Overview of space exploration in Nigeria: challenges and solutions for the effective operation of the sector," *Africa Space News*, April 15, 2018, https://africanews.space/overview-of-space-exploration-in-nigeria-challenges-and-solutions-for-the-effective-operation-of-the-sector/ (accessed December 10, 2018).

[172] Ibid.

to produce a Nigerian astronaut, to launch a satellite manufactured in Nigeria, and to build and launch a Nigerian-made satellite from a launch site in Nigeria on a Nigerian launch vehicle. Thus far, the country has had six satellites placed in orbit, as Table 3.13 details, with the first being NigeriaSat-1 in 2003 and the most recent NigeriaEduSat-1 in 2017.[173]

While the "infrastructural deficit is a big challenge to every sector in Nigeria", the government is "providing intervention funds for the development of an indigenous Design Center (DC) and an Assembly and Integrated Testing (AIT) centre to facilitate the growth of its space programme". However, "institutions of higher learning are yet to venture into actual space research and satellite development" with the exceptions of "one university [University of Ife, now Obafemi Awolowo University] with facilities to teach and research engineering physics, a discipline crucial to space science and instrumentation", and, another, the Federal University of Technology, Akure, which was involved in building NigeriaEduSat-1.[174,175,176] Increasing private sector participation is another challenge for Nigeria, and it is reported that the "Nigerian government is yet to create an environment for private sector participation to thrive".[177] Moreover, while Nigeria has announced the intention to send an astronaut to space by 2030, concerns have been raised as "[s]ome experts took to social media to express their doubt with the vision 2030, dubbing it as usual political rhetoric", while "[m]any Nigerians expressed concern over limited resources and disbelief that NASRDA has the capacity to achieve the vision".[178] Furthermore, a "critical analysis of Nigeria's space program reveals that sending an astronaut into space could be a misplaced priority or an unfounded claim" and "[a]t best, Nigeria may send an astronaut into space onboard a foreign spaceship", most likely in partnership with China.[179] In terms of the ambition to launch satellites from Nigeria, "experts decry the near total absence of necessary infrastructure to achieve this".[180]

Nevertheless, Nigeria has shown a steady progression in developing local expertise with each satellite, and a clear progression is visible in Nigerian capabilities. NigeriaSat-1 involved the training of 15 engineers, NigComSat-1 involved the training of 55 engineers, and NigeriaSat-2 involved the training of 27 engineers and 10 M.Sc. degrees awarded by the University of Surrey, while NigeriaSat-X was

[173]Space in Africa, "Over $3 billion have been spent on space projects in Africa since 1998," *Africa Space News*, May 11, 2018, https://africanews.space/over-3-billion-have-been-spent-on-space-projects-in-africa-since-1998/ (accessed December 10, 2018).

[174]Ibeh, "A Deep Dive into Nigeria's Space Sector."

[175]Tade Ipadeola, "The Terrestrial Challenges to Nigeria's Ambitious Space Program," Slate, March, 2017, http://www.slate.com/articles/technology/future_tense/2017/03/nigeria_s_ambitious_space_program_is_held_back_by_terrestrial_politics.html (accessed December 10, 2018).

[176]Chizea, "Space Technology Development in Nigeria."

[177]Ibeh, "A Deep Dive into Nigeria's Space Sector."

[178]Ibid.

[179]Ibid.

[180]Ipadeola, "The Terrestrial Challenges to Nigeria's Ambitious Space Program."

**Table 3.13** Nigerian satellites

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| NigeriaSat-1[a,b,c] | 2003 | Sun-synchronous | • Built in collaboration with Surrey Satellite Technology (SST)<br>• “Earth observatory satellite with a 32 m resolution camera and an optical sensor”<br>• “32-m resolution imager in 3 spectral bands”<br>• Launch site: Plesetsk, Russia | • Part of disaster monitoring constellation<br>• “Also paid for the training of Nigerian engineers”<br>• Key areas: Earth observation, capacity building |
| NigComSat-1[a] | 2007 | Geostationary | • “Failed in orbit in November the following year [2008] as a result of a poorly-built solar array”<br>• Built by China Great Wall Industry Corporation<br>• Nigeria received “NigComSat-1R as a replacement for the failed satellite at no extra cost. The loss was covered by insurance and CGWIC built a replacement to make up for the faulty NigComSat-1”<br>• Launch site: China’s Xichang Satellite Launch Centre | • Key areas: communication |
| NigeriaSat-2[d] | 2011 | Sun-synchronous | • Built by Surrey Satellite Technology Ltd (SSTL), under contract “for the supply of the NigeriaSat-2 Earth observation satellite, related ground infrastructure and a training programme to further establish a national indigenous space capability in the Federal Republic of Nigeria”<br>• Launch site: Yasny in southern Russia | • To “provide Nigeria with valuable geographically referenced high-resolution satellite imaging for applications in mapping, water resources management, agricultural land use, population estimation, health hazard monitoring and disaster mitigation and management”<br>• Key areas: Earth observation, capacity building |

(continued)

**Table 3.13** (continued)

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| NigeriaSat-X[a,e] | 2011 | Sun-synchronous | • "UK-based Surrey Space Technology Limited built the NigeriaSat-2 and provided technical training for Nigerian engineers to build NigeriaSat-X"<br>• "Developed by a team of 25 Nigerian trainee engineers at SSTL under a program to provide hands-on experience in all aspects of spacecraft development"<br>• Launch site: Yasny in southern Russia | • 22 m multispectral imaging system with an 600 km swath<br>• Key areas: Earth observation, capacity building |
| NigComSat-1R[a,f,g] | 2011 | Geostationary | • "Operated by Nigerian Communications Satellite Limited (NigCom LTD) and NASRDA. The communication satellite improved Nigeria's telecommunication sector with about 65% capacity usage"<br>• "Fitted with a total of 28 transponders (8 Ka-band, 14 Ku-band, 4 C-band and 2 L-band)"<br>• Launch site: China's Xichang Satellite Launch Centre | • "Super hybrid geostationary communications satellite"<br>• Key areas: communication |
| NigeriaEdu Sat-1[h,i] | 2017 | Low Earth orbit | • Part of Joint Global Multi-Nation Birds Satellite project. Acronym as 'Birds project'<br>• First Nigerian university satellite<br>• "Designed, built and owned by The Federal University of Technology Akure, FUTA, in collaboration with National Space Research and Development Agency, NASRDA, Abuja, Nigeria, and Kyushu Institute of Technology Japan" | • "Ground Station Equipment include:– Cross Yagi-Uda antennas (2 m and 70 cm), Icom Transceiver,– Yeasu Antenna Rotator, PC with Satellite tracking software"<br>• "Antenna development completed by NASRDA Engineers/ Scientists"<br>• Key areas: "capacity building, i.e. domesticating the satellite technology in a Nigerian university, |

(continued)

**Table 3.13** (continued)

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| | | | • Launch site: released from the International Space Station | FUTA, and making the technology a common business among staff and students of the university in Nigeria for the purpose of research, resources and environmental management and sustainable socio-economic development of the nation" |
| NigeriaEdu Sat-2[j] | Future | | • NASRDA "concluded all technical arrangements for the successful building and launch of a second NANOSATELLITE" • Collaboration with Landmark University, Omu-Aran Kwara State • "Technical work is set for EduSat-2, but activities will begin as soon as the budget is passed" | • Key areas: "for Universities to develop capabilities on satellite technology"; Agriculture: "detecting diseased crop" |
| Not yet known[j] | Future | | • "Nigeria in early 2018 announced a $550 million deal to acquire two communication satellites from China. The deal offers the Chinese company equity stake worth $550 million in Nigerian Communication Satellite (NigComSat Ltd). NigComSat Ltd is a state-owned communications satellite operator and services provider. The Nigerian government claims the deal will cost Nigeria nothing because they did not make any direct | |

(continued)

**Table 3.13** (continued)

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| | | | financial commitment to the deal" | |

[a]Ibeh, "A Deep Dive into Nigeria's Space Sector"
[b]Gunter Dirk Krebs, "NigeriaSat 1," *Gunter's Space Page*, December 11, 2017, https://space.skyrocket.de/doc_sdat/nigeriasat-1.htm (accessed December 10, 2018)
[c]Wood and Weigel, "Charting the Evolution of Satellite Programs in Developing Countries," 19
[d]Gunter Dirk Krebs, "NigeriaSat 2," *Gunter's Space Page*, December 11, 2017, https://space.skyrocket.de/doc_sdat/nigeriasat-2.htm (accessed December 10, 2018)
[e]Gunter Dirk Krebs, "NX (NigeriaSat X)," *Gunter's Space Page*, December 11, 2017, https://space.skyrocket.de/doc_sdat/nx.htm (accessed December 10, 2018)
[f]China Great Wall Industry Corporation, "NigComSat-1R Program," 2009, http://www.cgwic.com/In-OrbitDelivery/CommunicationsSatellite/Program/NigComSat-1R.html (accessed December 10, 2018)
[g]Nigcomsat Ltd, "NigComSat-1R," 2018, http://www.nigcomsat.gov.ng/fleet.php (accessed December 10, 2018)
[h]Space in Africa, "FUTA sets Nigerian record, to launch Nigeria's first Nanosatellite," *African Space News*, January 25, 2018, https://africanews.space/futa-sets-nigerian-record-to-launch-nigerias-first-nanosatellite/ (accessed December 10, 2018)
[i]Chizea, "Space Technology Development in Nigeria"
[j]Space in Africa, "NASRDA and Landmark University collaborates to build Nigeria EduSAT-2," *Africa Space News*, June 2, 2018, https://africanews.space/nasrda-and-landmark-university-collaborates-to-build-nigeria-edusat-2/ (accessed December 10, 2018)

"designed & built by Nigerian Engineers using SSTL Facilities".[181] The postgraduate Institute of Space Sciences and Engineering (ISSE) was also established in 2015 in Abuja to "address the growing needs of Space scientific knowledge and innovations in Nigeria and Africa continent at large" with the first students expected in 2018.[182] As mentioned, the Assembly Integration, Test, and Design Centre (AITDC) and the Mechanical Design Laboratory are progressing, with other major infrastructure developments including a planetarium and space museum.[183] As such, Nigeria can be considered as a second-tier EMSA and High Space Technology Country. The country also runs a "low-profile" sounding rocket programme at the Centre for Space Transport and Propulsion, Epe.[184]

[181]Chizea, "Space Technology Development in Nigeria."
[182]Ibid.
[183]Ibid.
[184]Samuel Oyewole, "Space Research and Development in Africa," *Astropolitics* 15, no. 2 (2017): 191.

*Ghana* is a recent entrant into the space arena, having established its Ghana Space Science and Technology Centre (GSSTC) as an arm of the Ghana Atomic Energy Commission (GAEC) in 2011.[185] The Centre is currently based at the Commission's Graduate School of Nuclear and Allied Sciences, Atomic Campus, and is an initiative of the Ministry of Environment, Science, and Technology (MEST). The goal of the Centre is to "coordinate, undertake, spearhead, steer and manage all space science (including Astronomy) programmes, projects and research activities in the country", with the mission to "establish a centre of excellence in space science and technology to foster teaching, learning, commercial application of space research for the economic transformation of Ghana and the sub-region".[186] There were "speculations" that the Centre was to have been converted to the Ghana Space Agency in 2016, "intended to lead the nation's civilian space exploration efforts, in accordance with the National Science, Technology and Innovation Policy and Development Plan for 2011–2015", but this has not yet occurred.[187]

Like Kenya, Ghana also launched its first satellite as part of the Birds Project (Joint Global Multi-Nation Birds Satellite project) in partnership with the Kyushu Institute of Technology and the Japan Aerospace Exploration Agency (JAXA).[188] The first phase of the Birds Project entailed that "students shall design, develop and operate 5 units of identical 1U CubeSats (1 kg, 10 cm cubic) belonging to the five participating countries and operated from 7 ground stations (operation is done at 7 ground stations; the 5 participating countries including Thailand and Taiwan) to form first time in the world a constellation of 5 CubeSats operated in 7 networked ground stations".[189] Ghana's satellite was developed by students of the All Nations University in Koforidua and was sent into orbit from the International Space Station in 2017 along with NigeriaEduSat-1.[190] GhanaSat-1 (see Table 3.14) has two missions, namely, "detailed monitoring of the coastlines of Ghana" and "an educational piece—we want to use it to integrate satellite technology into high school curriculum".[191]

Interestingly, the success of GhanaSat-1 has prompted the "support of the president and cabinet support", with plans "to develop a GhanaSat-2, with high resolution cameras, that could monitor things such as illegal mining, water use, and

[185]Ghana Space Science and Technology Centre, "Ghana Space Centre," 2012, http://gsstc.gov.gh/# (accessed December 10, 2018).

[186]Ibid.

[187]Space in Africa, "List of Space Agencies in Africa," *African Space News*, June 22, 2018, https://africanews.space/list-of-space-agencies-in-africa/# (accessed December 10, 2018).

[188]Kyushu Institute of Technology, "Joint Global Multi Nation Birds 1," 2017, https://birds1.birds-project.com/index.html#about (accessed December 10, 2018).

[189]Ibid.

[190]British Broadcasting Corporation, "Ghana launches its first satellite into space," July 7, 2017, https://www.bbc.com/news/world-africa-40538471 (accessed December 10, 2018).

[191]Space in Africa, "Africa Space Race: Ghana's launches first satellite, now orbiting earth," *Africa Space News*, January 5, 2018, https://africanews.space/africa-space-race-ghanas-launches-first-satellite-now-orbiting-earth/ (accessed December 10, 2018).

**Table 3.14** Ghanaian satellites

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| GhanaSat-1[a,b] | 2017 | Low Earth orbit | • Part of "Joint Global Multi-Nation Birds Satellite project. Acronym as 'Birds project'" • "Successfully designed and developed satellite by Ghanaian students in Japan" • "Low and high resolution cameras on-board to take pictures of our homeland and provide data that can be used to monitor coastal areas of Ghana" • Launch site: International Space Station | • "Also has Digi-Singer SNG mission from which the national anthem and other independence songs will be broadcast from space as well as collect requested songs from the ground and send to the satellite to broadcast in space. An initiative aimed at stimulating interest in science, technology, engineering and mathematics (STEM) education in high schools and tertiary institutions" • "Will also embark on a scientific mission to investigate the radiation effects on commercial-off-the-shelf microprocessors. This means it will measure the single event latch-up occurrence that degrades electronic system on board satellites due to the harsh space environment and analyse this data to contribute to scientific research" • "Collaboration between the ANUC and the Kyutech Institute of Technology (KYUTECH) in Japan" • Key areas: Earth observation, capacity building |
| GhanaSat-2 | Future 2019? | | • Project of All Nations University Space Systems Technology Laboratory (ANU-SSTL) | • Key areas: meteorological/Earth observation |

[a]Benjamin Bonsu, "Ghana's first satellite (GhanaSat-1) will be launched to the International Space Station (ISS) by Space X, flight 11 from Kennedy Space Centre in Florida, USA on June 1, 2017 at 21:55 UTC," *Embassy of Ghana in Japan*, May 29, 2017, http://www.ghanaembassy.or.jp/pdf/2017_05_29.pdf (accessed December 10, 2018)
[b]Kyushu Institute of Technology, "Joint Global Multi Nation Birds 1"

deforestation in the country".[192] In November 2018, an announcement was made by the All Nations University Space Systems Technology Laboratory (ANU-SSTL) that "GhanaSat-2 is intended to be a meteorological Satellite in collaboration with

[192]Ibid.

the Ghana Meteorological Agency (GMA) to improve weather forecast and other related activities", with the goal to realise this satellite "hopefully by end 2019".[193] Because of these developments, while Ghana remains a third-tier EMSA for now, it can be considered as a Medium Space Technology Country.

*Côte d'Ivoire* appears set to have its first satellite placed in space in the near future, potentially making it the ninth African country to do so.[194] It is reported that Airbus beat the China Great Wall Industry Corporation in its bid "to provide an Earth observation satellite" for Côte d'Ivoire, which is seeking to "monitor its maritime borders".[195] This follows the announcement in 2015 by the Minister of Telecommunications that the country intends to utilise a satellite to "fight threats from pirates and terrorists in the Gulf of Guinea".[196] The launch date for the satellite is expected to be 2020 and will "monitor maritime borders, tackle terrorism and obtain better meteorological data for the country with a population of 25 million located in West Africa".[197] Côte d'Ivoire for now remains a third-tier EMSA and Low Space Technology Country (Table 3.15).

*São Tomé and Príncipe* is noteworthy since, as mentioned in Chap. 2, the country signed an MoU with India in September 2018 for ISRO (the Indian Space Research Organisation) to set up "a Space Centre" in São Tomé and Príncipe.[198] While the goal is to "enhance India's Space capabilities in wide range of areas including communication, Space monitoring, remote sensing, etc.", the agreement will "also enable joint space research and development activities, cooperation in providing satellite launch services and development of ground infrastructure for satellite programs".[199] São Tomé and Príncipe is a third-tier EMSA and Low Space Technology

**Table 3.15** Ivoirian satellite

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| | 2020? | | • Built by Airbus Defence and Space | • Key areas: Earth observation, meteorology, capacity building? |

[193]Space in Africa, "All Nations University unveils and demonstrates GhanaSat-2 mission concept," Africa Space News, November 24, 2018, https://africanews.space/all-nations-university-unveils-and-demonstrates-ghanasat-2-mission-concept/ (accessed December 10, 2018).

[194]Space in Africa, "Ivory Coast to become the 9th African Country with Satellite in Space," *Africa Space News*, July 26, 2018, https://africanews.space/ivory-coast-to-become-the-9th-african-country-with-satellite-in-space/ (accessed December 10, 2018).

[195]Spacewatch Africa, "Côte d'Ivoire To Acquire Earth Observation Satellite From Airbus, Rejects China Great Wall Industry Corporation," *ThorGroup GmbH*, July, 2018, https://spacewatch.global/2018/07/cote-divoire-to-acquire-earth-observation-satellite-from-airbus-rejects-china-great-wall-industries-corporation/ (accessed December 10, 2018).

[196]Space in Africa, "Ivory Coast to become the 9th African Country with Satellite in Space."

[197]Ibid.

[198]Space in Africa, "India and Republic of Sao Tome and Principe sign MoU to set up Space centre," *Africa Space News*, September 9, 2018, https://africanews.space/india-and-republic-of-sao-tomi-and-principe-sign-mou-to-set-up-space-centre/ (accessed December 10, 2018).

[199]Ibid.

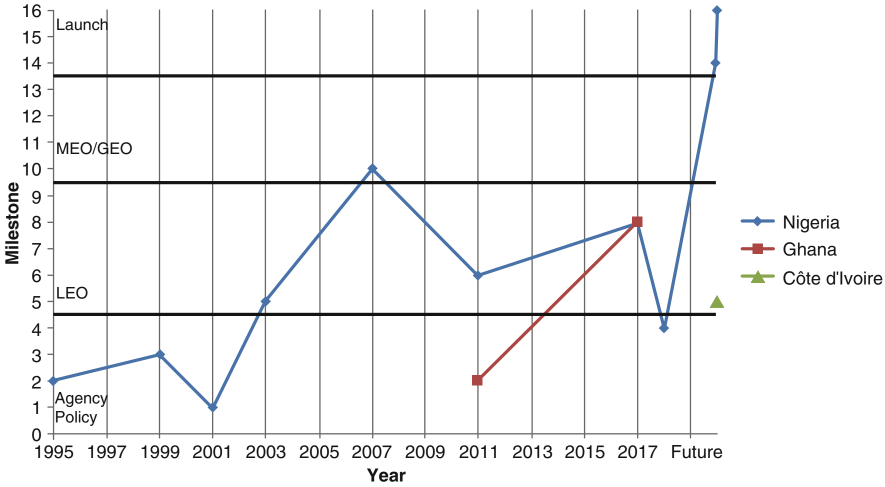


**Fig. 3.6** Milestone timeline—Community of Sahel-Saharan States (CEN-SAD)

Country, but this may pave the way towards setting up basic space activities in the country and a government space office.

As depicted in Fig. 3.6, Nigeria is by far the leading space actor in the region. It also has a wide-ranging engagement across categories of milestones. However, Ghana is a new and rising star, while Côte d'Ivoire will soon join with its first milestone. It is not certain if São Tomé and Príncipe will achieve a milestone in the near future, but it remains a country of note.

### 3.2.4 The East African Community (EAC)

A recent noteworthy development in the EAC region is that the East African Heads of State agreed during the 14th Northern Corridor Infrastructure Projects (NCIP) Summit in June 2018 "to launch a common Satellite that will serve the region".[200] This development follows on the 2012 signing of a deal between the East Africa Communications Organisation (EACO) and the International Telecommunications Satellite Organisation (ITSO) to "revamp the use of satellite technology in the region", and it is reported that the new common satellite will "help the region to easily enjoy access to telecommunications services for voice, data, video communications and internet".[201] It thus appears to be a planned communications satellite.

[200]Dan Ngabonziza, "EAC Leaders Agree on Common Satellite Project," *KT Press*, June 26, 2018, https://ktpress.rw/2018/06/eac-leaders-agree-on-common-satellite-project/ (accessed December 11, 2018).

[201]Ibid.

Under this agreement, ITSO will "help in developing human capital through training telecommunication experts within the region".[202] The proposed satellite is also meant to drive forward regional integration in the EAC region.

EAC members, Kenya (the only emerging space middle power identified within this REC) and Rwanda, have already been discussed earlier and will thus be excluded here. Among the remaining members, no country has as yet achieved, or is planning in the near future to achieve, any of the Space Technology Ladder milestones, although Tanzania has been reported as engaging in the "training of engineers and research collaborations" in relation to the African Space Policy and Strategy.[203]

### *3.2.5 Economic Community of Central African States (ECCAS)*

ECCAS counts among its members the Democratic Republic of the Congo, Rwanda, and São Tomé and Príncipe, which will thus be excluded here to avoid repetition. No emerging space middle powers were identified in this REC, although, as will be seen, Angola has the most promising space sector in the region.

*Angola* was identified in Chap. 2 as an underperformer in space when measured against expectations of its power internationally, but when considering its domestic space sector developments, this assessment is not warranted as the country is showing strong signs of ramping up its space efforts. Angola began its space efforts in 2006, when the AngoSat project was initiated through a decree.[204] This was followed in 2008 when a "government resolution established the need to set up a satellite telecoms infrastructure in the country".[205] While this resolution was directed at formalising the AngoSat project, it "covers not only the production, launch and operation of the satellite, but also the creation of national capability in human resources and infrastructure in the field of outer space".[206] Following this, in 2009, Angola signed an agreement with Russia for the development of the Angosat-1, and "[a]s part of the deal, Energia built a control centre in Funda, in north-western Angola, manned by local employees".[207]

[202]Ibid.

[203]Rusana Philander, "Tanzania, Three Other Nations Leading Africa into Space?," *TZ Business News*, no date, http://www.tzbusinessnews.com/tanzania-three-other-nations-leading-africa-into-space/ (accessed December 11, 2018).

[204]Jaroslaw Adamowski, "Angola eyes new satellite as African space race accelerates," *Space News*, June 12, 2018, https://spacenews.com/angola-eyes-new-satellite-as-african-space-race-accelerates/ (accessed December 11, 2018).

[205]Helena Correia Mendonça, "With Angosat-1 a New African Country Reaches Space," *Via Satellite*, March, 2018, http://interactive.satellitetoday.com/via/march-2018/with-angosat-1-a-new-african-country-reaches-space/ (accessed December 11, 2018).

[206]Ibid.

[207]Adamowski, "Angola eyes new satellite as African space race accelerates."

The AngoSat project also received attention in the National Development Plan 2013–2017 and the White Book on ICT from 2011, which "once again highlighted the need to develop national industries and know-how in space technology, an objective boosted by the AngoSat", and also provided a preliminary outline of the National Space Program and its objectives.[208] By 2013 the country had also set up the Inter-ministerial Commission for the General Coordination of the National Space Program (Gabinete de Gestao do Programa Espacial Nacional—GGPEN) and the Angolan National Office for Space Affairs, with the former mandated to oversee the AngoSat project and "study the need for a space agency in the country, among other responsibilities", while the latter was mandated to pursue "strategic studies aimed at establishing cooperation agreements in the space field, among other tasks".[209] In May 2017, the Angolan Space Strategy 2016–2025 was also published.

The strategy clearly outlines that, by 2025, Angola envisions itself as being a "country with space infrastructures, with scientific and technological capabilities in this field, which takes advantage of space for its socio-economic development—placing space at the service of its citizens, the industry and the State—and that assumes a leadership and cooperation role at the regional and international levels".[210] The strategy also outlines five pillars—space infrastructure, capacity building and promotion, industry and technology, international positioning, and organisation and cooperation—with three priority space projects, the AngoSat-1, the Angolan Centre for Space Studies, and the creation of a space agency.[211]

AngoSat-1 was the country's first communications satellite, which was built by Russia's RSC Energia, but failed relatively soon after it entered into service.[212] The loss of this satellite was covered by insurance "worth $121 million" with Russia covering the "remaining $199 million".[213] It is planned for a replacement AngoSat-2 to launch in 2020. In the interim, the country is "using capacity on third-party communications satellites paid for by Russia as part of a compensation package for the failure in orbit of AngoSat-1".[214]

Angola's efforts mean it is on the borderline of becoming a third-tier EMSA, and while it has, as yet, no space agency, it is a Medium Space Technology Country, meaning that it cannot be seen as an underperformer in the sector (Table 3.16).

*Gabon* is in the very beginning stages of establishing its space sector. In 2015, the Gabonese Agency for Space Studies and Observations (l'Agence gabonaise d'études

[208]Mendonça, "With Angosat-1 a New African Country Reaches Space."

[209]Ibid.

[210]Ibid.

[211]Ibid.

[212]Adamowski, "Angola eyes new satellite as African space race accelerates."

[213]Ibid.

[214]Spacewatch Africa, "Angola Using SATCOM Capacity Paid For By Russia As Compensation For AngoSat-1 Failure," September, 2018, https://spacewatch.global/2018/09/angola-using-satcom-capacity-paid-for-by-russia-as-compensation-for-angosat-1-failure/ (accessed December 11, 2018).

**Table 3.16** Angolan satellites

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| AngoSat-1[a,b] | 2017 | Geostationary | • "Power of 3753 W in the CKu band with 16 C + 6 Ku repeaters"<br>• "Primary control and mission centre in Angola and a secondary centre in Russia in Korolev"<br>• Launch site: Baikonur | • "Angola will be responsible for mission control during this period"<br>• "A crucial role in the proliferation of tele-medicine, a way of providing clinical care from a distance using telecommunications"<br>• "Expand satellite communications services, internet access, radio, and television"<br>• "Expected that the satellite will have a 99.2% of its capacity used, with 40% of the satellite capacity already assigned to operators, 10% to national security and defence services, and another 10% to social initiatives (such as in the sectors of education, health, and small businesses). The investment is expected to be recouped in about 2 years"<br>• Key areas: communication, capacity building |
| AngoSat-2[c] | Future 2020? | Geostationary? | • "Will have better technical possibilities than the lost AngoSat-1 satellite"<br>• "Roscosmos to build Angola's second satellite"<br>• Launch site: Baikonur? | • Key areas: communication |

[a]GlobalSecurity.org, "Angola in Space," 2018, https://www.globalsecurity.org/space/world/angola/index.html (accessed December 11, 2018)
[b]Mendonça, "With Angosat-1 a New African Country Reaches Space"
[c]Andrea Ayemoba, "Angola accepts Russian offer to build AngoSat-2," *Africa Business Communities BV*, April 26, 2018, https://africabusinesscommunities.com/news/angola-accepts-russian-offer-to-build-angosat-2/ (accessed December 11, 2018)

et d'observation spatiales—AGEOS) was established at Nkok, 27 km from the capital Libreville.[215] The Agency was established with "various technical and scientific partners including the National Centre for Space Studies (CNES), Zodiac Data Systems (ZDS), the U.S. Agency for Geological Studies (USGS), Telespazio France and the French Institute Development research [which] has helped to equip Gabon with this tool to improve and better manage its natural resources, land and marine space".[216] The Agency is reported to possess a "reception antenna which covers a 2800-kilometer circle encompassing 23 African countries, the totality of the Congo Basin and Ogooué Basin forests, a part of West Africa and the entire Gulf of Guinea" and has the goals of research, innovation, and development.[217] Telespazio France also maintains EarthLab in Gabon, which is an "environmental monitoring centre", and allows for the creation of local and regional momentum in the field of environmental monitoring, value added services in the fields of maritime surveillance and mapping, "[i]ncrease[d] momentum for space services in Gabon", and expertise in Africa in the field of satellite Earth observation.[218] EarthLab in part relies on "AGEOS infrastructure and resources (and in particular a satellite reception antenna over 7 meters wide)".[219]

Gabon for now remains a third-tier EMSA and borderline Medium Space Technology Country.

Figure 3.7 highlights that Angola is the space leader within the ECCAS region due to having achieved two milestones.

### *3.2.6 The Economic Community of West African States (ECOWAS)*

Since the membership of ECOWAS overlaps with that of CEN-SAD, no countries remain to be discussed here. Nigeria was the only emerging space middle power identified here.

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[215]Sylvain Moussavou, "Gabon: Inauguration de l'Agence gabonaise d'études et d'observation spatiales," *Koaci*, August 30, 2015, http://koaci.com/gabon-inauguration-lagence-gabonaise-detudes-dobservation-spatiales-90932.html (accessed December 11, 2018).

[216]Ibid.

[217]Ibid.

[218]FGIS Gabon, "EarthLab Gabon (EGSA)," 2014, http://www.fgis-gabon.com/?page_id=996# (accessed December 11, 2018).

[219]EarthLab, "Gabon confirms its space ambitions," *Telespazio France*, December 20, 2013, http://www.earthlab-galaxy.com/en/news/gabon-confirms-its-space-ambitions/ (accessed December 11, 2018).

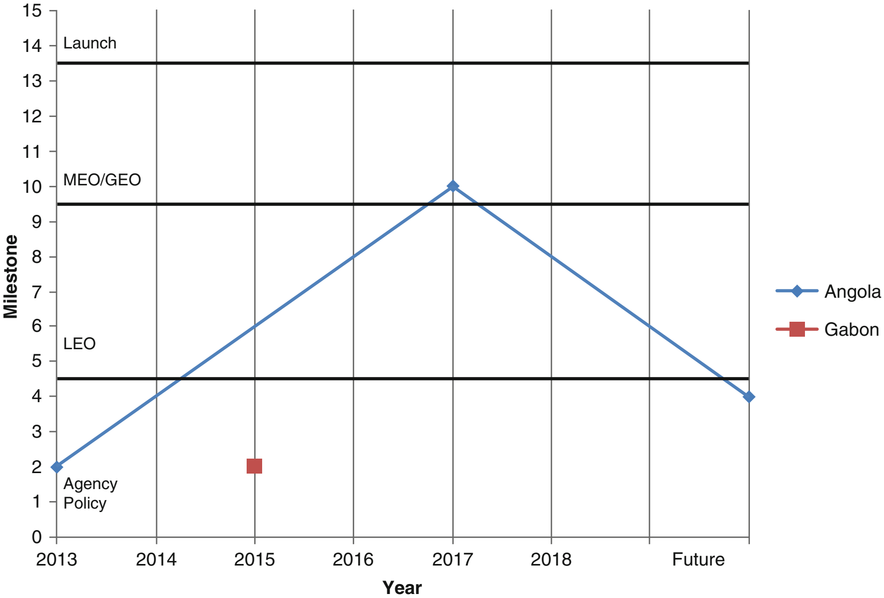


**Fig. 3.7** Milestone timeline—Economic Community of Central African States (ECCAS)

### *3.2.7 The Intergovernmental Authority on Development (IGAD)*

Apart from South Sudan, which has no space sector as yet, all countries of IGAD overlap with COMESA, and thus will not be repeated here. Kenya was the only space middle power identified in IGAD.

### *3.2.8 The Southern African Development Community (SADC)*

SADC includes among its membership Angola, the Democratic Republic of the Congo, Malawi, Zimbabwe, and Mauritius, and thus only the remaining countries will be considered here. South Africa was the only identified emerging space middle power, and the discussion will begin there.

*South Africa* can be rightfully considered as one of Africa's leading space nations, and it was, as seen in Chap. 1, the only African country identified by Harding as being a second-tier EMSA due to the launch vehicle development by the apartheid regime, which was cancelled at the time of democratic transition due to international pressures.[220] In the post-apartheid era after 1994, South Africa inherited space-related physical infrastructure, including "[a]t least six units within the Council for Scientific and Industrial Research [CSIR] [which] are actually or potentially space-related", with a Defence, Peace, Safety, and Security Unit, Materials Science and Manufacturing Unit, National Laser Centre, Satellite Applications Centre (SAC) (now known as SANSA Space Operations SSO), and high-speed computing network.[221] It also inherited the Institute of Satellite and Software Applications (ISSA), also known as Houwteq (and now operated by Spaceteq[222]), with "facilities for satellite integration: a clean room, the biggest anechoic chamber in the southern hemisphere, and a vacuum and thermal stress chamber", a vibration table able to test satellites weighing up to 1 tonne, 23 tonne capable gantry cranes, and work stations.[223] The third main component of heritage infrastructure is the Overberg Test Range, built as an "eastwards and polar space launch facility, with a control centre, three launch pads, a 4.5 m tracking antenna, cinetheodolites and radar tracking facilities, and an air transportable tracking station", in total covering 43,000 hectares and capable of hosting up to 120 engineers.[224] The South African Air Force's Test Flight and Development Centre with a primary runway 3115 m long, and "good telemetry and optical tracking facilities" with three prefab hangar bays capable of servicing a 5 tonne flying test bed each, or a 100 tonne technology demonstrator in total, plus the South African Airforce Waterkloof Base with engine test cells and "other very under-used R&D facilities", forms another component.[225] Upington Airport's 4.9-km-long runway is the longest in Africa, and "spacious aircraft parking facilities" makes it "suitable to become a test flight area".[226]

Various pieces of legislation have also been passed since 1993 relating to space. The first were the Space Affairs Act 84 of 1993, and the Space Affairs Amendment Act 64 of 1995, together addressing "the regulatory obligations accepted by the Government under international treaties".[227] Additionally, the Space Affairs Act of 1993 established the South African Council for Space Affairs under the Ministry of Trade and Industry to "undertake regulatory functions".[228] The Astronomy

[220] Harding, *Space Policy in Developing Countries: The Search for Security and Development on the Final Frontier*; Samuel Oyewole, "Space Research and Development in Africa," *Astropolitics* 15, no. 2 (2017): 191.

[221] Keith Gottschalk, "South Africa's space programme – Past, present, future," *Astropolitics* 8, no. 1 (2010): 4–5

[222] Spaceteq, "About," 2018, https://www.spaceteq.co.za/ (accessed December 11, 2018).

[223] Ibid.

[224] Ibid.

[225] Ibid.

[226] Ibid.

[227] Ibid., 6.

[228] South African Council for Space Affairs, "Report 2006–2009," 2009, 10, http://www.sacsa.gov.za/reports/SACSA_report_2009.pdf (accessed December 11, 2018).

Geographic Advantage Act 21 of 2007 provides powers to the government to "cap or ban radio and light pollution that would impair the sites of radio- and optical telescopes" in order to protect the Southern African Large Telescope (SALT) and subsequent Square Kilometre Array.[229] The South African National Space Agency Act 36 of 2008 provided for the creation of the South African National Space Agency (SANSA) in 2010 under the Department of Science and Technology, which "will not attempt to manufacture in-house, but will outsource building satellites and software development to the private sector".[230] Preceding the establishment of SANSA, the Department of Science and Technology issued the National Space Strategy and Policy.[231] SANSA works under its Strategic Plan 2015/2020, while the Department of Science and Technology is guided by its own 10-year innovation plan.[232]

Prior to these developments, space activities in the country during the mid- to late 1990s "took place in an isolated, uncoordinated ad hoc fashion at the institutional level and in a policy vacuum at national level".[233] One such activity was the building of South Africa's first satellite, SunSat, by students and academics at Stellenbosch University, launched in 1999 with the "first push-broom imager on a microsatellite platform that achieved a 12-m resolution", and this became the first object to be registered under the Space Affairs Act.[234] The spin-off company Sunspace also built the second South African satellite, Sumbandila[235], which was launched in 2009, with SunSat and Sumbandila being "Africa's first two microsats that were entirely constructed on the continent, demonstrating hi-tech industrial capabilities".[236] To date, South Africa has placed seven satellites in orbit (Table 3.17). The country has been described as having "the largest and most active space technology on the continent"[237] and as "the undisputed industrial hotspot of Africa's nascent space industry" with "a remarkable and intentional collaboration between government agencies, academic institutions and private sector companies in the development

[229]Ibid.

[230]Ibid., 6, 8.

[231]Peter Martinez, "The development and initial implementation of South Africa's national space policy," *Space Policy* 37, (2016):37.

[232]South African National Space Agency, "Documents," no date, https://www.sansa.org.za/documents/ (accessed December 11, 2018).

[233]Ibid., 31.

[234]Ibid.

[235]Sumbandila means 'lead the way' in Tshivenda, one of the 11 official languages of South Africa; South African Agency for Science and Technology Advancement, "Sumbandila – leading the way to a brighter future," November 9, 2009, http://www.saasta.ac.za/images/pdfs/EasyScienceNovember09.pdf (accessed December 14, 2018).

[236]Gottschalk, "South Africa's space programme – Past, present, future," 8.

[237]Fredrick Ngugi, "Top 5 African Countries with Advanced Space Programs," *Face2Face Africa*, August 15, 2017, https://face2faceafrica.com/article/top-5-african-countries-advanced-space-programs (accessed December 11, 2018).

**Table 3.17** South African satellites

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| SunSat[a] | 1999 | Sun-synchronous | • "Following instrumentation onboard: high resolution imager, precision attitude control, magnetometer, GPS array, retroreflector array: a hemispherical annulus mounted to the boom. The RRA has eight corner cubes made of fused silica, radio amateur communications (operated as OSCAR 35 or SO 35)"<br>• Launch site: Vandenberg Air Force Base | • "Primary mission objectives are imaging, worldwide store-and-forward email communications, and satellite engineering research. Secondary mission objectives are studies of the earth magnetic field, gravity field, atmosphere, and ionosphere plus intercomparison of GPS and SLR precision orbits"<br>• Key areas: Earth observation, capacity building |
| SumbandilaSat[b,c] | 2009 | Sun-synchronous | • Formerly ZASat-002<br>• "ZASat became in fact a National Space Program Initiative, consisting of two parts: (1) The development of a microsatellite bus by SunSpace as prime contractor; (2) The research and human resource development is largely the responsibility of Stellenbosch University over a period of 4 years (a considerable number of students will be involved in research work on various aspects of remote sensing satellites and payloads)"<br>• "GSD imager with a ground resolution of 6.25 m. Live downlinking of PAL video images during TT&C ground station passes will also be possible. Additional experiments are VLF measurements, an amateur radio payload, an AIS experimental payload and a vibrating string experiment"<br>• Launch site: Baikonur | • "Operated from the SANSA (South African National Space Agency) SSO (SANSA Space Operations) ground station in Pretoria, supported on an ad-hoc basis by Sunspace via the ESL (Electronic Systems Laboratory) ground station in Stellenbosch"<br>• Key areas: Earth observation, capacity building |

(continued)

**Table 3.17** (continued)

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| ZACube-1 (South Africa CubeSat-1)/ TshepisoSat[d,e] | 2013 | Sun-synchronous | • "A student-developed 1U CubeSat of CPUT (Cape Peninsula University of Technology), Cape Town, South Africa"<br>• "Main payload is a high frequency (HF) beacon transmitter that will be used to help characterize the Earth's ionosphere and to calibrate SANSA's (South African National Space Agency) auroral radar installation at the SANAE-IV base in Antarctica"<br>• "In-house developed subsystems:– VHF/UHF Transceiver—145.86 MHz Uplink—437.345 MHz Downlink– Payload Board—HF Beacon Transmitter—ADCS—Camera Payload– HF Antenna Deployment Mechanism"<br>• Launch site: Dombarovsky (Yasny), Russia | • "ZACube-1's ADCS was developed in a collaboration between F'SATI [French South African Institute of Technology] and ESL (Electronic System's Laboratory) at Stellenbosch University, Stellenbosch, South Africa"<br>• Key areas: technology, capacity building |
| Kondor-E[f,g] | 2014 | Low Earth orbit | • "Designed by NPO Mashinostroyeniya"<br>• "Features a S-band synthetic aperture radar (SAR), which can conduct both continuous swath surveys or detailed spot surveys. The swath width is 10 km. Ground resolution is 1–2 m in spotlight mode, 1–3 m in stripmap mode and 5–30 m in ScanSAR mode"<br>• Launch site: Baikonur | • "Operator: Russian Ministry of Defense"<br>• "Top-secret spy satellite"/"military satellite"<br>• "Project and details thereof are classified"<br>• "Project was first called Project Flute and then Project Consolidated Flute"<br>• "Reportedly a type frequently used for spying, capable of collecting radar images—at night through cloud cover—of objects as small as cars"<br>• "It appears SA has spent money financing a Russian company to build a satellite we will have no control over and won't be able to operate from SA"<br>• Key areas: military, surveillance |

(continued)

**Table 3.17** (continued)

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| nSight-1[h] | 2017 | Low Earth orbit | • "2U-CubeSat for technology development and upper atmosphere science"<br>• "Developed and built at SCS-Space, South Africa"<br>• "Carries the first flight model of the SCS Gecko imager, a very compact RGB camera with a ground sampling distance of approximately 30 m"<br>• "Carries the FIPEX (Flux-Φ-Probe Experiment) of TU Dresden as the primary payload for the QB50 project, which is able to distinguish and measure the time-resolved behaviour of atomic and molecular oxygen as a key parameter of the lower thermosphere"<br>• Launch site: International Space Station | • "Main objectives of the mission are: To comply with the QB50 mission objective of doing atmospheric research measurements in the lower thermosphere; To provide first space flight heritage for the SCS Gecko imager; To demonstrate a patented radiation mitigation VHDL coding technique developed by Nelson Mandela Metropolitan University; To showcase the capability of South Africa's private space sector"<br>• "It is a part of the QB50 constellation to gather science data in the upper layers of the troposphere in the altitude range from 350 km down to 200 km. The QB50 project, which demonstrates the possibility of launching a network of 50 CubeSats built by Universities Teams all over the world to perform first-class science in the largely unexplored lower thermosphere"<br>• Key areas: Earth observation, technology, capacity building |
| ZA-AeroSat[i,j] | 2017 | Low Earth orbit | • "2U-CubeSat for technology development and upper atmosphere science"<br>• "Carries four feather communication antennas, which are also used for passive aerodynamic stabilisation"<br>• "Developed and built at the Stellenbosch University, South Africa"<br>• Launch site: International Space Station | • "Part of the QB50 constellation to gather science data in the upper layers of the troposphere in the altitude range from 350 km down to 200 km. The QB50 project, which demonstrates the possibility of launching a network of 50 CubeSats built by Universities Teams all over the world to perform first-class science in the largely unexplored lower thermosphere" |

(continued)

**Table 3.17** (continued)

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| | | | | • "Stellenbosch University, the mother of South Africa's civil space research, established its second spin-out company—CubeSpace (first was SunSpace) to commercialize its microsatellite programme. CubeSpace built the ZA-AeroSat mini-satellite for the European Union's QB50 constellation of 50 CubeSats" • "Science data, telemetry data, as well as images captured by the star and Nadir cameras were sent to the ground station with each communications opportunity" • Key areas: technology, capacity building |
| XinaBox ThinSat[k] | 2018 | Low Earth orbit | • "Sensors and the data to be collected include: An inertial measurement unit (IMU) to measure and report the ThinSats' angular rate, and the magnetic field surrounding the body, using a combination of accelerometers, gyroscopes, and magnetometers. This data will allow the students to calculate pitch, yaw and roll of the satellite to describe its flight; A set of light sensors to assess visible light (lux), Ultra-Violet A and Ultra-Violet B. Using this data, the teams can calculate the light available for the solar cells to charge the on-board batteries, as well as the UV-Index experienced by the satellite, as it has no protection from our Earth's | • "Schools participating include 16 schools in the Western Cape of South Africa, collaborating on one ThinSat. These schools will be able to share their data with the USA-based schools collaborating on 54 ThinSats, collectively creating a BIGData project with never-before collected data" • "Fifty-five student ThinSats will be deployed at an altitude of roughly 250 km and will enter what is known as Extreme Low Earth Orbit (ELEO)" • Key areas: capacity building, technology |

(continued)

**Table 3.17** (continued)

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| | | | atmosphere; Multiple temperature sensors on the frame of the satellite, as well as the interior of the ThinSat. The satellites will experience extreme temperature swings from way below zero when in the Earth's shadow, and over 150 degrees centigrade when in full sun. Everyone is hoping to collect the temperature profile as the ThinSat burns up in our atmosphere!; Radiation detection in the Infra-Red range, to complete the knowledge of the conditions the ThinSat finds itself; Each set of six ThinSats will have a GPS giving their location in orbit, and at least one will have a camera for orbital selfies"<br>• Launch site: Wallops Island in Virginia, USA | |
| ZACube-2[l,m] | December 2018 | Sun-synchronous | • "The most advanced Nanosatellite from Africa"<br>• "Developed at the French South African Institute of Technology (F'SATI), of CPUT (Cape Peninsula University of Technology), Cape Town, South Africa"<br>• "Will serve as technology demonstrator for essential subsystems and form the basis on which an innovative Software Defined Radio (SDR) platform will be developed as primary payload"<br>• "Additionally, the satellite will feature a medium resolution imager as secondary payload to demonstrate the feasibility of future remote sensing | • "The mission will further grow the core expertise of CPUT and its technology partners and validate the technology innovations that result from it. ZACube-2 will be a test bed for a ship tracking payload and will be used to validate the use case of employing nanosatellites in ocean vessel detection through the Automatic Identification System (AIS) protocol. Additionally, the satellite will carry medium resolution imagers as a secondary payload to demonstrate the feasibility of using a nanosatellite for imaging applications, such as ocean colour monitoring and fire tracking" |

(continued)

**Table 3.17** (continued)

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| | | | applications such as ocean colour monitoring and large fire tracking"<br>• "Initiative funded by the Department of Science and Technology, the South African National Space Agency, the National Research Foundation and the Cape Peninsula University of Technology. Other technology partners on the project include the CSIR, Stone Three, Clyde Space, Stellenbosch University and Astrofica"<br>• Launch site: Vostochny, Russia | • "Main payload on the satellite is an AIS (automatic identification system) receiver with which navigational data will be received from ships along our coast. This data, which includes the ships' GPS coordinates, registration information, speed and direction of travel, will assist the authorities to track ship traffic in our exclusive economic zone, and improve the safety of ships. ZACube-2 also carries an advanced camera, which will detect forest and veldts fires. ZACube-2 serves as a precursor mission for two future satellite constellations—the one for Maritime Domain Awareness in support of Operation Phakisa and the other a FireSat constellation to track fire on the African continent"<br>• Key areas: capacity building, disaster monitoring, navigation, technology |
| EOSat-1[j,n] | 2020? | | • "High resolution multispectral imaging satellite, which will be used for urban planning and development, safety and security, disaster management and food security"<br>• "EOSat-1 will have a 2.5 m resolution imager and is planned to have a life span of 7 years. Launch is scheduled for 2020. However, the programme is hampered by a lack of funding—in addition to the satellite, the ground station and | • "EOSat-1 forms part of the African Resource Management Constellation (ARMC)"<br>• "Denel's Spaceteq—a subsidiary of Denel Dynamics, a division of Denel SOC Ltd, a South African armaments development and manufacturing company entirely owned by the South African Government. Spaceteq incorporated the satellite manufacturer, SunSpace, and absorbed its assets, engineering |

(continued)

**Table 3.17** (continued)

| Satellite | Launched | Orbit | Features | Focus |
|---|---|---|---|---|
| | | | launch also need to be funded. For instance a new X-band antenna will need to be built for EOSat-1" | talents and legacies including the SumbandilaSat. Spaceteq is developing the EOSat-1" |
| nSight-2 and nSight-3[n] | 2019 and 2020? | | • "SCS is now working on nSight-2 and nSight-3, with nSight-2 to be launched in 2019 and nSight-3 in 2020" | • "They will be used for agricultural applications" |
| Unknown[j] | | | • "Mzanzisat is building a satellite infrastructure to provide internet access to remote communities in South Africa" | |

[a]Gunter Dirk Krebs, "Sunsat (SO 35, Sunsat-OSCAR 35)," *Gunter's Space Page*, December 11, 2017, https://space.skyrocket.de/doc_sdat/sunsat.htm (accessed December 11, 2018)
[b]eoPortal, "SumbandilaSat," European Space Agency, https://directory.eoportal.org/web/eoportal/satellite-missions/s/sumbandilasat (accessed December 11, 2018)
[c]Gunter Dirk Krebs, "Sumbandila (ZA-002, SO 67, SumbandilaSat-OSCAR 67)," *Gunter's Space Page*, December 11, 2017, https://space.skyrocket.de/doc_sdat/sumbandila.htm (accessed December 11, 2018)
[d]Gunter Dirk Krebs, "ZACube-1 (TshepisoSat, ZA 003)," *Gunter's Space Page*, December 11, 2017, https://space.skyrocket.de/doc_sdat/zacube-1.htm (accessed December 11, 2018)
[e]Renier Siebrits, "The First African CubeSat, ZACube-01," Cape Peninsula University of Technology, August 7, 2011, http://mstl.atl.calpoly.edu/~bklofas/Presentations/SummerWorkshop2011/Sebrits_ZACUBE-01.pdf (accessed December 11, 2018)
[f]Gunter Dirk Krebs, "Kondor-E," *Gunter's Space Page*, August 5, 2018, https://space.skyrocket.de/doc_sdat/kondor-e-1.htm (accessed December 11, 2018)
[g]Mybroadband, "Top-secret South African satellite," October 26, 2014, https://mybroadband.co.za/news/security/112881-top-secret-south-african-satellite.html (accessed December 11, 2018)
[h]Gunter Dirk Krebs, "nSIGHT 1 (QB50 AZ02)," *Gunter's Space Page,* June 25, 2018, https://space.skyrocket.de/doc_sdat/nsight-1.htm (accessed December 11, 2018)
[i]Gunter Dirk Krebs, "ZA-AeroSat (QB50 AZ01)," *Gunter's Space Page,* June 25, 2018, https://space.skyrocket.de/doc_sdat/za-aerosat.htm (accessed December 11, 2018)
[j]Ibeh, "Why the South African Space Industry is Progressive"
[k]Space in Africa, "Satellite built by South African students to be launched on Thursday," *Africa Space News*, November 11, 2018, https://africanews.space/satellite-built-by-south-african-students-to-be-launched-on-thursday/ (accessed December 11, 2018)
[l]Gunter Dirk Krebs, "ZACube-2 (ZA 004)," *Gunter's Space Page,* November 20, 2018, https://space.skyrocket.de/doc_sdat/zacube-2.htm (accessed December 11, 2018)
[m]Space in Africa, "ZACube-2, Africa's most advanced Cubesat to be launched on December 25," *Africa Space News*, November 18, 2018, https://africanews.space/zacube-2-africas-most-advanced-cubesat-to-be-launched-on-december-25/ (accessed December 11, 2018)
[n]Guy Martin, "South Africa to increase focus on space," *DefenceWeb*, April 17, 2018, http://www.defenceweb.co.za/index.php?option=com_content&view=article&id=51386:south-africa-to-increase-focus-on-space&catid=35:Aerospace&Itemid=107 (accessed December 11, 2018)

of space industry ecosystem"[238], as is also reflected in Table 3.17, and is a second-tier EMSA and High Space Technology Country. While the country is not seeking launch capability, the University of Kwazulu-Natal maintains its Phoenix Hybrid Sounding Rocket Program (HSRP), which was started in 2010 within the School of Engineering's Aerospace Systems Research Group (ASReG).[239] It's most recent and most advanced sounding rocket is the Phoenix-1B Mk II, with a design apogee of 35 km and with development started in 2017.[240]

*Namibia* has recently set up its National Space Science Council (2015), with a mandate to facilitate the development of a "national agenda related to Space Science in all sectors", which "may include national space policy development, provide a strategic direction on matters related to Space Science e.g. ethics in space science research, identify space activities relevant to Namibia, and promote space research and development".[241] One of the country's citizens has also enrolled at the Kyushu Institute of Technology (KYUTECH) in the Space Engineering International Course (SEIC), with the aim of having Namibia join the Birds Project in 2020 and develop its first satellite, NamSat.[242] For now, Namibia remains a third-tier EMSA and Low Space Technology Country.

Figure 3.8 depicts the milestones achieved by South Africa and Namibia, and while SADC includes other members such as Angola, South Africa is the clear leader in space capabilities based on the Space Technology Ladder. South Africa's space legacy stems from the 1980s in particular, and while the country does not maintain launch capability, as it was on the verge of achieving in the early 1990s, this achievement is included in the figure since the infrastructure and skills legacy of that period largely remain in the country.

## 3.3 Other Capabilities

Having thus considered the capabilities and achievements of African countries in the context of the modified Space Technology Ladder, in concert with Harding's model of emerging space actors (EMSAs) and the space technology categories of Al-Rumhi et al. (as well as concepts from the Technology Readiness Level framework—such as

[238]Joseph Ibeh, "Why the South African Space Industry is Progressive," Africa Space News, November 29, 2018, https://africanews.space/why-the-south-african-space-industry-is-progressive/ (accessed December 11, 2018).

[239]University of Kwazulu-Natal, "Phoenix Hybrid Sounding Rocket Program," no date, http://aerospace.ukzn.ac.za/Projects/Phoenix.aspx (accessed December 11, 2018).

[240]University of Kwazulu-Natal, "Phoenix-1B Mk II Hybrid Sounding Rocket," no date, http://aerospace.ukzn.ac.za/Rockets/Phoenix-1B_Mk_II.aspx (accessed December 11, 2018).

[241]National Commission on Research Science and Technology, "National Space Science Council Established," March 5, 2015, http://www.ncrst.na/news/64/-National-Space-Science-Council-Established/ (accessed December 11, 2018).

[242]Space Generation Advisory Council, "The first Namibian steps towards space," August 17, 2018, https://spacegeneration.org/namibian-steps-to-space (accessed December 11, 2018).

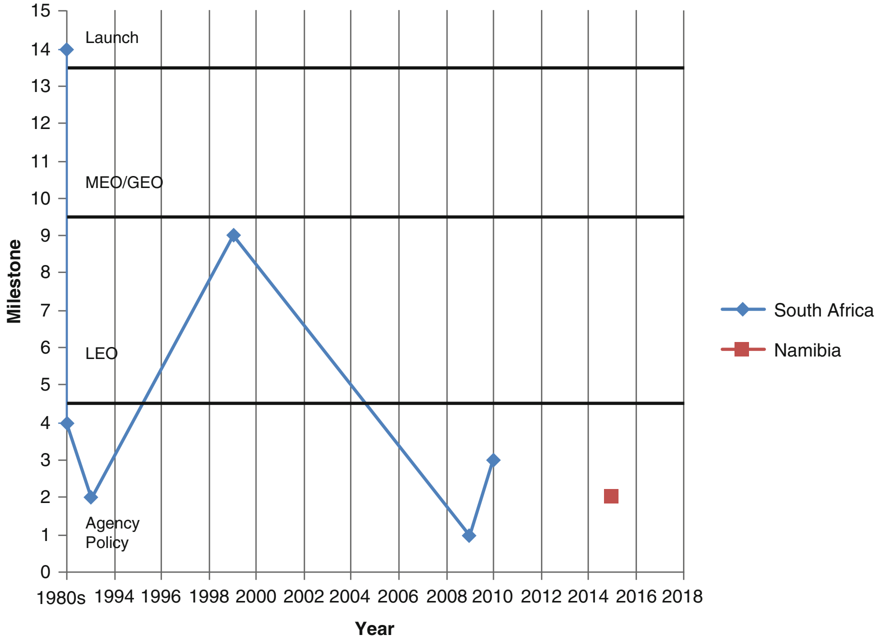


**Fig. 3.8** Milestone timeline—Southern African Development Community (SADC)

reported upcoming satellites), this section will supplement this overview with a selection of other space-related capacities and factors. The first of these will be astronomy-related capabilities and other ground segment infrastructure not already discussed. The second will consider a brief overview of Africa's scientific and research output related to space, since a consideration of space capabilities is incomplete without also considering intellectual endeavours. The third, and final, factor will be that of space-related budgets and expenditure. As Oyewole put it, it "is important to understand the priority given to space by governments of African states vis-à-vis their capacities to pay the bill".[243]

### *3.3.1 Ground Segment Infrastructure*

Some aspects of ground segment infrastructure have already been discussed earlier, such as satellite testing and integration centres, and satellite control centres set up in the context of satellite contracts of various African countries, such as Angola and its Russian-built control centre in Funda for AngoSat-1. The Square Kilometre Array was also discussed in Chap. 2. This section will thus present a summary of Africa's space ground infrastructure, including developments detailed earlier in this volume. In some cases, such as the Hammaguir launch site in Algeria, facilities were not in

[243]Oyewole, "Space Research and Development in Africa," 195.

use in for extended periods of time, but nevertheless warrant inclusion as heritage infrastructure, and for their legacy that might in future be taken up again.

Table 3.18 provides a good indication of Africa's space-related ground infrastructure and also includes new and ongoing developments such as the Chinese-funded New Cairo Space City. The next section will consider the scholarly output of Africa related to the space sector.

### *3.3.2 Scientific and Research Output*

One of the great concerns echoed throughout this volume is that much still needs to be done in terms of investment in science, mathematics, engineering, and related skills, which are of absolute necessity to growing the continent's space sector. The result of the "decades'-long individual national attitude of its member states towards science and technology, the indisputable foundation of any space programme"[244] was observed in March of 2018 when Elsevier reported that "Africa generates less than 1% of the world's research"[245]. This shocking statistic is a clarion call to the continent's decision-makers and leaders to implement the goals outlined in the Agenda 2063 as discussed in Chap. 1. Before investigating how this relates to the space sector, a few other observations are noteworthy.

First, in a more positive view, Elsevier also reports that Africa "has by far the strongest growing scientific production: 38.6 percent over a 5-year period from the start of 2012 to the end of 2016" and that "[t]he number of authors is growing at an equally astounding rate of 43 percent over that period".[246] Second, while this is a positive growth trajectory, it is also undeniable that much of Africa's research is produced in only a few countries and the "bulk of Africa's scientific production originates from Algeria, Egypt, Kenya, Morocco, Nigeria, South Africa and Tunisia"[247]—not coincidentally also the *exact same* countries identified as Africa's emerging space middle powers. Of these, South Africa is "the highest research output producing country in Africa, holding two positions in the top 200 Times Higher Education World University Rankings".[248] This powerfully suggests that scientific research and output have a strong impact on, and correlation with, the success of a country's space efforts. However, a few other rising stars were also

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[244] Abiodun, "Trends in the Global Space Arena – Impact on Africa and Africa's Response," 288.

[245] Charon Duermeijer, Mohamed Amir, and Lucia Schoombee, "Africa generates less than 1% of the world's research; data analytics can change that," *Elsevier*, March 22, 2018, https://www.elsevier.com/connect/africa-generates-less-than-1-of-the-worlds-research-data-analytics-can-change-that (accessed December 12, 2018).

[246] Ibid.

[247] Ibid.

[248] Ibid.

**Table 3.18** African ground facilities

| Name/ Locality | Facilities | Country/ Organisation |
|---|---|---|
| Béchar/ Reganne | Sounding rocket launch site | Algeria |
| Hammaguir | Rocket launch site | |
| Arzew | Satellite ground station | |
| Arzew | Space Technology Centre (STC) | |
| Oran | Centre for Satellite Design (CDS)—assembly, integration, and test facility | |
| | Space Applications Centre (SAC) | |
| | Telecommunication Systems Operating Centre (CEST) | |
| Ouargla | Centre de Réception et d'Exploitation des Images Satellitaires (CREIS) | |
| Funda | Satellite control centre | Angola |
| | Extended facility for the Square Kilometre Array radio telescope | Botswana |
| | 1-m Marly telescope, University of Ouagadougou | Burkina Faso |
| Douala | RASCOM Satellite Operation Centre/network control centre/customer service centre | Cameroon/ RASCOM |
| Kapani Tonneo, Katanga | Sounding rocket launch site, airstrip | Congo (Democratic Republic of) |
| Cairo Governorate | Kottamia observatory centre & 1.9 m telescope | Egypt |
| Al-Hammam | NileSat Satellite Operation Centre | Egypt/NileSat |
| Sixth of October City | NileSat Satellite Operation Centre | Egypt/NileSat |
| Aswan | Receiving station | Egypt |
| New Cairo Space City | New Cairo space control station, new satellite manufacturing, test, integration, and assembly facility | |
| Jabal Hamzah | Ballistic missile test and launch facility | |
| Mt. Entoto | Mount Entoto Observatory Centre | Ethiopia |
| Addis Ababa | Ethiopian Space Science and Technology Institute | |
| Nkok | Agency for Space Studies and Observations, Satellite antenna | Gabon |
| | Extended facility for the Square Kilometre Array radio telescope | Ghana |
| Accra | Ghana Space Science and Technology Centre | |
| | Extended facility for the Square Kilometre Array radio telescope | Kenya |
| Malindi | Luigi Broglio Space Centre and San Marco launch platform | |
| Tawiwa | Sounding rocket launch site | Libya |
| Tripoli | Centre for Remote Sensing and Space Sciences | |
| Gharyan | RASCOM Satellite Operation Centre | Libya/RASCOM |

(continued)

**Table 3.18** (continued)

| Name/ Locality | Facilities | Country/ Organisation |
|---|---|---|
| Bras d'Eau | Mauritius Radio Telescope, Low frequency radio telescope | Mauritius |
| | Extended facility for the Square Kilometre Array radio telescope | |
| | Extended facility for the Square Kilometre Array radio telescope | Madagascar |
| Rabat | Royal Centre for Remote Sensing, Satellite ground station | Morocco |
| Atlas mountains | Oukaïmeden Observatory, 0.5-m telescope | |
| | Extended facility for the Square Kilometre Array radio telescope | Mozambique |
| Gamsberg | Gamma ray telescope, High Energy Stereoscopic System | Namibia |
| Swakopmund | Chinese satellite ground station | |
| | Extended facility for the Square Kilometre Array radio telescope | |
| Jos | Centre for Remote Sensing | Nigeria |
| Toro | Centre for Geodesy and Geodynamics | |
| Abuja | Centre for Satellite Technology Development, Satellite control centre | |
| Epe | Centre for Space Transport and Propulsion, Sounding rocket launch site | |
| Nsukka | Centre for Basic Space Science and Astronomy, 0.25-m and 0.15-m telescopes | |
| Ile-Ife | Centre for Space Science and Technology Education | |
| | Satellite ground station planned | Rwanda |
| | ISRO Space Centre | São Tomé and Príncipe |
| Sutherland | South African Large Telescope, 9-m telescope | South Africa |
| | MeerKAT/KAT-7 radio telescopes | |
| | Square Kilometre Array radio telescope | |
| Hartebeeshoek | Satellite Application Centre | |
| | HartRao—VLBI, geodesy, and radio telescope | |
| Arniston | Overberg Test Range, orbital launch pad and satellite ground station | |
| Grabouw | ISSA—Houwteq, Satellite testing facility and ground station | |
| Hermanus | SANSA Space Science, previously the Hermanus Magnetic Observatory (HMO)—South Africa's national geomagnetic research facility | |
| Khartoum | Remote Sensing and Seismology Authority | Sudan |
| | National Centre of Research's Institute of Space Research and Aerospace | |

(continued)

**Table 3.18** (continued)

| Name/ Locality | Facilities | Country/ Organisation |
|---|---|---|
| Tunis | National Centre for Cartography and Remote Sensing of Tunisia | Tunisia |
| Sfax | Sfax Technople, Development of a new assembly, integration and microsatellite testing facility and engineering centre for microsatellites | |
| | Extended facility for the Square Kilometre Array radio telescope | Zambia |
| | Zimbabwe National GeoSpatial and Space Agency | Zimbabwe |

Sources: Oyewole, "Space Research and Development in Africa," 190–191; Luncedo Ngcofe and Keith Gottschalk, "The growth of space science in African countries for Earth observation in the 21st century," *South African Journal of Science* 109, no. 1/2 (2013): 4; Morocco Oukaïmeden Sky Survey, "Oukaïmeden Observatory," *Société jurassienne d'astronomie*, September 8, 2018, http://moss-observatory.org/ (accessed December 12, 2018); South African Astronomical Observatory, "The General Assembly of the International Astronomical Union to be hosted on African soil for the first time in 2024," August 30, 2018, https://www.saao.ac.za/press-release/the-general-assembly-of-the-international-astronomical-union-to-be-hosted-on-african-soil-for-the-first-time-in-2024/ (accessed December 12, 2018); All Nations University College, "Quick Info," https://anuc.edu.gh/about/quickinfo (accessed March 26, 2019); Discussions above related to individual countries and related sources

identified by Elsevier, with "Mozambique, Rwanda and Zambia [having] more than double the world average citation impact".[249]

How then does Africa fare in terms of space-related scientific research and output? One measure is the Scimago Journal and Country Rank, which is a "publicly available portal that includes the journals and country scientific indicators developed from the information contained in the Scopus® database (Elsevier B.V.)".[250] Three particular subject categories relating to space were selected here for use in the country rankings. These are Space and Planetary Science, Astronomy and Astrophysics, and Aerospace Engineering. These are the most useful and indicative, since other subjects such as Space Law are lumped together under broader categories such as Law. For the purposes here, the indicator "Citable Documents" for the years 1996–2017 was selected, which refers to all articles, reviews, and conference papers produced on the continent contained within the Scopus database (the largest abstract and citation database of peer-reviewed literature in the world[251]). Table 3.19 outlines the findings for all African countries and ranks them on the continent in terms of citable scientific output. The seven countries producing the bulk of Africa's scientific production (and the emerging space middle powers) are indicated in bold text. When

[249]Ibid.

[250]Scimago Lab, "About Us," 2018, https://www.scimagojr.com/aboutus.php (accessed December 12, 2018).

[251]Scopus, "Search for an author profile," *Elsevier B.V.*, 2018, https://www.scopus.com/freelookup/form/author.uri (accessed December 12, 2018).

**Table 3.19** Citable documents (articles, reviews, conference papers) produced by African countries for the period 1996–2017 in space-related categories

| Rank | Country | Space and planetary science | Rank | Country | Astronomy and astrophysics | Rank | Country | Aerospace engineering |
|---|---|---|---|---|---|---|---|---|
| 1 | **South Africa** | 4250 | 1 | **South Africa** | 3874 | 1 | **South Africa** | 977 |
| 2 | **Egypt** | 702 | 2 | **Egypt** | 676 | 2 | **Egypt** | 866 |
| 3 | **Nigeria** | 384 | 3 | **Algeria** | 241 | 3 | **Algeria** | 426 |
| 4 | **Algeria** | 257 | 4 | **Nigeria** | 222 | 4 | **Tunisia** | 354 |
| 5 | **Morocco** | 172 | 5 | **Morocco** | 167 | 5 | **Nigeria** | 240 |
| 6 | Namibia | 138 | 6 | Namibia | 130 | 6 | **Morocco** | 190 |
| 7 | **Tunisia** | 115 | 7 | **Tunisia** | 84 | 7 | Cameroon | 81 |
| 8 | Ethiopia | 109 | 8 | Ethiopia | 51 | 8 | Libya | 43 |
| 9 | **Kenya** | 66 | 9 | Benin | 33 | 9 | **Kenya** | 39 |
| 10 | Senegal | 48 | 10 | Burkina Faso | 29 | 10 | Ethiopia | 37 |
| 11 | Sudan | 42 | 11 | Sudan | 19 | 11 | Senegal | 23 |
| 12 | Cameroon | 41 | 12 | Cameroon | 19 | 12 | Sudan | 14 |
| 13 | Benin | 36 | 13 | Mauritius | 19 | 13 | Uganda | 12 |
| 14 | Botswana | 32 | 14 | **Kenya** | 17 | 14 | Ghana | 10 |
| 15 | Côte d'Ivoire | 30 | 15 | Côte d'Ivoire | 13 | 15 | Tanzania | 9 |
| 16 | Burkina Faso | 29 | 16 | Libya | 10 | 16 | Côte d'Ivoire | 7 |
| 17 | Niger | 23 | 17 | Senegal | 10 | 17 | Botswana | 7 |
| 18 | Uganda | 23 | 18 | Uganda | 10 | 18 | Niger | 6 |
| 19 | Congo | 22 | 19 | Burundi | 8 | 19 | Zimbabwe | 6 |
| 20 | Mauritius | 22 | 20 | Tanzania | 6 | 20 | Madagascar | 6 |
| 21 | Ghana | 19 | 21 | Zimbabwe | 6 | 21 | Rwanda | 4 |
| 22 | Tanzania | 18 | 22 | Swaziland | 5 | 22 | Chad | 3 |
| 23 | Libya | 17 | 23 | Botswana | 5 | 23 | Reunion | 3 |
| 24 | Zambia | 15 | 24 | Zambia | 5 | 24 | Mauritius | 3 |
| 25 | Zimbabwe | 13 | 25 | Eritrea | 5 | 25 | Gabon | 3 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 26 | Eritrea | 12 | 26 | Niger | 4 | 26 | Cape Verde | 3 |
| 27 | Chad | 10 | 27 | Reunion | 4 | 27 | Mali | 2 |
| 28 | Rwanda | 10 | 28 | Rwanda | 4 | 28 | Benin | 2 |
| 29 | Reunion | 8 | 29 | Mali | 4 | 29 | Congo | 2 |
| 30 | Madagascar | 7 | 30 | Ghana | 4 | 30 | Malawi | 2 |
| 31 | Cape Verde | 7 | 31 | Chad | 3 | 31 | Namibia | 1 |
| 32 | Mozambique | 6 | 32 | Madagascar | 2 | 32 | Mozambique | 1 |
| 33 | Swaziland | 6 | 33 | Guinea | 2 | 33 | Mauritania | 1 |
| 34 | Mali | 5 | 34 | Mozambique | 1 | 34 | Swaziland | 1 |
| 35 | Angola | 5 | 35 | Angola | 1 | 35 | Angola | 1 |
| 36 | Lesotho | 3 | 36 | Cape Verde | 1 | 36 | Lesotho | 1 |
| 37 | Guinea | 3 | 37 | Congo | 1 | 37 | Guinea | 1 |
| 38 | Mauritania | 3 | 38 | Central African Republic | 1 | 38 | Gambia | 1 |
| 39 | Seychelles | 3 | | | | 39 | Eritrea | 1 |
| 40 | Gambia | 2 | | | | 40 | Zambia | 1 |
| 41 | Djibouti | 2 | | | | 41 | Djibouti | 1 |
| 42 | Gabon | 2 | | | | | | |
| 43 | Central African Republic | 2 | | | | | | |
| 44 | Malawi | 2 | | | | | | |
| 45 | São Tomé and Príncipe | 1 | | | | | | |
| 46 | Comoros | 1 | | | | | | |

Scimago Journal and Country Rank, "Country Rankings," *Scimago Lab*, 2018, https://www.scimagojr.com/countryrank.php (accessed December 12, 2018) considering the amount of citable scientific output, it is clear the seven countries, plus Ethiopia, Namibia, Senegal, Cameroon, Libya, and Sudan, produce by far the largest volume of scientific and research output, with South Africa clearly the most prolific, followed by Egypt.

However, for reference, the United States, which is the world leader in all three categories, produced 191,590 citable documents in Space and Planetary Science, 118,775 in Astronomy and Astrophysics, and 118,150 in Aerospace Engineering over the same period (1996–2017). South Africa, which is the highest ranking African country in all three categories, reached 27th place in Space and Planetary Science, 26th in Astronomy and Astrophysics, and 36th in Aerospace Engineering—clearly highlighting the extent of the imbalance between Africa's population and scientific output.

The next section will consider Africa's space-related spending, since this is another critical facet of space capabilities.

### 3.3.3 African Spending on Space

While definitive, recent figures detailing African spending on space are hard to come by, some general trends are discernible. As mentioned earlier in this chapter, since 1999, about $3 billion has been spent in Africa on space projects, a number which are set to increase rapidly given that 40% of all African satellites have been launched in the last 2 years, with more to come as the analysis above revealed.

In 2014, African civil space programme spending was "about $185-million compared to the global $42.4-billion"[252], increasing to $62.2 billion by 2016 according to Euroconsult data, which also reports for the same year that Algeria spent $115 million on its space programme, Morocco $73 million, Angola $63 million, Nigeria $61 million, Egypt $53 million, the Democratic Republic of the Congo $20 million, and South Africa $20 million[253]. Oyewole also provides an overview of major spending in Africa, indicating that for 2016, Nigeria appropriated $62 million for its civil space programme, while NASRDA "was floated in 2001 with an investment of $93 million".[254] South Africa was also planning to spend $270 million in preparation for the SKA between 2009 and 2012, with the SKA "operations and maintenance . . . likely cost[ing] €150–200 million per annum", with SALT's first 10-year cost amounting to $36 million.[255] Kenya was also expected

[252]Sarah Wild, "Making the case for African investment in space programmes," *Africa Portal*, February 6, 2018, https://www.africaportal.org/features/making-case-african-investment-space-programmes/ (accessed December 12, 2018).

[253]Euroconsult, "Government Spending in Space Programs Reaches $62 Billion in 2016," May 30, 2017, http://euroconsult-ec.com/30_May_2017 (accessed July 5, 2018).

[254]Oyewole, "Space Research and Development in Africa," 193.

[255]Ibid.

to pay $102 million to establish its space agency.[256] Ethiopia's Entoto telescopes cost $3 million in 2013.[257]

More recent figures, especially related to satellite spending, are reported as follows: the Algerian space programme, 2006–2020, was reportedly allocated a budget of "about $1.3 billion"; Angola's AngoSat-1 cost "almost $300 million"; Egypt's five satellites cost "over $600 million"; Ghana spent $500,000 on its first satellite in 2017, while the government "allocated GHC $38.5 million ($10 million) to nuclear and space science technology in 2015 as it aims to further space education and benefit from its own satellite imagery"; Kenya's satellite cost "about $1.2 million"; Morocco's latest satellite Mohammed VI A cost "about $500 million"; and Nigeria "built capacities in satellite design and manufacturing spending over $500 million on satellite projects since 2003".[258]

Spending specifically by South Africa and Nigeria in particular are insightful, since "South Africa and Nigeria have always been in a supremacy battle on who is the number one in Africa".[259] Figures for Nigeria for 2018 are reported as follows:

> Federal Ministry of Science and Technology received ₦75,677,747,631 ($209m) and ₦5,573,471,146 ($15.4m) of this was allocated to the National Space Research and Development Agency (NASRDA) headquarters located in Abuja. A total of ₦13,688,991,138 ($37.8m) was budgeted for space science and technology, which is approximately 18.1% of the total budget of the Federal Ministry of Science and Technology. The breakdown of this allocation is: Centre for Atmospheric Research ₦618,394,407 ($1.7m); Advanced Space Technology Application Laboratory Uyo Akwa Ibom State ₦588,631,420 ($1.6m); Advanced Aerospace Engine Laboratory Oka Akoko, Ondo State. ₦350,000,000 ($970k); NASRDA Institute of Space Science and Engineering, Abuja ₦275,000,000 ($760k); Zonal Advanced Space Technology Application, Kashere, Gombe State ₦250,000,000 ($691k); Zonal Advanced Space Technology Application, Langtang, Plateau State ₦250,000,000 ($691k); Centre for Geodesy and Geodynamics—Toro Bauchi State ₦766,908,554 ($2.1m); African Regional Centre for Space Education—Ile Ife, Osun State ₦661,825,984 ($1.8m); Centre for Space Transport Propulsion—Epe, Lagos ₦1,199,579,288 ($3.3m); Centre for Basic Space Science—Nsukka ₦1,052,103,658 ($2.9m); National Centre for Remote Sensing—Jos, Plateau State ₦2,103,076,081 ($5.8m).[260]

For South Africa, figures are reported as follows:

> South Africa's Department of Science and Technology (DST) budget this financial year increased to R779 billion ($550m)—out of this, the South African National Space Agency receives R138 million ($9.7m). This is an improvement on the last financial year's budget for the space agency which was R131-million ($8.6m). The Square Kilometre Array project receives R709 million ($50m) this year; altogether, approximately, R847 million ($60m) about 10.9% of the total budget of the department of science and technology is spent on space activities.[261]

[256] Ibid.

[257] Ibid.

[258] Space in Africa, "Over $3 billion have been spent on space projects in Africa since 1998."

[259] Space in Africa, "South Africa and Nigeria supremacy battle on space investment," *Africa Space News*, September 17, 2018, https://africanews.space/south-africa-and-nigeria-supremacy-battle-on-space-investment/ (accessed December 12, 2018).

[260] Space in Africa, "South Africa and Nigeria supremacy battle on space investment."

[261] Ibid.

Together, these figures powerfully counter the "popular opinion that there are no Space Activities going on in Africa".[262] This is especially the case given that South Africa's "aerospace sector is worth $1.8 billion in market size".[263] In terms of Africa's overall expenditure on space, Oyewole reports that research and development costs are split between governments, private investors, and external actors, with roughly 62% of satellites "fully funded" by governments, as are most astronomical observatories, ground stations, and sounding rocket launch sites.[264] A further 19% of satellites are cosponsored by governments or agencies and investors. The question thus often becomes why are African governments spending so much on space when other pressing concerns such as poverty loom large? As discussed previously, this question is often directed against Africa's perceived "frivolous" or "wasteful" spending on space.

However, several critical points need to be made in this regard. First, despite this spending, "[e]ven Algeria, Egypt, Nigeria, and South Africa, which have the most advanced space programs on the continent, spend less than 1% of their GDP on R&D", with Africa having the "lowest ratio of R&D to GDP in the world".[265] Second, as the figures above show, Africa is "responsible for a tiny proportion of both civil space spending and global space spending".[266] Thus, contextualising African spending on space is critical to avoid creating a false image of excessive spending. Third, "industry spending dwarfs civil spending, but it does so by building on government investment", and "[w]ithout government investment in space, you don't get an industry that burgeons around it".[267] This point clearly outlines how government spending is crucial to bolstering private industry and investment in the sector. Fourth, this spending also does not come without return. One aspect of this is the creation of direct employment opportunities, the "revolutionizing" of the mining, agriculture, and information and communications technology sectors, as well as reducing the dependency of the continent on foreign technology.[268] In this regard, the views expressed by Spacewatch are apt and worth repeating at length here:

> However, the question of justifying the cost of a space initiative is one that looms large, and whilst the socio-economic benefits are obvious, the investment that has to be made to kick off a space programme is enormous. Partnerships and collaboration can help considerably, but the fundamental stumping up of cash is critical and whilst a government may see the long-term benefits of launching a satellite into space, the rest of the world looks critically on. Why should other countries send aid to a nation that cannot even afford to feed its own people, yet alone build a satellite and get it to space? That said, space programmes have to begin somewhere. Should space simply be for those who can afford it? Space is becoming more affordable, and it can help to solve some significant problems through the provision of

[262] Space in Africa, "Over $3 billion have been spent on space projects in Africa since 1998."

[263] Ibeh, "Why the South African Space Industry is Progressive."

[264] Oyewole, "Space Research and Development in Africa," 194.

[265] Ibid., 196.

[266] Wild, "Making the case for African investment in space programmes."

[267] Ibid.

[268] Oyewole, "Space Research and Development in Africa," 197–198.

> critical data, imagery and communications. The socio-economic benefits of space programmes are undeniable. It is enormously encouraging to see such interest in space from players that, ten years ago may not have even given space a second thought in terms of their country's future. In nurturing a space industry, nations, such as the ones we have read about here, are investing in the future of their people and the world as a whole. It is true that we have to look to our skies and beyond our planet both today and in the future. However, the question will always dominate of just how much of a priority space actually is to countries that have more fundamental problems facing them.[269]

## 3.4 Conclusion: The Rise of Africa's Space Middle Powers in the Context of Meeting Primary Needs

This chapter has aimed to complete the picture, presented in Fig. 3.1, of Africa's space growth poles by utilising the modified Space Technology Ladder, Harding's emerging space actor framework, and some basic concepts from the European Space Agency's Technology Readiness Level framework (such as reports of basic principles observed regarding upcoming satellites, concepts, and functions). Together with the analysis of African space engagement in Chap. 2, these capability and infrastructure considerations now allow conclusions to be drawn regarding Africa's space growth poles and emerging space middle powers in the context of primary needs (contextualised in Chap. 1).

First, strong upward trajectories in terms of milestone achievements are visible in a range of countries across the continent. The most prominent are Algeria, Egypt, Nigeria, Kenya, and South Africa and, to a lesser (but no less significant) extent, Angola, Ethiopia, Tunisia, Morocco, and Ghana, with others showing promise as well. Combined with an assessment of their status within the emerging space actor framework as well as that of Al-Rumhi et al., it is now possible to identify Africa's space growth poles, as well as to provide an updated assessment of the continent's space sector. This is done in Table 3.20, combining engagement in space and national space capabilities and identifying national trajectories and key focus areas based on the analysis above.

Table 3.20 reinforces the sense of the rapid pace at which African states have been increasing their space-related capabilities, and since Harding argued that South Africa was a second-tier EMSA in 2013, two more states can arguably be counted in that category today, with two more approaching that point through development of significant capabilities in terms of space technology. Institutionally, African states have also been expanding their capabilities, with Zimbabwe a very recent example. This reflects a recognition among African leaders and decision-makers of the value and importance of space for societal development. Figure 3.9

[269]Spacewatch Middle East, "#SpaceWatchME Op'ed.: Satellite Sovereignty – Africa," *ThorGroup GmbH*, 2018, https://spacewatch.global/2017/01/satellite-sovereignty-part-2/ (accessed December 12, 2018).

**Table 3.20** African space growth poles

| Cross-border cooperation and engagement in space | | National space capabilities and priorities | | | | | |
|---|---|---|---|---|---|---|---|
| *Emerging space middle powers* | *Other rising actors* | Emerging space actor framework status (tier) | Space technology status | Highest technical complexity and autonomy | National trajectories in the space sector (space technology ladder milestones) | Key areas (primary needs) | Orbits |
| South Africa | | Second | High | Yes | Strengthening domestic space sector, including manufacturing and promoting private sector | Earth observation, capacity building, technology, navigation | Sun-synchronous, Low Earth orbit |
| Nigeria | | Second | High | Yes | Building up diverse domestic space sector with full-range capabilities, including eventual launch capability and manned space programme | Earth observation, capacity building, communication | Sun-synchronous, Geostationary, Low Earth orbit |
| Algeria | | Second | High | Yes | Building up technical capability and skills. Moving toward greater autonomy | Earth observation, capacity building, collaboration, communication | Sun-synchronous, Geo-synchronous |
| Egypt | | Emerging second | High | Yes | Key focus on communications and on building up manufacturing capabilities | Communication, capacity building, Earth observation | Geostationary, Sun-synchronous, Low Earth obit |
| Kenya | | Third | High | | Building up engineering capabilities in small satellite design | Capacity building | Low Earth orbit |
| Morocco | | Third | Medium | | Nascent industrial capabilities, key focus on surveillance and Earth observation | Earth observation, capacity building, military | Sun-synchronous |
| Tunisia | | Emerging second | Medium | | Building up engineering and satellite facilities | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ghana | Third | Medium | | Building competencies in Earth observation and engineering | Earth observation, capacity building | Low Earth orbit |
| | Angola | Third | Medium | | Focus on communication and establishing local space industry and capacities | Communication | Geostationary |
| | Ethiopia | Third | Medium | | Creation of domestic space capacities. Plans for domestic manufacturing and launch capabilities | Capacity building | |
| | Gabon | Third | Emerging medium | | Focusing on efforts to establish capacities in environmental monitoring | | |
| | Sudan | Third | Emerging medium | | Building up skills, particularly in remote sensing and engineering | Capacity building | |
| | Libya | Third | Low | | Main focus on remote sending | | |
| | Mauritius | Third | Low | | Preparing first satellite | Earth observation | |
| | Rwanda | Third | Low | | Preparing first satellite and regional collaboration | Communication | |
| | DR Congo | Third | Low | | Attempts at first communication satellite. Private attempts at sounding rockets | Communication | |
| | Malawi | Third | Low | | Initial talks about potentially pursuing space efforts | | |
| | Zimbabwe | Third | Low | | Recently established space agency | | |
| | Côte d'Ivoire | Third | Low | | Pursuing first satellite | Earth observation, meteorology | |
| | Namibia | Third | Low | | Initial efforts to promote space science | | |


**Fig. 3.9** Summary of African space achievements

provides a summary of the achievements and milestones of African countries as discussed in this chapter.

The analysis in this chapter, by way of the modified Space Technology Ladder, also makes it possible to compare the approaches or pathways of countries in pursuing space capabilities. Egypt and Angola have, for instance, placed great emphasis on communication via their NileSat and AngoSat programmes—recently also joined by Algeria with its AlComSat-1. Morocco, on the other hand, has pursued high-resolution Earth observation for both developmental and military objectives, thus turning to foreign manufacturers to provide these sophisticated tools. Meanwhile, Kenya, Ghana, Mauritius and, in some cases, Morocco and South Africa have developed satellites and engineering skills via international initiatives such as the Birds programme, or the TUBSAT programme, or other collaborations such as ThinSat. This is often reflective of the initial efforts of countries to build up a cadre of space professionals and clearly demonstrates the democratisation and opening up of space to developing nations through the small satellite revolution. Algeria, Nigeria, and South Africa have also focused heavily on developing their domestic manufacturing capabilities, and in all three cases, this has been guided by a clear strategy, driven by a responsible space authority. Egypt is also joining in this effort via its new Space City development, as is Tunisia via its Sfax Technopole project, and thus these states form the core of what was referred to in Chap. 1 as the African Regional Space Regime Complex. Via the frameworks utilised in this chapter, it is thus possible to identify comparable groups of countries based on their space sector initiatives. South Africa, Nigeria, and Algeria form the core, and Egypt and Tunisia are approaching the core, while Kenya, Morocco, Ghana, Angola, and Ethiopia are key rising space actors, with Gabon, Sudan, Libya, Mauritius, Rwanda, the Democratic Republic of the Congo, Malawi, Zimbabwe, Côte d'Ivoire, and Namibia undertaking establishment of their capabilities.

This chapter has also reinforced the sense of overlap between the RECS, which serves to strengthen the need for continental coordination via an African Space Agency, for example. However, it is also clear that this overlap is good for building the African Regional Space Regime Complex and reinforces the power of space to overcome divisions within the RECS, and thus across Africa. An excellent example of this is the call for the Arab Maghreb Union, which is "wallowing in and bitterly grappling with various political, social and economic problems, yet tenaciously refusing to stand united" to form a Maghreb Space Agency given the high level of space activities in the region.[270] This

> might not solve the political problem in the region, [but] it could lead to significant growth in the region. The exchange of information at the highest level will create a safer region, thus attracting more foreign direct investment and more tourists. The region's backyard is too messy for the five countries not to cooperate in order to solve their socio-economic problems. Investors are looking for political stability and security, and the cost of a lack of intra-regional cooperation is simply too high.[271]

While the likelihood of such an initiative being undertaken in the context of the African Union's effort to establish a continental space agency is low, it nevertheless points to a way in which space cooperation and collaboration can build closer relationships within the RECs, and thus the continent, in the spirit of *ubuntu*. This has been recognised by the East African Community in its effort to obtain a common satellite.

However, as the opening quote by Vikram Sarabhai suggested, the Space Technology Ladder serves to demonstrate that progress in establishing a space sector requires long-term, consistent planning, vision, and effort. This is clearly visible in the space trajectories of Africa's best performers such as Algeria and Nigeria. It also

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[270]Space in Africa, "Is a Maghreb Space Agency the solution to the North African Supremacy Battle?," Africa Space News, July 7, 2018, https://africanews.space/is-a-maghreb-space-agency-the-solution-to-the-north-african-supremacy-battle/ (accessed December 13, 2018).

[271]Ibid.

requires a clear focus on bringing space to bear in meeting the challenges facing the continent and in particular in meeting the most basic, primary, needs of its citizens. This was encapsulated in the primary needs approach to African space activities model presented in Chap. 1. This focus will be carried through to the next volume, which follows on and further develops the overview of how space is serving Africa and how African states are approaching their efforts to establish space capabilities.

For this reason, having established the broad socio-economic context of Africa, the international engagement of African states in space, and their space-related capabilities, the next volume will investigate the space applications used to further the key primary needs areas served by space, the policies driving them, and the critical relationship in the space sector between Africa and the European Union (and the European Space Agency). Doing so will further clarify how Africa's space-related spending is benefitting the continent and what Africa is doing to advance, as Dr. Sarabhai put it, the "application of advanced technologies to the real problems of man and society". As a final note, the insights of Carl Sagan regarding the deep and pervasive societal impact of pursuing space technology—and clear motivation for Africa to continue efforts in this regard—are worth repeating here. They succinctly point to the powerful emancipatory potential of space and why the future of this beloved continent depends on it:

> Spaceflight speaks to something deep inside us—many of us, if not all. An emerging cosmic perspective, an improved understanding of our place in the Universe, a highly visible program affecting our view of ourselves might clarify the fragility of our planetary environment and the common peril and responsibility of all the nations and peoples of Earth. . . . Exploratory spaceflight puts scientific ideas, scientific thinking, and scientific vocabulary in the public eye. It elevates the general level of intellectual inquiry. The idea that we've now understood something never grasped by anyone who ever lived before—that exhilaration, especially intense for the scientists involved, but perceptible to nearly everyone—propagates through the society, bounces off walls, and comes back at us. It encourages us to address problems in other fields that have also never before been solved. It increases the general sense of optimism in the society. It gives currency to critical thinking of the sort urgently needed if we are to solve hitherto intractable social issues. It helps stimulate a new generation of scientists. The more science in the media–especially if methods are described, as well as conclusions and implications–the healthier, I believe, the society is. People everywhere hunger to understand.[272]

[272]Carl Sagan, *Pale Blue Dot: A Vision of the Human Future in Space* (New York: Ballantine Books, 1994), 226–228.

# Appendix

| Organisation | Details |
|---|---|
| African Union Commission | African Union Headquarters<br>P.O. Box 3243 ǀ Roosevelt Street (Old Airport Area) ǀ W21K19 ǀ Addis Ababa ǀ Ethiopia<br>Tel: (251) 11 551 77 00<br>Fax: (251) 11 551 78 44<br>Website: www.au.int<br>Email: dic@africa-union.org (Directorate of Information and Communication) |
| Arab Maghreb Union/(AMU/UMA) | 73 Rue Tansift ǀ Agdal, Rabat 10080 ǀ Morocco<br>Tel: (212) 537 68 13 74/73/72/71<br>Fax: (212) 537 68 13 77<br>Website: http://www.umaghrebarabe.org/?q=en<br>Email: Sg.uma@maghrebarabe.org |
| Common Market for Eastern and Southern Africa (COMESA) | COMESA Centre<br>Ben Bella Road ǀ P. O. Box 30051 ǀ Lusaka ǀ Zambia<br>Tel: +260 211 229725<br>Fax: +260 211 225107<br>Website: http://www.comesa.int/<br>Email: info@comesa.int |
| • Indian Ocean Commission | Commission de l'Océan Indien<br>Blue Tower – 3ème étage ǀ Rue de l'Institut ǀ Ebène ǀ Maurice<br>Tel : (+230)4026100<br>Fax : (+230)4656798<br>Website: http://www.commissionoceanindien.org/accueil/<br>Email : secretariat@coi-ioc.org |
| • Economic Community of the Great Lakes Countries (ECGLC) | Tel: 0788307061 / 0788309395 / 0788301764<br>Website: http://www.cepgl.org/<br>Email: http://www.cepgl.org/webmail |

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A. Froehlich, A. Siebrits, *Space Supporting Africa*, Studies in Space Policy 20,
https://doi.org/10.1007/978-3-030-12173-0

| Organisation | Details |
|---|---|
| The Community of Sahel-Saharan States (CEN-SAD) | CEN-SAD Secretariat<br>Place d'Algeria ǀ P.O. Box 4041 ǀ Tripoli ǀ Libya<br>Tel: +218 21 3614832 / (218) 3614832 – 3614833<br>Fax: +218 21 3346854 / (218) 3614832<br>Website: http://www.cen-sad.org/ (not functional)<br>E-mail: censad_sg@yahoo.com / info@cen-sad.org |
| East African Community (EAC) | EAC Close ǀ Afrika Mashariki Road ǀ P.O. Box 1096 ǀ Arusha ǀ United Republic of Tanzania<br>Tel: +255 (0) 27 216 2100<br>Fax: +255 (0) 27 216 2190<br>Website: https://www.eac.int/<br>Email: eac@eachq.org |
| Economic Community of Central African States (ECCAS/CEEAC) | Haut de Guégué ǀ BP: 2112 ǀ Libreville ǀ Gabon<br>+(241) 01 44 47 31<br>+(241) 01 44 47 32<br>Website: http://www.ceeac-eccas.org/index.php/en/<br>Email: contact@ceeac-eccas.org |
| • Central African Economic and Monetary Community (CEMAC) | Commission de la CEMAC<br>Immeuble CEMAC ǀ Avenue des Martyrs ǀ BP 969 ǀ Bangui ǀ République centrafricaine<br>Tel: +236 61 0922<br>Fax: +236 61 2135<br>Website: https://www.cemac.int/<br>Email: cemac@cemac.int |
| Economic Community of West African States (ECOWAS) | 114 Yakubu Gowon Crescent ǀ Asokoro, Abuja ǀ Nigeria<br>P.M.B. 401 ǀ Abujaǀ Nigeria<br>Tel: (234) (9) 31 47 6479<br>Fax: (234) (9) 31 43 005 / (234) (9) 31 47 646<br>Website: http://www.comm.ecowas.int/<br>Email: info@ecowas.int |
| • West African Economic and Monetary Union (UEMOA) | Head office in Ouagadougou<br>Commission de l'UEMOA ǀ 380 Avenue Professeur Joseph ǀ KI-ZERBO 01 BP 543 ǀ Ouagadougou ǀ Burkina Faso<br>+226 25 31 88 73<br>+226 25 31 88 74<br>+226 25 31 88 75<br>+226 25 31 88 76<br>+226 25 31 88 72<br>Website: www.uemoa.int<br>Email: commission@uemoa.int |

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|---|---|
| • West African Monetary Zone (WAMZ) | The West African Monetary Institute<br>Gulf House \| Tetteh Quarshie Interchange<br>PMB CT 75 \| Accra \| Ghana<br>Tel: (+233-302) 743801<br>Fax: (+233-302) 743807<br>Website: http://www.wami-imao.org/<br>E-mail: info@wami-imao.org |
| • Manu River Union | Website: http://manoriverunion.int/ (not functional) |
| • Liptako-Gourma Region Integrated Development Authority | Autorité de Développement Intégré de la Région du Liptako Gourma<br>417, Avenue Kwamé N'KRUMAH<br>01 BP 619 \| Ouagadougou 01 \| Burkina Faso<br>Tel: (+226) 25 30 61 48/49<br>Fax: (+226) 25 30 85 88<br>Website: http://www.liptakogourma.org<br>Email: dg@liptakogourma.org |
| Intergovernmental Authority on Development (IGAD) | IGAD Secretariat<br>Avenue Georges Clemenceau \| P.O. Box 2653 \| Djibouti \| Republic of Djibouti<br>Phone +253-21354050 / 352 880<br>Fax +253-21356994 / 284<br>Website: https://igad.int/<br>Email: igad@intnet.dj |
| Southern African Development Community (SADC) | SADC House<br>Plot No. 54385 \| Central Business District \|<br>Private Bag 0095 \| Gaborone \| Botswana<br>Telephone: +267 395 1863<br>Fax: +267 397 2848 / +267 318 1070<br>Website: www.sadc.int<br>Email: registry@sadc.int |
| • Southern African Customs Union (SACU) | Physical Address:<br>Corner Lazarett and Feld Street \| Private Bag 13285 \| Windhoek \| Namibia \| 9000<br>Postal Address:<br>The Executive Secretary<br>Private Bag 13285 \| Windhoek \| Namibia \| 9000<br>Telephone: +264 (61) 295 8000<br>Fax: +264 (61) 245 611<br>Email: info@sacu.int<br>Website: http://www.sacu.int/ |
| Regional African Satellite Communication Organisation (RASCOM) | Website: http://www.rascom.org/# |

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| SCS Space | Physical Address:<br>3rd Floor St Andrews Building ǀ Somerset Links Office Park ǀ De Beers Avenue ǀ Somerset West ǀ Cape Town 7130 ǀ South Africa<br>Postal Address:<br>PO Box 12037 ǀ Die Boord ǀ Stellenbosch 7613 ǀ South Africa<br>T: +27 21 300 0060<br>F: +27 21 300 0064<br>Website: http://scs-space.com/<br>Email: info@scs-space.com |
| FarmPin | Tel: +27 82 829 7212 / +27 82 374 5157<br>Website: https://farmpin.com/ |
| Square Kilometre Array (South Africa) | Cape Town Office<br>SARAO<br>2 Fir Street ǀ Black River Park ǀ Observatory (North Gate entrance) ǀ 7925 ǀ South Africa<br>Tel: +27 (0)21 506 7300<br>Fax: +27 (0)21 506 7375<br>Website: https://www.ska.ac.za/<br>Email: enquiries@ska.ac.za |
| Group on Earth Observations | 7 bis, avenue de la Paix ǀ Case postale 2300 ǀ CH-1211 Geneva ǀ Switzerland<br>Tel: +41 22 730 8505<br>Fax: +41 22 730 8520<br>Website: http://www.earthobservations.org/index2.php<br>Email: secretariat@geosec.org |
| • AfriGEOSS | Website: http://www.earthobservations.org/afrigeoss.php |
| African Regional Institute for Geospatial Information Science and Technology (AFRIGIST) | Off Road 1 ǀ Obafemi Awolowo University Campus ǀ P.M.B. 5545 ǀ Ile-Ife ǀ Osun State ǀ Nigeria<br>Tel: +234-8064042198<br>Website: https://afrigist.org/<br>Email: info@afrigist.org |
| Regional Centre for Mapping of Resources for Development (RCMRD) | P.O. Box 632-00618 ǀ Nairobi ǀ Kenya<br>Roysambu ǀ Kasarani ǀ Nairobi ǀ Kenya<br>Tel: +245 020 2680748 / 2680722<br>+254 723 786161 / +254 735 981098<br>Website: https://www.rcmrd.org/<br>Email: rcmrd@rcmrd.org |

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| African Association of Remote Sensing of the Environment (AARSE) | Attention: Prof. Harold Annegarn I 3 Dover Road I Muizenburg I 7945 I<br>South Africa<br>Website: http://www.africanremotesensing.org/<br>Email: info@africanremotesensing.org |
| Women in Aerospace Africa (WIA) | Website: https://wia-africa.org/<br>Email: info@wia-africa.org |
| African Space Foundations (ASF) | Website: https://www.africanspacefoundation.org |
| Foundation for Space Development | Website: https://developspacesa.org/<br>Email: info@developspacesa.org |
| International Astronautical Federation | 100 Avenue de Suffren I 75015 Paris I France<br>Tel: +33 1 45 67 42 60<br>Fax: +33 1 42 73 21 20<br>Website: http://www.iafastro.org/ |
| Environmental Information Systems (EIS) Africa | Website: http://www.eis-africa.org/ |
| Space Generation Advisory Council (SGAC) Africa | c/o European Space Policy Institute I<br>Schwarzenbergplatz 6 I 1030 Vienna I Austria<br>Phone: +43 1 718 11 18 30<br>Website: https://spacegeneration.org/regions/africa<br>Email: info@spacegeneration.org |
| United Nations Office for Outer Space Affairs (UNOOSA), including United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) and United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) | United Nations Office at Vienna I Vienna International Centre I Wagramerstrasse 5 I<br>A-1220 Vienna I Austria<br>Telephone: +43-1-260 60 4950<br>Fax: +43-1-260 60 5830<br>Website: http://www.unoosa.org/ |
| • African Regional Centre for Space Science and Technology Education – English Language | Yellow House I Obafemi Awolowo University Campus I Ile Ife I Nigeria<br>P.M.B. 019 I OAU Post Office I Ile Ife.<br>Telephone: 08028327463<br>Website: http://arcsstee.org.ng/index.php/home, Email: director@arcsstee.org.ng /<br>gagbaje@gmail.com / admin@arcsstee.org.ng |
| • Centre Régional Africain des sciences et technologies de l'espace en langue français | Avenue Ibn Sina I BP 765 I Agdal Maroc I<br>10090 Rabat I Maroc<br>Tél: (+212)537681826<br>Fax: (+212)537681824<br>Website: http://crastelf.org.ma/<br>Email: craste@emi.ac.ma |

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| Arabsat | Diplomatic Quarter \| Alfazari Square \| Abdulla Bin Huthafa Al Sahmy Street \| Public Pension Agency Complex \| C-6 Riyadh 11431 \| Saudi Arabia<br>Tel: +966-11-482-0000<br>Fax: +966-11-488-7999<br>Website: https://www.arabsat.com/english/home<br>Email: info@Arabsat.com |
| International Institute of Space Law – Manfred Lachs Space Law Moot Court | International Institute of Space Law<br>94bis \| Avenue de Suffren \| 75015 \| Paris \| France<br>Website: https://iislweb.org/lachs_moot/<br>Email: secretary@iislweb.org |
| International Astronomical Union Office of Astronomy for Development (OAD) | Postal address<br>P.O. Box 9 \| Observatory \| South Africa \| 7935<br>Street address<br>South African Astronomical Observatory<br>1 Observatory Road \| Observatory \| 7925 \| South Africa<br>Tel: +27 (0) 21 460 6297<br>Website: http://www.astro4dev.org/<br>Email: info@astro4dev.org |
| Global Partnership for Sustainable Development Data – African Regional Data Cube | Website: http://www.data4sdgs.org/initiatives/africa-regional-data-cube<br>Email: info@data4sdgs.org |
| Inter Islamic Network on Space Sciences and Technology | ISNET Secretariat<br>SUPARCO Headquarters \| Suparco Road \| PO Box 8402 \| Karachi-75270 \| Pakistan<br>Tel: +92 21 34654132<br>Fax: +92 21 34644928, 34694941<br>Website: http://www.isnet.org.pk/<br>E-mail : admin@isnet.org.pk |
| Joint Global Multi-Nation Birds Satellite (BIRDS) Project | Tejumola Taiwo<br>Department of Applied Science for Integrated System Engineering \| Laboratory of Spacecraft Environment Interaction Engineering \| Kyushu Institute of Technology \| 1-1 Sensui-cho \| Tobata-ku \| Kitakyushu \| 804-8550 \| Japan.<br>Tel: +81-93-884-3228<br>Website: https://birds1.birds-project.com/<br>Email: n350949r@mail.kyutech.jp |
| KiboCUBE (See UNOOSA) | Email: hsti-kibocube@un.org |

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| TUBSAT | Website: https://www.raumfahrttechnik.tu-berlin.de/menue/forschung/abgeschlossene_projekte/tubsat/v_menue4/tubsat/ |
| BRICS (Brazil, Russia, India, China, South Africa) | Tel: +27 12 351 1000<br>Website: http://www.brics2018.org.za/<br>Email: info@dirco.gov.za |
| Surrey Satellite Technology Ltd. | Surrey Satellite Technology Limited<br>Tycho House I 20 Stephenson Road I Surrey Research Park I Guildford GU2 7YE I United Kingdom<br>Tel: +44 (0)1483 803803<br>Fax: +44 (0)1483 803804<br>Website: https://www.sstl.co.uk/<br>Email: info@sstl.co.uk |
| Italian Space Agency – Luigi Broglio Space Center | 'Luigi Broglio' Space Centre (BSC) – Malindi<br>P.O. Box 450 80200 I Malindi I Kenya<br>Tel: +254 42 20999<br>Fax: +254 42 20611<br>Website: https://www.asi.it/en/agency/bases/broglio<br>Email: urp@asi.it |
| Algerian Space Agency | Mohamed Arab Metaiche I Bouzareah I Algeria<br>Tel: (213) 21 94 11 07<br>Website: http://www.asal.dz/ |
| Morocco Royal Centre for Remote Sensing | 21 Angle Avenue Sanawbar et Avenue Allal El Fassi I quartier Hay Riad I Rabat I Maroc<br>Tel: (+212) 5 37 71 54 48/98<br>Fax: (+212) 5 37 71 14 35<br>Website: https://www.crts.gov.ma/Royal%20Centre%20for%20Remote%20Sensing |
| Centre National de la Cartographie et de la Télédétection (Tunisia) | Route La Marsa I L'Aouina I BP 200 I 1080 Tunis Cedex<br>Tel: (+216) 71 761 333<br>Fax: (+216) 71 760 890<br>Website: http://www.cnct.defense.tn/<br>Email: cnct@defense.tn |
| Libyan Centre for Remote Sensing and Space Science | Website: http://www.lcrsss.ly/<br>Email: info@lcrsss.ly |
| National Space Secretariat Kenya (Ministry of Defence) | The Principal Secretary I Ministry of Defence I Ulinzi House I Lenana Road I PO Box 40668 – 00100 I Nairobi I Kenya<br>Tel: +254 20 2721100<br>Fax: +254 20 2737322<br>Website: http://www.mod.go.ke/?p=1932<br>Email: publicaffairs@mod.go.ke |
| National Authority for Remote Sensing and Space Sciences (Egypt) | 23 Joseph Tito Street I El-Nozha El-Gedida I P.O. Box I 1564 Alf Maskan I Egypt<br>Phone: (202) 26251299 / (202) 26251200<br>Fax: (202) 26225800 / (202) 26225833<br>Website: http://www.narss.sci.eg/contact<br>Email: info@narss.sci.eg |

(continued)

| Organisation | Details |
| --- | --- |
| Remote Sensing and Seismology Authority (Sudan) | National Center For Research ǀ Alsayed Abd Alrahman Street ǀ P.O. Box: 2404 ǀ Khartoum ǀ Sudan<br>Tel/Fax: +249 183 770701<br>Website: https://rssa.gov.sd/contact/<br>Email: rssa@ncr.gov.sd |
| Ethiopian Space Science Society: ESSS | Addis Ababa University Institute of Technology (5Kilo Campus) ǀ 4th floor<br>Room 405 ǀ PO. Box.: 8412 ǀ Ethiopia<br>Tel: +251 118 677 699/+251 111 261 668/ +251 111 261 200<br>Website: https://www.ethiosss.org.et/<br>Email: ethiopiaspace@gmail.com |
| Ethiopian Space Science and Technology Institute | Tel: +251-118-961050<br>Website: http://etssti.org/ |
| Rwanda Utilities Regulatory Authority (RURA) | KN 39 St ǀ Kigali ǀ Rwanda<br>Tel: +250 252 584 562 |
| National Space Research and Development Agency (Nigeria) | Umaru Musa Yaradua Express Way ǀ PMB 437 ǀ Lugbe ǀ Abuja ǀ Nigeria<br>Website: http://nasrda.gov.ng/en/<br>Email: contact@nasrda.gov.ng |
| Ghana Space Science and Technology Centre | P.O. Box LG 80 ǀ Legon ǀ Accra<br>Website: https://gsstc.gov.gh/<br>Email: info@spacecentre.gov.gh |
| Gabinete de Gestão do Programa Espacial Nacional (Angola) | Tel: +244 222728234<br>Website: http://www.ggpen.gov.ao/<br>Email: geral@ggpen.gov.ao |
| Agence gabonaise d'études et d'observations spatiales (Gabon) | BP 3 850 ǀ Centre-ville ǀ Immeuble Les Arcades – 1er étage ǀ Libreville ǀ Gabon<br>Tel: +241-01 74 17 16 / +241-03 00 77 79 (Secrétariat ZES de NKOK)<br>Website: http://www.ageos.ga/ (not functional) |
| Earthlab Gabon | Website: http://www.earthlab-galaxy.com/gabon/en/ |
| South African National Space Agency | Physical Address:<br>Enterprise Building ǀ Mark Shuttleworth Street ǀ Innovation Hub ǀ Pretoria 0087 ǀ Gauteng ǀ South Africa<br>Postal Address:<br>PO Box 484 ǀ Silverton ǀ 0127 ǀ Gauteng<br>Tel: 012 844-0500<br>Fax: 012 844-0396<br>Website: https://www.sansa.org.za/<br>Email: information@sansa.org.za |
| Namibian National Commission on Research Science and Technology | ERF 490 ǀ Platinum Street ǀ Prosperita ǀ Private Bag 13253 ǀ Windhoek<br>Tel: +264 61 431 7000<br>Fax: + 264 61 216 531<br>Website: http://www.ncrst.na/about-us/programme-policies/47/<br>Email: info@ncrst.na |

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