Assessing the contribution of space policy to development and security in Nigeria and South Africa

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Dedication

I dedicate this thesis to (1) the Creator of the Universe and all attendant mysteries;

(2) all those that have committed various efforts to demystify the knowledge of outer space and develop human capacities to explore this infinite frontier for peaceful purposes.

(3) all those that have advanced and supported the aspirations of the governments and peoples of Nigeria and South Africa, as well as other African countries, in space exploration for development, peace and security.

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List of Abbreviation

±	plus, or minus
AAEL	Advanced Aerospace Engine Laboratory
AARSE	African Association of Remote Sensing of the Environment
AAS	African Astronomical Society
ACLED	Armed Conflict Location and Events Database
ACTINT	ACTionable INTelligence
ADCS	Attitudinal Determination and Control Systems
ADS	Airbus Defence and Space
AEB	Atomic Energy Board
AFL	Atlantic Factorial Limited
AfriCultuRES	AgriCultural Systems with the support of Remote Sensing
AGU	American Geophysical Union
AIS	Automatic Identification System
AIT	Assembling, Integration and Testing
AL	Arab League
AMD	Aerospace Maritime & Defence Industries Association
ANC	African National Congress
ANSAs	Armed Non-State Actors
APC	Armor Personnel Carrier
AQIM	Al Qaeda in the Islamic Maghreb

Arabsat	Arab Satellite Communications Organisation
ARCSSTE-E	African Regional Centre for Space Science and Technology Education-English
ARM	African Resource Management
Armscor	Armaments Corporation
ASA	African Space Agency
ASEAN	Association of South Eastern Asian Nations
ASReG	Aerospace Systems Research Group
ASSA	Astronomical Society of Southern Africa
ASTAL	Advanced Space Technology Application Laboratory
ASTAL-SW	Advanced Space Technology Applications Laboratory- Southwest
ATE	Advanced Technologies & Engineering
AU	African Union
au	astronomical unit
AUST	African University of Science and Technology
AWB	Astronomers Without Borders
BPE	Bureau of Public Enterprises
BST	Berlin Space Technologies
BUK	Bayero University, Kano
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CAA	Cape Astronomical Association

CAC	Corporate Affairs Commission
CAMA	Companies and Allied Matters Act
CAR	Centre for Atmospheric Research
CBSSA	Centre for Basic Space Science and Astronomy
CDSA	Chief of the Defence Space Administration
CEO	Chief Executive Officer
CER	Centre for Environmental Rights
CESRA	Centre for Space Research and Applications
CGA	Centre for Geographical Analysis
CGG	Centre for Geodesy and Geodynamics
CGWIC	China Great Wall Industry Corporation
CJTF	Civilian Joint Task Force
CNC	Computer Numerical Control
CNES	Centre National D'études Spatiales
COIN	Counter-insurgency
COMSEC	Electronic Communications Security (Pty) Ltd
COPINE	Cooperative Information Network
COPUOS	United Nations Committee on the Peaceful Uses of Outer Space
Covid-19	Coronavirus
CPUT	Cape Peninsula University of Technology
CSD	Centre for Satellite Development

CSGs	Civil Society Groups
CSIR	Council for Scientific and Industrial Research
CSSTE	Centre for Space Science and Technology Education
CSTP	Centre for Space Transport and Propulsion
DAB	Dombarovsky Air Base
DACST	Department of Art, Culture, Science and Technology
DALRRD	Department Agriculture, Land Reform and Rural Development
DAS	Denel Aerospace Systems
DBC	Department of Basic Education
DCDSA	Deputy Chief of the Defence Space Administration
DCDT	Department of Communications and Digital Technologies
DCOC	Defence Cyber Operation Centre
DCs	Developed Countries
DCS	Directorate of Cyber Security
DDSI	Defence Decision Support Institute
DE	Department of Education
DEFF	Department of Environment, Forestry and Fisheries
Denel ISM	Denel Integrated Systems & Maritime
DEO	Directorate of Earth Observation
DEOC	Defence Earth Observation Centre
DFA	Directorate of Finance and Account

DEECE	Department of Electrical, Electronic, and Computer Engineering
DHESI	Department of Higher Education, Science and Innovation
DHET	Department of Higher Education and Training
DIRCO	Department of International Relations and Cooperation
DLSO	Directorate of Launch Services and Space Operations
DMC	Disaster Management Constellations
DNPT	Directorate of Navigation, Positioning and Timing
DOC	Department of Communication
DOD	Department of Defence
DoJ & CD	Department of Justice and Constitutional Development
DOT	Department of Transportation
DP	Directorate of Procurement
DPCI	Directorate for Priority Crime Investigation
DPPR	Directorate of Policy, Planning and Research
DSA	Defence Space Administration
DSC	Directorate of Satellite Communication
DSCC	Defence Satellite Communication Centre
DSI	Department of Science and Innovation
DSS	Department of State Service
DST	Department of Science and Technology
DTI	Department of Trade and Industry

DTPS	Department of Telecommunications and Postal Services
EARSC	European Association of Remote Sensing Companies
ECA	Economic Commission for Africa
ECCAS	Economic Community of Central African States
ECNS	Electronic Communications Network Services
ECOMOG	ECOWAS Monitoring Group
ECOWAS	Economic Community of West African States
ECS	Electronic Communications Services
EO	Earth Observatory
ESA	European Space Agency
ESL	Electronic System Laboratory
ESS	Electronic and Simulation System
EU	European Union
F'SATI	French South African Institute of Technology
FAO	Food and Agriculture Organisation of the United Nations
FCT	Federal Capital Territory
FDI	Foreign Direct Investment
FGN	Federal Government of Nigeria
FMCT	Federal Ministry of Communication Technology
FMST	Federal Ministry of Science and Technology
FPGA	Field Programmable Gate Array

FRD	Foundation for Research Development
FRN	Federal Republic of Nigeria
FSD	Foundation for Space Development
FSDSA	Foundation for Space Development, South Africa
FTTH	Fibre To The Home
FUT	Federal University of Science and Technology, Minna
FUTA	Federal University of Science and Technology, Akure
G-77	Group 77
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GGC	Gulf of Guinea Commission
GIS	Geographical Information Systems
GNI	Gross National Income
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
GSM	Global System Mobile
GSN	Geoinformation Society of Nigeria
HartRao	Hartebeeshoek Radio Astronomy Observatory
HEIs	Higher Education Institutions
HQs	Headquarters
HSRC	Human Sciences Research Council

HSRP	Phoenix Hybrid Sounding Rocket Program
IAEA	International Atomic Energy Agency
IAF	International Astronautical Federation
IAU	International Astronomical Union
ICCPR	International Covenant on Civil and Political Rights
ICESCR	International Covenant on Economic, Social and Cultural Rights
ICT	Information and Communication Technologies
IDI	In-depth Interview
IDPs	Internally Displaced Persons
IGOs	International Governmental Organisations
IMF	International Monetary Fund
IMSO	International Mobile Satellite Organisation Treaty
IMT	Institute for Maritime Technology
INEC	Independent National Electoral Commission
INS	Inertial Navigation System
IPOB	Indigenous People of Biafra
IRR	Institute for Rocket Research
ISIS	Islamic State in Iraq and Syria
ISPs	Internet Service Providers
ISSE	Institute of Space Science and Engineering
ITSO	International Telecommunications Satellite Treaty

JAA	Johannesburg Astronomical Association
JARIC	Joint Air Reconnaissance Intelligence Centre
JOD	Joint Operations Division
JTF	Joint Task Force
KELT	Kilodegree Extremely Little Telescope
KI	Key Informant
KII	Key Informant Interview
KIT	Kyushu Institute of Technology
km	kilometre
km/s	km per second
KSC	Kennedy Space Centre
KWh	Kilowatt Hour
LAAS	Los Angeles Astronomical Society
LDCs	Less Developed Countries
LGAs	Local Government Areas
LSC	Legal Subcommittee
m	meters
MASSOB	Movement for the Actualisation of the Sovereign State of Biafra
MBNP	Ministry of Budget and National Planning
MCF	Magnetic Clean Facility
MDAs	Ministries, Departments and Agencies

MDGs	Millennium Development Goals
MNCs	Multinational Corporations
MNOs	Mobile Network Operators
MoE	Ministry of Education
MRLP	Mobile Rocket Launch Platform
MWO	Mount Wilson Observatory
N	Naira
NA	Nigerian Army
NACI	National Advisory Council on Innovation
NAF	Nigerian Air Force
NAS	Nigerian Astronomical Society
NASA	National Aeronautics and Space Administration
NASENI	National Agency for Science and Engineering Infrastructure
NASRDA	National Space Research and Development Agency
NATO	North Atlantic Treaty Organisation
NBO	Nigerian Budget Office
NBS	National Bureau of Statistics
NCC	Nigerian Communication Commission
NCOP	National Council of Province
NCRS	National Centre for Remote Sensing
NCSA	National Committee on Space Application

NDC	National Defence College
NDMC	National Disaster Management Centre
NDT	New Dawn Technologies
NGOs	Non-Governmental Organisations
NGS	National Geographic Society
NIA	National Intelligence Agency
NIDR	National Institute of Defence Research
NigComSat	Nigerian Communication Satellite
NIMET	Nigerian Meteorological Agency
NITDA	National Information Technology Development Agency
NMA	Nigerian Metrological Agency
NM-AIST	Nelson Mandela African Institute of Science and Technology
NMETS	Nigerian Meteorological Society
NMMU	Nelson Mandela Metropolitan University
NN	Nigerian Navy
NOUN	National Open University of Nigeria
NP	National Party
NPF	Nigerian Police Force
NQF	National Qualification Framework
NRF	National Research Foundation
NRSC	National Remote Sensing Centre

NSE	Nigerian Society of Engineers
NSFAS	National Student Financial Aid Scheme
NSPS	Nigerian Society of Physical Sciences
NSS	NewSpace Systems
NSSTS	National Space Science and Technology Strategy
NSTDA	National Science and Technology Development Agency
NWGSST	National Working Group on Space Science and Technology
NWU	North-West University
OAD	Office of Astronomy for Development
OAE	Office of Astronomy for Education
OAO	Office of Astronomy for Outreach
OAU	Obafemi Awolowo University
OECD	Organisation for Economic Cooperation and Development
PES	Propulsion and Engine System
R	Rand
R&D	Research and Development
RASCOM	Regional African Satellite Communication Organisation
RASP	Royal Academy of Sciences in Paris
RF	Radio Frequency
RRS	Reutech Radar Systems
RSA	Republic of South Africa

RSUST	River State University of Science and Technology, Port Harcourt
SAA	South African Army
SAAF	South African Air Force
SABC	South African Broadcasting Corporation
SAC	Space Advisory Company
SAC	Space Advisory Council
SACSA	South African Council for Space Affairs
SADC	Southern African Development Cooperation
SADF	South African Defence Force
SAEEC	South African Electrotechnical Export Council
SALT	South African Large Telescope
SAN	South African Navy
SANDF	South African Defence Force
SANDF-ID	Defence Intelligence division of the SANDF
SANSA	South African National Space Agency
SAPS	South African Police Service
SARRG	South African Rocket Research Group
SASA	South African Space Association
SASAA	South African Space Affairs Act
SASAS	South African Society for Atmospheric Sciences
SASS	South African Secret Service

SCDC	Security and Civil Defence Corps
SCS	Space Commercial Services
SDGs	Sustainable Development Goals
SDR	Software-Defined Radio
SEERL	Space-Earth Environment Research Laboratory
SGAC	Space Generation Advisory Council
SIDC	Space Innovation and Development Centre
SIS	Structural Integration System
SKA	Square Kilometre Array
SOE	State-Owned Enterprise
Space SPiN	Space Science Popularisation Programme in Nigeria
sq	squares
SQUID	Superconducting Quantum Interference Device
SSA	State Security Agency
SST	Space Science and Technology
SWAP	Space Weather and Atmospheric Physics Laboratory
SWC	Space Weather Centre
TIA	Technology Innovation Agency
TROPOMI	TROPOspheric Monitoring Instrument
TSC	Technical Subcommittee
TT&C	Tracking, Telemetry, and Command

TUT	Tshwane University of Technology
UAE	United Arab Emirate
UAV	Unmanned Aerial Vehicle
UCS	Union of Concerned Scientists
UI	University of Ibadan
UKZN	University of KwaZulu Natal
UN	United Nations
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples
UNESC	United Nations Economic and Social Council
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNGA	United Nations General Assembly
UNIBEN	University of Benin
UNIJOS	University of Jos
UNILAG	University of Lagos
UNISA	University of South Africa
UNN	University of Nigeria, Nsukka
UN-OOSA	UN Office of Outer Space Affairs
USA/ the US	United States of America
USSR	Union of Soviet Socialist Republics
UWC	University of Western Cape
VDES	VHF data exchange systems

VLBI	Very Long Baseline Interferometer
WAROAD	West African Regional Office of Astronomy for Development
WDI	World Development Indicators
WESSA	Wildlife and Environment Society of South Africa
WHO	World Health Organisation
Wildtrust	Wildlands Conservation Trust
Wits	University of Witwatersrand
WMO	World Meteorological Organization
WTO	World Trade Organisation
WWF	World Wide Fund for Nature
XSLC	Xichang Satellite Launch Centre
ZASTA	Zonal Advanced Space Technology Application

Abstract

The end of the Cold War has witnessed a significant increase in the actors and expansion in the interests that are involved in space. Beyond the growing importance of non-state actors, many developing countries have developed space strategies and transformed space politics from the exclusive club of technological advanced and powerful countries. These have also transformed national interests in space from militarised security and prestige to diverse (national and human) development and security aspirations. These developments call for maximum utility of space and attendant technologies, multidisciplinary approaches to space studies, with more room for social sciences, and attention for the underexplored experiences of the developing countries. Accordingly, this study interrogates decades of space activities in Nigeria and South Africa, and their contribution to the development and security aspirations of affected governments and peoples. This is critical to determine the utility of space policy and investment in these countries, and contribute to the development of African perspectives in space politics and policy studies, and associated narrative in International Relations.

This study adopted multilayer triangulation, covering theory (such as utilitarianism, realism, liberalism, dependency and social constructivism), data (form – qualitative and quantitative – and sources – primary and secondary), research site (five locations per country), and (mixed) method. On these bases, the space policy interests of Nigeria and South Africa were reviewed with their strategic policy conceptions of development and security, and then interrogated in the framework of triangulated theory as well as their historical, socio-economic, and political backgrounds. This study further provides an overview of (state and non-state) actors that are involved in (civil, commercial and defence) space policy and strategies, and the underlining politics, in these countries. Amidst these, space capabilities, including institutions, human and financial resources, infrastructural facilities (for radio and optical astronomy; designing, assembling, integration, testing, launching and tracking of satellites; accessing and converting satellites data, among others) and space assets of Nigeria and South Africa were assessed.

This study observed that space policy and capabilities of Nigeria and South Africa have had varying degrees of effects on economic growth and transformation, national competitiveness, local technological capacity, national defence, power projection, internal law enforcement, disaster management, human rights and freedom, democratisation and good governance, food and water security, environmental sustainability, quality of health and education systems, poverty alleviation and employment opportunities, and international cooperation.

Nevertheless, space capabilities remain largely underutilised, and their potential impacts on development and security of these countries are yet to be fully realised. The study, therefore, recommends strategic management of available resources and cooperation for these countries to maximise utility from space and attendant technologies for their development and security.

Keywords: Africa, development, Nigeria, outer space, security, South Africa, space policy

CHAPTER 1

Introduction to the Study

1.1. Brief background to the Study

Space policy broadly covers all human interests and associated activities in outer space and the celestial bodies. The interests can be political, military, and socio-economic in nature, and their projectors can be a state or non-state actor like international organisations, civil society groups, and corporate bodies (Chaisson, 1998; Dolman, 2002; Dudley-Flores and Gangale, 2012; Harding, 2013; Hickman, 2008; Klein, 2006; Sadeh, 2002a; 2011; Zakutnyaya and Odintsova, 2009). Space policy entails a series of programmes and activities, including rocketry and space flights (either manned or unmanned), artificial satellite systems (for research, communication, navigation and remote sensing), astronomy and cosmology, and all related research and development (R&D). Human belief system on space has evolved from being considered as home of the gods and related metaphysical constructs (Fomenko et al., 2004; Lewis, 2003; Lilly, 1852; Master, 2015; Maternus, 1975; Peeters, 2012), to being viewed as a frontier to advance the development and security interests of mankind and states with required capacity (Harding, 2013; Newell, 2014; Schwartz, 2017a; UN, 2002). Airspace, land and sea are other available frontiers for humanity and nation-state to advance development and security interests (ECA, 2016; Gray, 2012; HDoA, 2015; Johnson, 2008; OECD, 2016; Otto and Hoekema, 2012).

Space has attracted international political attention since the advent of rocket flight, and particularly the long-range ballistic missiles (Air Command and Staff College, 2009; Chertok, 2005; 2006; Chun, 2005; Van Riper, 2004; Werrell, 1985). Yet, the success of the Union of Soviet Socialist Republics (USSR) in placing the first artificial satellite of the Earth in orbit on October 4, 1957 is considered as the advent of space age (Chertok, 2006; Kornilenko, 2007). Thereafter, space exploration between 1957 and 1980s was dominated by the Cold War rivalry between the USSR and the United States of America (USA) (Dolman, 2002; Sadeh, 2002a; Chertok, 2009; 2011; Siddiqi, 2000). Other notable players in space from the Cold War era are Britain, China, France, Japan, Italy, India, Israel, and Brazil (Dolman, 2002; Harding, 2013; Sadeh, 2013). In addition, there are emerging space players like South Africa, Pakistan, South Korea, North Korea, Egypt, Iran, Iraq, Argentina, Algeria, Indonesia, Taiwan, Turkey, and

Nigeria among others (Harding, 2013; Mistry and Gopalaswamy, 2012; Delory, 2011; Oyewole, 2017; Pirards, 1991; Wood and Weigel, 2012). As at 2017, the Satellite Database of the Union of Concerned Scientists (UCS, 2017a) shows that no fewer than 56 countries own at least one satellite in orbit. Euroconsult (2017) equally recognised that 70 countries invested in space in 2016, amidst which more than 60 of them spent more than US$10 million and seven of them (the US, China, Russia, Japan, France, Germany, and India) spent above US$1 billion.

Space activities involved a limited number of actors during the Cold War, when space politics was dominated by competition for power and prestige, and space policy was militarised and directed toward state-centric security interests (Dolman, 2002; Harding, 2013; Sadeh, 2011; 2013). Hence, there is a growing understanding that the expanding number of countries that are involved in space is contributing to the democratisation of outer space and diversification of the motivating interests (Harding, 2016:1). The interests in space have been renewed globally since the end of Cold War, and in developing regions particularly, on the basis that it holds significant prospects for security and development aspirations of the concerned peoples and governments (Argoun, 2012; Harding, 2013; Reibaldi, 2003). In this case, satellites and their widely consumed applications are critical to space popularisation. Satellites are employed for different purposes based on their designs. A communication satellite supports tele-communication, tele-education, tele-medicine, e-governance and e-commerce, among other applications. Earth observatory satellite supports remote sensing for weather forecast, precision agriculture, land and ocean survey, health survey, urban and regional planning, resource mapping, as well as early warning and disaster management (DOS, 2016; Maini and Agrawal, 2014; Pelton et al., 2017). Military powers also prioritised space based or supported command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) in their defence and security (Ercan and Kale, 2017; HDoA, 2009; Heintze, 1993; Klein, 2006).

Despite the progress recorded by a growing number of developing countries in space, there is limited attention to their experiences and perspective in space policy studies (Argoun, 2012; Harding, 2013; Harvey at el., 2010; Wood and Weigel, 2012). Amidst these, the experiences of space players in Africa, Sub-Saharan Africa particularly, are the least heard. A report by African Association of Remote Sensing of the Environment (AARSE) and European Association of Remote Sensing Companies (EARSC) (2016:28) revealed that there are more than twenty national remote sensing agencies and regional centres, and over 45 universities dedicated to building expertise in Earth Observatory (EO) technologies across Africa. Yet,

South Africa and Nigeria are leading space players in Sub-Saharan Africa, with records that are only matched by Algeria and Egypt in North Africa. These are the first set of countries to develop space policy and establish agency for this purpose in Africa (Martinez, 2016:38). Their space inventories also place them ahead of other countries in the region. As of 2017, 23 out of the 29 satellites sponsored by African nations are by these four countries, with the least of them having five satellites (Oyewole, 2017; UCS, 2017). Besides, their first satellites were placed in orbit between 1998 and 2003, making them the most experienced space players in the region. In 2017/2018, Morocco had only sponsored and cosponsored two satellites in two decades; while Ghana, Angola and Kenya only sponsored or cosponsored one satellite each in between 2017 and 2018. These partially explain the reasons why this study prefers to focus on Nigeria and South Africa, as the leading and most experienced space players in Sub-Saharan Africa.

The South African National Space Agency (SANSA) was established in 2008 and national space policy was adopted in 2009. However, South Africa's first satellite was launched into orbit in 1999. Unlike other space players in Africa, South Africa designed and produced all its satellites, with exception of one, between 1999 and 2019. Driven by military-oriented national security concerns, the apartheid regime in South Africa developed the most sophisticated space programme in Africa between 1960s and 1980s (Gottschalk, 2010; van Wyk, 2009; Stapleton, 2010). Its quest for nuclear weapons was also accompanied by policy commitments to develop missile and space launcher capabilities and a satellite (Albright and Stricker, 2016; Gottschalk, 2010; UNDDA, 1991; Van Wyk, 2014a). While the satellite programme survived the country's political transition in 1990s, a considerable shift in policy focus from military-security to R&D objectives led to unilateral destruction of the nuclear weapons and suspension of the intermediate-range missile/orbital launcher programme. With the launch of Condor E2 in 2014, South Africa became the first country with a military satellite in Africa. Besides, South Africa can be described as the most advanced African nation in space science, given a host of space facilities of the country, such as the Hartebeeshoek Radio Astronomy Observatory (HartRao), the South African Large Telescope (SALT), and the ongoing Square Kilometre Array (SKA).

Nigeria declared interest in space during the Cold War, particularly in 1976, but committed little policy measures to this end until late 1990s (Abiodun, 2017; James et al, 2014). The Nigerian National Space Research and Development Agency (NASRDA) was established in 1999, and its first satellite was launched in 2003 (Boroffice, 2008). Nigeria had sponsored six satellites as at 2017. Amidst these, one of its satellites was designed and developed by some

British trained Nigerian engineers (NigeriaSat X launched in 2011) and another one in collaboration with Japanese counterparts (EduSat 1 launched in 2017). It also has three satellites at different stages of production. These include NigeriaSat-3, which was supposed to be fully produced in Nigeria and initially scheduled for completion in 2018. Beyond its satellite inventory, Nigeria is also developing its capacity in rocket flight and missile systems (Fashade, 2008; Zhao, 2018: 268), as well as astronomical facilities. Nigeria institutionalised its military space programme, as it established Defence Space Administration (DSA) in 2014.

The space policy commitments of Nigeria and South Africa have reflected in their investments and spending on space programmes and projects. NASRDA took off with a budget of US$90 million (Oyewole, 2017). In 2013, the US$70 million spent by Nigeria on space was more than the US$68 million spent by the next top three in Sub-Saharan Africa (that is, Angola, Congo and South Africa) combined (Keith, 2014). In 2014, space expenditure in Nigeria was US$66 million, and US$32 million in South Africa (Bochinger, 2016). Amidst their various economic crises in 2016, Nigeria spent US$61 million and South Africa spent US$20 million on space programmes. It is important to note however that Algeria, Morocco, and Angola outspent Nigeria in space, and in addition to the four countries, Egypt also outspent South Africa, in 2016 (Euroconsult, 2017). Nigeria sponsored NigComSat-1 in 2007 at the cost US$300 million, and its NigComSat 2 and 3 under construction are scheduled to cost US$600 million. South Africa purchased Condor E2, launched in 2014 for about US$108 million, and invested in Intelsat New Dawn satellite, which was launched in 2011 at the cost of US$250 million, while locally built microsatellites SunSat and SunbandilaSat cost less than US$5 million (Oyewole, 2017).

Against this background, the policy priority and investment that space affairs are receiving from emerging space players and developing countries like Nigeria and South Africa have become a subject of debate. This is important in the light of pressing policy demand to advance the security and development aspirations of the peoples and governments of these countries. As a consequence, the connection between space policy priority and investment on one hand and the aspirations of the peoples and governments of these countries called for interrogation. It is on these bases that this research seeks to assess the space policy motivations and commitments of these emerging space players and developing countries, as well as the extent to which the identified policy objectives are served by selected space programmes and investment.

1.2. Statement of Problem

The South African National Space Policy (2008) identified that "the pursuit of space activities in South Africa is informed by the overarching principle that these contribute to the country's economic growth and social development." Equally, the National Space Policy and Programme (2001) identified that Nigeria needs to possess the "technical know-how to participate actively and independently in space activities and as a service provider of these products and services that have helped to serve the social and economic needs of the country." These indicated that these countries have notable years of experiences in the application of space technologies with record of benefits that deserve research attention. However, most of the existing studies on this subject matter largely focus on historical context, institutional development and the prospects and (possible) challenges of space policy and programmes in Nigeria and South Africa (Boroffice, 2008; Gottschalk, 2010; James et al, 2014; Martinez, 2016; van Wyk, 2009). In view of these, the convergence and divergence of what Nigeria and South Africa intended to achieve through space policy and what they have actually achieved over the years have received inadequate academic attention of policy analysts and social scientists generally. This concern cannot be ignored in the light of the growing space spending and investment in these countries, considering the possibility of rechannelling the policy attention and associated funding to terrestrial means of addressing some pressing national developmental and security challenges.

Developing countries like Nigeria and South Africa embraced space policy based on some associated developmental and security promises: its potentials to inspire or contribute to economic growth, poverty alleviation, job creation, quality education, sustainable infrastructure, food security, water management, environmental sustainability, quality of health system, law enforcement, management of political and criminal violence, military modernisation, and credible disaster management capability among others (Argoun, 2012; Ercan and Kale, 2017; Harding, 2016; NASA et al. 2015; Olla, 2009). However, their experiences and perspectives remain largely unaccounted for. Hence, the rationale for space policy priority and spending in these and many other emerging players are entangled in the space popularisation projects of the advanced players, whose core aim is to increase support base for their programmes locally, and power, prestige, and commerce internationally (Detsis and Detsis, 2013; Lieberman, 2017; Oikonomou, 2017; Reibaldi, 2003). Accordingly, an enquiry into the space policies of Nigeria and South Africa is an important step in assessing the myths and realities of space popularisation, especially on the benefits in space spending to

the emerging players. These are the primary subjects of concern that this study seeks to investigate.

1.3. Aim of the Study

This study seeks to assess the space policy programmes of Nigeria and South Africa as well as their contributions to socio-economic development and security.

1.4. Research Objectives

This study seeks to achieve the following objectives:

1. To determine the policy objectives of Nigeria and South Africa in space.
2. To examine the development of space policy in Nigeria and South Africa.
3. To assess the benefits of space policy to the enduring developmental aspirations of the peoples and governments of Nigeria and South Africa.
4. To examine the security utilities of space policy in Nigeria and South Africa.

1.5. Research Questions

1. What are the policy objectives of Nigeria and South Africa in space?
2. What are the development paths for space policy in Nigeria and South Africa?
3. To what extent is space policy benefiting the enduring developmental aspirations of the peoples and governments of Nigeria and South Africa?
4. Of what benefit is space policy to security interests and capabilities of Nigeria and South Africa?

1.6. Justification for the Study

This study is significant for academic and policy purposes. The first academic significance of this study is its contribution to the knowledge of the use of extra-terrestrial means to realise terrestrial socioeconomic and security policy ends. Secondly, this study seeks to contribute to space politics and policy studies from the experiences and perspective of a developing region, using the cases of the two leading spacefaring countries in Sub-Saharan Africa: Nigeria and South Africa. The decline of universalist or “one size fit all” models in social science, which are largely criticised as “globalisation of western ideas”, have encouraged the rise of post-

colonial models, with the principal aim of promoting the experiences and perspectives of the developing countries (Ake, 1982; Gill, 2008; Saul, 2009; Sylvester, 2014). Notably, African experiences are understudied, and its perspective is marginalised in the field of International Relations (Cornelissen et al., 2015). Hence, there is a growing call to raise the visibility and relevance of African studies and perspectives to fill the gap in the field of International Relations. Notably, therefore, African experiences and perspectives are hardly heard in space politics and policy studies. This study is therefore expected to fill some gaps by bringing space issues into crucial components of African Studies, such as development, governance, policy, and security.

The policy significance of this study is in its attempts to assess and understand the nature of space policy, and its contributions to development and security aspiration of the governments and peoples of developing countries like Nigeria and South Africa. This is important at the local or national level, in a region where the state is largely considered to be disconnected from the society, and policymakers are seen to be acting out of popular will or rational public interests, as they often preside over government with weak legitimacy (Bayart, 1999; Clapham, 1996; Collier, 2010; Pring, 2015). This scepticism is aptly captured by Claude Ake (1996:1), when he argued that the assumption so readily made that there has been a failure of development in Africa is misleading; the problem is not so much that development has failed as that it was never really on the agenda in the first place. Consequently, this study offers an opportunity to test and assess the commitments of African policymakers in Nigeria and South Africa to development, through the kind of policies they prioritise, and the investment set out to achieve it. Amidst these, the knowledge of space science and engineering, the associated policies and programmes, and their benefits in developing countries such as Nigeria, South Africa, and other African countries are limited. In this case, the knowledge of space policy programmes, their motivations, as well as cost and benefits in Nigeria and South Africa will help us to identify the level of utility that is currently derived from public policy priority and investment in this area, and how to maximise the benefits of the existing space assets and policies. At the same time, the variation in the characters, motivations, cost and benefits of space policies, programmes, and investments in these two countries can provide cross-examined knowledge of the subject.

At the regional level, Nigeria and South Africa are hegemons that have major influence on the regional security architecture and development paths of other countries in Africa (Adebajo,

2010; 2017; Amusan and Oyewole, 2017; Ogunnubi, 2014). Hence, this study will help us to understand the contributions of space policies of Nigeria and South Africa to their status, power capabilities and influence, and some of the accruable benefits for space policy programmes and associated development and security in other countries in Africa. The knowledge of space policy and its contributions to development and security in Nigeria and South Africa locally and their influence in the region are significant to predicting the prospect of other Sub-Saharan Africa countries in space policy priority, investment, and associated benefits as well as in regional cooperation, institution-building, and possibly competition in this subject area.

At the global level, the militarised Cold War's reductionism of the motivation for space policy and programme to competition for power and prestige has encouraged securitisation of some emerging nations in space as threat to international security in the post-Cold War era. This explains the scepticism and hostility against some emerging nations in space including apartheid South Africa, Iran, Libya, and North Korea (Mistry and Gopalaswamy, 2012; Gottschalk, 2010; Hart and Kile, 2005; Sariak, 2017; Starun, 2017; UNDDA, 1991). This also informs the restriction in transfer of space technologies by some advanced nations like the US (Noble, 2008; Sadeh, 2015). Recently, the British government also came under pressure to cut foreign aid to the top five African countries, and other developing countries like India, that are engaged in space programmes (Oyewole, 2017). Bearing in mind that there are different understandings on motives for space globally, and the tendency or attempts of some actors to misunderstand or misrepresent the involvement of emerging nations in space, it is important that this study seek to investigate space policy based on the experiences and perspective of developing countries like Nigeria and South Africa. It is also important to assess the specific benefits of space policy priority and the investments of these countries as against the prevailing and generalised understanding of space benefits that are associated with space popularisation projects of the advanced space powers.

1.7. Conceptual Framework of Analysis

1.7.1. Space

If policy is detached from space policy in the context of this study, we will be left with the concept of space, which deserves a considerable clarification in order to avoid misconception. Space is an important concept that has attracted interdisciplinary scrutiny and interpretation. Aristotle (1928) observed that space takes precedence over all other things, because without it

nothing else can exist. It is no surprise therefore that there is no universal consensus on what constitutes a space. As "one of those words that frequently elicits modification", Harvey (2004:2) described the challenges of operationalizing the concept of space as follows:

> "The complications perhaps arise more out of the modifications (which all too frequently get omitted in the telling or the writing) rather than out of any inherent complexity of the notion of space itself. When, for example, we write of "material", "metaphorical", "liminal", "personal", "social" or "psychic" space (just to take a few examples) we thereby indicate a considerable diversity of contexts which so inflect matters as to seem to render the meaning of space itself entirely contingent upon the context. Similarly, when we designate its range of applications in terms such as spaces of fear, of play, of cosmology, of dreams, of anger, of particle physics, of capital, of geopolitical tension, of hope, of memory, or of ecological interaction (again, just to indicate a few of a seemingly infinite range of potential sites of deployment of the term) then we seem to be saying that the arena of application defines something so special about the meaning of space as to render any general consideration of its properties a hopeless task."

The divergent perspectives on the concept of space can be narrowed down to a series of debates between physicists and philosophers (Disalle, 2006:1). At the broadest level, the concept of "space" is a source of debate between social sciences and humanities on one hand as well as pure and applied sciences on the other. Humanities and social sciences keyed into philosophical understanding of space to situate space in social and relational context; while pure and applied sciences keyed into physical understanding of space, which is absolute and geometric (Lefebvre, 1991). Accordingly, there are social and geometric dimensions to space and the conceptions of the two vary in terms of tangibility and measurability. Harvey (2004) however observed that both social and geometric conceptions of space can fit into the understandings of space in absolute, relative, and relational sense (cf Disalle, 2006).

1.7.1.1. Perspectives on the Concept of Space

1.7.1.1.1. Absolute Space

This notion of absolute space is mainly associated with Newton and it is usually represented as a geometrically Euclid, fixed frame for event planning, pre-existing and immoveable grid

amenable to cadastral mapping and standardized measurement, and open to calculation and engineering practices (Harvey, 2004:2; Disalle, 2006:13-20). Socially, this is the space of private property and other bounded territorial designations (such as states, administrative units, city plans, and urban grids) (Harvey, 2004:2).

1.7.1.1.2. Relative Space

Einstein developed the idea of relative space. Prior to this, Kant has provided ample criticism of absolute space and a German mathematician and Physicist, Carl Friedrich Gauss (1777-1855) has developed rules of non-Euclidean spherical geometry. The central argument is that all forms of measurement depended upon the frame of reference of the observer. It is hence considered impossible to understand space independent of time under this formulation, and this mandate an important shift of language from space and time to space-time or spatiotemporality (Harvey, 2004; Disalle, 2006).

1.7.1.1.3. Relational Space

The concept of relational space, which is largely associated with Leibniz, also emerged as a criticism against Newtonian absolute space. The relational view of space holds that there is not such thing as space outside of the processes that define it. Processes do not occur in space but define their own spatial frame (Harvey, 2004). Like the relative space, this conception also supported the fusion of time and space in analysis. Hence, an event or a thing at a point in space cannot be understood by appeal to what exists only at that point in time, but through everything else going on around it (although in practice usually within only a certain range of influence). A wide variety of disparate influences swirling over space in the past, present, and future concentrate and congeal at a certain point to define the nature of that point (Harvey, 2004). This will later help us to understand the connection between space and policy.

1.7.1.2. Dimensions in Conception of Space

1.7.1.2.1. Social space

Social space can be described as the structure of the system that gives meaning to the struggles of individuals (Healy, 207). At the individual level, the life course is a sequence of statuses and roles achieved by particular people, together with their own representations of their

biographies. At the macro level, it is a more-or-less institutionalized set of roles (and rules governing transitions between them), together with collective representations of what a well-ordered life ought to look like (Healy, 2007:107). It is described by Zieleniec (2007: xii) as the territory of self-actualising techniques, of developmental and faith-based systems of meaning, promised enlightenment and the expansion of the minds' horizons beyond the corporeal or physical world of existence. It is relevant for explaining developmental puzzles and predict suitable ways forward for political, economic, social and cultural affairs or domain of a group of people, society, the state, and at the broadest level, the international community.

1.7.1.2.2. Geometric space

Geometric space involves the interval of time, or distance between lines, objects or locations (Abhyankar and Sathaye, 1974). This is applicable to mathematics, geography, and physics.

1.7.1.3. Range of Application

Space in this study is outer space. Hence, the range of the application of the concept of space is generally geometric and specifically astronomical as well as relative. In this consideration, space is a place (Lambright, 2003). This is a frontier that can be related to land, water, and air (HDoA, 2015; Schwartz, 2017). Space is simply a region between all astronomical objects in the universe (Encarta Dictionaries, 2009). Scientific enquiry in the area of astronomical space seeks to advance human knowledge or exploration of planet Earth, its atmospheres and satellite, the solar system, the galaxies and the universe (Hawking, 1996; 2001; Hawking and Mlodinow, 2010; Liu, 2008; Mo et al., 2010; NASA, 2001; Rottner, 2017; Schneider, 2006; Seeds and Beckman, 2010; Sparke and Gallagher, 2007). In the solar system, space or distance is often calculated using the standard astronomical unit (au): the mean distance from the centre of the Sun to the centre of the Earth, which denotes 149,597,870.691 kilometre (km) plus or minus (±) 30 meters (m), or 92,955.807.267 international miles ±100 feet (Vanderbei and Belikov, 2007:91). Also, light-year—the distance light travels during one year—is a common unit used by astronomers to describe distances in the universe. Light travels at the pace of 3×10^5 km per second (km/s), making a light-year 9.46×10^{12} km (9,460,000,000,000 km) (Fraknoi, 2017:16).

Space is also the infinite region that lies beyond the Earth's atmosphere, and all that it contains (Encarta Dictionaries, 2009). This definition loosely includes every astronomical object except

planet Earth as space. Zieleniec (2007: xi) described this space as "somewhat outside this world, somewhere up there." Most of the United Nations' (UN) resolutions, principles, and treaties on space use the word to cover all celestial bodies (UN, 2002). Many national space policy papers and legislations follow this pattern. However, the Earth's atmosphere is made up of multiple layers, which start from troposphere to tropopause, between 8 km and 17km altitude (height above the ground or sea level); stratosphere, 17km to 50km; mesosphere, 50km to about 80km; thermosphere, 80km to 500km; and end with exosphere, 500km to 1000km altitude (Moore, 2002:40; Matzner, 2001). Thus, there are different postulations on where space starts from the Earth point of view. Using different criteria, the boundary of space from the Earth have been postulated to starts from 80km, 100km, 118km, 122km, 129-150km, and 400-800km altitudes (Kois, 2004; Lal and Nightingale, 2014; Srughold et al., 1951; Williams, 2016). Amidst these, the 100km altitude, postulated by Theodore Von Karman as the boundary between aeronaut and astronaut and taken as the starts of space from the Earth, and named after him as Karman line, is widely in use and accepted by the International Astronautical Federation (IAF) (Macdonald, 2014).

1.7.2. Space Policy

While the foregoing understanding of space is relative to human knowledge of the Earth and its location in the universe, space policy means space in relation to policy. Policy falls into the class of social space, while outer space fits into geometric concept of space. Thus, knowledge of the concept of policy is considered to be important to understand space policy properly. Policies are purposive courses of action devised in response to a perceived problem (Cochran and Malone, 2014:3). This is a general definition that gives no hint on the likely actor and problem, and overlooks the possibility of having a response designed based on perceived opportunity instead of problem. In the light of this, space policy can be described as a purposive course of action devised in response to perceived socio-economic, political and military challenges and opportunities in or from outer space. In this consideration, the action can be to explore or exploit the outer space, the space actor can be state or non-state actors, the context can also be public or private, and at individual, domestic and international levels.

In a limited context, space policy can be considered as a form of public (national) policy, such as the health, economic, defence and foreign policies. Cochran and Malone (2014:3) defined public policy generally as the overall framework within which government actions are

undertaken to achieve public goals, and specifically government decisions and actions designed to deal with a matter of public concern. In the context of outer space, Tronchetti (2013: IX) observed that the term policy refers to the official approach of a state towards the exploration and use of outer space. Space policies include both the making of space policy through legislative process and the execution of that policy by civilian, military bodies, and regulatory agencies (Tronchetti, 2013: ix). This definition helps to identify major policy actions (policy making and executions) that are required in space and the actors in each case.

Sadeh (2002b) shares similar perspective with Tronchetti's (2013: ix), with more details, on the concept of space policy. Sadeh (2002b: xiv) argued that space policy involves both the process (space politics) of policy formation and policy change over time, and the courses of action taken to achieve politically and technologically determined outcomes (space policy). In the light of this, Sadeh (2002b) observed that space politics involves the process by which historic conditions, rationales for space, and advocacy coalitions interact with and impact agenda-setting; actors and institutions (Presidents, Congress, and the space bureaucracy) interact with and impact public policy formulation and implementation; and how policy outcomes bring about policy change (emergence of privatization and commercialization). Equally, space policy deals with the outcomes that include such areas as the environment, law, commerce, international cooperation, and national security (Sadeh, 2002b: xiv). This understanding further sharpens the place of space-time and relational meaning of outer space policy. However, this conception leaves one to wonder why space policy broadly equates input and output on one hand, and on the other hand output alone also equates to space policy.

Tronchetti's (2013: ix) argued that a ''space policy'' describes a nation's strategy regarding its civilian space programme, and the military and commercial utilization of outer space. As such, Klein (2006:137) observed that policy commonly provides guidance for governmental departments and agencies, while delineating resources to make political goals a reality. In the light of these, some scholars have tried to differentiate between space policy and space strategy (Klein, 2006; Sadeh, 2013). Although policy includes elements of strategy, the two concepts are considerably different. Policy is the official governmental positions, either in the form of documents or speeches, which provide the necessary guidance to reconcile competing requirements in order to balance one's "ends" with one's limited "means" (Klein, 2006:137). Strategy involves one's ends and means, and how they are managed. Sadeh (2013b:1) argued that the purpose of space strategy is to coordinate, integrate, and prioritize space activities

across security, commercial, and civil sectors. Without strategy, space activities continue to provide value, but it becomes difficult to identify and execute long term programs and projects and to optimize the use of space for security, economic, civil, and environmental ends (Sadeh, 2013b:1). Nevertheless, the conceptions of space policy and space strategy are too overlapping that the difference between the two is not well pronounced and the idea and attempts to distinguish them are less significant in this consideration.

Against this background, this study generally agrees with Harding's (2012) definition of space policy. He concisely defines national space policy as the conscious and specific use of space and its attendant technologies to promote the security and socioeconomic interests of the state (Harding, 2012:5). This definition identified four major concepts that need to be understood in any conception of space policy, and these are space, space technology, security, and socio-economic interests of a state. The concept of space has been considered above. In exploring the concept of space technology, this section pays attention to the scope of this study, which focuses on satellite. The conception of socioeconomic interests of the state was alternatively used as development by the author. Thereafter, the concept of security will be considered. However, this study only agrees with the general framing of the definition, but disagrees with its state-centric nature, which necessitated the distinction between development and security. This study thus considered the two concepts as indistinguishable development-security nexus.

1.7.3. Space Technologies: Satellite and Satellite System

Satellites are important set of space technology. However, this concept can be used in two different ways in space studies. *Philip's Astronomy Encyclopaedia* defined a satellite to mean smaller body orbiting a larger one (Moore, 2002:358). At the most massive end of the scale, this can be taken to mean small galaxies orbiting a larger primary galaxy like M32 and NGC 205 in relation to the Andromeda Galaxy. These are often called satellite galaxies. At the end of the scale, some planets have their own natural satellites as it is the case with every planet in the Solar System except for Mercury and Venus. For instance, the Moon is the satellite of the Earth. Hence, these are referred to as planetary satellites. Amidst these, planets can also be referred to as satellites of their star, as it is the case of the eight planets orbiting the Sun in the Solar System, although they are rarely spoken of in this way (Moore, 2002:358). In all these cases, satellites are "astronomical objects", and are alternatively referred to as "natural satellites".

Due to improvement in pure and applied sciences as well as engineering, human being has developed the capacity to build what is known as "artificial satellite". This form of satellite can be loosely referred to as artificial object in space. However, it is not all artificial objects in space that qualify to be called satellite. The better word for this according to Macdonald (2014) is spacecraft. A spacecraft is a vehicle or vessel designed to operate beyond the von Kármán ellipsoid, that is, 100 km above the sea or ground and beyond (Macdonald, 2014:25). This definition broadly covers crafts like space vehicles, ships or vessels, as well as rovers or landers, and may be extended to platforms that host human presence in space for considerable periods of time like space stations. At the same time, a spacecraft can be described as a platform onto which the payload is mounted (Macdonald, 2014:25). In this case, the payload is the biological passengers, or the part of a robotic vehicle that produces revenue, a product or a service; while the principal purpose of the rest of the spacecraft is to serve the needs of the payload, positioning it where it needs to be in space, while providing it with power, communications and the desired thermal environment, whilst also ensuring it is pointing in the correct direction on a sufficiently stable platform (Macdonald, 2014:27). This is typical of a satellite. It is also important to recall that satellite is a smaller body orbiting a larger body. This makes it impossible to refer to a launch vehicle with spacecraft payload as a satellite. In general, space ships, vessels, vehicles, landers and rovers don't qualify to be called satellites.

UCS (2017b) *Satellite Database User's Manual* adopted a restricted definition of satellites with focus on currently manoeuvring and/or communicating ones. This definition prioritises "active satellites", and excludes satellites still orbiting but are no longer in use (though some of these may still be occasionally used for training operators or for other secondary purposes), as well as passive satellites that are used for laser ranging and radar calibration, such as LAGEOS 1 and LAGEOS 2 and the CALSPHERE satellites (UCS, 2017b).

Despite the foregoing, there is a need to identify the concept of satellite systems, and then differentiate it from satellites. The basic assumption here is that a satellite, or better still, an active satellite system is not an independent object in space, it is being controlled from the Earth, from where it receives command, processes it, and sends feedback to maintain its activeness. In view of these, a space system is divided into space and ground segments. A satellite is the space segment of a satellite system, just as what a spacecraft is, generally, to a space project. The ground segment is generally defined by Macdonald (2014) as everything before the von Kármán ellipsoid and consists of the entirety of hardware, software, and human

resources required to manage and control a space vehicle. This can also be divided into two, the flight operations segment and the payload data ground segment. The flight operations segment is focused largely on the command and control of the spacecraft, while the payload data ground segment is mostly defined by the mission objectives and the data product. In most cases in a mission, the spacecraft control centre usually receives the flight operations data and the data product, which will then be passed on to the payload data ground segment, which may be collocated (Macdonald, 2014:28-29). This mostly explains, with the receiver and transmitter, exchanges that usually occur between the devise in space and the control station on the ground.

1.7.4. Development

The concept of development has multiple meanings across time and space; it is thus a subject of academic and public debate (Esteva, 2010). Hettne (2005:27) observed that there is always this tendency for official, politically-recognised and generally acceptable understanding to emerge among theoreticians and practitioners to undermine other perspectives, hence making control over discourses a dimension of power. Accordingly, a distinction is made between *mainstream* and *counterpoint* on the concept of development, the former referring to the predominant view, focusing on modernisation and economic growth from either a state or a market perspective. The latter refers to certain oppositional, sometimes "anti-modern" ideas from "civil society", typically arguing for inherent superiority of small-scale, decentralised, ecologically sound, community-centred, human and stable models of societal development (Hettne, 2005:27). Studies on means and ends of development have shed more light to this dichotomy and their historical trajectories (Martinussen, 1997; Pieterse, 2010). Hettne (2005), Martinussen (1997) and Pieterse (2010) shared similar views on how meanings or ends of development have evolved since 1945. However, Pieterse's (2010) review of conceptions of development is more historical, with focus that spread from the 1800s to the 2000s, as evident in Table 1.1, although the term "development" was not necessarily used initially in most cases.

Table 1.1: Meanings of development over time

Period	Perspectives	Meanings of development
1800s	Classical political economy	Remedy for progress, catching up
1870 >	Latecomers	Industrialization, catching-up
1850 >	Colonial economics	Resource management, trusteeship
1940 >	Development economics	Economic growth – industrialization
1950 >	Modernization theory	Growth, political and social modernization
1960 >	Dependency theory	Accumulation – national, autocentric
1970 >	Alternative development	Human flourishing
1980 >	Human development	Capacitation, enlargement of people's choices
1980 >	Neoliberalism	Economic growth – structural reform, deregulation, liberalization, privatization
1990 >	Post-development	Authoritarian engineering, disaster
2000	Millennium Development Goals	Structural reforms
2015	Sustainable Development Goals	Advancing structural reforms, welfare globally

Source: Pieterse (2010:7) with author's update

In relation to the meaning of development, classical political economy in 1800s largely focused on how to address shortcomings and maladies of progress, such as population growth, social inequalities, social dislocation, and wealth distribution, from where Thomas Robert Maltus (1766-1834) and Karl Marx (1818-1883) among others emerged prominent (Pieterse, 2010). As such, Marx's conception of development entails a proletarian revolution that will replace capitalism with socialism, and with the final aim of achieving communism (Marx, 2010; Marx and Engels, 1848). Similarly, many social scientists are increasingly responding as well as calling for more responses to political, economic, legal, and cultural questions, including opportunities and challenges, which are associated with the advancement in pure and applied sciences as well as engineering that underscore space exploration and exploitation with all their various space problematisation perspectives and attendant choice of actions contained in recommendations (Dick, 2015; Pass, 2006; 2011; Wolter, 2006; Chertok, 2006; 2009; 2011).

With the dawn of industrial revolution in Western Europe, industrialisation and catching up become the dominant ends of development, particularly in the rest of the continent, and most especially from 1870s (Pieterse, 2010). This conception of development is equally relevant to developing countries of the global-South in their bids to catch up with developed countries of the global-North, and specifically in this case, the advanced space players. For example, developing countries like China, India and Brazil that Harding (2013) referred to as first tier space players considered catching up with the developed countries and advanced space players like the US, Russia, and Western Europe as ends of development. Trusteeship and access to colonial resources was also considered to be key to development from 1850s (Pieterse, 2010). This is related to the growing advocacy for human colony or settlement and resources exploitation in space and celestial bodies (Dudley-Flores and Gangale, 2012; Munévar 2014). In fact, there are space advocates that believe that space colonialism is an unavoidable stage of development that is underscored by social, political, and economic trends. In the same way that colonialism was considered exportation of civilisation by the metropolis to the colonies, some advocates also observe the need to take civilisation to other worlds (Schwartz, 2017a).

Since the 1940s, the concept of development has emerged prominently out of what used to be conceived as progress and evolution (Martinussen, 1997:34). Amidst these, economic growth and industrialisation were popularly considered as ends of development in the 1940s (Pieterse, 2010). This conception of development remains popular, despite its well-known inadequacy, most especially in the developing countries (Todaro and Smith, 2015; Nafzinger, 2006). In relation to this conception of development however, the potentials of space exploration and exploitation to inspire economic growth have been recognised (Harding, 2013). Moreover, from the 1950s, modernisation thesis popularly advocated for the adoption of Western technologies and socio-political system, while the dependency thesis has encouraged national self-reliance since the 1960s (Martinussen, 1997: 38-40; Pieterse, 2010). The former conception of development can be relevant in the attempt to understand the growing demand for space products, and to an extent, technological transfer to the developing countries, while the latter can help us to explain the drive for independent capacity including space technologies by several developing countries (Argoun, 2012; Harding, 2012; Wood and Weigel, 2011; 2012).

Starting from the 1970s, the foregoing conceptions of development have been criticised as state-centric by advocates of alternative development (Pieterse, 2010). Amidst these,

community development was conceived with ends of human flourishing. Philips and Pittman (2009) defined community development as "a *process*: developing and enhancing the ability to act collectively, and an *outcome*: (1) taking collective action and (2) the result of that action for improvement in a community (a place or interest group) in any or all realms: physical, environmental, cultural, social, political, economic, etc." Equally, human development has emerged since the 1980s with focus on enlargement of people's choices (UNDP, 1990: 10; Dalal-Clayton and Bass, 2002; Elliott, 2006; Korten and Klauss, 1984; Pieterse, 2010; Martinussen, 1997; McGillivray et al., 2011; Strange and Bayles, 2008). Space and attendant technologies are relevant in this consideration for job creation and poverty alleviation, urban planning, precision agriculture and food production, as well as management of water, transportation, health and environment among others that are strategic to community and human interests and development (Dick, 2015; Kotze, 2014; Olla, 2009; Sheffield et al., 2014; Zhang, 2016).

From 1980s, neoliberalism has become a popular perspective with emphasis on economic growth based on structural reform, deregulation, liberalisation, and privatisation which are aimed to roll back government and reduce market-distorting interventions and in effect lead or inspire 'development' (Pieterse, 2010). This is important to liberalisation and the growing involvement of private firms in space exploration and exploitation (Hudgins, 2002; Machay and Steinberg, 2015; Pelton, 1992). Nevertheless, neoliberalism is also considered as an anti-development perspective, not in terms of objectives but in terms of means. Post-development thinking has therefore put forth an anti-development position, which is more radical for it applies not merely to the means (the state is accused of authoritarian engineering) but also to the goals (economic growth is repudiated) and the results (which are deemed a failure or disaster for the majority of the population) (Pieterse, 2010:7; cf. Ake, 1996; Hertz, 2001; Saul, 2009; Stiglitz, 2002; 2007; 2013). This perspective is relevant to the growing concerns, scepticisms and criticisms of private/ corporate interests and activities in space, which is also considered as the common or highest frontier (Banner, 2008; Lave, 1986; Sadeh et al., 2005).

It is against this background that the United Nations (UN) adopted vision 2015, Millennium Development Goals (MDGs) in 2000 (Pieterse, 2010). This programme was conceptualised to entail eight different goals, which include to (1) eradicate extreme hunger and poverty, (2) achieve universal primary education, (3) promote gender equality and empower women, (4) reduce child mortality, (5) improve maternal health, (6) combat HIV/ aids, malaria and other

diseases, (7) ensure environmental sustainability and (8) develop a global partnership for development (UN, 2001). MDG was replaced with a broader vision 2030, Sustainable Development Goals (SDGs) in 2015 (UN, 2015). This entails 17 goals, which include to:

(1) End poverty in all its forms everywhere; (2) End hunger, achieve food security and improved nutrition and promote sustainable agriculture; (3) Ensure healthy lives and promote well-being for all at all ages; (4) Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all; (5) Achieve gender equality and empower all women and girls; (6) Ensure availability and sustainable management of water and sanitation for all; (7) Ensure access to affordable, reliable, sustainable and modern energy for all; (8) Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all; (9) Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation; (10) Reduce inequality within and among countries; (11) Make cities and human settlements inclusive, safe, resilient and sustainable; (12) Ensure sustainable consumption and production patterns; (13) Take urgent action to combat climate change and its impacts; (14) Conserve and sustainably use the oceans, seas and marine resources for sustainable development; (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; (16) Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels; (17) Strengthen the means of implementation and revitalize the global partnership for sustainable development (UN, 2015).

1.7.5. Security

The concept of security is a dicey one, and its meaning has attracted significant academic and public attention and has generated tense policy debates and controversies across time and space. Dillon (1996) observed that the genealogy of security primarily deals with how order of fear forms a people and its implication for what is political. In view of this, security is a principal device for constituting political order and for confining political imagination within the laws of necessity of the specific rationalities thrown-up by their equally manifold discourses of danger (Dillon, 1996:16). In this consideration, evolution theory is of the view that tribal societies developed a centralised source of authority with army of men over a given piece of land out of fear of losing the property, owned by individual members or the group collectively,

to their neighbours (Fukuyama, 2012). At the same time, the State, in social contract theory, is thought to have emerged with monopoly of violence to guarantee security against the perpetual fear of impunity that characterised the state of nature (Hobbes, 1651).

Security studies is generally dominated by students of International Relations that are known as realists. Accordingly, the concept of security traditionally means national security. Louw (1978:10) defined national security as the condition of freedom from external physical threats which a nation-state enjoys. Huntington (1957:1) however offers a much broader and policy-driven definition of national security. He observed that national security policy can be considered in three forms: military, internal, and situational security policies. Military security policy is the programme of activities designed to minimise or neutralise efforts to weaken or destroy the nation by armed forces operating from outside its institutional and territorial confines (Huntington, 1957:1). Internal security policy also deals with threat of subversion—the efforts to weaken or destroy the state by forces operating from within its territorial and institutional confines (Huntington, 1957:1). Situational security is mostly concerned with the threat of erosion resulting from long time changes in social, economic, demographic, and political conditions tending to reduce the relative power of the state (Huntington, 1957:1).

The foregoing conception of security has been largely criticised for nationalistic and state-centric reductionism, with greater focus on territoriality and regime as principal objects to be protected, at the expense of humanity. On many occasions, this rationale has been used to justify the impunity of the state against defenceless people. These among others have contributed to the decline of realism and its conception of security (Booth, 2011; Buzan, 2014; Buzan and Wæver, 2003; Burchill et al., 2005; Wendt, 1999; Williams, 2005). Hence, the concept of human security has emerged to prominence with emphasis on the fundamental freedom of the people to live a good life (UNDP, 1994). It is important to note that justice, coordination, efficiency, and stability demand that a social arrangement is based on the principle of liberty (Rawls, 1999). Components of human security include economic security, food security, health security, environmental security, community security, personal security and political security (UNDP, 1994: 24-25). These dimensions of human security are briefly considered below:

1. Economic security: It requires an assured basic income – usually from productive and remunerative work or, in the last resort, from some publicly financed safety net (UNDP,

1994:25). In this consideration, unemployment, underemployment, job insecurity and job loss, inflation, high dependency ratio, and living below international poverty line of US$1 per day are considered as threats and concerns to human security.

2. Food Security: It means that all people at all times have both physical and economic access to basic food (UNDP, 1994:25). Anderson (1990) was recognised by du Toit (2011:3) to have identified food security conception in three levels: national, community, and household levels. At national level, food security implies the condition whereby the country is able to manufacture, import, retain, and sustain food needed to support its population with minimum per capita nutritional standards (du Toit, 2011:3). At the level of community, food security means the condition whereby the residents in a community can obtain safe, culturally accepted, nutritionally adequate diets through a sustainable system that maximises community self-reliance (du Toit, 2011:3). At household level, it is the availability of food in one's home which one has access to. In this consideration, a household is regarded as food secure when the members of the family do not live in hunger or fear of starvation (du Toit, 2011:3). In this case, Amartya Sen (1981:40-41) defined starvation as lowness of the typical level of food consumption and declining trend of food consumption, and famine as sudden collapse of the level of food consumption. Shaw (2007:384) also argued that food security is affected by overarching major global concerns, such as environmentally sustainable development, water resources, world trade, human security and rights, climate change and the current pattern of globalization, which penetrate and affect the concerns at the local and national levels. In general, food security entails availability, accessibility, and affordability of food, which are complex issues that encompass a wide range of interrelated economic, social, and political factors that are both internal and external to a nation (Clover, 2003:7).
3. Health security: Freedom from diseases and the general condition or wellness of body, mind and soul are also essential to human security. Accordingly, poor nutrition, environmental degradation like water and air pollution, as well as the rise and spread of infectious and parasitic diseases are considered as threats and concerns to human security.
4. Environmental security: this focuses on interdependent relations between humanity and the totality of its ecosystem or every other thing in the surrounding, which include air, waters, land, and space as well as the resources therein. In this consideration, environmental degradation is a major threat at the local level, while climate change is a global threat.

5. Community security: Most people derive security from their membership of a group – a family, a community, an organization, and a racial or ethnic group that can provide a cultural identity and a reassuring set of values (UNDP, 1994:31). Hence, security of this type is important for human security, although there is a concern about this form of security as capable of being used as a driver of oppression, and hatred and terror of members and non-members. This dimension of human security is supported by the International Covenant on Economic, Social and Cultural Rights (ICESCR) of 1966, the International Covenant on Civil and Political Rights (ICCPR) of 1966, and the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) of 2007 among others.
6. Personal security: This is arguably the most important dimension of human security. It focuses on freedom of individuals from threats from the state (physical torture), threats from other states (war), threats from other groups of people (ethnic tension), threats from individuals or gangs, against other individuals or gangs (like crime and street violence), threats directed against women (such as rape and domestic violence), threats directed at children based on their vulnerability and dependence (child abuse), threats to self (such as suicide and drug use) (UNDP, 1994:30).
7. Political security: The emphasis here is on the level of respect accorded to human rights, rule of law and public participation in a given political system under which individuals live. Accordingly, the principle of self-determination has been recognised as a right by extant international conventions and declarations, as evident in the 1945 Charter of the United Nations (UN), the Universal Declaration of Human Rights of 1948, the ICESCR of 1966, the ICCPR of 1966, and the UNDRIP of 2007 among others. Article 1(1) of the ICESCR described self-determination as "the rights of all peoples to freely determine their political status and freely pursue their economic, social and cultural development."

Against this background, the concept of human security is usually seen as an attempt to shift the focus of security from its traditionally state-centred to people-centred. However, the possibility of a good life outside a state remains debatable, given the fear of anarchy that is associated with freedom without social obligation or constraint (Nozick, 1974). This sounds like a caution to some advocates of human security that tend to present the concept as a mutually exclusive and irreconcilable alternative to state security interests. Accordingly, the concept of security most accommodates both state and human security concerns. Imobighe (2003) thus argued that security has recently come to be understood as freedom from, or

elimination of, threat not only to the physical existence of the state, but also to its ability to self -protection and development, and the enhancement of the general wellbeing of all the people. Beyond social constraint on liberty in form of obligation, justice and stability require a state to guarantee equal scheme of liberty for all (Rawls, 1999). Therefore, security broadly requires political, social, environmental, economic, military, and cultural systems that will together give people the building blocks of survival, livelihood, and dignity (UNCHS, 2003).

The conception of "space security", "security in space", "space in security" or "security dimension of space exploration and exploitation" among others has increasingly followed the same trend along with conception of security as identified above. Accordingly, "space security" was observed by Sheehan (2015:7-8) with the following submission:

> Traditionally, it has been associated with the military security of states, and this is still the predominant understanding of the term. It certainly remains the case that a fundamental aspect of "space security" is the contribution that satellites make to the military security of states and the maintenance of international stability and balances of power, as well as the military threats to satellites and their ability to support international security. However, there has been a widening of the understanding of space security in recent years so that, while the military dimension remains fundamental, other crucial issues have been brought within the scope of the concept… Changes in the understanding of space security mean that it now similarly embraces a broad understanding of the requirement of freedom of access to and use of space by all states who wish to use it for the socioeconomic benefit of their populations.

The socioeconomic benefits of space and its attendant technology cover poverty alleviation, job creation, urban planning, precision agriculture and food security, as well as water, health, environmental, and transportation management. In the final analysis of space policy and strategy, under the general framework of security policy and strategy, the relevance of space to military capabilities, law enforcement, and disaster management can now be considered together with the issue of food security, water and health management, environmental sustainability, among other concerns, to both state and human dimensions of security. In this way, the line between development and security has become increasingly blurred.

There are growing academic and policy efforts to bridge the gap between development and security priorities (Chandler, 2007; Stern & Öjendal, 2010; Hettne, 2010; Pupavac, 2010; Buur

et al., 2007; Denney, 2011; Keukeleire and Raube, 2013; Reid-Henry, 2011). This is not totally a new development. Extant literatures published in inter-and-post World Wars years have shown that the seed of peace and security cannot germinate without development and economic progress. However, this position and its advocacy has taken new momentum since the end of the Cold War and particularly since the 9/11, and the attendant securitisation. As such, development is presented as an essential tool of security policy. Accordingly, there is a belief that the development discourse and industry is increasingly co-opting security practices in order to strengthen poverty reduction efforts (Denney, 2011: 278). The expanded definition of security to cover people-centric interests constitute one of the bases for development-security nexus. In this way, UNDP also considered security as a dimension of human development.

Despite the foregoing, it is often neglected in recent development-security nexus discourse how the so-called state-centric security has also co-opted development into efforts to build military and law enforcement capabilities of a state. Tellis et al (2000) observed that military capabilities cannot be adequately assessed without paying attention to the quantity and quality of strategic resources, including human and material resources, which are made available to the military by the society. In essence, the level of education, healthiness, and general standard of living of the population will influence the level of their productivity and the percentage that can be channelled to building military capabilities. Equally, military spending and industrial development have for a long time relied on the assumption that they contribute to development as justification for their continuous relevance. Besides, human development and security indicators have become indispensable factors for assessing the tendency for stability and instability in the political system in recent times (World Bank, 2011; Collier et al., 2005; Collier, 2007; 2009; 2010). This is therefore important for assessing the law enforcement capability of a state. Amidst all these, it is compelling to examine the contribution of space to these multiple and interweaving indicators of development and security as it applies to Nigeria and South Africa.

1.8. Scope and limitations of the Study

1.8.1. Scope of the Study

This study is interested in the policy dimension of space rather than its science and engineering in Nigeria and South Africa. However, space policy can be only be operationalised through a series of programmes. This study devotes special attention to satellite programme, which is a

minimum requirement or the first step for a country to be considered as a spacefaring nation, member of space club, participant in space age, or a space player (Harding, 2013; Kornilenko, 2007; UCS, 2017a; Wood and Weigel, 2011; 2012). Considering this, satellite programme covers sponsorship, ownership, and controls of satellite in the orbit and the ways and manners it is utilised to serve policy purposes. Considerable attention is also voted to astronomy and rocket R&D on the subject of space programmes in selected countries. The choice of Nigeria and South Africa is informed by the sophistication of their national space policy programmes, especially their leadership positions with satellite and other space inventories as well as years of experience in their utilisation, in Sub-Saharan Africa. In view of these and the concern for consequentialism in this study, this research devotes special attention to the space programmes of the two countries since 1999 without ignoring their historical trajectories. However, the creation of Nigeria's NASRDA and the launch of South African's first satellite in 1999 are milestones for the development of space policy in these countries and the continent of Africa.

In terms of content, the scope of this study extends beyond national or state-centric interests to human-centred interests in the conception of development and security in both Nigeria and South Africa. Issues such as the level of technological transfer received, national adoption and self-reliance or capacity developed in space technologies, associated economic growth, and socio-economic transformation are considered under state-centric development interests. The contributions of space technologies to the military, law enforcement and, to an extent, disaster management capability of both Nigeria and South Africa are also considered under national security. Considering power and influence as elements of security and development, this study also seeks to examine the foreign policy and investment dimensions of Nigeria's and South Africa's involvement in space. In addition to these, this study is interested in the contributions of space technologies to policy initiatives to eradicate extreme poverty, hunger and diseases, as well as improve governance, education, health, and commitments to sustainable environment under human development and security interests.

1.8.2. Limitations to the Study

There are many factors that serve as limitations to this study. Prominent among them is funding. To cover all the selected research sites in Nigeria and South Africa, which are identified to be relevant to this study, required more money (for the trips and lodging) than what my personal saving and support from relatives can fund within a reasonable period of time as required for

the field work. However, the negative effects of this factor were minimised with the support of bursaries received from the North-West University (NWU) and my Faculty.

Access to some desired or targeted informants and the time involved is another limitation to this study. I started to secure relevant links to key informants with the help of my supervisor and friends from the early stage of the project. Nevertheless, some targeted informants failed to respond to interview request, while some declined for security reason, and a few others reneged on their earlier acceptance due to the lockdown that followed the outbreak of Covid 19 pandemic in the study areas. Most informants were also reluctant to divulge relevant information, based on their sensitivity, oath of office, and national security concerns. Consequently, the study adopted the use of multiple sources of data which include, observation and engagement with academics, private companies, and civil society groups as well as secondary sources on the subject matter to fill some gaps in the final analysis.

Access to some important but restricted materials (especially those that are subscription based) also constituted a limitation to this study. Although NWU virtual library and subscription provided me access to enormous materials (books and journals) on space politics and policy, development, security, African affairs, South Africa, and Nigeria, it did not cover some reports and databases that are critical to this study. For instance, efforts to get the university to subscribe to some reports and databases published by Euroconsult, Space Foundation and Space in Africa didn't materialise. Moreover, the cost of access to these materials is too high for me to bear. For instance, a single user license to access the pdf and excel files of "Government Space Programs: Benchmarks, Profiles & Forecasts to 2026" by Euroconsult is 6,000 Euro. Efforts to secure access to the files through some contacts in other universities in South Africa, Canada, UK and New Zealand also failed. Conseequently, this study lacked access to such a flexible data for analysing space expenditures of selected countries, among other things. However, the effects of this limitation are managed through the use of summaries, government and press reports, industrial presentation, and scholarly publications where some of the findings of these reports were found. Again, the Nigerian Budget Office (NBO), and National Bureau of Statistics (NBS), as well as Statistics South Africa and the Department of Science and Technology (DST) among others provided this study with some alternative data in the two countries studied.

1.9. Ethical Considerations

This study adopted and adhered to relevant ethical principles, which are core values of NWU. All the sources of quotations, paraphrasing, figures and tables are acknowledged through references. Direct access and observation of facilities are based on permission of appropriate authorities. Interviews were conducted with voluntary participation. Participants were provided with a consent form, which stated their rights and requested for permission to use information supplied. This equally contained details on the confidentiality of participants in coding and analysis of data.

Neuman (2014: 170) identified personal openness and integrity of the individual researcher as central ethical issues in a qualitative study; while quantitative analysis relies on the principle of replication, adherence to standardized procedures, measurement with numbers, and analysis of data with statistics to ensure neutrality and objectivity. These principles were adopted in this study, and the analyses were done in a manner that promote neutrality, objectivity, transparency, honesty, and integrity. Accordingly, data were subjected to rigorous cross-checking and cross-verification from multiple sources and use of multiple methods at different stages of the study. Standard procedure in relation to the methodology and theoretical framework were clearly highlighted and followed in analysis of this study. These among other ethical details were observed in this study.

1.10. Organisation of the Study

To address the questions raised in this study, this research endeavour proposes seven chapters. The first chapter will be generally introductory, covering issues like background, statement of problems, research questions, the aims and objectives, justification, scope and limitations, the conceptual framework of analysis, as well as the organisation of the study. The chapter two of the study focuses on review of relevant literature. Chapter three covers research design, with details on methodology and theoretical framework of the analysis. Chapter four and five are designed to examine space politics and policy in the study areas I and II, Nigeria and South Africa respectively. In addition to these, Chapter six and seven focus on the contribution of space policy programmes to development and security in the two study areas, Nigeria and South Africa respectively. The eighth and last chapter provides a summary, conclusion and recommendation on the operationalisation of space policy in Nigeria and South Africa.

CHAPTER 2

Review of the Literature

2.1. Introduction

Space politics and policy is receiving increasing academic attention that cannot be ignored. A growing number of studies have addressed the question of why human and nations are interested in outer space; and concerns on the international politics of space exploration and exploitation; space expenditure; project prioritisation and budget allocation, and sources of funding; advocacies for and against space policy and spending as well as their strategies; administrative framework for space programmes and projects; space dimension to military capabilities and modern warfare; societal impacts of space research and development, among others. Accordingly, extant literature on space politics and policy have highlighted some prospects and challenges of space policy programme in many spacefaring nations across time and space, although with emphasis for the most part on the advanced space players.

This chapter seeks to examine the literature on space politics and policy that are relevant to this study, and locate what, where, and how this study can contribute to knowledge. Literature review is a critical part of research. Saliu (2004) described it as the nerve centre of a research. It is expected to establish the intellectual context(s) of the subject matter (research theory and philosophy), to trace the background to present thinking (history of subject area), to examine current issues being investigated, discuss the conflicting arguments, and to detect a gap in knowledge (latest research and developments in subject area), and explore relevant practical techniques for the project (research methods) (Walliman, 2011:59). In view of these, Saliu (2004:19) observed that "it is quite pathetic that many studies that were aimed at advancing the course of knowledge have their potential buried in the wilderness because of weak theoretical bases as well as obscured bases in the existing continuum of knowledge." This chapter therefore seeks to examine the continuum of knowledge on space policy and development-security nexus in Nigeria and South Africa, and situate this study in the context.

There are many important and enduring questions and debates in extant literature on space policy. Of interest to this chapter are questions: Why do outer space as well as its exploration and exploitation matter to humanity and the state? Why should students of humanities and social sciences, and particularly political science and international relations, care about

exploration and exploitation of space? What are national interests in space and how can they be assessed? In addressing these questions, this study will pay attention to the debates on the dichotomy between developed and developing countries in development studies as well as the emphasis on variation in power capabilities in security studies. These are expected to provide this study with sound theoretical and philosophical contexts, with historical trends, latest thinking and development as well as methodological clues, with which to assess the contribution of space policy to development and security nexus in emerging space players such as Nigeria and South Africa.

This chapter adopts a combination of thematic and study-by-study strategies in reviewing the literature, with dominant use of the former in general context and limited use of the latter in specific context. Thematic review is an argument-based review of literature, where a major theme or idea is identified from several relevant studies, which are assessed together. The study-by-study otherwise known as author-based review of literature provides a detailed summary and assessment of each study grouped under a broad theme (Creswell, 2012:102). The two methods have their merits and demerits. Pierce (2008:106) believes that author-based review is done by inexperienced students, because "such approaches are over-long; at best overly descriptive and, at worst, obvious plagiarism, confusing and boring. In particular, they lose the interest of the writer and reader, and tend to give least attention to the most recent texts." Instead, he concluded that a critical synthesis is required which focuses on the ideas and arguments rather than the authors (Pierce, 2008:106). Creswell (2012:102) however observed that thematic review is usually too brief, less detailed and associated with journals, although it can be used in dissertations and theses; while study-by-study review appears to be more detailed and used in journal articles that summarise the literature and dissertations and theses.

Against this background, this chapter is further divided into five sections, which include the following: (1) why we should care about space? Rationales for assessing space policy, (2) Assessing space policy: what matters, how, where, and when (3) Space policy assessment in Nigeria and South Africa, and (4) Concluding thoughts and summary of gaps in the literature.

2.2.Why do we care about space? Rationales for Space Policy and its Assessment

This section seeks to examine the body of knowledge on why humanity generally care about space, and specifically why policymakers and academic community care and some of their

identifiable interests in space. In this case, the rationales for assessing space policy is generally classified into two, that is: to advance academic, and policy interests. While the distinction between these two categories of interests are theoretically significant, they may be hardly distinguishable in practice. It is important to note that every policy interest in space have their academic dimension. Equally, what is considered as a policy interest at a point in time may be mere subject of academic interests over time, and vice versa. Nevertheless, the attempt to distinguish these interests are required for the sake of clarity and indebt probe.

2.2.1. Academic Interests in Outer Space: Beyond Science and Engineering Reductionism in Space Studies

The reasons why humanity cares about space and the development of the interests are essential to understanding why the academic community, and particularly those in social sciences at the macro level and policy studies at the micro level of this focus, are interested in assessing human understanding of and activities in outer space. With evidence that can be traced back as far as the dawn of human civilisation, humanity has always felt the curiosity to understand what lies beyond the Earth and connect with them (Peeters, 2012; Hawking and Mlodinow, 2010). This interest and associated academic research and development (R&D) started as an art, which has been revolutionised by pure and applied sciences and engineering, and is increasingly witnessing the emergence and accommodation of social sciences and humanities in space. Table 2.1 offers an insight into the multidisciplinary development and dichotomy.

Table 2.1: Multidisciplinary Trajectories of Space Studies

General fields	Specific fields	Techniques of study	Main merits	Main concerns
Art	Astrology, Philosophy, and Theology.	Divining, speculative, metaphysical, value-laden, normative, and philosophical.	It is the earliest science, pseudoscience, and art of human study of space and the celestial bodies.	It is largely unscientific and loaded with myths.
Pure and Applied Sciences, and Engineering	Astronomy, Cosmology, Astrophysics, Astrobiology, Astrochemistry, Mathematics, Geology, as well as Electrical, Mechanical and Computer Engineering etc.	Regularity, verification, sophisticated techniques, quantification, integration, generalisation and systemisation in research.	It offers better understanding of the universe as well as the place of humanity within it and the prospects of extra-terrestrial exploration and exploitation.	Growing social impacts of space R&D made the science and engineering reductionism of the subject matter unsustainable.
Humanities and Art redux	History, Fine Art, Theatre Art, and Literature.	Drawings, paintings, fictional and non-fictional stories, music, movies and games.	It offers the opportunities to build a society that is capable of sustainable space R&D.	It is largely normative, speculative and imaginary, and chronicle when it is realistic.
Social Sciences	Astropsychology, Astropolitics, Astrosociology, Astrotheology and Economics	Social theories and empirical analysis with scientific methods.		It remains less developed with multidisciplinary gaps.

Source: Designed by the author.

2.2.1.1.Between Astrology and Astrophysics: The Art, Sciences and Engineering of Space

Human interests in space started in the ancient times as an art and practices mostly dominated by astrologists, philosophers, theologians and perhaps later historians to advance knowledge and what can be broadly described as sociocultural interests. Different human civilisations across time and space have displayed interests in space and the celestial bodies, and constructed different meanings out of them, with most emphasis on the Sun, Moon and Stars (Holbrook et al., 2008; Popovic, 2006; Raman, 1992; Seva, 1902). These gave birth to astrology, which is

the ancient version of astronomy. This is recognised as the earliest science of stars, the pseudoscience of divining the positions of planets and other celestial bodies, and the art of constructing and deconstructing the influence of signs of heaven on human affairs (Maternus, 1975; Liu, 2008). Accordingly, there are several studies that have attempted to show or read the connection between signs of heaven and human destinies across traditions (Lewis, 2003; Lilly, 1852; Hartmann, 1889; Orion, 2007). Amidst these, religious astrology emerged with various constructs and beliefs that the sky is the gateway to heaven, the home of the gods, and that celestial bodies are gods (Baker, 1996; Lilly, 1647; Master, 2015; White, 2013). Peeters (2012) also argued that space science is the cradle of philosophy.

The art devised in understanding space and the celestial bodies, and the associated practices by astrologists, diviners, philosophers, and theologians are largely speculative, metaphysical, value-laden, normative, philosophical and spiritual in approach. These have been criticised as being largely unscientific and loaded with myths (Abhyankar and Sathaye, 1974; Disalle, 2006; Fraassen, 1970). In contrast, modern and increasingly emerging scientific attempts on the subject matter emphasise regularity, verification, sophisticated techniques, quantification, integration, generalisation, and systemisation in research. With the advancement in modern science, therefore, myths have continued to give way to realities in human understanding of the outer space and the celestial bodies (Fraknoi et al., 2017; Hawking, 1996; 2001; Moore, 2000; Ronan, 1982; Smith, 2001; Henriets, 1958). Hence, astronauts, cosmonauts, physicists, mathematicians, biologists, chemists, geologists among other pure and applied scientists, and engineers are replacing astrologists, diviners, philosophers, and theologians as the primary, dominant, and most authoritative determinants of contemporary understanding of outer space and the celestial bodies. Accordingly, space R&D has mainly fallen under the purview of Science, Technology, Engineering and Mathematics (STEM), with emphasis on astronomy/cosmology, and specifically astrophysics, astrobiology, astrochemistry, as well as electrical, mechanical, and computer engineering.

As a result of scientific revolution of space R&D, humanity now has better understanding of the natures, interactions, structure, and development of our planet Earth and its atmosphere, satellite (Moon), star (Sun) and neighbouring planets, asteroids and comets among others that made up the solar system, as well as hundreds of billions of stars and their systems across hundreds of billions of known galaxies, and the universe as a whole (Bate, 1971; Bishop, 2016; Böhm-Vitense, 1997; Coles and Lucchin, 2002; Duric, 2004; Liddle, 2003; Perkins, 2009;

Pradhan and Nahar, 2011; Raine and Thomas, 2001; Schneider, 2006; Sparke and Gallagher, 2007). This knowledge has further helped humanity in building required capacity to develop and deploy spacecrafts to explore the space and the celestial bodies in the solar system, with records of using space technologies to advance terrestrial interests (Chertok, 2006; 2009; 2011; Taverney & Rendleman, 2011). These are also relevant for the prospects of establishing permanent human habitation, resources mining, and contact with any intelligible civilisation in space (Arnould, 2012; Brearley, 2006; Dick, 2014; Schwartz, 2017b; Sommariva, 2015). These have encouraged science and engineering reductionism of space studies, which many social scientists are challenging with their emphasis on social, political, and economic structures and dynamics that are essential to the rise and suitability of space R&D (Chaisson, 1998; Dick, 2015; Jurist et al., 2006; Pass, 2006; 2011; Vedda, 2008).

2.2.1.2.Humanities and Art Redux and the Case for Social Sciences and Policy Studies in Space Research and Development

Despite the relevance of the scientific revolution of space R&D, a growing number of social scientists have challenged the science and engineering reductionism of the subject matter. Many scholars in social sciences and humanities have pointed out the historical and continuous relevance of philosophy to the development of science and engineering, as well as the contributions of the works of art such as drawings, paintings, fictional stories, music, movies, and games to the motivations for space exploration and associated technological development (Blount and Fussell, 2012; Majsova, 2016; Ormsby et al., 2011; Peeters, 2012). Historians with specialty in scientific and technological advancement also have considerable chronicles of significant contributions to the knowledge of space through their documentations, recordings, narrations, descriptions, and interpretations of general and specific thoughts, past events and development on the subject matter (Chertok, 2006; 2009; 2011; Deblois, 1999; Disalle, 2006; Sadeh, 2002a; Siddiqi, 2000). For instance, Aristotle (1928), who is mostly considered as the father of politics, documented some important thought about space during his lifetime (384–322 BC) in Athens. Nevertheless, this category of R&D on the outer space is generally more descriptive than analytical. In specific cases of philosophy and the works of art, their knowledge productions on space are largely more normative, speculative, and imaginary than realistic. In the case of history, where knowledge productions are more realistic, they are also less futuristic.

While challenging the science and engineering reductionism of space R&D, some scholars are however willing to accept that most fields in social sciences and, to an extent Humanities, lag behind on the subject matter. While the community of scientists and engineers are busy with their enquiries on space and associated technologies, this category of scholars consider it as a duty call and responsibility of the social scientists to search and locate their place and role in the framework as they are unfolding (Pass, 2006; 2011; 2015; Vedda, 2008). Although efforts have been made to identify and differentiate the dimensions of space such as the case between geometric space like outer space and social space like the public where policies are made, the interactions of these two spheres cannot be ignored from the relational perspective, as discussed in chapter one. In this case, the impacts of knowledge production in space science and engineering on cultural, social, political, economic, and security spheres of live and associated knowledge productions cannot be ignored, and vice versa (Arnould, 2013; Bainbridge, 2014; Bjørnvig, 2013; Dick, 2015; Launius, 2003; Machay and Steinberg, 2015; NASA et al. 2015; Pass, 2015; Steinberg, 2011; Vedda, 2008; Vrolijk and Szajnfarber, 2015).

There is a growing effort to close the gap between pure and applied sciences, and engineering on one hand and humanities and social sciences on the other hand in space R&D. This is a gap that must be closed to maintain dynamic spacefaring societies that are required to sustain advancement in space exploration (Pass, 2006; 2015; Reibaldi, 2003). This is also important to determine how political and socioeconomic realities are shaping the pace of advancement in astrophysics (Chaisson, 1998; Jurist et al., 2006; Vedda, 2008). This gap has been long recognised and significant efforts have been committed towards this ends in the fields of political science and mostly in its sub-field of International Relations, and recently, public policy analysis. As a result, space politics and policy studies have increasingly emerged as a subject of enquiry and, in some cases, a field of study. Given the dominant position of students of International Relations however, this subject of enquiry has been dominated by concern for defence, security, power, and prestige that are accruable to a state from its space activities (Baines, 2004; Chertok, 2009; 2011; Deblois, 1999; Klein, 2006; 2012; Harvey et al., 2010; Lupton, 1998; Lutes et al., 2011; Mowthorpe, 2004; Siddiqi, 2000; Sariak, 2017; Woodell, 2000). This position has been criticised from both within and outside the political science field.

As it will be shown in subsequent chapter in this study, several schools of thought have emerged to challenge the predominant position of realism in International Relations, as well as its power, prestige, defence, and security reductionism in space politics and policy (Gray, 1996;

Lieberman, 2017; Harding, 2013; Sadeh, 2013; Woodell, 2000). Also, some political scientists and policy analysts have criticised the limited indicators and external-oriented assessment of most students of International Relations. Instead, they have called for more comprehensive and multidimensional perspectives, and a balanced view of both domestic and external dynamics, on the study of space policy (Chaisson, 1998; Sadeh, 2002a). The rising space interests of other disciplines in social sciences have further encouraged the growing call for multidisciplinary perspectives in the subject matter (Dick, 2015; Pass, 2006; 2011; 2015). These are responsible for the emergence of astro-psychology, astro-politics, astro-sociology, astro-theology and astro-economics or space economics among others as perspectives and subjects of enquiry (Ambrosino, 2016; Caroti, 2011; Dickens and Ormrod, 2007; Pass, 2006; 2015; Chaisson, 1998; Maxwell, 2003; OECD, 2014; Salla, 2014; Space Foundation, 2015b).

Astropolitics is arguably the most developed perspective and subject of enquiry that has bridged social science and space science and engineering. *Space Policy* and *Astropolitics* published since 1985 and 2003 respectively till date are leading journals that are offshoots or products of this emerging discipline. Astropolitics, as evidenced in academic courses and publications, focuses on space activities acknowledged to exist by governmental and non-governmental entities, and their public policy implications (Salla, 2014 cf. Chaisson, 1998). Astrosociology is another emerging field of study, which was largely pioneered and championed in its current form by Jim Pass in 2004 (Pass, 2004a &b). It is the scientific study of astrosocial phenomena, or social and cultural patterns related to the ecology of the outer space (Pass, 2006; 2011; 2015). The field has since produced a flag journal of Astrosociology published since 2014. Another emerging field of enquiry in this case is Astropsychology. Many publications and the available course curriculum of the Academy of Astropsychology make it difficult to differentiate this subject from astrology (Miller, 2006; Perry, 2016). Yet, some other studies are employing scientific approach to address the subject of psychology of space exploration, and are contributing to the attempts to bridge the gap between social sciences and space sciences and engineering (Vakoch, 2011). Although astroeconomics is still associated with the astrological forecast of business prospects and economy (Williams, 1959; Morris, 2010), there is a growing scientific attention for the economics of outer space activities (Crawford, 2016; Dudley-Flores and Gangale, 2012; Jurist et al., 2006; OECD, 2014; Sommariva, 2015).

Against this background, it can be easily assumed that the subject of space policy has received adequate academic attention. However, this will be an erroneous conclusion, given the limited attention the subject has received in the general framework of social science research and the existing gap in the literature, some of which are considered in this chapter. Even in an advanced space power like the US, space studies education has not been accepted by national educational systems to any great extent despite the enormous wealth of new knowledge it offers (Sadeh, 2002b). Journal of *Space Policy* that is published by Elsevier recognised space policy as an international and interdisciplinary subject of enquiry which draws on the fields of international relations, economics, history, aerospace studies, security studies, development studies, political science, and ethics to provide discussion and analysis of space activities in their political, economic, industrial, legal, cultural, and social contexts. In view of these, students of International Relations have to pay more attention to the need to close the multidimensional and multidisciplinary gaps that exist within social sciences in space policy studies, as they struggle to close the gap with pure sciences and engineering.

2.2.2. Policy interests in Space: Perspectives on Terrestrial Actors and Interests in the Extra-terrestrial Frontier

Another justification for assessing space policy is the need to understand its unique features across time and space; the actors and interests that are involved in the policy process; the ends and means of the policy; the inherent prospects and challenges, and their distribution. This section is interested in different conceptions of terrestrial interests in outer space based on variation in unique nature of policy actors. The prospects and achievement that have been recorded in space exploration and exploitation have made it impossible to ignore or overlook this development as well as its actual and potential influence or impacts in the social space, which include political, economic, social, and cultural spheres of life. Accordingly, issues of space exploration and exploitation have received significant, not necessarily adequate, policy attention of several actors across time and space, and most importantly since the middle of the 20th century. What constitutes policy interest in space varies according to the unique nature of actors that are involved in this consideration. Actors in international relations that are relevant in this case can be broadly categorised into state and non-state (Frankel, 1988; Haass, 2008; Kegley and Raymond, 2010; Magstadt, 2009; Mingst, 1999; Nye and Weltch, 2013). Some scholars have identified unrecognised state as quasi-states (Horowitz, 2003; Kolstø, 2006),

although they are usually considered as non-state actors: secessionist movements and regions in mainstream literature. Table 2.2. offers an insight into actors and interests in space policy.

Table 2.2: Perspectives on actors and interests in Space Policy

Broad category of actors	Perspectives	General actors	Specific actors	Core interests in space	Major means
State	Statist	National government	State policymakers	Defence and security	Military capabilities
	Pluralist	Arms, departments and agencies of government	Legislature	Legislation of state space policy ends and means	Legislative power
			Executive	Overseeing space politics as well as formulating relevant policy, strategy, and tactics, and operationalising them.	Executive power of the office of the president, space agencies and other government agencies and departments
			Judiciary	Interpret laws and adjudicate cases involving conflict of interest in national space policy.	Judicial power and court
		Civil society groups		Support for and against space R&D generally or specific policy, programme, and project.	Public campaigns and lobbying of critical policymakers.
		Private Individuals and organisations		Commercialisation, privatisation and individualisation of freedom in space.	Investment in space R&D and associated advocacy.
Non-state actors	Globalist	Conventional non-state actors	IGOs	Cooperation and shared benefits among nations in space	Global and regional alliances
			NGOs	The use of space technologies to advance humanitarian courses.	Access to space technologies.
			National, multinational and transnational corporations	Commercialisation and privatisation of space R&D.	Investment in space R&D and associated advocacy.
		Non-conventional non-state actors	Armed non-state actors	The use of space technologies to advance unconventional causes.	Access to space technologies.

Source: Design by the author.

2.2.2.1. State Actors and Interests in Space

The state is the dominant actor in international relations, despite its relative decline in primacy. According to Article 1 of the *Montevideo Convention on Rights and Duties of States* adopted on December 26, 1933, a state should possess the following qualifications: (a) a permanent population; (b) a defined territory; (c) government; and (d) capacity to enter into relations with the other states. A permanent population is a group of individuals that inhabit a given territory of a state as citizens (van Steenbergen, 1994; Vincent, 1992). A definite territory is the geolocation of a state, which include airspace, land and maritime domains and all the resources within such jurisdiction. Government is the machinery that formulate, express and realise the will of the state (Anifowose, 1999; Ball, 1983; Magstadt, 2009). Sovereignty is the supreme and final legal authority within a jurisdiction (Bodin, 1955; Laski, 2010). It covers domestic sovereignty, organisation of public authority within a state and the level of control exercised by those holding the authority; interdependency sovereignty, the ability of public authority to control transborder movement; international legal authority, the mutual recognition of states or other entities; Westphalia sovereignty, the exclusion of external authority from domestic authority configurations (Krashner, 1999:9; 2004). Other essential or associate features of statehood are legitimacy, recognition, independence, self-determination, permanency, nationalism and non-interference in the internal affairs of a state (Anifowose, 1999; Lapidoth, 2012; Newton and van Deth, 2010; Nolan, 2002; Ojo and Sesay, 2002; Scruton, 2007).

There are different enduring debates on how and why state exists, how it should be governed, what should constitute its interests and how they should be pursued among others (Barrow, 1993; Bluntschli, 2000; Fukuyama, 2012; Hobbes, 1651; Matravers and Pike, 2003; Nozick, 1974; Rawls, 1999). Most of these debates are directly or indirectly relevant to understanding policy processes and expected outcomes, of which space policy is not an exception. In this case, the structures and processes that are involved or should be involved in the formulation, implementation and analysis of space policy interests of a state have attracted a series of debates, which have placed the realists and the pluralists at different edges of the spectrum.

2.2.2.1.1. Statist/Realist Perspective of State Interests in Space

The State is considered by the realists as a unitary actor that is characterised with indivisible sovereignty personified in government locally, and as the most important unit internationally

(Booth, 2011; Bull, 1977; Frankel, 1988; Morgenthau, 1991; Waltz, 1979). Policymakers are assumed to be rational and objective in situation assessment to make the best policy decision in the interests of their state (Coleman and Faroro, 1992; Schelling, 1980; Snidal, 1985). In classical realism, international system is assumed to be anarchical (that is without central controlling authority) and characterised with self-centred state actors, who for their self-help have to struggle or compete for power to guarantee their core interest—survival, from where security dilemma always arise (Bull, 1977; Morgenthau, 1991; Brown and Ainley, 2005). Amidst these, neorealism considered powerful states as the only important unit of analysis, because order in international system is a function of the structural arrangement of states based on their power capabilities (Waltz, 1979; 1993; 2000; Booth, 2011; Buzan and Wæver, 2003; Little, 2007; Volgy et al., 2011). Accordingly, international politics has been defined as unipolar, bipolar, and multipolar in cases where the dominant state/s are one, two or more respectively in given states system (Kissinger, 1994; Nye and Weltch, 2013; Zakaria, 2008).

Studies on space policy are pioneered and dominated by scholars that are rooted in realism and neorealism. Hence, space players have been reduced to state actors, and for the most part of 20th century, the space policies of the superpowers constituted the central focus of attention. In this consideration, policy interests in space traditionally revolved around military power-security-prestige (Dolman, 2002; Durch, 1984; Sadeh, 2002a; 2011; 2013; Lutes et al., 2011). The initial policy interests in rocket science and engineering were military motivated, it started as a search for long range weapons delivery systems (missiles), which were converted to space launch vehicle in the wake of space age (Chertok, 2005; 2006; Chun, 2005; Mistry and Gopalaswamy, 2012; Siouris, 2004; Van Riper, 2004; Werrell, 1985). The military stakes in satellites for communications, navigations, and remote sensing is also salient in its progress (Chertok, 2006; Durch, 1984; Trimble, 2007). The prospects of military base and weapons in space also underscored exploration of space and celestial bodies by superpowers during the Cold War (Preston, 2002; Mowthorpe, 2004; Chertok, 2009; 2011). These are expected to enhance the national power and security as well as the prestige of the concerned space powers. As suggested by the realist tradition, however, this has led to security dilemmas, which are born out of the streamlined interests of space players, that is, struggle and competition for space power and security, which simply translate to space control for the established powers such as the US and USSR/Russia and space access for emerging powers like China, India, Iran, North

Korea among others (HDoA, 2009; Klein, 2006; 2012; Mistry and Gopalaswamy, 2012; Sadeh, 2002a; 2013; Sariak, 2017).

The realist and neorealist perspectives on terrestrial interests in space have been challenged from multiple angles. The state-centric reductionism of this perspective ignored the important roles played by international organisations and private corporations as well as their interests in space. The idea that state is a unitary actor in international system also reduces government to an automated policymaking machine in response to external affairs, at the expense of internal dynamics that are essential to space among other subjects of concern in policy processes: advocacy, formulation, implementation, support and assessment. The military security reductionism of state interests missed the emerging demand for human security, and the power politics context has been challenged by the growing significance of economic and socio-cultural issues in the international affairs. With the emphasis on competition for power and struggle for security, this perspective ignored, and to an extent, foreclosed the prospect of cooperation among nations in space. This has been proved wrong in many cases (see Crawley and Rymarcsuk, 1992; NASA, 2014; Withee et al., 2004), despite some enduring concerns (Moltz, 2014; Sadeh, 2002c). The international space station remains an epitome of international collaboration in space (Manzione, 2001). Equally, what is considered as policy interests in space in this consideration is largely the interests of major powers, because the experiences and perspectives of the emerging space players and developing countries are always ignored or underestimated (Harding, 2013; Wood and Weigel, 2011; 2012). Finally, policymakers globally have continued to appreciate the limitation of what a state can achieve in isolation among the vast terrestrial interests in the infinite space and complexity associated with multiplicity of actors in an increasingly crowded space (Moltz, 2014; Vedda, 2008).

2.2.2.1.2. Pluralist Perspective of State Interests in Space

The liberal pluralists offer an alternative perspective to realism in conception of state, policy formations or processes and interests. They considered the state as an organised diversity in the public realm (that is largely made up of arms, departments, and agencies of government on one hand and civil society groups on the other hand) and the private realm (that is made up of individuals and corporate bodies) (Cloete and de Coning, 2014; Dowse and Hughes, 1986;

Edwards et al., 2014; Magleby et al., 2014; Newton and van Deth, 2010). Hence, policies are assumed to be generated from a complex politics that involve both public and private actors (Dowse and Hughes, 1986; Easton, 1957; Furtado et al., 2015; Sapru, 2004). The parliament usually sets the framework of a policy in a democratic setup, through legislation that define policy interests, establish institutions responsible for execution of such interests, and approval of associated programmes and activities through allocation of resources. The executive arm of government is responsible for operationalisation of policy interests, through design and implementation of appropriate strategy and programmes (Ball, 1983; Edwards et al., 2014; Magleby et al., 2014; Magstadt, 2009). This arm of government covers office of the president or head of state, and different departments or ministries (such as department of defence, state/ external/ foreign affairs, education, science and technology, mineral resources and agriculture) and agencies, which are usually responsible for the design and implementation of extant strategies, tactics, and operations with the aim of achieving overarching grand strategy.

Despite their unique agendas, civil society groups, the media, influential individuals and private corporations often serve as platforms to channel public or private opinion and interests, and lobby the legislature and executive arms of government with the aim of influencing policy direction (Dowse and Hughes, 1986; Edwards et al., 2014; Magleby et al., 2014; Newton and van Deth, 2010). The ideological orientation of political parties is also important in defining policy direction of the government of the day. All these actors also play important roles in communication of policy agendas for public education and mobilisation. Private corporations are also involved in policy implementation in economically liberal societies, through contractual implementation of public projects and private ones that key into relevant policy strategy and programme. In the final analysis, what turns out to be a public policy is a compromise reached through political processes from competing interests of multiple actors (Dowse and Hughes, 1986; Newton and van Deth, 2010). Different public and private actors often compete to influence policy directions, even though their cooperation is required to implement compromised interests in order to fully realise national potentials and optimum utility (Easton, 1957; Furtado et al., 2015; Sapru, 2004). In view of any conflicting interests, the judiciary is well positioned to interpret the law and adjudicate dispute among policy actors (Ball, 1983; Edwards et al., 2014; Magleby et al., 2014; Magstadt, 2009).

The pluralists have made significant efforts to understand policy interests in space as well as the actors and processes that produce them. This perspective took off from the point of view

that there are multiple terrestrial interests in space as advanced by several political actors, who always compete to influence the direction of space policy of a state (Kaminski, 2012; Blamont, 2016). Amidst these, studies have shown through survey that public opinion and support usually influence, often correlate with, and are sometimes critical of, space activities generally, and legislation, budgeting, and spending specifically (Dick, 2015; Purdy, 2011; Steinberg, 2011). Prominent individuals, works of scholars and public campaigns by civil society groups and corporations are also shaping space policy orientation at different levels of governance with myths and realities of space frontiers: either for its prospects (in advancing space institutionalism, knowledge, resources exploitation, business, security, and habitation) or its challenges (in financial, technical, sociocultural, legal, and political terms) (Brennan and Vecchi, 2011; Hudgins, 2002; Lave, 1986; Newell, 2014; Schwartz, 2017a, b &c; Tronchetti, 2014). Amidst these, several individuals and corporations are investing their resources in private space programmes and projects, despite the enduring debates on privatisation and public-private partnership in the common frontier (Anderson, 2013; Balsano, 1995; de León et al., 2017; Delgado-López, 2015; Elliott, 1997; Tronchetti, 2014; Utrilla, 2017).

The legislature provides the framework for space policy activities through legislation that define national interests in space, establish principal institutions responsible for execution and regulation of such interests, specify other actors that are relevant for interests actualisation, approve and manage programmes and activities through allocation of resources (Basu and Kurlekar, 2016; Filho, 1995; Hancock, 2005; Kallender-Umezu, 2013; Lazare, 2013; Man, 2017; Marshall, 1985; Reddy, 2017; Sekhula, 2013 Tronchetti, 2015; von der Dunk and Negoda, 2002; Momoh, 2008). The parliament also debates, deliberates and conducts public hearing and assesses space policy, making it a platform to accommodate public opinion and major target for lobby by both public and private actors (Kelso, 2016; Venkateshmurthy & Nagendra, 2016; Williamson, 1992). The executive arm of government has evolved to prominent place with most pronounced roles in space policy formulation and implementation in most countries (Vedda, 1996). The office of the president coordinates space strategy, hence the personality and orientation of the occupants are central to space policy priority and investment (Reddy, 2017). Besides, Ministry or Department of Defence (DOD) and civil space agency possess significant influence on conception of national space strategy and dominate its execution (Kloman, 1988). They are often joined by several other departments, including communication, education, science and technology, agriculture, mineral resources, and

associated agencies. Hence, the presidency, various departments and agencies are targets on space policy lobby. Inter-agency competition, conflict, compromise, and cooperation have also characterised space policy circle (Johnson-Freese, 1992; Kloman, 1988). Although the role of the judiciary is the least heard in national space policy processes, it is also important in interpreting the law and adjudicating conflict of interests among actors.

The pluralists erroneously assume that all the major actors and interests that feature in space policy processes and associated political dynamics can be determined. This ignores the fact that not all information about space activities and interests are acknowledged by the state and are accessible to any analysts at a given time (Salla, 2014). At the broadest level, the pluralists often identify so many competing actors and interests in space policy, and then fall into the trap of ranking actors with interests that correlate with policy decision as influential. At the specific level, they do identify one or a few actors and hence overemphasise or overestimate their interests and influence in space policy. Generally, pluralists are often simplistic in equating correlation in interests of actors and space policy outcomes with influence in policy process. Besides, there are so many actors that are naturally important to policy process that have not received adequate attention of space policy analysts, meaning that this perspective is largely underdeveloped in space policy studies. Although some studies are looking into the interconnectivity of domestic and international environments in space policy (Beasley et al., 2013; Handberg and Li, 2007); the former is more salient and predominant in pluralism. This perspective has been challenged as being culturally biased and mostly applicable in liberal democracies (Wu, 2018). Its applicability in developing societies has been further criticised for ignoring the primordial public and ideas that often underscore policy interest in affected countries (Eisenberg and Kymlicka, 2011; Ekeh, 1975; Young, 1976). It equally ignores the elitist nature of space policy, and considerably widespread ignorance of the subject matter in the public. Yet, this perspective is important for those that care about building or developing a society or generation that can support and sustain interests of spacefaring nations (Dick, 2015).

2.2.2.1.3. Non-State Actors and Interests in Space

International Relations and world politics have witnessed the ascendancy of entities other than states as well as their powers. Globalisation is increasing the interconnectivity of people across the world, in such a manner that is reducing state primacy in the world politics, as well as undermining the capability of some states to cope amidst the changing order (Hay, 2005; Sauls,

2009; Soroos, 1986; Stiglitz, 2002; 2007). The declining capabilities of many public authorities to exercise effective control within their jurisdiction, exclude external authority from domestic authority configurations, control transborder movement of people, goods and information, as well as the growing mutual recognition of other entities as legal or illegal actors, have continued to challenge the statist view of international system (Krashner, 1999; 2004; Marshall and Cole, 2011). Accordingly, there is an alarming trend of proliferation of collapsed, failed, failing, fragile, and weak states (Clapham, 1996; Collier, 2007; 2009; Collier et al., 2005; Fund for Peace, 2012; Newman, 2009; Osaghae, 2007; Patrick, 2006). It is on this background that non-state actors and their importance are rising in international system (Haass, 2008; Davis and Pereira, 2003; Norwitz, 2009; Russett et al., 2006; Schlichte, 2009).

Traditionally, non-state actors are narrowly defined as non-sovereign entities in international system, and largely reduced to international governmental organisations (IGOs) with little or no attention to multinational corporations (MNCs) and transnational movements (Chandra, 2004; Frankel, 1988; Khanna, 2004; Palmer and Perkins, 2007). Glocalization has however repositioned local events and actors to attract global attention and vice versa. Hence, non-state actors are broadly defined as non-sovereign entities that exercise significant economic, political or social power and influence at national and/or international levels (NIC, 2007:2). They can be conventional or non-conventional (Magstadt, 2009). Conventional non-state actors are non-sovereign entities with legally and politically acceptable existence at the international level. These include IGOs, corporate actors and non-governmental organisation (NGOs) (Kegley and Raymond, 2010; Little and Smith, 1991; Magstadt, 2009; Mingst, 1999; Nye and Keohane, 1971; Nye and Welch, 2013; Russett et al., 2006; Vincent, 2006). Unconventional non-state actors are illegally constituted and politically debatable or nationally and internationally rejected non-sovereign entities. They are organised political actors, not directly connected to the state but pursue aims that affect vital state interests (Pearlman and Cunningham 2012:3). This category mainly comprises - armed non-state actors (ANSA).

IGO is an institutionalised arrangement or body that is made up of states. The policy interests of IGOs in space centres around challenges and limitations of individual state interests and capabilities, and the prospects for cooperation and shared benefits among nations in space exploration and exploitation. Aside from the unique interests of each IGOs, there is a general disagreement in the scope of their interests, depending on whether the arrangement is global or regional. Prominent examples of global IGOs are the UNO and its associates such as UN Office

of Outer Space Affairs (UN-OOSA), World Bank, International Monetary Fund (IMF), World Trade Organisation (WTO), Food and Agriculture Organisation of the United Nations (FAO), United Nations Educational, Scientific and Cultural Organisation (UNESCO), and World Health Organisation (WHO), among others. In this case, regional IGOs broadly cover transcontinental grouping such as Group 77 (G-77), North Atlantic Treaty Organisation (NATO), and Organisation for Economic and Development (OECD). Examples of continental grouping are Africa Union (AU) and European Union (EU). There is also the sub-regional grouping of IGOs such as Association of South Eastern Asian Nations (ASEAN), Arab League (AL), Economic Community of West African States (ECOWAS), Economic Community of Central African States (ECCAS), Gulf of Guinea Commission (GGC), Gulf Cooperation Council (GCC), and the Southern African Development Cooperation (SADC) among others.

The global IGOs, most especially the UN, can be associated with the idea of universal policy interest in space. In this way, a series of international conventions, declarations and treaties consider space as a frontier for states to cooperate in pursuit of those interests with shared benefits for mankind (UN, 2002; Lele, 2017). Article 1 of *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies* adopted on 19 December 1966 and entered into force on 10 October 1967 acknowledged that "the exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind" (UN, 2002). This viewpoint assumed that mankind has common interests is space, including the area of security (Bormann and Sheehan, 2009; Wolter, 2006). This is helpful in fostering cooperation among nations and setting global standard in space activities. Yet, the extent of common interest of mankind is a subject of debate. Moreover, while peoples across nations are increasingly reaping from the benefits of space exploration, the level of accessibility to space and its benefits vary across time and space, with the least recorded in developing regions (Abiodun, 2008; Harding, 2012; Kansakar and Hossain, 2016).

Some regional IGOs are promoting limited or selective cooperation in space, as a form of bridge between national and universal perspectives on terrestrial interests and actors in space. While this perspective agrees with the universal perspective on the need for cooperation among states in pursuit of terrestrial interests in space, it differs on the basis that there are compatible and incompatible interests among nations that limit the issues or geography of cooperation.

These have encouraged regionalised space awakening, agencies, policies, and programmes (Abiodun, 2008; Heintze, 1993; Sigalas, 2012; Venet and Barnes, 2013). In this case, the European Space Agency (ESA) is a model of a regional space agency. Since the Cold War era, the desire to catch up with the superpowers and defend unique regional interests has been evident in Europe as it has also been with emerging blocs in the developing regions with the goal of catching up with the advanced space players. African Space Agency (ASA), Regional African Satellite Communication Organisation (RASCOM) and Arab Satellite Communications Organisation (Arabsat) are other examples of regional space initiatives. This perspective assumes that common interests exist in a limited (issue or geographical) context, and cooperation among states is possible and encouraged (Giannopapa et al., 2018; Martinez, 2012a; Munsami and Offiong, 2017; Petroni et al., 2018; Sagath et al., 2018). However, this viewpoint does not rule out the possibility of competition and conflict in terrestrial interests in space. It also provides a hiding place for discriminate interests of space players against universal interests in space.

Corporate actors (of national, transnational, and multinational characters) constitute another category of conventional non-state actor that are playing active roles with varying degrees of interests in space. With the global wave of economic liberalisation, most especially from the 1980s, several state owned satellites across the world and the few countries (US, Russia, China, Japan and India) with independent orbital launch vehicles have increasingly commercialised these space capabilities (Elliott, 1997; OECD, 2014; DOS, 2016; Marshall, 1985; Space Foundation, 2015a). However, space R&D in many countries across the world started with private individuals and organisations, before their national governments established a sort of control and dominance in this area (ACSC, 2009; Chertok, 2005; 2006; Gottschalk, 2010; Siddiqi, 2000; Van Riper, 2004). In essence, private sectors have always been involved in space activities across time and space. Amidst these, some private actors have made history in space R&D. The Germans arguable pioneered and dominated records of corporate actors and interests in transnational relations (multinational investment and technological transfer or trade) in space, most especially rocketry and missile technologies, between 1945 and 1970s (Chertok, 2005; 2006; Chun, 2006; Pirards, 1991; Siddiqi, 2000; Van Riper, 2004). Besides, there have been a growing record of satellites constructed and sponsored by corporate actors and interests. These have supported the spread of space technologies, their applications, and benefits globally. The launch sector that remains largely monopolised by states have also witnessed

deregulation, most especially in the US. Hence, corporate actors like Space X, Blue Origin, and Virgin Galactic among others are leading players in the liberalisation of this sector.

The commercialisation of space actors and interests can be identified as the market perspective to terrestrial interest in space. It is mostly concerned with global corporate interests in space economy, politics and policy (Pelton, 1992; Machay and Steinberg, 2015; OECD, 2014; Space Foundation, 2015a). This perspective is critical of the state-driven policy and investment in space as well as the associated progress archived in making space accessible to humanity, which need to be free for market to achieve optimum utility. This is important to provide humankind with competitive access to space through tourism, and space technologies like satellites and their applications. This perspective is also encouraging human settlement in and colonisation of space and the exploitation of celestial bodies for resource extraction (Anderson, 2013; Bruhns and Haqq-Misra, 2016; Hertzfeld, 2007; Utrilla, 2017). These are linked to emerging debates on interplanetary trade and extra-terrestrial politics of mankind (Dudley-Flores and Gangale, 2012; Hickman, 2008; Schwartz, 2017). In view of these, Hudgins (2002) described space as "free market frontier", the next frontier for capitalist expansion. Yet, there are scepticisms against the capacity and willingness of private companies to drive investment in areas with little prospects for immediate profits. Corporate interests in space have also raised questions on democratisation of space policy, inequality in space access and benefits, and territoriality and sovereignty in space (Delgado-López, 2015; Machay and Steinberg, 2015; Schwartz, 2017; Tronchetti, 2014). These among others fit into the enduring scepticism and criticism of capitalism and associated expansionism (Coll, 2013; Hertz, 2001; Korten, 2015; Marx, 2010).

NGOs have emerged as important players in international politics (Ahmed and Potter, 2006; Lewis, 2001). They are non-profit entities that are relatively independent of government and are active in humanitarian course in different fields or walks of life (like human rights, policy and politics, environment, health and education, etc.) in accordance to their specified purposes. Among others, these broadly cover development, human rights, environmental, education, science, space, disarmament and demilitarisation advocates and aid workers (Bebbington et al. 2008; Carroll, 2002; Charnovitz, 1997; Kilby, 2015; Lewis, 2001; Rissanen, 2002; Robins, 2008; WEF, 2013). They also include non-state philantropical entities that are active in development agendas (Moran, 2014). A growing number of NGOs are displaying interests in space and attendant technologies globally. Policy advocacy for and against different aspects of

space R&D or its entirety at national and international levels have been dominated by NGOs (Dark, 2006; Dick, 2015). Various associations of scientists and engineers, and particularly astronauts, are at the forefront of advocacies for space policy priority and investment by corporate actors, national governments, space powers, and IGOs globally. The capacity building efforts or activities of some NGOs are strategic to the future of space exploration (Lukaszczyk and Williamson, 2010; Reibaldi and Grimard, 2015). In most cases, however, space advocacies are rising in competition with other advocacies that consider terrestrial solutions to terrestrial problems to be more appealing and pressing than space and whatever benefits it has to offer (see Chaisson, 1998; Detsis and Detsis, 2013; Vedda, 2008).

A growing number of NGOs are using space technologies to revolutionise their operations. Although there are notable interests to own or sponsor satellite in orbit by some leading international NGOs, most of them rely on state or corporate, free or purchased satellite data. These account for remote sensing by NGOs (Olbrich, 2018). Human rights groups are now using remote sensing data from satellites to gather information about human rights abuses in inaccessible conflict theatres (Alston and Gillespie, 2012; Corbane et al., 2016; de Vos et al., 2008; Edwards and Koettl, 2011; Hong, 2013; Kalliatakis et al., 2017; Lavers et al., 2009; Madden and Ross, 2009; Marx and Goward, 2013; Smith, 2014; Whitty, 2010; Witmer, 2015). The technology has been used by different NGOs to monitor human rights in one of the greatest African conflicts in Dafur, Sudan (Bromley, 2010; Knoth & Pebesma, 2017; Parks, 2009; Prins, 2008; Sulik & Edwards, 2010). Aid agencies and workers are increasingly using the same to attend to Internally Displaced Persons (IDPs) and refugee crisis (Bjorgo, 2000a &b; Lodhi et al., 1998). It has also become a tool of many advocates on disarmament and demilitarisation (Aday and Livingston, 2009; Atwood, 2002; 2006). Satellite televisions and radios as well as easy access to social media through smart phone, which can work in remote areas of the world with the aid of telecommunication satellites, are also promoting and globalising NGOs and taking their messages to targeted audiences worldwide (Apodaca, 2007; Powers, 2016). Telemedicine and tele-education are also revolutionising the fieldwork of NGOs in the areas. Although roles of NGOs are largely limited to humanitarian causes, policy makers and analysts sometimes criticise their insensitivity on national security. Some developing countries also see this development as a ploy to promote Western global interests, and a trend that can cause instability if not properly addressed (cf. Christol, 1978). Besides, space advocacies by many

NGOs often ignore or underestimate the bigger picture of space within policy and investment framework, whenever it does not serve their interests.

Armed non-state actors broadly include bandits, warlords, mafias, bandits, Vikings, Teutonic Knights, privateers, pirates, militias, mercenaries or private security or military firms, cartels, rebels, terrorists, and insurgents (Bobbitt, 2008; Bunker, 2013/14; Brooker 2010; Davis and Pereira, 2003; Okumu and Ikelegbe, 2010; Norwitz, 2009; Gumedze, 2011; 2008). While there have been little efforts to register their presence in space, or trying to place a satellite in orbit or develop space shuttle, perhaps with the exception of private security firms that appear to be more conventional, many non-conventional non-state actors have displayed their willingness and in some cases ability to adopt, adapt, disrupt, hijack, and threaten space technologies and their applications in order to advance their strategic goals. It is important to note that there are corporations that provide security services to armed forces or defence industry some of which have sponsored, owned and maintained satellites in orbit. However, these firms cannot be classified as unconventional actors in this consideration, rather they are conventional actors in the class of national, transnational or multinational corporations. These are largely approved legally and politically in many countries across the world provided they are law abiding, and willing to submit their activities to state review. Nevertheless, there are mercenaries branded as private security companies, which are involved in combat roles in conflict theatres, in contradiction of extant laws.

Sophisticated bandits and pirate groups in the Gulf of Guinea and the Indian Oceans have displayed their ability to adopt satellite applications, adapting navigation potentials of Global Positioning System (GPS) to track their own locations and that of their (potential) victims (ships) on high sea, while using satellite phones that are often difficult to track in the affected region during ransom negotiations (perhaps except by the USA, which has the capacity to track all all satellite phones globally) (Oyewole, 2015; Murphy, 2009; World Bank, 2013). Sophisticated rebel, terrorist, and insurgent movements as well as cartels have also displayed similar interests in space technologies. Satellite-based or supported traditional and new media are also promoting and globalising terrorist and insurgent groups as well as their ideologies and violence. These are strategic for terrorists to build their organisation capabilities to attract recruits, sympathisers and funding, and improve their technological knowhow and training (Conway, 2017; Feldman, 2006; Hoo et al., 1998; Klausen, 2015; Mishra, 2003; Rudner, 2017). More alarmingly, terrorists have become a major source of threat to space technologies with

the growing record of non-state cyber-attacks - a concern that cannot be ignored in security architecture of network of satellite systems (Fritz, 2013; Rao and Rao, 2011). There is also the tendency for legally established private security firms to turn rouges, and become threats to cyber space or state secretes on space technologies.

2.3. Assessing Space Policy: What Matters, How, Where, and When?

So far, this chapter has demonstrated that space policy assessments or studies are necessary to appreciate and advance the course of knowledge on the subject matter in multidisciplinary ways as well as interests of various actors that are directly or remotely involved either locally or internationally. Although several actors are involved in space policy processes, institutions of state remain the dominant determinant of context and content or manners of involvement of other actors in space. These are not surprising, because states are in control of the whole habitable surface of the earth and, since any other organisation must operate somewhere, it must either acquire the control of a state or become subject to one (Frankel, 1988:67). More so, sovereignty distinguishes the state as an embodiment of supreme and final legal authority within a jurisdiction, which covers internationally recognised right to control domestic affairs and transborder movement without external interference (Bodin, 1955; Krashner, 1999). By implication, the place of non-state actors in space is determined by commission (willingly or intentionally) or omission (accidentally or unintended) in space policies of one or more states.

Institutions of state often accommodate, absorb, and project interests of some non-state actors (such as private individuals, civil society groups, IGOs, NGOs, ANSAs, as well as national, transnational and multinational corporations), and distil or repel others, in the final policy that are authoritatively formulated and implemented at the national or international levels, which actually deserve assessment. This explains the centrality of the state in most analyses of space policy (Anantatmula, 2013; Boroffice, 2008; Filho, 1995; Gottschalk, 2010; Martinez, 2016; Murthia et al., 2010; Sadeh, 2002a; 2011; 2013; Starun, 2017; Siddiqi, 2000). Yet, states among themselves are unequal in terms of capabilities and interests in space as any other frontiers. By implication, there are enduring debate on the impacts of variation in capabilities in space on their studies or assessment across nations (Harding, 2013; Harvey et al., 2010; Klein, 2012; Lupton, 1998; Lutes, 2011; Mistry and Gopalaswamy, 2012; Sariak, 2017; Buzan and Wæver, 2003; Volgy et al., 2011). As this section is concerned with how and what to assess in space policy, it also pays attention to how variation in capability matters in this consideration.

2.3.1. Commonalities and Differences among Nations, and Space Policy Analysis

There are studies that have shown that humanity have common challenges and prospects in space, including in the area of security and, as a result, there is little reason for national space interests to differ or conflict (Wolter, 2006; UN, 2012). Some other studies have shown that states have similar interests to pursue in space (Bormann and Sheehan, 2009; Durch, 1984). In this way, some studies have shown that medium and emerging space powers like the space superpowers have considerably the same or similar interests, including in the use of space and attendant technologies for military C4ISR (Durch, 1984; Ercan and Kale, 2017; HDoA, 2005; Klein, 2012; Sariak, 2017). Spacefaring states have also been observed to be faced with common challenges of setting coherent national interests in space especially since the end of Cold War (Stine, 2008); or suffer from a lack of explicit space strategies, which can provide a roadmap for connecting ways and means to achieve ends established by space policy (Sadeh, 2013:2). Studies have equally shown that space exploration and exploitation have evolved to the benefits of humanity, with little or no discrimination based on nation's specific involvement in space (Kansakar and Hossain, 2016; NASA et al., 2015). These have been used to encourage partnership among nations in space (Balogh et al., 2017; Kansakar and Hossain, 2016; MacLeish et al., 2015; Moltz, 2014; NASA, 2014; Olla, 2009; Withee, 2004).

Many attempts to define space policy and what it entails have also drifted toward unification of state interests in space. As noted earlier, Harding (2013:5) defined national space policy as the conscious and specific use of space and its attendant technologies to promote the security and socioeconomic interests of the state. The author thereafter proceeded as if there are pre-determined and unanimous global consensus on the meanings of security and socioeconomic interests of all states. Stine (2008:12) also identified the reasons for the USA space exploration to include knowledge and understanding, discovery, economic growth (job creation and new markets), national prestige, defence, international relations and workforce development. It is important to note however that these among others are the same or common reasons for space exploration for almost all other countries across the world, including the emerging nations in space (Becerra, 2014; Boroffice, 2008; Cottom, 2018; Ercan and Kale, 2017; Harding, 2013; Hussain and Ahmed, 2018; Lopez, 2015; Lopez et al., 2018; MacLeish, et al. 2015; Nair, 2016; Ortiz, 2008; van Wyk, 2009). On the assumption that states have common interests in space, one may be tempted thus to erroneously adopt the same metrics to assess space policies of nations with different levels of development and varying capabilities on the subject matter.

Variation in development, capabilities and associated power across nations cannot be ignored in space policy analysis (Harding, 2013; Klein, 2012). As evident in the various conceptions of development in chapter 1, policy objectives can be to find remedy, to progress, maintaining lead and catching up, establishing colony, exploiting resources, industrialisation, economic growth, political and social modernisation, independent national capacity, human flourishing, enlargement of people's choice, liberalisation of productive activities, and sustainability. In view of these, variation in space capabilities and general socioeconomic development among nations often influence their policy orientations, which cannot be ignored in policy analysis. For instance, for any nation to be considered as space players, it must have seen space and attendant technologies as remedy to challenges or limitation of, and progress from, terrestrial technologies in the immediate and the long run (Harding, 2013; Macdonald and Badescu, 2014; Schwartz, 2017a). As a result, almost every nation can now access space technologies for remote sensing, communications, positioning and navigation. These can help human flourishing, enlarge people's choices and sustainable development across all nations (Balogh et al., 2017; Olla, 2009; Peter, 2006; NASA et al., 2015; Witmer, 2015). However, people within and across nations, just like nations among themselves, are unequal in capacity to access space, its technologies and associated benefits. In fact, space power entails the ability to use space while denying reliable use to any foe (Gray, 1996; HDoA, 2005; Klein, 2012).

Nations have varied interests and power in space. In term of immediate policy ends, advance space powers desire space control (Anantatmula, 2013; Chertok, 2009; 2011; Durch, 1984; Grimard, 2012; HDoA, 2005; Klein, 2006; Mowthorpe, 2004), medium space powers desire secured space access (Klein, 2012; Sariak, 2017; Starun, 2017), emerging space players are preoccupied with mere space access or registered presence in space (Argoun, 2012; Harding, 2013; McKenna-Lawlor, 1998; Othman, 2003; Wood and Weigel, 2011; 2012a&b; 2014), while others can be considered as mere consumers of space technologies. For some advanced space players like the US, Russia, China, and West Europe, space is a frontier to be explored for human colonisation and resource exploitation (Bruhns and Haqq-Misra, 2016; Collis and Graham, 2009; Hickman, 2012; Munévar, 2014; Paikowsky and Tzezana, 2018; Tepper, 2018). It is also a frontier to inspire, build, test, and host modern and next generation technologies in medicine, agriculture, warfare among other essential elements of national defence, security, and power (Baines, 2004; Grigoriev et al., 2009; NASA et al., 2015; Siouris, 2004; Zhang, 2016). Despite their merits in space R&D in developing countries; space technologies, their

transfer, liberalisation and benefits, including in the areas of human development, have become assets in the quest for prestige, dominance, soft power (world model) and cultural irredentism (Fukuyama, 1992; Lieberman, 2017; MacLeish et al., 2015; Murthi and Shoba, 2010; Nye, 2004; Oikonomou, 2017), which less advanced countries are encouraged to embrace in the name of modernisation. In this manner, the US wants to maintain its lead in knowledge production, few countries want to catch up, some just want modest capacity to confirm and benefit from space R&D, while others are ready to consume anything made available to them.

Developing countries in the category of medium, emerging, or aspiring space players are mostly interested in independent national capacity to achieve their development and security interests that range from modest to limited scope (Broniatowski and Weigel, 2008; Chandrasekhar et al., 2000; Harding, 2013). For majority of the countries in this category, catching up with the advanced nations as well as direct involvement in exploration for human colonisation and resource exploitation in space are remote, distant or unforeseeable policy objectives. Moreover, liberalisation of the space sector beyond satellite data remains a long-term objective in many developing countries (FMST, 1999; Othman, 2003). Meanwhile, spaceflight and the quest for resources and space tourism are undergoing privatisation in the US; space corporations producing and launching satellites have undergone commercialisation in Russia; China and India, and profiting from satellite data have been globalised by MNCs (Chang, 2015; OECD, 2014; Space Foundation, 2015a). In view of these, it appears to be inappropriate to assess or compare the objectives, programmes, achievements, and challenges of space policies of two or more nations at different stages of development as if they have uniform immediate strategic goals and capabilities over a given period of time. A good knowledge of classification and the place of space players is this context is therefore important in the assessment of space policy of two or more countries, especially when it involves comparison, in order to reduce possible impacts of selection bias in few cases, and spuriousness and ecological fallacies on inferences drawn (Landman, 2008; Newton and van Deth, 2010).

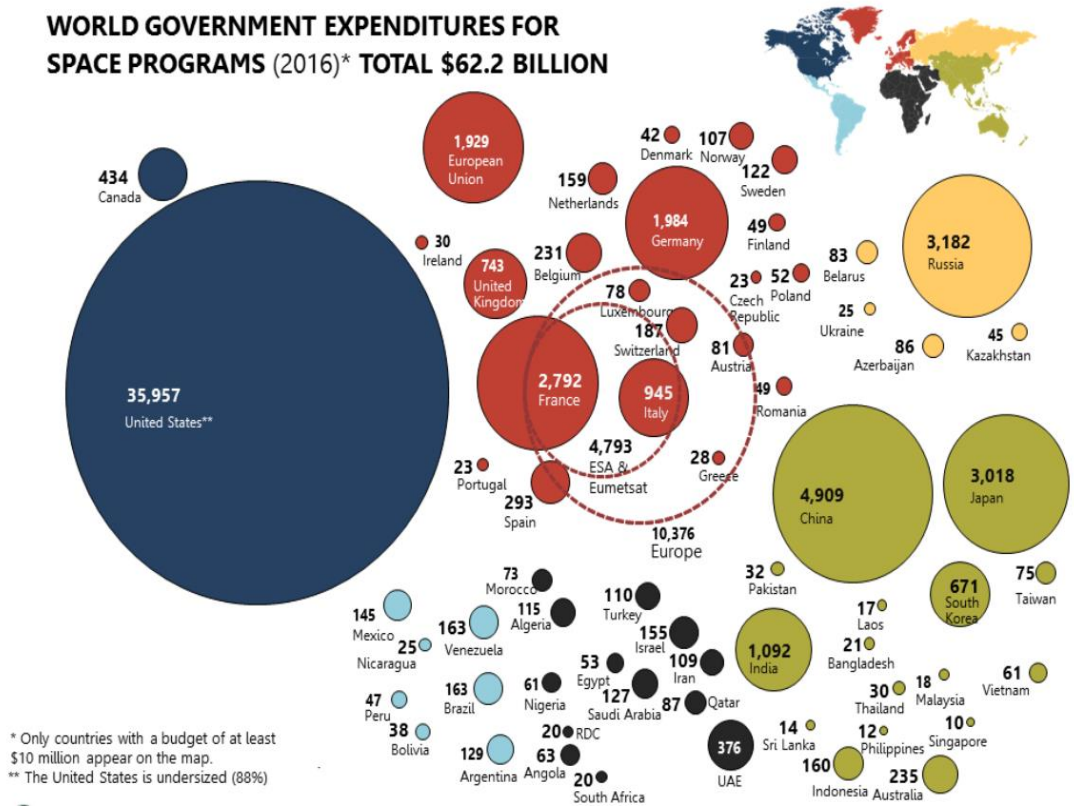
2.3.2. Capabilities and Interests Matter! Assessing Space Policy Programmes, and Classifying the Players

Interest determine capabilities and vice versa. Different studies have adopted different mechanisms to arrive at different classifications of space players based on capabilities and interests, all with their prospects and shortcomings. Amidst these, different perspectives can be

observed, including the financial perspective, materialist perspective, the local industrial capacity and service-centred view, and the attempted "holistic view". Using financial perspective, the capabilities of space players can be considerably determined through their budget for or expenditure on space programme (Bochinger, 2016; Euroconsult, 2017; Lal et al., 2015). As evident from figure 1.1, government expenditures on space programme in 2016 varies from tens of billions to billions, hundreds of millions, tens of millions, and others that are less significant in the bigger picture. Hence, the interests and capabilities of those countries that are spending billions of dollars cannot be indiscriminately equated with those that are spending tens of millions. Yet, figure 1.1 does not adequately capture the significance of historical trajectories and accumulation, from where wrong inferences can be drawn. It is possible therefore for someone to erroneously rate Angola and Morocco that did not have a satellite in orbit as at 2016 better than Nigeria and South Africa that have considerably maintained assets in space for decades (Oyewole, 2017; Froehlich and Siebrits, 2019), although the situation has changed for Morocco since its launched two dual used satellites in 2017 and 2018.

While it is possible to address the historical accumulation gap of the financial perspective in space capabilities assessment through trend analysis of space budget or expenditure, this will still fail to fully capture the variation in value achieved for money spent. This is the case of the Indian Mars mission, which is the cheapest ever and nine times cheaper than a similar mission in the US, and at the same time made the country the first to succeed in such a mission in the very first attempt (Amos, 2014; Lele, 2015; SPC, 2015). Similarly, South Africa has spent lesser amount of money to acquire most of its satellites in comparison with other space players in Africa. For instance, South African SumbandilaSat launched in 2009 was two times more expensive to build than its SunSat launched in 1999, yet they are four to six times cheaper than NigeriaSat-1 launched in 2003 and the Algerian Alsat-1 and 2 launched in 2002 and 2010 respectively (Oyewole, 2017). These among other reasons make it imperative for one to exercise caution in dealing with expenditure as a yardstick for assessing space capabilities.

Figure 1.1: Global map of government expenditures for space programme in 2016



Source: Cropped from Euroconsult (2017).

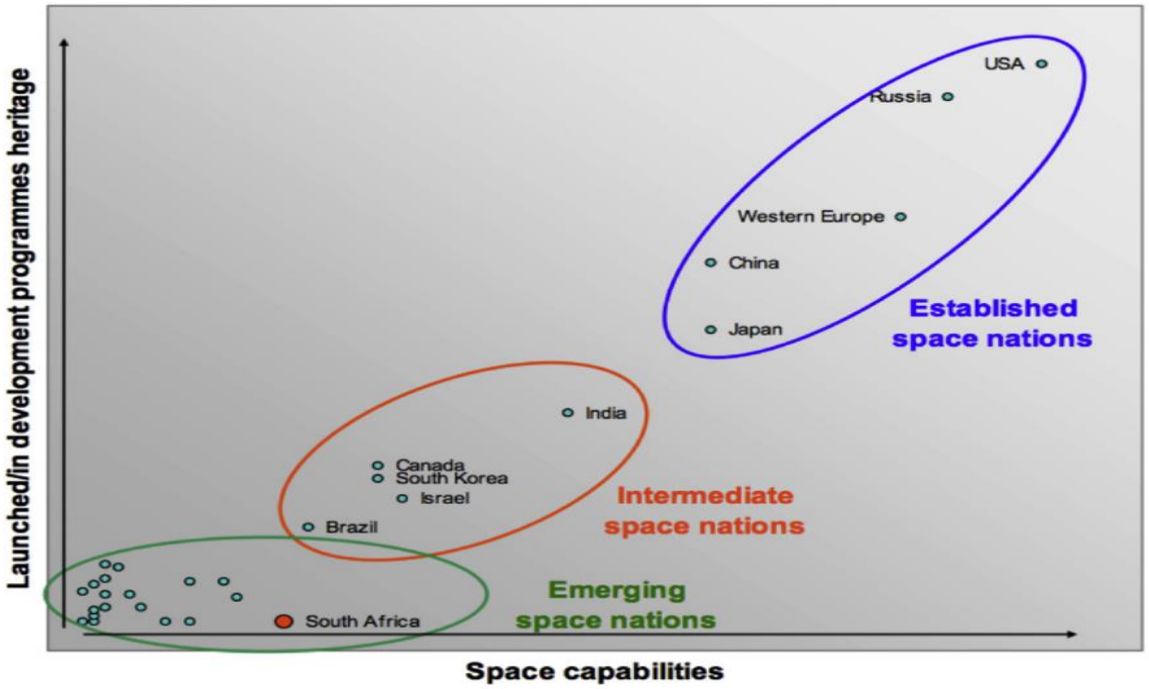
The materialist perspective offers a nuanced view of space capabilities assessment. This point of view is concerned with the total assets that spacefaring countries have or programmes run in an attempt to determine their capabilities and the associated variation across nations (OECD, 2014; Space Foundation, 2015b; UCS, 2017a). This can be in form of the number of satellites, robotic launches, or crewed missions that a country has in space. This method offers an analyst the opportunities to assess the inventories of one or more spacefaring countries over a given period of time, either as currently evident or with addition of historical accumulated assets or achievements in relation to the number of satellite and other basic space assets that made up a country's inventories. However, this method of assessing capabilities does not distinguish between programmes or projects based entirely on indigenous capabilities and programmes developed in cooperation with foreign industry, or fully sourced from abroad (Martinez, 2016). At the same time, it does not provide a sufficient framework to assess the quality behind quantity in space inventories. This is the case when comparing a country with numerous

satellites with short lifespan (like between three months and two years), which require constant replacement to maintain a significant space capabilities or presence at a given point in time, with another country having fewer number of longer lifespan satellites. (like 15 to 25 years): as evident in the case of the USSR and the US during the Cold War (Durch, 1984; UCS, 2017a).

Local industrial capacity and services provided by a spacefaring country constitute another perspective and indicator for assessing its capability. This can be assessed through the level of independence or partnership that produce a space project. This often covers a survey of state with various capacity to develop and control satellite as well as manned and unmanned space ships (Argoun, 2012; Broniatowski and Weigel, 2008; OECD, 2014; Wood and Weigel, 2011; 2012; 2014). As such, Klein (2012:111) developed a typology of emerging powers, medium powers, and superpower in space. Emerging space powers cover numerous nations that can develop or control satellites without the ability to launch them through indigenous means. Medium space powers are countries like France, the United Kingdom (UK), India, Israel, Japan, and Iran with the indigenous capability to develop, launch, and control satellites. Space superpowers are countries like the US, Russia, and China with aforementioned medium space power capabilities and indigenous capability of human spaceflight (Klein, 2012:111). The share of a country in global space economy can also be used to assess its capability (Africa in Space, 2019; OECD, 2014; Lal et al., 2015; Space Foundation, 2015b).

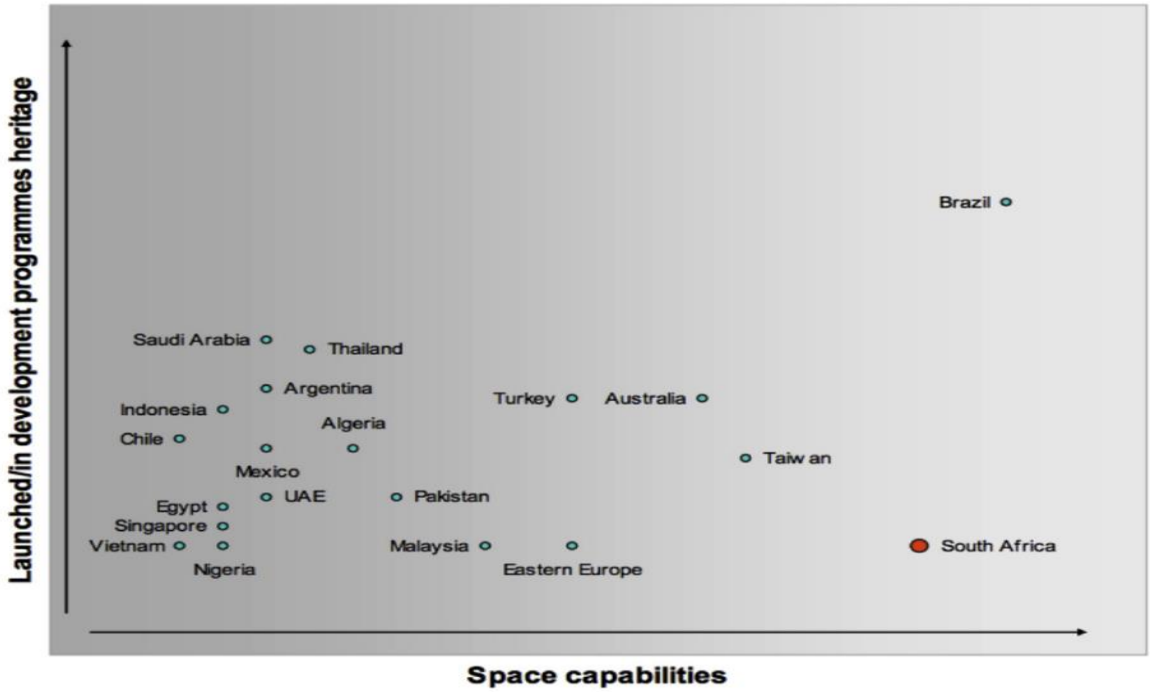
There is a doubt whether the industrial capacity of a country in space can be fully understood outside production trend, quantity, and quality of products, and launched records. Integration of industrial capacity and launched record can therefore produce better analysis of space capabilities. As evident in figure 1.2 and 1.3, a 2008 report of the South African DST used this method to classify space players into established, intermediate and emerging space nations (Martinez, 2016:35-36). In this case, US, Russia, Western Europe, China and Japan are classified as established space nations; India, Canada, South Korea, Israel and Brazil are grouped as intermediate space nations; while Australia, Eastern Europe, Argentina, Chile, Indonesia, Turkey, Pakistan, Thailand, Taiwan, Algeria, Egypt, South Africa, Nigeria among others are the emerging space nations (Martinez, 2016).

Figure 1.2: Heritage versus industrial capacity of nations in space



Soruce: DST (2008) reproduced in Martinez (2016:3)

Figure 1.3: Heritage versus industrial capacity of emerging space nations



Source: DST (2008) reproduced in Mertinez (2016:3)

Although the integration of industrial capacity and launched record provides better analysis of capabilities of spacefaring countries, it is not holistic enough. Most importantly, it tends to portray capabilities in disconnection with its utility or stages of development of a country. This is the precondition for what can be considered as an "attempted holistic view" of space capabilities of a country. In this way, Harding (2013) divided space players into developed and developing countries. US, Russia, Europe and Japan are classified as developed space players. The developing countries are further divided into first tier states like China, India and Brazil; second tier like Iran, Iraq, Israel, and South Africa; and several countries as third tier.[1] The third-tier states always collaborate with advanced states, mostly purchase and contribute little to space technology. The second-tier states produce some of their own space technology, have basic launch capacity and collaborate frequently where necessary. First tier states have largely developed the capability to autonomously produce space technology and indigenous launch vehicles for both orbital and geosynchronous satellite placements (Harding, 2013:78).

Despite the commendable scope of his study, Harding's (2013) typology tends to suffer from ethnocentrism and cultural biasness in its focus on development as well as time lag, most especially in classification of states in each tier. Amidst these, the place of China in this classification will worry many students of space policy, who consider the country as peer of the US and Russia (Anantatmula, 2013; Klein, 2012; Krepon and Thompson, 2013). In space, India is also considered as peer of France and Britain (Klein, 2012), who form the core of Western Europe that is classified as developed states. It is notably worrisome that Harding (2013) used currently non-existing or optimal capabilities previously possessed by Iraq and South Africa as criteria to rank them as second tier states. It is debatable that Pakistan, Indonesia, North Korea, Argentina and perhaps Mexico ranked far below the so called second tier states like Iraq, Iran, and South Africa. In essence, the gap between most of the second-tier states and some of the third-tier states are not as pronounced as presented in the classification. Moreover, it does not capture or provide clue on the place of space players like South Korea, Canada, Australia, Ukraine, United Arab Emirate (UAE) Saudi Arabia and Turkey, which are notable emerging or intermediate space nations as patent in figure 1.2 and 1.3.

[1]This include Latin American countries like Argentina, Bolivia, Chile, Colombia, Ecuador, Mexico, Peru, Uruguay and Venezuela; African countries Algeria, Egypt, Nigeria and Tunisia; and Asian countries like North Korea, Kazakhstan, Azerbaijan, Vietnam, Indonesia, Bangladesh, Pakistan, Malaysia, Taiwan, Philippines and Thailand.

Against this background, this section aligns with the broad classification of space players into established and emerging space nations, while cautiously noting the variation in capabilities of countries even within each of the two categories. Although state actors across the world do have their unique and distinguishing features, national interests generally and the space interests in particular can be associated with general level of socioeconomic development of a country as well as associated power capabilities and relative position in the international system, and specific level of advancement that has been recorded in space exploration and exploitation (Lieberman, 2017; Harding, 2013; Klein, 2012; Mistry and Gopalaswamy, 2012). However, it is notable that most extant literature on space policy and politics focus on the so-called developed, established. and advanced space players like the US, Russia, China, and Europe at the expense of developing and emerging players such as Nigeria and South Africa. Given the limitation of universalist's overgeneralisation therefore, it is important to promote particularism in space policy studies for emancipation of disadvantaged nations in knowledge production.

2.4.Space Policy in Nigeria and South Africa

In connection with the established pattern of this review, which distinguish academic and policy rationales for space studies, extant literature on space policy in Nigeria and South Africa can be viewed from two broad spectra. From the academic angle, extant literature on the subject matter can be classified into pure and applied science and engineering on one hand as well as humanities and social sciences at the other. Amidst these, space studies in these two countries and the continent of Africa as whole are overtly dominated by the former, with little or no visibility of the latter. To avoid repetition of what have been considered in the broader multi-disciplinary assessment however, this dichotomy will be streamlined and explored within social context of politics and policy consideration. In this case, space policy in Nigeria and South Africa have received academic attention mostly as emerging and developing space players, leading players in Africa or regions within it, and individually as nations in their own right.

2.4.1. Nigeria and South Africa as Global Emerging Space Players

Nigeria and South Africa have featured among other emerging and developing space players in most space policy studies that consider it necessary to shift academic attention on the subject

matter to accommodate these and other countries other than advanced, developed, and established space players (Argoun, 2012; Harding, 2013; 2016; McKenna-Lawlor, 1998; Mistry and Gopalaswamy, 2012; Wood and Weigel, 2011; 2012a; 2014). The end of Cold War and the growing accessibility and adoptability of small satellites in developing and emerging nations are changing the geopolitical dynamics of space in ways that cannot be ignored by space policy analysts. Amidst these, Harding (2013) described security and socioeconomic development as universal interests of all space players, recognised that the experiences of the developing countries are yet to receive adequate attention, and went on to document these for about 30 developing countries across the world. As recognised earlier however, the study provides little or no clue on the meaning of security and socioeconomic development beyond economic growth for majority of these countries, and in some cases military security. Nevertheless, some other studies have paid attention to the struggle for independent capacity in production and utilisation of satellites and in some cases launch vehicles as the dominant forms of development ends in the developing and emerging nations (Argoun, 2012; Mistry and Gopalaswamy, 2012; Shabbir and Sarosh, 2018; Wood and Weigel, 2011; 2012a; 2014).

Despite the foregoing, most space policy studies on developing and emerging countries have devoted little or no attention to Nigeria and South Africa, and Africa generally. In this way, one can argue that the experiences and perspective of space players in Africa are the least heard. It is notable that a major study on emerging space powers by Harvey et al (2010) only focuses on Asia, the Middle East, and South America. The limited and insubstantial reference to Africa and its space players in some of the recent yearbooks of space policy is another testimony of the position of the continent in knowledge production on the subject matter (Al-Ekabi and Ferretti, 2018; Al-Ekabi et al., 2017; Burger and Bordacchini, 2019). Equally, Harding's (2013) volume that focused on several developing countries only recognised South Africa, Egypt, Nigeria, Algeria and Tunisia among space players in Africa, and devoted 10 out of 236 pages to them. Some studies focused on Algeria, Egypt and Nigeria (Argoun, 2012; Wood and Weigel, 2012), while others include Kenya and South Africa to their limited list of developing and emerging countries from Africa, they studied their space policies (Wood and Weigel, 2014).

Although the foregoing studies and some other related ones have generated more attention for Nigeria and South Africa, and Africa generally, in space policy studies globally, they lack depth in most cases. Meanwhile, an in-depth study of these space players among others in Africa can

contribute significantly to scholarship by unravelling or deepening our knowledge on what Harding (2016) described as diverse interests that are associated with growing number of developing countries in space. Moreover, most of these studies always focus on very limited indicators of development and security, with little or no theoretical bases in the field of International Relations and related disciplines in social sciences. Accordingly, there is often lack of harmony between conceptual and empirical details in these studies, and are often inadequate in comprehensive, systematisation, and strategic or critical policy analysis. Sometimes, studies do recognise the connection between space applications and sustainable development, but fail to explore the progress of the selected countries in achieving synergy in their space policies beyond paper works and political talks (Argoun 2012; Bhaskaranarayana et al, 2009).

Against this background, studies on globally emerging space players have provided limited theoretical focus and empirical details of African experiences and perspective that Nigeria and South Africa represent and have always championed. In as much as the global-South, or better still, developing and emerging countries-oriented studies are essential for emancipation of Africa amidst global-North or better still Western dominated knowledge production in the field of International Relations, the uniqueness in the continent's experiences and perspective cannot be totally ignored (Smith, 2015). More importantly, very few Africans are involved in this category of research: hence, the experiences of the continent and its leading space players such as Nigeria and South Africa are dominantly written by foreigners with their attendant value bias and interests (cf. de Klerk & Buchanan, 2017). In some of these cases, therefore, the literatures are largely a continuation of the dominant global narrative, space popularisation projects of leading global players, and marginalisation of African experiences and perspective.

2.4.2. Nigeria and South Africa as Leading Space Players in Africa

Nigeria and South Africa have featured prominently in space studies in Africa as leading players in the continent. Although it still remains considerably limited, there is a growing number of literatures on space and associated policy in Africa. In comparison with studies on global emerging space players, significant space studies on Africa are authored by Africans or those that are affiliated to African institutions (Abiodun, 2008; Froehlich and Siebrits, 2019; Luncedo and Gottschalk, 2013; Martinez, 2012a &b; Munsami and Offiong, 2017; Oyewole, 2017; Wangari, 2016). Using a simple survey of major journals on space policy like

Astropolitics, *Space Policy*, *Acta Astronomica* among others, it is evident that available studies on space policy and politics in Africa are dominantly carried out by Africans. Yet, this cannot be taken too far, because the proportion of African studies in the framework of space policy studies is generally not significant. Even in pure and applied sciences that tend to fair better, the proportion of space studies on Africa by Africans remains troubling. For instance, de Klerk & Buchanan (2017) surveyed the use of remote sensing for conservation and ecological studies in Africa and found 580 studies with authorship that spread across 98 countries. Amidst these, the US tops the list with 34 per cent of record, followed by South Africa with 22 per cent of the record. Besides, only seven African countries are listed in the top 20 countries.

Despite the foregoing, there is an emerging body of literature on space policy in Africa. The subjects of concern cover a series of debates that range from regional to national space actors and associated dynamics in Africa. At the regional level, there are studies that have tried to locate Africa in the global arena or trend of space R&D, and largely provided a worrisome conclusion that the continent continues to lag behind its peers in policy priority and investment as well as advancement in the subject area (Abiodun, 2008). In contrast, some are considerably impressed and fascinated with the growing profile, visibility, and importance of the continent in space R&D as well as politics and policy (Froehlich and Siebrits, 2019; Martinez, 2012c; Oyewole, 2017; Space in Africa, 2019a). Some studies have explored the emerging trend and prospects of regional space collaboration and institutions, such as the African Resource Management (ARM) constellation, the ASA and the African Leadership Conference on Space Science and Technology (Gottschalk, 2008; Martinez, 2012a &c; Mostert and Jacobs, 2008; Munsami and Offiong, 2017; Offiong and Munsami, 2018). A recent study by Froehlich and Siebrits (2019) provides a comprehensive survey of these among other IGOs and the least explored INGOs that are critical to regionalisation of space activities in Africa. This set of studies look beyond state-centric reductionism of policy priority and investment as well as political commitments for sustainable space R&D for humanity sake in the continent.

Regardless of the growing momentum for cooperation and regionalisation of space policy and programmes in Africa, the strength of nationalism that have underscored space programmes of key players across the continent have generated some concerns about regional integration, and particularly, the establishment of ASA in the model of ESA (Martinez, 2012b; Munsami and Offiong, 2017). These among others continue to indicate the enduring relevance of regional powers and particularly key space players in space policy analysis in the continent (Froehlich

and Siebrits, 2019; Oyewole, 2017). In view of these, there is an emerging body of literature that is counting and keeping scores or taking stock of space assets of African countries as a basic attempt to assess the capabilities of affected space players (Froehlich and Siebrits, 2019; Luncedo and Gottschalk, 2013; Oyewole, 2017; Space in Africa, 2019a). However, some of these studies are just more than stock taking.

Many studies have looked into the level of international collaboration that underscored the capabilities of space players in Africa (Froehlich and Siebrits, 2019; Oyewole, 2017; Space in Africa, 2019a). Moreover, Oyewole (2017) assessed space policy priority and investment of African countries as well as associated cost and benefits. Cost was assessed in terms of funding by local public and private actors, foreign direct investment (FDI), and priority amidst policy pressing concerns, while benefits were considered in terms of development in economic, education, governance, and security. However, the scope of the study is generally too broad and less in-depth. Besides, the study does not assess the achievement in space vis-à-vis designed strategic objectives of the affected countries. Froehlich and Siebrits's (2019) study filled some of these gaps by identifying socioeconomic objectives that are strategic to most African countries and available space related means and capabilities to attain them. Yet, the study shows very little empirical evidence of how space capabilities have advanced some of the identified socioeconomic objectives of the region. Again, Space in Africa (2019a) arguably offered the most comprehensive account of space industry and economy in Africa. Beyond the liberal conception of development as deregulation, privatisation, and economic growth however, it offers limited insight into how space means have advanced desired policy ends. Therefore, case study analysis needs to provide in-depth and multidimensional assessment of the contribution of space policy to development and security in the continent.

2.4.3. Nigeria and South Africa as Space Nations

There is a small but growing body of literature that has treated Nigeria and South Africa as space nations in their own right. Studies of this nature are mostly in form of case study analysis, and their authors are dominantly citizens at home or in diaspora, and most importantly affiliated to national institutions. This set of literature can be categorised into historical and current dynamics of space policy institutions, operations, strategies in Nigeria and South Africa. Notably, the focus of space studies in Nigeria and South Africa are largely dominated by operational dynamics, which are dominated by pure and applied scientists and engineers. In

the case of Nigeria, there is a growing body of literature on the prospects, progress, operations, and challenges of space technology adoption, with significant attention to satellite for remote sensing (Boroffice and Agbaje, 2006; Ogunsua, 2018; Ogunsua et al., 2018; Ojo, 2017). Beside the basic space technology adoption, space studies in this category in South Africa also cover the design, R&D, and operationalisation of satellites produced in the country (Koekemoer et al., 1999; Mostert et al., 2008; Mostert and Koekemoer, 1997; Schoonwinkel et al., 2003). However, most of these studies often pay little or no attention to social dynamics, and particularly institutional and strategic dimensions of the subject matter.

Most studies on space policy in Nigeria focused on space institutions, their structures, laws, history, and in some cases the policy ends they are designed to achieve, and mechanisms, projects, and programmes initiated to attain them (Abiodun, 2017; Boroffice, 2008; Fashade, 2008; James et al., 2014; Mohammed, 2011; Momoh, 2008; Tella, 2018). Amidst these, NASRDA and its affiliated centres as well as their activities have dominated academic attention. Thus, literature is largely government or state-centric, with little recognition of non-state actors (especially private firms and civil society groups), who are in cooperation, competition, and conflict with public institutions in space policy formulation and implementation as well as technological adoption and marketing. This is partly due to the predominance of state institutions in space initiatives, activities, sector and policy processes in Nigeria. Besides, the subjects of concern have attracted little research attention of social scientists, most especially economists and political scientists, as well as relevant specialists in International Relations, policy and strategic studies, and pubic administration.

Space policy studies in South Africa have largely focused on space history, institutions, laws, policy strategies, capacity building as well as programmes and projects (Gottschalk, 2010; Martinez, 2009; 2016; Munsami, 2014; SANSA, 2014a; Sekhula, 2013; The Tauri Group, 2011; van Wyk, 2009). Amidst these, the role of non-state actors, most especially private individuals, firms and civil society groups, in South Africa's space policy, programmes/activities, initiatives, sector and related history are more developed and recognised than in the case of Nigeria, even though they remain underrepresented in extant literature (Gottschalk, 2010; The Tauri Group, 2011). Similar to the case of Nigeria, social scientists, and particularly students of political economy, International Relations, policy and strategic studies, and pubic administration have devoted little attention to the subject matter to the detriment of its associated social dynamics.

Against this background, it can be observed that space policy studies are underdeveloped in Nigeria and South Africa, as pure and applied scientists and engineers remain the principal policy analysts while social scientists have taken the back seats. As a result, it is not a surprise that the social dynamics, including political economy, policy and strategy, administrative and international among other determinants and implications of space policy and activities in the two countries have not received sufficient academic attention. In this way, most of the achievements, prospects and challenges of space programmes in these countries have not been properly assessed in relation to the development and security aspirations of the peoples and governments of these countries. Amidst these, the experiences of Nigeria, South Africa like other African countries generally have been largely buried under the space popularisation projects of the advanced space players. Hence, space policy studies in this consideration are dominated by what ought to be instead of what is (for instance what these countries ought to benefit from space policy priority and investment based on the experiences of the advanced space players and not what they have actually benefited in their own right).

2.5. Concluding thought and Summary of gaps in the literature

This review has so far examined why we care about space generally, and assess space policy in particular, what matters, how, where, and when in such assessment, and the positions of Nigeria and South Africa in this framework. Space policy assessment has been necessitated by the need to advance academic and policy interests. The academic interests in space are generally dominated by scientists and engineers, who are not properly equipped to grab the social dynamics that are associated with space R&D. The emerging efforts in art, humanities and most especially social sciences to close this gap have however remained less developed, when compared with that of pure and applied sciences and engineering counterparts. The literature on space has thus suffered from lack of multidisciplinary framework or harmony. Policy interests in space are dominantly state-centric, while overlooking or underestimating the relevance of non-state actors, who coexist with states in cooperation, competition, and conflict at local and international levels.

Despite the growing influence of non-state actors, state remains dominant in space affairs. However, it should not be taken for granted that all states are not equal in terrestrial and extrametrical realms. Therefore, space policy assessment should pay attention to variation in interests, development, capabilities, and associated power across nations and the geopolitical

implications. In view of these, different paradigms have been devised to differentiate space players from each other, including classifying them into space superpower, great powers, medium powers, and small powers, or the advanced, intermediate, and emerging space nations scheme, among others. Amidst these, emerging space nations like Nigeria and South Africa have received the least attention in space policy studies. These countries under consideration have appeared in extant literature as emerging global space players, leading space players in Africa, and space nations in their own rights. Nevertheless, their experiences have not been sufficiently captured and assessed in relations to the development and security aspirations of their peoples. Hence, the experiences and perspectives of these countries, and the continent where they are leading players, have been largely buried in space popularisation projects of the advanced players, a trend that should be reversed in time.

CHAPTER 3

Research Design: Theoretical Framework of Analysis and Methodology

3.1. Introduction

Research design is the array of methods, strategies and techniques that are required to fulfil the objectives of a study. At the broadest level, design starts from how a topic is selected and ends with the conclusion of the research (Creswell and Crenswell, 2018; Leavy, 2017). In a restricted sense, however, it is a section meant for communicating plan for evaluating whether a thesis can be sustained, and explicitly defending the choices made regarding which aspects of the phenomenon to be studied, how to translate concepts into knowable entities, and which types of sources or actual information are required to determine their values (Baglione, 2016:121). It is this process of translating something problematic or puzzling into something upon which valid data can be gathered and compelling inferences can be made (Schmitter, 2008). This is the conceptual structure within which research is conducted; it constitutes the blueprint for the collection, measurement, and analysis of data (Kothari, 2004:31; Crano and Brewer, 2002).

For analytical purposes, Gary King, Robert O. Keohane and Sidney Verba (1994:13) divide all research designs into four components: the research question, the theory, the data, and the use of the data. In connection with research questions raised in chapter one of this study, the focus of this chapter on research design is directed toward theory and method, including the sources, nature, and use or analysis of data. The decision to bring theory and methods together in the same chapter is informed by the quest for harmony in exploring the nexus between them and achieving better synergy in research design. This is considerable in the light of the significance of theory to methods. As such, Norman K. Denzin (1978: 3-4) observed that research methods are of little use until they are seen in the light of theoretical perspectives. Gary King, Robert O. Keohane and Sidney Verba (1994:28-29) equally argued that observable implications of the theory must guide our data collection and help distinguish relevant from irrelevant facts.

Triangulation is adopted as the research design for this study. Triangulation originated from mathematics, particularly in positioning geometry, where it literally means the act of making a triangle (Malamatidou, 2018:25; De Loera, Rambau and Santos, 2010; Sterling, 2014). No fewer than three points and connecting lines are required to develop a triangle or represent a piece in this manner on a surface in space. The early development of triangulation came from

surveying and the art of constructing maps – cartography, where surveyors and cartographers used triangles as the basic geometric feature for calculating distances between points on the Earth's surface and a position's elevation above sea level (Hjelle and Morten Dæhlen, 2006: V). GPS and other navigation satellite systems also rely on triangulation between and among spacecrafts and ground receivers to determine location on the Earth (Grewal, Andrews and Bartone, 2013; Hofmann-Wellenhof, Lichtenegger and Wasle. 2008; Leick, Rapoport and Tatarnikov, 2015; Teunissen and Montenbruck, 2017; Trimble, 2007). This method has been revised and adapted into many other research fields over the years.

It is against this background that triangulation was adapted into social science research in the1950s and 1960s (by the likes of Campbell and Fiske, and Webb, Campbell, Schwartz, and Sechrest), and properly articulated and popularised in the 1970s (mainly by Denzin) (Flick, 2018:777). This is the idea of looking at a social phenomenon from multiple points of view to improve accuracy (Neuman, 2014:166). Triangulation is aiming at broader, deeper, more comprehensive understandings of what is studied (Flick, 2018:784). At the broadest level, triangulation involves the use, combination, and integration of multiple data, theoretical perspectives, methods, and investigators (Denzin, 1978; Malamatidou, 2018). As evident in the sections that follow the introduction of this chapter, this study adopts triangulation of subject, theory, data, method, strategy, and technique. Accordingly, this chapter is further divided into two broad sections (the theoretical framework of analysis and methodology) and the concluding section.

3.2 Theoretical Framework of Analysis

Different theoretical perspectives have emerged on what space policy ends and programmes should entail and what actors can, should, intend to or have achieved in this consideration. These include those by pure and applied scientists and engineers, whose primary focus and preoccupation are to develop, test and apply different perspectives to science and technologies of and for space activities, and the secondary concern is to understand policies that promote or undermine their primary objective. However, there are many emerging perspectives in social sciences and humanities, which are primary concerns with different dimensions and levels of space policy, some of which are increasingly turning into sub-fields of study. These include among others astropolitics, astrosociology, Astrotheology, Astro-psychology, and space commerce and economics (Pass, 2015; Chaisson, 1998; Launius, 2013; Maxwell, 2003; OECD,

2014; Salla, 2014; Space Foundation, 2015b). Amidst these, Astropolitics is the oldest field with several well developed and popular theoretical perspectives on space policy studies.

Astropolitics, as evidenced in academic courses and publications, focuses on space activities acknowledged to exist by governmental and non-governmental entities, and their public policy implications (Salla, 2014; Chaisson, 1998). Astropolitics has come of age and given birth to several perspectives, which made some to consider and hope it is accepted as a sub-field or field of study (Sadeh, 2013b;). It emerged as a framework of analysis that is developed by political scientists on the prospects and challenges of space exploration and exploitation in and for politics. Given the impact of Cold War international system on pioneer countries in space policy, the field of International Relations have come to dominate what is known as the politics that is associated with astropolitics. Accordingly, students of this field are associated with the oldest and most advanced policy perspectives that are relevant to the understanding and operationalisation of space age. However, they have borrowed extensively from other fields and sub-fields; prominently are: political philosophy, political economy, political sociology, political psychology, national and comparative politics, and public administration.

Recognising that no single perspective says it all, this section adopts triangulation of theory to enrich this study. This requires multiple theoretical perspectives to plan a study and avoid narrow particularistic interpretation of data (Denzin, 1978: 298; Malamatidou, 2018; Neuman, 2014:167). In this process, empirical and normative theories are considered and factored into the theoretical design of the study. Normative theory deals with what ought to be, while empirical theory deals with the factual state of things (Johari, 2012:47-50). Despite the focus on International Relations, multidisciplinary perspectives are considered with references to political philosophy, political economy, political sociology, political psychology, and national and comparative politics. Triangulation of theory requires that all relevant theories, their propositions and meaning are examined for their suitability to the focus of the study, and then tested for their validity with empirical data (Denzin, 1978; Saliu and Oyebanji, 2004). These among others are expected to enrich the understanding and operationalisation of concept, and subsequently enhance the quality of data to be gathered, help to locate the gap between expectation and the observable reality in analysis, and chart paths to relevant policy recommendations.

Despite the foregoing, many pitfalls are associated with this method. Prominent among them is that students are fond of turning this into another review of relevant and irrelevant literatures or theories. As such, they identifying many perspectives without triangulating or connecting and applying them to their study in the final analysis. To avoid this and other related pitfalls, this section adopts utilitarianism as general theory, which is employed as overarching framework of analysis for other theories that are adopted and integrated for specific purposes. Prominent among other theories considered are realism, liberalism, critical theory (with emphasise on dependency theory) and constructivism as well as their different variants. In view of these, this section is further divided into six sub-sections: utilitarianism, realism, liberalism, dependency theory, social constructivism and concluding thought on their application and triangulation.

3.2.1. The General Theory: Utilitarianism

Utilitarian theory is a veritable framework for assessing the action, decision, or policy programme of any actor whatsoever, no matter their interest, in almost if not in all situations. This includes the policy interests and activities or programmes of any state (regardless of their level of development or power capabilities) and non-state actors (regardless of their individuality or organisational nature as well as their locality or internationality) in space. This is unlike any major theories of International Relations. For instance, realism only focuses on state as the central player in space, reduces its interests to defence, security and power projection, and tends to foreclose the prospects of international cooperation (Deblois, 1999; Ercan and Kale, 2017; Klein, 2006; Mowthorpe, 2004). Equally, liberalism focuses on the rights, freedom and duties of all states to explore the space peacefully in cooperation for the benefits of mankind (Wolter, 2006; Hudgins, 2002; UN, 2002); taking for granted the inequality in access to space, its technologies and associated benefits. While social constructivism creditably offers multiple perspectives on actors and their interests in International Relations, and by extension in space, it remains largely advocatory with little or no concise parameter for a study that it seeks to assess.

Utilitarianism is deeply rooted in the works of ancient moralists and philosophers like Mo Tzu (around 481 to 221 BC), Jesus Christ, Plato, Aristotle, Epicurus (341 to 271 BC), French Jean François, Marquis de Chastellux and Claude Helvétius, Scottish Francis Hutcheson (1694–1746), English David Hume (1711–76), Joseph Priestley (1733–1804), Adam Smith, William

Paley (1743–1805), William Godwin (1756–1836), Jeremy Bentham (1748–1832) and John Stuart Mill (1806–73), Herbert Spencer and Henry Sidgwic (Scarre, 1996; Albee, 1962; Rosen, 2003; Barrow, 2010; Mulgan, 2007; West, 2007; Schultz, 2017). Prominent in the new wave of utilitarian scholars are T. H. Green, L. T. Hobhouse, D. G. Ritchie and J. A. Hobson (Bayles, 1968; Weinstein, 2007). Amidst these, Jeremy Bentham and John Stuart Mill are considered to be leading pioneers and prominent proponents that articulate the theory as it is known today. Although the theory and its principles remain a subject of debate in philosophy classes, they are widely borrowed, employed, and applied across all fields in social sciences and humanities.

This study adopts utilitarianism as a general framework of analysis, within which other theories that are adopted for specific reasons are interpreted, because it is universally applicable to every actors, actions, and situations of interests. Bentham (2000:14) argued that the principle of utility is a universal notion which approves or disapproves every action (either by private individuals/ groups or government) whatsoever, according to the tendency that it appears to have augmented or diminished, in other words to promote or oppose the happiness of the party whose interest is in question. Utility is the property in any object, action or policy that tends to produce benefit, advantage, pleasure, good, or happiness, or prevent the happening of mischief, pain, evil, or unhappiness to the party whose interest is considered, individually or community generally (Bentham, 2000:15-16). It is ethical, moral, just, and rationally sound to direct the actions of an individual, a group or government, to the production of the greatest possible quality and quantity of happiness of the one or those concerned and whose interests are in view (Bentham, 2000; Crimmins, 2011; Mill, 2001; Ng and Ho, 2006; Sen and Williams, 1992; Schultz, 2017). As such, it can be argued that utility is everything a state aspired to achieve in space exploration.

There are multiple perspectives and variants of utilitarianism. Prominent among the variants are act-utilitarianism, rule-utilitarianism, and institutional utilitarianism. Act-utilitarianism is interested in the rightness or appropriateness of action or policy measure in accordance to how it maximises well-being (Mulgan, 2007 Scarre, 1996). Yet, there are those that believe that priority should be given to causal utility or the utility of motive (want and desire) that gives rise to an action in the final analysis of its utility (Adams, 1990). Closely related to these is indirect utilitarianism, which also consideres decision procedures (issue like clarity or transparency, timeliness, friendliness, and resource management) as a priority in analysis (Mulgan, 2007; Sen and Williams, 1992). Rule-utilitarianism is premised on the notion that an

action or policy can be said to conform to utilitarian principles when it follows moral, rational and widely accepted codes or rules that maximise well-being (Mulgan, 2007; Lyons, 1965; Bayles, 1968). Institutional utilitarianism argues that the best political, administrative, economic or social institutions, arrangements or regimes are those that maximise total welfare of those concerned. Besides these, there is consequentialism, which focuses more on the outcome or effects of an action or policy, with priority for the one that best maximise the happiness or welfare of the party (Bentham, 2000; Mulgan, 2007; Sen and Williams, 1992; Smart and Williams, 1975).

Utilitarianism assesses actions, policies, and institutions based on their contribution to welfare or happiness of the affected parties. Economics often tends to operationalise happiness to mean standard of living, with priority for wealth production and distribution, of which per capital income is considered critical (Bruni and Porta, 2007; Edward, 1992). Generally, however, the term happiness means quality of life or wellbeing (Schultz, 2017; Veenhoven 2004). This can be assessed using both qualitative and quantitative methods. From a political psychology perspective, it involves chances of good life or actual good life. Quality of life can mean liveability of an environment, life-ability of the person, utility of life, and satisfaction with life. Satisfaction can be of pleasure, part-satisfaction, top-experience, and enduring or life-satisfaction (Bentham, 2000; Veenhoven 2004; Ng and Ho, 2006). Moreover, wellbeing can be subjective (mostly when its analysis is qualitative based) or objective (when is quantitative based) (Canaviri, 2016; Edward, 1992; Mill, 2001). These among other things are pointers to assess development and security, which are primary to the focus of this study on space policy.

Despite the foregoing, there are many enduring concerns within and against utilitarianism. This theory recognises the right of every person to obtain benefits or happiness from the policy of their government as concerned parties/citizens. Yet, the same action that brought happiness or benefits to some parties can be disadvantageous to others, who may experience pain or pay the price for such action (Bentham, 2000; Mill, 2001). Many critics of utilitarian theory has described this as “taking from Paul to enrich Peter” and capitalised on this to question the ethical, rational, and just bases of its principles (Rawls, 1999; Sen and Williams, 1992; Smart and Williams, 1975; Lyons, 1968). The principle of utility, however, encourages action with the tendency to promote the happiness of the community more than it diminishes (Bentham, 2000:15). Beyond rational appeal of different variants of utilitarianism that are well recognised, the logic of cost-benefit and causal-effect analyses tend to address this concern.

Other major concerns revolve around information, reductionism, and idealisation (Mulgan, 2007; Sen and Williams, 1992; Lyons, 1968). Information is critical to utilitarian assessment, and its inadequacy can undermine consequential analysis. The tendency to consider all situations, actors and interests as the same amount to reductionism. Idealisation involve preferences and choices, particularly on selection of what is allowed to count or not (Sen and Williams, 1992; Lyons, 1968). However, most of these concerns are addressed in this study with the adoption of multiple triangulations, including in operationalisation of concepts, theory, data gathering and method of analysis. As evident in the next sub-section, multiple theoretical perspectives guide the preference and choices of this study in conception of utility in relation to development and security. The next section also consideres multiple options in choice of forms, sources, methods, techniques, and strategies for data gathering and analysis in this study.

Against this background, utilitarian theory is a suitable framework for assessing the contributions of space policy to development and security in Nigeria and South Africa. Harding (2013:5) is sensitive to the principle of utility when he argues that space policy involves conscious and specific use of space and its attendant technologies to promote the security and socioeconomic interests of the state. Moreover, it offers an opportunity to bridge many other theories that are central to understanding human and state-centric development and security. The principle of utility can help to re-examine the quality of life that is at stake when the interests of the party in view align with realist conception of national security (Ercan and Kale, 2017; HDoA, 2009; Klein, 2006). It can also re-examine the liberal conception of freedom of all states to access space and of all peoples to access associated benefits, as well as of cooperation among space players, in view of cost and benefits (Crawley and Rymarcsuk, 1992; Dick, 2015: Harding, 2013). Hence, this framework is flexible to accommodate as much as possible perspectives and indicators that are required for assessment of space policy in emerging players like Nigeria and South Africa and its contribution to development and security aspirations of their peoples and governments.

3.2.2. Specific Theory I: Realism

Realism is a dominant theoretical framework in International Relations as well as in space politics and policy studies. Some elements of this perspective were identified under review of literature on actors and interests in space in chapter two. As a theoretical framework, however, realism has a deep root in works of historians (like Thucydides' History of the Peloponnesian

Wars in 4th century BC), philosophers and counsels of statesmen (like Thomas Hobbes and his conception of state of nature, and Machiavellis letter to the Prince respectively in the 16th and 17th centuries) as well as theoretical articulation by scholars (like Hans Morgenthau, Kenneth Waltz among others since late the 1940s). This theory was articulated after the end of World War II as a resistance against idealism, which was criticised for simplistic believe that peace is possible and war is avoidable through international cooperation and organisation (League of Nation), and appeasement policy (of Britain and France toward Nazi Germany and fascist Italy) (Beitz, 1999; Morgenthau, 1991; Aron, 2017; Calvocoressi, 2001; Kissinger, 1994; Waltz, 1979; Zakaria, 2008). It has however evolved to produce variants like classical, structural-realism and neoclassical realism.

Realism is broadly associated with some basic assumptions, which include:

(1) state is the central unit of analysis in international system;

(2) international system is anarchical without central controlling authority;

(3) survival is the primary interest of state in the international system;

(4) states are self-centred and can only resort to self-help to guarantee their survival;

(5) power is the major determinant of state behaviour and the struggle for it or its pursuit is the only means to guarantee state survival;

(6) state is a unitary actor in consideration and making of decision, and policymakers are rational enough to determine what is in the best interest of their country.

On these bases, classical realists believe that human nature is naturally self-fish, and this will reflect in the rational decision made by policymakers (Morgenthau, 1991; Johari, 2009). Neo/structural realism is mainly interested in powerful states as the central unit of analysis in international politics, because they alone can influence the structure of the system, which is the most important determinant of state behaviours in this consideration (Waltz, 1979; Lake, 2009; Ikenberry, Mastanduno, and Wohlforth, 2011). Owing to international structure, state behaviour can be offensive or defensive. Neoclassical realism bridges both classical and structural realisms by exploring the nexus of human nature and international structure in determining state behaviours in the international system (Baylis, Smith and Owen, 2014).

Power is accessed or measured in realism as control and in some cases influence over resources, actors, or event and outcomes (Hart, 1976; Morgenthau, 1991). Power has hard, soft, and smart dimensions in international politics. Hard power involves carrot and stick (mainly expressed through economic and military means), while soft power entails the appeal of one's ideas or the ability to set political agenda in a way that shapes preference of others (Nye and Welch, 2013; Nye, 2011). Smart power involves proportionate combination of both hard and soft power to achieve targeted goals. Elements of national power in international politics include geography, natural resources, industrial capacity and economic development, military preparedness, population, political legitimacy, national morale, access to information and quality of governance, culture, and diplomacy among others (Jablonsky, 2008; Morgenthau, 1991; Tellis et al., 2000). Power can be projected via air, land, maritime, and space frontiers. These elements of power and frontiers of its projection can be utilised or branded as hard, soft or smart measures (Dolman, 2002; Durch, 1984; Gray, 2012; Sadeh, 2002a; Klein, 2006). Power can be generally utilised to advance security, which is principally conceived in military term, and secondarily as internal security and situational security as identified in chapter one.

To neorealists, power determine order and structure of the international system, which in turn determines state behaviours. International order is based on the arrangement of states according to their power, ranked in descending order of superpowers, great powers, and medium or regional powers with little or no attention for small states or powers (Buzan and Wæver, 2003; Calvocoressi, 2001; Huntington, 1999; Kissinger, 1994; Little, 2007; Waltz, 1976; 1993; 2000; Zakaria, 2008). Superpower is a status that requires global interests, sophisticated and broad-spectrum capabilities (first-class elements of power such as military, political and economic capabilities that are actively exercised worldwide and projected through all available frontiers), together with self-constructed image that is substantially accepted, across the whole of the international system. Great power requires interests and active roles in more than one region, with a single or few critical elements and frontiers of power as the basis for status and recognition. Regional power is a status that allows an actor to concentrate its interests and capabilities, and actively play major roles in a definite region (Buzan and Wæver, 2003). Regional power is a state which displays the material (military, economic, and demographic), organisational (political) and ideological resources for regional power projection (Nolte, 2010). Nigeria and South Africa are regional powers in Africa, and their status is relevant to analysis.

Extending realism theory of International Relations to space politics and policy studies, many students of the emerging field are known for some assumptions:

(1) space is a frontier (like air, sea and land domains) for scramble, conquest, and occupation;

(2) state alone (and for those with neorealism orientation, only powerful states) matter in space exploration and are important unit of analysis in space policy studies;

(3) space exploration is primarily driven by national interest of self-centred state;

(4) security, power, and prestige are the core interest of state in space;

(5) state behaviour in space is shaped or motivated by competition, conflict, and selective cooperation (with allies) (Mistry and Gopalaswamy, 2012; Preston, 2002; Mowthorpe, 2004; HDoA, 2009; Klein, 2012; Sariak, 2017).

Against this background, space is seen as a frontier to boost military capabilities, industrialisation and economic growth, political legitimacy, or better still, populism, national morale, access to information, national image and influence in international system, as well as to explore for the control of territory, human colony, and natural resources (Bruhns and Haqq-Misra, 2016; Dolman, 2002; Durch, 1984; Klein, 2006; Sadeh, 2011; 2013). It is on this basis that countries that are actively involved in space exploration and exploitation are referred to as space power (DeBlois, 1999; Gray, 1996; Lutes et al., 2011; Lupton, 1998; Peter, 2010).

Against this background, realism is suitable for assessing the contribution of space to national security and power. However, its suitability for the overall focus of this study is affected by the following:

(1) its emphasis on the centrality of state in space policy and politics overlook the importance of non-state actors like corporate bodies, international organisations, and NGOs among others;

(2) it promotes international political rationalism and disregard local political dynamics as well as economic and sociocultural rationalism;

(3) it focuses on rationalism of decisionmakers at the expense of pluralism in policy process;

(4) the military-security reductionism of state interest in space misses the growing attention on human security and development;

(5) it promotes selfish national interest, competition, and domination at the expense of international cooperation and institutionalism;

(6) most proponents of this theory are preoccupied with the interests of the few powerful nations that are advanced in space policy and politics and not the numerous developing nations like Nigeria and South Africa that are emerging space players. These among others are reasons why this study cannot employ this theory, but adapted some of its relevant elements and propositions into application and triangulation of utilitarian theory.

3.2.3. Specific Theory II: Liberalism

Liberalism is another major perspective to the subject of space policy and politics in International Relations. It is deeply rooted in idealism and philosophies of Immanuel Kant, John Locke and Adam Smith on ethics, law, freedom, individualism and market economy (Fukuyama, 1992; Clark and Neumann, 1996). The theory is associated with the following assumptions: first, in contrast to the realist position that human nature is selfish and evil, liberals argued that human nature is generally good and the evil part (such as aggression and injustice) is a result of corrupt or inadequate social institutions and misunderstanding among leaders. Hence, human nature can be improved and evil can be minimised or eliminated through collective action and institutional reform that expand human freedom through openness in political (democracy) and economic (well-managed market capitalism) spaces (Mingst and Arreguín-Toft, 2017; Griffiths, 1992; Goldstein and Pevehouse, 2014; Fukuyama, 1992; Johari, 2009).

Second, liberals recognise that international system is made up of multiple actors that are important in their own unique ways. Besides state-actors, there are several non-state actors that are active in the system. As earlier discussed in chapter two, non-state actors can be broadly classified into conventional (IGOs, NGOs and national/multinational/transnational corporations) and non-conventional (armed non-state groups) (Kegley and Raymond, 2010; Little and Smith, 1991; Magstadt, 2009; Russett et al., 2006; Rosenberg, 1994). Third, promotion of international cooperation and organisation or world federation/ governance can guarantee world peace (Baylis et al., 2014; Goldstein and Pevehouse, 2014). Fourth, the spirit

of laissez-faireism, that is, free market, and unrestricted international economic exchanges (such as investment and trade as against nationalistic protectionism) will boost the wealth of nations (mostly conceived as economic growth). Fifth, even in anarchical competition by self-centred actors, complex interdependency among them will promote cooperation and peaceful coexistence (Baylis et al., 2014; Nye and Keohane, 1971; Keohane, 1984; Ravenhill, 2005; Nye and Welch, 2013). This is related to the argument of system theorists that international system is made up of different states that are autonomous and interconnected, and whose cooperation are relevant to stability in the system (Kegley and Raymond, 2010; Mingst and Arreguín-Toft, 2017; Johari, 2009).

Sixth, state behaviours in international system is a product of complex domestic politics that involves multiple actors as against policymakers' rationalism of realists (Keohane and Milner, 1996; Rosenberg, 1994; Frankel, 1988). Finally, liberals believe in change: self-centred actors, anarchy and aggression can give way to cooperation, order and peaceful world. Accordingly, liberalists are leading advocacy and working with policymakers to formulate policy, promote cooperation and institutions, and coordinate efforts to make the world a better place. For instance, the US justified its decision to join the World War I to make the world safe for democracy (Kegley and Raymond, 2010; Kissinger, 1994). These assumptions among others can be related to different variants of liberalism, including legalism, institutionalism, pluralism, democratic peace thesis, globalism, and complex interdependence thesis among others.

Some students of space politics and policy studies that identify with this school of thought can be associated with some related assumptions. First, they recognise that space policy and its operationalisation (exploration and exploitation) involve multiple actors (both state and non-state actors) (OECD, 2014; Space Foundation, 2015a). Second, they conceive and encourage a growing body of international law to make space free for all to explore as a form of right and not for anyone to lay exclusive claim to it as a form of duty. For liberal justice school of thought, this means all states should be free to pursue their interests in space (UN, 2002; Lele, 2017). Market-oriented liberals however extend this to mean that interests in space and associated activities should be commercialised and increasingly driven by private investors. Third, many liberals are of the view that space is a frontier to pursue economic interests, which are mainly conceived as profits, in the case of corporate bodies, as well as innovation, industrialisation and economic growth, and transformation for concerned nations (Hudgins, 2002 Anderson, 2013 Elliott, 1997; Sadeh et al., 2005; Tronchetti, 2013; 2014). Fourth, there

is a growing position of the liberal pluralists that decision-making among others in space policy processes should be opened for wide political participation, inclusion, transparency, and legitimacy in spacefaring democracies (Kelso, 2016; Venkateshmurthy and Nagendra, 2016; Williamson, 1992).

Fifth, all states are encouraged to explore space in cooperation (and the principle of collective security should extend to this frontier) for the benefits of humankind (Dick, 2015; Kansakar and Hossain, 2016; Lal, 2015; Manzione, 2001; NASA, 2014; NASA et al. 2015; Withee et al., 2004; Wolter, 2006). Hence, a series of international resolutions and treaties since 1958 have emphasised and re-emphasised that outer-space including the celestial bodies are free to all states to explore without any form of discrimination nor national appropriation by claim of sovereignty (UN, 2002; Lele, 2017; Tronchetti, 2013). Last but not the least, space should be explored in accordance with the spirit of international law and importantly for peaceful purpose. These among other positions contrast with state-centric actors, military-security interests, competitive and conflict-prone as well as power and prestige motivated space policy that realism preached. Accordingly, the theory is suitable for assessing some aspects of space policy and its contribution to socioeconomic development, peace promotion, international cooperation, and institutional building.

Despite the foregoing, the liberal perspective of space policy is characterised by some notable weaknesses. Although space activities now involve many actors as argued by liberalists, they are largely subjected to state jurisdictions or dependent on cooperation among them. Hence, state actors and their interests, of which security is central, retain a principal place in space policy. Many liberalists emphasise profit at the expense of service to humanity in their conception of corporate interests in space. They equally reduce conception of national interests in space to liberal economic benefits, such as space exploration and its privatisation will create more wealth, job, innovation and transformation. As a result, there is a contradiction between liberal propositions on freedom and rights of all to be involved and benefits from space on one hand and market-driven policy. Similarly, there is a contradiction between their advocacies for market/economic rationalism and pluralism in decision-making and space policy processes.

As cooperation gradually outmodes competition among nations in some areas, space powers have not abandoned their desire for competitive advantage, as the emerging powers are also struggling to catch up with them. The restriction policy of leading space powers on the spread

of some space technology, particularly launcher capability that can be converted to missile capability, also questioned the level of freedom of affected states and cooperation in space (Mistry and Gopalaswamy, 2012; Noble, 2008). Besides, lack of necessary technological capacity kept many countries away from enjoying their rightful freedom to explore outer-space decades after the space age commenced. Equally, liberalism takes lightly the inequality that exists among (people within and across) states in its notion of Universalist idea of spreading the space benefit to humankind (Wolter, 2006; Abiodun, 2008). It is not surprising therefore that emerging space players (like Nigeria and South Africa) and experiences have received limited attention in this framework. However, there are some propositions of the theory that are relevant to this study.

3.2.4. Specific Theory III: Dependency Theory

Dependency theory is one of the approaches that are often associated with critical theory of International Relations. Although it is an unpopular theory in space politics and policy studies, its principal focus on developmental aspirations, challenges and prospects of the developing countries are unique in International Relations (Amin, 1977; 2011; Frank, 1978; Wallerstein, 1979; 2004; Sylvester, 2014). It is therefore considerable for a study that seeks to assess the development and security utility of space policy in developing countries like Nigeria and South Africa to pay attention to propositions of this political economic perspective. This theory has its deep root in the work of Karl Marx on the stages of development and its critiques in V.I. Lenin's Imperialism the Highest Stage of Capitalism (Marx, 2010; Owen & Sutcliffe, 1972; Ranis and Schultz, 1998). The critiques of westernisation under the guise of modernisation theory by Third World's scholars and in some cases statesmen like Raul Prebisch, Kwame Nkrumah, AG Frank, Sami Ami, Bade Onimode and Claude Ake among others contributed to the development of dependency perspective (Ake, 1981; Jhigan, 2007; Sylvester, 2014).

The theorists believe that the world is divided based on economic development into developed countries (DCs) and the less developed countries (LDCs). The DCs are rich and powerful countries otherwise known as the core or the metropolitan countries, while the LDCs are mostly the post/neo-colonial countries that are relatively poor, developing and weak in the global economic exchange. Geopolitically/economically, DCs are largely concentrated in the northern hemisphere, while the LDCs are concentrated in the global-south (Wallerstein, 1979; 2004). The LDCs were underdeveloped through historical accumulation of developed capitalist states

and the integration of the former into the global capitalist system through colonialism and imperialism to serve as periphery, appendages or dependent of the latter (Ake, 1981; Amin, 1976; 1977; 2011; Frank, 1972; 1978; Nkrumah, 1965; Rodney, 1972; Wallerstein, 1978).

The socioeconomic relations between the DCs and LDCs are better described as unequal exchange and development to the detriment of the latter (Amin, 1976; 1977; Frank, 1972; 1978; Voskressenski, 2017). It is believed that post-colonial states granted political without economic freedom, which amount to neo-colonialism (Ake, 1982; 1996; Nkrumah, 1965; Sylvester, 2014). Hence, the triad alliance of bourgeoises in the DCs with local petti-bourgeoisies and political elites in the LDCs have sustained the unequal exchange between the two sides. The theorists are thus critical of the activities of international financial institutions, trade regimes, MNCs and their home states in the LDCs (Ake, 1982; Amusan and Oyewole, 2012; Gill, 2008; Hertz, 2001; Saul, 2009; Stiglitz, 2002; 2007; 2013). Amidst these, the liberal students of this theory recommended collective engagements by LDCs with DCs to address the inequality and advance their developmental interests. In contrast, the radical school prefers the former to delink from the unfavourable exchange and follow the path of social democracy to development, which is largely conceived as industrialisation and national accumulation or technological capacity and self-sufficiency (Ake, 1981; Barrow, 1993; Calvert, 2005; Martinussen, 1997).

Although there is hardly anything that can be called dependency theory in space politics and policy studies, there are emerging perspectives that focus on and/or from the developing countries or the global-South, which are mostly emerging or aspiring space players. Notably, this set of literatures lack coherent position or focus. As such, this/these perspectives lack concise advocates in space politics and policy studies. However, most studies with global-South focus tend to generally consider space as a frontier mostly for national development and encourages the developing countries to develop required capacity in this case (Argoun, 2012; Abiodun, 2008; Ansdell et al., 2011; Bhaskaranarayana et al., 2009; Chandrasekhar et al., 2000; Harding, 2013; 2016; Othman, 2003; Oyewole, 2017; Wood and Weigel, 2011; 2012a; 2014).

Dependency theory is important to understand the inequality between DCs and LDCs in space policy and its operationalisation. Until recently, most LDCs are only relevant in space policy studies as unobtrusive observers, fans and admirers of space powers, and at best, consumers of selected products of space science and technologies. This theory leads us to believe that efforts

of some DCs to restrict spread and obstruct or prevent the acquisition of space-related technologies by LDCs are aimed to keep the latter perpetually underdeveloped and dependent on the former (Mistry and Gopalaswamy, 2012; Gottschalk, 2010; Sariak, 2017; Noble, 2008; Sadeh, 2015). Hence, LDCs need to act collectively to engage the DCs or be unilaterally deviant to international norms promoted by the latter to pursue their interests in space. These among others makes the theory partially relevant to the focus of this study on development. However, the theory underestimated the relevance of security interests in International Relations and by extension space. It has also failed to capture evolving dynamics in conceptions of development.

3.2.5. Specific Theory IV: Social Constructivism

The preceding theories specifically adopted in this study (realism, liberalism, and dependency theory) collectively offers the opportunity to assess utilities of space policy in terms of national security and development in developing nations like Nigeria and South Africa. However, they provide limited space to accommodate emerging dynamics in conceptions of development and security, with emphasis on human development and security. In line with these and the underlining triangulation of subject, as evident in the conceptual section of this study in chapter one, social constructivism is also adopted as a specific theory within the utilitarian framework of analysis. Social constructivism has been promoted by political sociologists in International Relations and space policy studies. It is rooted in the work of Michael Foucault, Alexander Wendt, Nicholas Onuf, Friedrich Kratochwil, Anthony Gidden, Ted Hopf among others (Acharya, 2018; Wendt, 1999; Devetak, Burke and George, 2012; Jackson and Sørensen, 2013; Mingst, and Arreguín-Toft, 2017; Schieder and Spindler, 2014; Neumann and Wæver, 1997).

Social constructivism is principally focused on identity, how individuals, policymakers, and state view themselves and conceive their interests in the international system. Students of this school of thought prioritise how ideas shape actors, interests, and structures in the international system (Acharya, 2018; Wendt, 1999; Weber, 2010). The major proposition of the theory is that object and concept do not have fixed meaning but are constructed through social interaction and discourse. Accordingly, state, its interests, and international system are social constructed and their meanings are based on prevailing discourses and interactions, which are amenable to change. The theory recognises that actors in international system are made up of states, peoples, elites, and cultures among others. It is believed that state interests are whatever

they are called by the elites; thus, state behaviours are not predictable, it can be cooperative, competitive, or conflictual, depending on the underlining social construct. Equally, anarchy is believed to be whatever we/states make of it (Jackson and Sørensen, 2013; Neumann and Wæver, 1997; Mingst, and Arreguín-Toft, 2017; Schieder and Spindler, 2014; Wendt, 1999).

Proponents of this theory reject military-reductionism of security by the realists and economic dominated conception of development by liberalists and dependency theory. Instead, they consider them to be whatever individuals, policymakers, and states conceive them to be (Acharya, 2018; Wendt, 1999; Weber, 2010 Wight, 2006). Accordingly, development can mean economic growth, industrialisation, colonisation, self-sufficiency or independent capacity to promote self-reliance, flourishing community, democratisation, privatisation, secured human freedom, environmental sustainability, and human poverty reduction among others that are identified in the conceptual section in chapter one (Pieterse, 2010; Martinussen, 1997; Hettne, 2005; UN, 2015; UNDP, 1994). Equally, security can be conceived in terms of military, law and order, situational stability, as well as food, water, gender, freedom, and environment among other related utilities identified in the conceptual section in chapter one (Buur et al., 2007; UNDP, 1994; UNCHS, 2003). These all depend on who says what, when, and how? This theory is therefore unique for its ability to accommodate and project ideational actors (peoples and culture) and interests, particularly human development and security interests, amidst and against state-centric notions of actors and interests in theories of International Relations.

Social constructivism has been extended to space politics and policy studies by many students of political sociology (Caroti, 2011; Dick, 2015; Dickens and Ormrod, 2007; Pass, 2004b; 2006; 2011). There is a growing number of studies that have examined how ideas and cultures are shaping space exploration (including national policy interests in space) and vice versa (Bjørnvig, 2013; Blamont, 2016; Kaminski, 2012 Hudgins, 2002; Newell, 2014; Schwartz, 2017a &b). Unlike realism that focuses on state interest, this perspective believes that space policy should mirror the interest of the people, a belief that is not conceived in Universalist term like the liberalism, but are unique to an individual. Political sociologists are therefore interested in space popularisation as well as public knowledge, opinion, attitude, and values on and toward space matters and how these affect or influence space policy formulation (as a public priority) and implementation (in relation to investment or funding) (Bainbridge, 2014; Launius, 2003; Oikonomou, 2017; Steinberg, 2011; Pass, 2015). This perspective is equally

suitable to assess post-state-centric structures, actors, and interests. This helps to assess human (individuals and peoples) dimension to development, security interests. and utilities in space exploration.

Despite the fact that it tends to cover all subjects of concern, social constructivism is inadequate or cannot be used alone in this study. Notably, it bridges so many theoretical perspectives that, at the end, it is very difficult to identify or operationalise its key indicators without resorting to some other relevant theories. For instance, it allows for security to be considered as both national and human in dimensions. However, it lacks originality in national or traditional conception of development and security, where it considerably relies on realism and liberalism. Besides, the emphasis or preference given to human security and development by promoters and supports of this theory, in attempts to differentiate it from traditional conceptions, tends to present it as alternative to the latter (Nnoli, 2006; Gurr, 1970; UNDP, 1994; UNCHS, 2003). This development has encouraged a sort of incompatibility and animosity between advocates of national security and human security in many developing countries, of which the support that the latter is receiving from the DCs has become a subject of concern for students of dependency theory. This theory has been criticised for being more of a critical perspective than a programme or tool of analysis (Mingst, and Arreguín-Toft, 2017). Marxists have criticised its ideological emptiness in the analysis of social discourse and interactions in International Relations (Amin, 1977; 2011; Frank, 1978; Jackson and Sørensen, 2013). Nevertheless, this study finds this theory to be suitable for assessing some aspects of space policy programme and its contribution to development and security in developing countries such as Nigeria and South Africa.

3.2.6. Conclusion

In the quest for suitable theoretical framework of analysis, this section employed triangulation of theory. Accordingly, utilitarianism is adopted as the general framework of analysis, which is expected to direct this study to assess the utilities that the governments and peoples of Nigeria and South Africa have derived from their policy priority and investment in space. This will be considered in relation to expected utility, motivation, and cost. However, to operationalise development and security utilities in International Relations, this section further considered and adapted realism, liberalism, dependency theory and social constructivism into utilitarian framework. Realism provides this study with the theoretical bases to assess space policy and

its utilitarian contribution to national security, power, prestige, and influence of the affected states. Liberalism offers this study the opportunities to examine the utilities of space policy, priority, and investment in relations to wealth creation and distribution, and international cooperation and institutional building. Dependency theory makes it possible to appreciate the utility of self-reliance and capacity building in space in international relations. Finally, social constructivism provides unique clues on human development and security utilities that should be considered.

3.3. Methodology

This section examines the type of data that are suitable for this study, as well as how they will be collected and analysed. In line with the adopted research design, this section operationalises how triangulation of data and method are used in this study. Taking into consideration the high likelihood of not getting adequate data from one or few methods, which may or may not be connected to the sensitivity of the subject matter, this study adopts multiple or multilevel triangulation of data and method as evident in this section. Accordingly, this section is divided into three subsections, which focus on data collection, method of analysis, and the conclusion.

3.3.1. Data Collection

This study employed triangulation of data type, hence both qualitative and quantitative data were collected for the purpose of this study. Qualitative data are soft data that include photos, words, sentences, and symbols, and quantitative or hard data are numeric in nature (Neuman, 2014: 167). Data collection for this study was also triangulated to cover primary and secondary sources.

3.3.1.1. Secondary Data

Data are secondary when they are already available, that is they have been collected and analysed by someone else (Kothari, 2004:111). Some of the data for this study were collected from secondary sources, such as archives, databases, books, journal articles, magazines, newspapers, television programmes and online materials. Archives of NASRDA, National Assembly, as well as Ministries of Communication, Defence, and Science and Technology, and National Defence College (NDC) among others in Nigeria were considered for the purpose

of this study. Archives of SANSA, parliament and the Departments of Defence, Science and Technology, Communications, among others were also considered in South Africa.

Relevant quantitative data were largely gathered from databases and statistical reports. The UCS Database was used to assess satellite inventories. Due to inability to afford subscription charges, limited open access data were gathered from the Euroconsultant, Statista, Space Foundation, and to a limited extent, Space in Africa, especially on space expenditure. However, the reports of NBO, DST and SANSA equally offered some relevant data on the cost of space policy programmes. DST and SANSA reports also contained data on the benefits of space policy. The Nigerian Bureau of Statistics (NBS) and Statistics South Africa provided socioeconomic data of the two countries, while the African Statistical Yearbook and the World Development Indicators (WDI) provided similar data for the continent and the world respectively. SIPRI Databases and the Military Balance are equally relevant to assess the military capabilities and the power projection of the two countries, while Armed Conflict Location and Events Database (ACLED) is relevant for assessing security situation, especially conflict trend in Nigeria. These datasets are important for assessing socioeconomic and security situations of the countries under consideration.

Both qualitative and quantitative data are gathered through books and journals that cut across different disciplines, with greater emphasis on social sciences. Amidst these, priority is given to those on space policy programmes and associated development and security consideration. Hence, this study consults specialised journals on space policy such as *Acta Astronautica*, *Astropolitics: The International Journal of Politics & Policy*, and *Space Policy*; magazines like *New Space* and specialised Newspapers like *Space in Africa* and *Space News*. Online archived television broadcasts and videos that are relevant to space programmes as well as national and human development and security in Nigeria and South Africa are sourced from YouTube.

3.3.1.2. Primary Data

Primary data can be obtained either through observation or through direct communication with respondents in one form or another (Kothari, 2004:95). Vanderstoep and Johnston (2009:65) simply defined primary data as self-reported data. In this study, primary data were gathered mainly through observation and interview. The observation covered satellite tracking and direct visitation of selected space facilities, institutions and actors that are involved in space policy

advocacy, formulation, and implementation in research sites. It equally involves participatory or non-participatory observation in academic activities like seminars, public lectures, and conferences on space, policy, security, and development in Nigeria and South Africa. Key Informant Interview (KII) and In-depth Interview (IDI), with semi-structured questions, will be conducted face-to-face and by phone calls and possibly skype, among other applications. Appendix I shows the semi-structured questions that are broadly framed without missing specific interests and were easily adaptable to different contexts and actors in the field.

3.3.1.2.1. Population and Samples

3.3.1.2.1.1. The population of study

The population for the subject matter generally covers peoples that directly or indirectly have contributed to, and ought or actually benefited from, space policy programmes of Nigeria and South Africa. Ideally, the general population contribute to policy through participation in election, public opinion, debate, advocacy, and funding (paying taxes), among other supports. They are also expected to benefit from the policy directly or indirectly. Space policy in Nigeria and South Africa equally has international dimensions, with targeted external benefactors and beneficiaries. Therefore, the general population that is relevant to space policy studies in Nigeria and South Africa extend beyond these countries into Africa, where they are recognised as the leading spacefaring nations and regional hegemons, and beyond the continent.

Despite the foregoing, adopted method of data collection (KII and IDI) suggests a limit to the population of study, which is defined to cover those actors (institutions and individuals) that are directly involved in space policy and associated development as well as security as contributors and beneficiaries. Space popularisation is very low in the region, and most people are not aware of space as the source of some of the daily utilities they enjoy. Accordingly, people use space products indirectly and, in most cases, are unaware of their space connection. Besides, the industry is very small and knowledge of the subject matter remains little in the academic, most especially among social scientists, in the countries and region under consideration. Even in developed spacefaring nations, engagements of social scientists with the population shows that the knowledge of the subject matter is limited (Pass, 2015; Oikonomou, 2017; Steinberg, 2011). These among other things informed adopted sampling technique and sample of this study.

3.3.1.2.1.2. Sampling Technique

This study adopts purposive sampling, which is considerably suitable for KIIs and IDIs. In line with triangulation of data, this study is designed to capture more than one perspective on the subject matter, so participants are recruited from different clusters. Ritchie et al. (2003:87) identified three major issues in this consideration. First, the group or subpopulation that is of central interest to the subject matter of the study should be considered. This involves deciding which population will, by virtue of their proximity to the research question, be able to provide the richest and most relevant information. The appropriate population may be obvious, but often it will be necessary to think through the roles, knowledge or behaviour of different groups and their ability to shed light on different aspects of the research question (Ritchie et al., 2003:87). Second, there are subsets of the central population that should be excluded, because their specific circumstances or experiences set them outside the scope of enquiry, or because it would be inappropriate or even insensitive to include them in the sample (Ritchie et al., 2003). Third, there are additional groups or subpopulations that should be included because their views, experiences and so on would bring contrasting or complementary insights to the enquiry (Ritchie et al., 2003:87).

Ritchie et al. (2003) suggested that the population of the study can be divided into one excluded and two included groups. Hence, this study excluded actors (individuals and institutions) that are not directly involved in advocacy, formulation, administration and analysis of policies on space, development, and security. The governments of Nigeria and South Africa are central to the subject of space policy in their respective countries. However, their space agencies are the principal actors and the closest to this research interest, from where the most relevant and the richest information can be generated. This made NASRDA and SANSA the principal targets for recruitment of key informants for targeted in-depth interview. In the spirit of triangulation, however, perspectives and experiences of other government institutions, most especially those that are involved in development and security, are considered to be important to generating some competing or complementary insights to the subject matter. To avoid or neutralise state-centric dominated narratives of the subject matter however, it is considerable to add corporate bodies, NGOs, or civil society groups (CSGs), and members of the academic community to the latter group.

This study aims to provide analysis that involves multiple or multilevel triangulation that are linked and integrated together at best in a complex matrix and at worst in a simple matrix of data collected from interviews. At the same time, taking into consideration the likelihood of not getting all the targeted informants or adequate information from them, which may or may not be connected to sensitivity of the subject matter, this study sees a need to draw a relatively large sample size. This is expected to enrich the study if all informants respond favourably to the invitation to participate in the research. This measure is equally expected to serve as shock absolver, to mitigate the negative implications of any targeted informant's unwillingness or reluctance to participate or decision to withdraw participation. This is important for upholding the ethical standard that is guiding this study without undermining the research schedule itself.

Against this background, this study adopts four clusters of targeted key informants: government institutions, private corporations, civil society groups and the academic community. On this basis, this study can produce a simple triangulated analysis with four participants, one each from the four categories, in each of the two countries, making eight participants. However, the study hopes to attempt a multiple triangulation, which involves a complex matrix of intra and inter triangulation of the four clusters. Accordingly, this study sought out to engage maximum of 30 participants in each of the affected countries, and maximum of 60 participants all together. In the worst-case scenario, this study planned for a minimum of four informants, one from each cluster, in each of the study areas, and minimum of eight key informants (KIs) all together.

3.3.1.2.1.3. Sample

The study targeted IDIs with minimum of four and maximum of 30 key informants each in Nigeria and South Africa. At the broadest level, 15 KIIs were planned with government officials (such as policymakers that make decisions, and civil servants or technocrats that operationalised relevant policies) with proximity to research questions and another 15 KIIs from NGOs/SCGs, private sector, and academic community for complementary or competing insights. As such, five key informants each in NASRDA and SANSA and their affiliated facilities are targeted for interview as the core of the central population. In addition, senior level government officials in ministries, departments, or agencies that have substantial relations with the space agency in each of the two countries are targeted for KIIs. In this case, special attention is given to relevant research, media and communication or information, and

operational units of the Departments or Ministries of Defence, Science and Technology, Communications, Agriculture, Forestry and Fisheries, Environment, Water, Solid Minerals, and Disaster Management in the two countries.

Three key informants from the corporate world and two from NGOs/CSOs are targeted for interview in each of the countries. In South Africa, this study targeted corporate orgaisations like Space Advisory Company (SAC), SunSpace and Reutech Communication, as well as NGOs/CSOs like the South African Space Association (SASA) and the Foundation for Space Development (FSDSA). In Nigeria, this study targeted NGOs/CSOs like EarthSpace and Space Generation Advisory Council (SGAC), and corporations like Nigerian Communication Satellite Limited (NigComSat), and Space in Africa. The limited scope of the space industry and related advocacy groups in Nigeria and South Africa is taken into consideration in this case.

Finally, ten senior researchers on space and associated applications, policy, development, security and International Relations each in Nigeria and South Africa are targeted for critical IDIs. Priority was given to researchers based in universities with significant contribution to operationalisation of space policy. These include Obafemi Awolowo University (OAU) in Ile-Ife, University of Jos, Jos, University of Lagos, Lagos, and the Federal University of Technology, Akure (FUTA) in Nigeria; and University of Stellenbosch, University of Western Cape, Cape Peninsula University of Technology (CPUT), and the University of South Africa (UNISA) in South Africa. At best, this study sought to engage key informants across all these institutions, and at worst a key informant from any of these institutions in each of the clusters in each country.

3.3.1.2.1.4. Research Sites

Figure 3.1. above offers the geographical scope and location of the research sites on the map. Targeted informants for this research spread across the affected countries, in a manner that reflects data triangulation in space, that is, multiple research sites (Denzin, 1978; Malamatidou, 2018). Targeted research sites in Nigeria are Lagos, Ile-Ife in Osun State, Jos in Plateau States, Akure in Ondo State, and the Federal Capital Territory (FCT). In South Africa, Pretoria, Johannesburg and Hartebeeshoek in Gauteng Province, and Stellenbosch and Arniston in the Western Cape are targeted sites. These are some of the leading hubs of space policy

processes— advocacy, formulation, implementation and analysis— in these countries and the continent of Africa.

Figure 3.1: Map of Research Sites



Source: Mapped by the author using Map Maker

3.3.2. Method of Data Analysis

In assessing the contribution of space policy to security and development in Nigeria and South Africa, this study adopted a comparative method (also known as comparable cases strategy or focused comparison) rather than the experimental and statistical approaches to comparative analysis (Landman, 2008:28; Porta, 2008:201). This method is suitable when the number of cases is low for statistical manipulation. However, the comparative method can adopt the same logic as the statistical method, adapting it to those situations in which we deal with complex phenomena without the large number of cases necessary for a statistical analysis: the famous situations of 'many variables, small *N*' (Porta, 2008:201). Because of this and triangulation of method, this study adopts a mixed method, using both qualitative and quantitative methods

concurrently at various stages of analysis: classification, coding, testing, and inference drawing.

3.3.2.1. Quantitative method

This study employs descriptive statistics for congruent testing, which mainly focuses on the values of both the dependent and independent variables (Bennett, 2004). In this case, the space policy of Nigeria and South Africa is the independent variable, while development and security in the two countries constitute the dependent variable. Of concern here are relevant quantifiable indicators such as the financial cost of space policy programmes and projects, the size of space application market, the socioeconomic conditions (like population distribution, health data, economic size, growth and innovation, per capital income, in/equality, un/employment rate, access to safe drinking water, agriculture and food production etc) and security threats (crime rate and conflict trend), and capability (force strength: personnel and equipment) assessment in Nigeria and South Africa. These are important for ascertaining the developmental and security context and content of space policy programmes, and projects in the aforementioned countries.

Despite the foregoing, congruent testing is unlikely to provide, among other researches in social sciences, an exhaustive conclusion. Hence, this study employs it within the context of comparative method and triangulation. The choice of comparative method is not just a second-best one imposed by the availability of data; it is also justified by its capacity to go beyond descriptive statistical measures, towards an in-depth understanding of historical processes and individual motivations (Porta, 2008:202). Notably, the likelihood of getting all desired data to quantitatively assess space policy and its contribution to development and security in Nigeria and South Africa is limited. This is due to the level of sensitivity of the subject and openness of the politics, and associated publicity. Besides, quantitative reductionism is likely to miss the quality of African perspectives and narratives, which the study desired to examine and project. These among other things raised the importance of qualitative techniques in this analysis.

3.3.2.2. Qualitative method

This study utilises content analysis, historical analysis, and structural phenomenology. Content analysis deals with analysis of substance of documentary or verbal information (Kothari, 2004; Drisko and Maschi, 2016; Neuendorf, 2017). In this case, textual criticism, narrative analysis

and historical method are employed. The narrative analysis aimed is to locate a narrative in the audience's members' resources or poll of data gathered from multiple sources, so as to strengthen or modify them (Pierce, 2008:297-8). Textual criticism is used to determine the authenticity, originality, validity, and reliability of data, most especially, text. This involves the reading, presenting, interpreting, critiquing, and drawing of inferences from different category of information gathered (Hoey, 2001; Ogunnubi, 2014). The historical method entails investigating, recording, and presenting analysis and interpreting facts leading to construction, deconstruction, and reconstruction of the past (Ogunnubi, 2014). In this case, history is considered and represented in non-linear (continuous) term (Harvey and Press, 1996).

Phenomenology focuses on people's experience with a particular event, incident, or trend; how they construct their meanings of the experience; and how these meanings shape public meanings (Vanderstoep and Johnston, 2009:206). This can help us to understand some of the motivations behind influential ideas and activities. As a method, phenomenology seeks to avoid all misconstructions and impositions placed on experience in advance, whether these are drawn from religious or cultural traditions, from everyday common sense, or, indeed, from science itself (Moran, 2000; Smith, Flowers and Larkin, 2009). This study however adopts elements of structural phenomenology. This involves the process of coding data pieces that are merged into categories and refined through several iterations of cases and thereafter explores for the relationships or patterns across categories, so as to identify major themes that are relevant to understanding the context and the object of study (Ary et al., 2014:519).

3.4. Conclusion

This chapter examines the adopted research design for this study, that is, multi-level triangulation. In this case, theory, data, methods, sources, sites, and analysis are triangulated to enhance the findings of this study. In triangulation of theory, this study adopted utilitarianism as the general theoretical framework, with admixture of elements of specific theories such as realism, liberalism, dependency, and social constructivism. In triangulation of data and source, both quantitative and qualitative data are gathered from primary and secondary sources. In triangulation of site, multiple locations and institutions were mapped out for gathering of data. Finally, data that are gathered in this process are scheduled to be analysed through mixed methods. These are all important to enrich and strengthen the findings of this research.

CHAPTER 4

Study Area I: Space Politics and Policy in Nigeria

4.1. Introduction

As identified in the conceptual section in Chapter I (1.7.2.), space policy broadly covers the courses of action pursued in space and the politics that produced them. Space politics involves interactions of different factors (opportunities and challenges), their conceptions and assessment by different actors (state and non-state ones) based on their various interests (for or against) that inspired, conditioned, or shaped space programme. Amidst these, what becomes the policy objectives of a state in space is important vis-à-vis the political process that produces it and associated strategic rationales. Accordingly, the unique conditions of a state and conception of national space policy cannot be ignored, even amidst the appeals of Universalist's position that space activities globally are driven by common utilitarian goals, that is, to advance, promote or protect the development and security aspirations of concerned party. It is therefore important to understand the space policy interests of a country in context of the development and security factors (challenges and opportunities) that necessitate them.

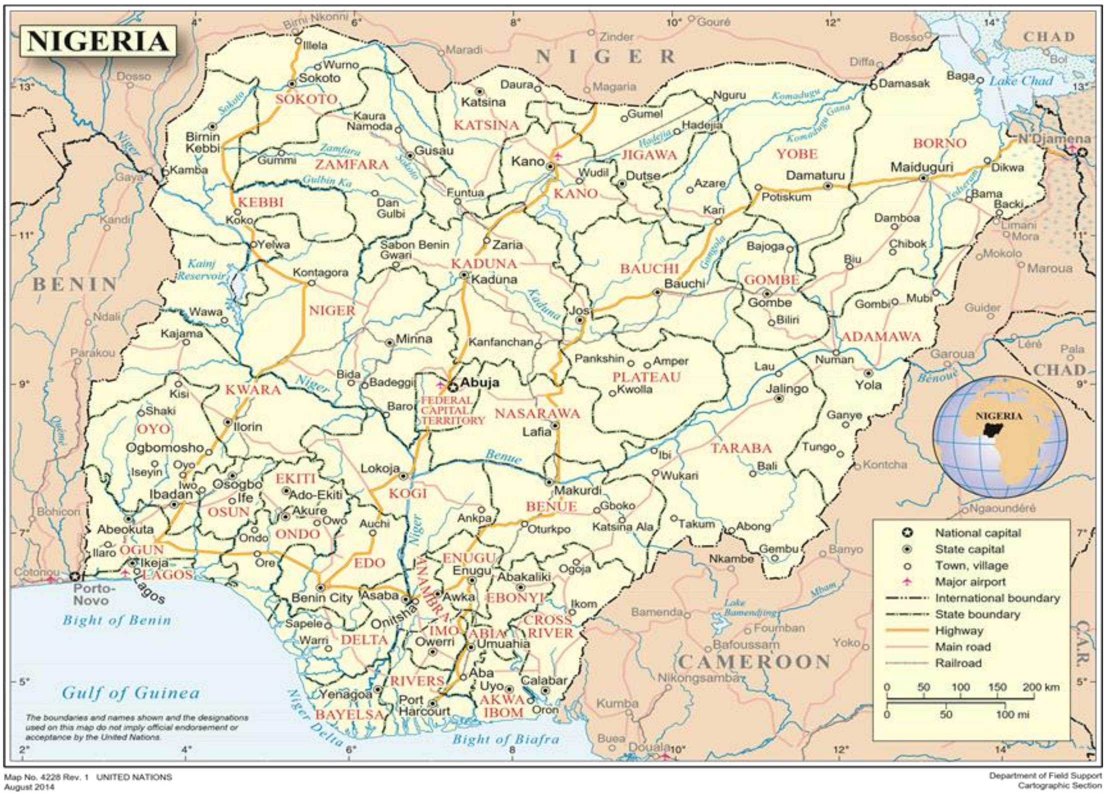
This chapter examines space policy interests and programmes in the context of their social, economic, political, and historical determinants in Nigeria, which is study area I. Besides this introduction, this chapter is further divided into four sections. The first section focuses on the background information about the country, which are necessary to understand political dynamics of its space policy. The second section examines space R&D in Nigeria in the context of the history, politics, economy and society that shapes its development. This is important to understanding the third section, which focuses on space policy and strategy of the country. The last section of the chapter draws conclusion that are relevant for chapter six of this study.

4.2. Study Area I: Background Information on Nigeria

This section is interested in a brief background information on the people and government of Nigeria. This will briefly cover geographical, historical, sociocultural, economic, political, and security development of the country. The Federal Republic of Nigeria (FRN) is situated in the west coast of Africa, between 3^0 and 14^0 East Longitude and between 4^0

and 14^0 North Latitude. It occupies 923,769 square (sq) kilometres (km) (made up of 909,890sq km of land area and 13,879sq km of water area). Beside its 853 km coastlines in the Gulf of Guinea (along the Atlantic Ocean), its 4,477 km land boundaries are shared with Benin Republic, Cameroon, Chad and Niger (NBS, 2017; CIA, 2020). The country hosts a network of internal waters, which include several rivers (prominent among them are Niger and Benue rivers), lakes, and lagoons. Besides a host of plateaus, Nigeria has a large rain forests, creeks, grassland, which explains variation in its climate from equator in the south to tropical at the centre and arid in the north (CIA, 2020; NBS, 2017; Udo, 1980). The map of Nigeria as evident in Figure 4.1. offers insight on the location of major cities and towns in the country.

Figure 4.1.: Map of Nigeria



Source: UN (2020)

The entity that is presently known as Nigeria was created through British colonial conquest, occupation, and administration between 1860 and 1960. Prior to this period, different pre-colonial political entities that range from small city-states to modest kingdoms as well as large empires and Caliphates occupied and flourished in the region (Ikime, 1980). Nigeria

became a self-governing or independent political entity on October 1, 1960. It is a heterogenous country, which has about 250 ethnic groups and over 500 linguistic groups, making Nigeria one of the most ethnically diverse countries in the world (NBS, 2017; Ojo, 2009). Prominent among them are Hausa, Yoruba and Igbo, which constitute about 61 per cent of the total population (CIA, 2020). These among others explain why federalism was adopted in Nigeria, which is currently divided into 36 states and the Federal Capital Territory (FCT) as well as 768 Local Government Areas (LGAs) (see figure 4.1.).

With estimated inhabitants of over 214 million in 2020, Nigeria is the most populous African country and the sixth most populous in the world (CIA, 2020). Its population is about 15 per cent of the total population of the 54 African countries (AfDB et al., 2019). Nigeria has a pyramid-form age structure: 41.7 per cent are between 0 and 14 years, 20.27 per cent are between 15 and 24 years, 30.6 per cent are between 25 and 54 years, 4.13 per cent are between 55 and 64 years, and 3.3 per cent are above 65 years (CIA, 2020). Amidst these, 62 per cent of adults above age 15 were literate in 2018, which was an improvement over the 51 per cent literacy rate in 2008. Gross school enrolment into primary education was 85 per cent and secondary education was 42 per cent in 2016, while tertiary education was 10 per cent in 2011. In 2006, educational attainment of 1.6 per cent of adults (age 25 and above) was at least master's degree or equivalent (World Bank, 2020). The country however possessed over 62 million total labour force (the 10th largest in the world), of which about 8 per cent are unemployed by national estimation, in 2019 (World Bank, 2020; CIA, 2020).

Nigeria's Gross Domestic Product (GDP) at current US$ stood at 397 billion, which is about 17 per cent of Africa's total, in 2018. This made the country the largest economy in Africa and 24th largest in the world (AfDB et al., 2019; World Bank, 2020; CIA, 2020). The economy is largely based on services, which constituted 56.4 per cent of the GDP in 2017. At the same time, industries contributed 22.6 per cent, agriculture contributed 21.1 per cent and manufacturing contributed 8.8 per cent to the GDP (AfDB et al., 2019). Although oil and gas sector accounted for about 10 per cent of GDP, it is the major source of government revenue. Government revenue to GDP stood at 7.3 per cent in 2018, making it the lowest in Africa. In 2017, government revenue was 6.6 per cent of the GDP, while its expenditure was 11.8 per cent (AfDB et al., 2019). Accordingly, government has increasingly relied on borrowing to fund its growing expenditure. External debt in 2018 stood at US$ 18 billion,

which was about 5 per cent of Gross National Income (GNI) (Word Bank, 2020). Nigeria's GDP per capital is US$2,028 in 2018, making it the 19th in Africa (AfDB et al., 2019).

Nigeria's fourth republic has proved to be its longest years of democratic dispensation. In 1999, when civil rule finally returned to Nigeria, the military had ruled for 28 of 39 years of its political independence (Adekanye, 1981; Ojo, 2009; Siolun, 2013). Nigeria practices a presidential system of government since its 1979 constitution abolished the inherited West-minister system. It operates a bicameral National Assembly or legislature. On one hand is the Senate, which is made up of 109 members, three from each state and one from the FCT. On the other hand, there is House of Representatives, which has 360 seats (FGN, 1999). The tenure of the president and that of the parliamentarians is four years, and the former is only renewable once. Hence, elections are generally periodically held every four years, although their freeness and fairness are subject of debate (Agbaje and Adejumo, 2006; Hamalai et al., 2017). The Nigerian public space is infamous for deception, corruption and sectionalism, which are largely responsible for widespread deprivation, state failure and armed conflict in the country (Adebanwi and Obadare, 2013; Campbell, 2010; Joseph, 1991; Maier, 2000; Nnoli 2008; 2011; Omotola and Alumona, 2016; Osaghae, 2011; Smith, 2007). These among others are relevant to understanding the ideas behind Nigeria's space policy and strategy, and their developments in the contexts of socioeconomic and political dynamics.

4.3. The Development of Space Politics and Policy in Nigeria: The Historical, Political, and Socio-economic Perspectives to Space R&D

This section provides some insights into the development paths of space R&D in the framework of politics and policy in Nigeria. It pays attention to the historical, political and socio-economic contexts, determinants, and factors that characterised the development of space R&D of the country. Accordingly, it serves as a background to the space policy and strategies of Nigeria, which are considered in the subsequent sections of this chapter.

Space R&D in Nigeria has its distant origin in astrology and cosmological visions of different pre-colonial cultures and traditions in the country. These are largely characterised by systems of belief, which included myths and rituals, that revolved around the celestial bodies as well as their interactions with terrestrial affairs, including humanity (Chukwuezi, 2008; Sègla, 2008; Urama, 2008). The knowledge produced in this process were largely

passed from one generation to another through oral tradition, and to a limited extent through documented education, most especially in the northern part of the country, where influence of Arabic civilisation has penetrated. Yet, the knowledge of development as modernisation, industrialisation, monetised economic growth, constructive destruction as well as aggressive human conquest of nature was introduced to Nigeria and most other parts of Sub Saharan Africa through Western education and European colonisation (Ake, 1981; 1982; Hartmann, 1999; Martinussen, 1997; Pieterse, 2010; Rodney, 1972). Amidst these, modern space R&D was born as a subject of academic interests within pure and applied sciences in Nigeria.

The foundation of future space R&D was laid in Nigeria with the introduction of universities and polytechnics, which made advanced studies in science and engineering possible, in the country from the 1940s (Livsey, 2017). Prior to these, and after this period, many Nigerians have been trained abroad in relevant fields. In 1958, the National Aeronautics and Space Administration (NASA) sponsored the installation of a ground tracking device at University College of Ibadan, old Western Region of Nigeria, in order to support the launch and operation of the first U.S. satellite *Explorer-1* among other space R&D (Abiodun, 2017). In 1960/1961, shortly after the independence, NASA sponsored the installation of a tracking station in Kano, old Northern Region of Nigeria, in order to support the Apollo missions, which led to a series of manned spaceflight to the Moon. In 1962, Zagami— a meteorite from Mars that weighed about 18kg—landed in the present day Katsina State, Nigeria (Abiodun, 2017).

On August 23, 1963, Nigeria's first Prime Minister, Tafawa Balewa, became the first to have the first ever satellite telephone conversation with the then U.S. President, John F. Kennedy. In a conversation that lasted for about two minutes, Kennedy told Balewa that what they were doing was made possible through peaceful use of space, while the latter congratulated the former for the great achievement (US Naval History Blog, 2019). Prior to this, there were efforts to establish an observatory in Nigeria in 1962, as Profs. Gaustard and Hans Haubolt introduced astronomy and astrophysics to University of Nigeria, Nsukka (UNN). In 1965, a Nigerian, Samuel Okoye (1939-2009) became the first black African to obtain a PhD in Astrophysics at Cambridge University, London. He soon returned back to Nigeria and joined Faculty of Sciences in University of Ibadan (UI) and UNN later, where a pool of human resources was increasingly being developed (Chukwuezi, B. 2008; CBSSA,

2020). These among others are indicators of Nigeria's encounter with space R&D at the beginning of space age.

Despite the foregoing, there was little or no policy interest in space R&D in the first 15 years (1960-1975) of Nigeria's independence. There are many factors that are responsible for this development. First, policy makers in the country were mostly preoccupied with terrestrial policy for pressing socio-economic and security questions. Life expectancy at birth was between 36 and 50 years between 1960 and 2008. The GDP per capital was around US$100 in the 1960s, and did not surpass US$ 1000 (at current value) until 1982. Electricity consumption was 23.57-kilowatt hour (KWh) per capital in 1971. Although the economy relied on agriculture, which also doubled as the largest employer of labour in the country, it was less mechanised. For instance, there was less than 1 tractor per 100 squares (sq.) km of arable land between 1960 and 1969 (World Bank, 2020). Second, Nigeria recorded a series of political crises, which undermined policy attention for R&D, during this period. These include ethno-regional conflicts, militant party politics, three successful military coups, three secessionist attempts, including one that led to three years of civil war, which claimed more than 2 million lives (Anifowose, 2011; Diamond, 1988; Nnoli, 2008; 2011; Osaghae, 2011). Amidst these, Nigeria failed to develop a serious policy and institutional framework for science and technology, where space policy interests could be nurtured, during this period.

There were also international dynamics to Nigeria's early engagement with space age. Space R&D was largely considered globally as a luxury, a race for prestige and domination among super powers and a few of their allies who were great powers, during the Cold War, and most especially in the 1960s and 1970s. With restricted opportunity for technological transfer, the huge investment that space R&D required also made it less attractive to developing countries like Nigeria. Space expenditure of the US rose from US$1.1 billion in 1960 to US$7 billion in both 1964 and 1965, while that of USSR was estimated to had risen from about US$2 billion in 1960 to US$ 6.7 billion in 1969 (CIA, 1966; 1969; Nimmen, 1976). Although the two super powers spent less than five per cent of their GDP on space, such investment was so huge for a country like Nigeria, whose GDP was US$6.6 billion in 1969, thanks to 21.4 per cent growth rate that was recorded as against negative growth recorded in the preceding three years. Notably, the proposed space R&D at the cost of £700 million in Zambia in 1964 failed the test of policy interest for a year-old country with a GDP

of $855 million (Oyewole, 2017; De Middel, 2012). These among others might have informed Nigeria's path in space.

In 1973, Nigeria joined the UN Committee on the Peaceful Uses of Outer Space (COPUOS). However, it was at the 1976's meeting of the Economic Commission for Africa (ECA) and the Organisation of African Unity (OAU) (now African Union- AU) in Addis-Ababa that Nigeria declared interest in space and associated technologies (Abiodun, 2017; Akinyede and Boroffice, 2013). At the same time, Nigeria displayed serious policy interest in nuclear R&D and considered it as a weaponization option, which was never taken seriously (Adeniji, 2000; Lowbeer-Lewis, 2010). There are many factors that are responsible for this sharp departure from the initial indifferent approach of the country to space among other R&D. Amidst these, the civil war (1967-1970) with the rise and fall of Gen. Murtala Muhammed's regime (1975-1976) transformed the Nigeria's national (both socioeconomic and security) and foreign policy disposition from conservative to radical path (Ekoko and Vogt, 1990; Fawole, 2003; Imobighe, 2003; Tamuno and Atanda, 1989). The succeeding Gen. Olusegun Obasanjo's regime (1976-1979) vigorously pursued the policy of economic nationalism, capacity building, and industrialisation with R&D. The aggressive turn of Nigeria's activist foreign policy against neo/colonialism and the apartheid regime in South Africa, which had developed some capabilities in space, missile and nuclear R&D as at then, significantly inspired interests in space amidst considerations on defence, security, and power projection.

In 1976, the Federal Government of Nigeria (FGN) established the National Science and Technology Development Agency (NSTDA), which was transformed into Federal Ministry of Science and Technology (FMST) by Act No.1 1980. The ministry was merged with the Ministry of Education (MoE) in 1985 and subsequently regained its independence in 1992 (FMST, 2020). Between 1976 and 1980, Nigeria tried unsuccessfully to a launch centre for remote sensing (Shaba, 2012). In 1977, Okoye secured private funding and the support of University of California to acquire a 10-m dish operating at 327 MHz for astronomical R&D in UNN. He also planned a two-station pulsar observation with India and a Very Long Baseline Interferometer (VLBI) observation programme with Germany. However, the effort was not supported by the government, and the dish was never operationalised (Okeke, 1999). The lack of policy support may be partly related to the post-civil war scepticisms among policymakers against the former secessionist eastern region of the country led by the Igbos, most especially in R&D with uncertain security implications (Adekanye, 1983;

Osaghae et al., 2002). Moreover, Nigeria's interests in space received no significant attention between 1979 and 1987. The Second Republic under President Shehu Shagari (1979-1983) and the subsequent regime of Gen. Muhammadu Buhari had no significant interest in space policy.

In April 1987, the regime of Gen. Ibrahim Babangida (1985-1993) set up Inter-Ministerial committee to produce the blueprint for the establishment of National Remote Sensing Centre (NRSC), which was approved in 1988, but did not take off until 1996, during the regime of Gen. Sani Abacha (1993-1998) (Abiodun, 2017; Akinyede and Boroffice, 2013; Isoun and Isoun, 2013; Shaba, 2012). Equally, in 1987, FMST created a National Committee on Space Application (NCSA) with membership drawn from the academic, armed forces and research centres among other relevant government Ministries, Departments, and Agencies (MDAs). The National Agency for Science and Engineering Infrastructure (NASENI) was established in 1993 with a mandate that covered space R&D. This Agency subsequently formed a committee of nine experts, drawn from both home and the diaspora, to develop a draft National Space Science and Technology Policy. These among others paved the way for the creation of National Space Research and Development Agency (NASRDA) on May 5th, 1999, shortly (24 days) before Gen. Abdulsalami Abubakar's regime (1998-1999) finally returned the country to civil rule, after 25 years of unbroken military government (Abiodun, 2017; Akinyede and Boroffice, 2013; Isoun and Isoun, 2013; James et al., 2014; Shaba, 2012).

For half century, and particularly between 1976 and 1999, Nigeria failed to substantiate its interests in space, among others, with policy reality due to political instability, leadership crisis, inadequate commitment to R&D, policy summersault, and economic mismanagement, which plagued every aspect of the society in the wake of the 21st century (Joseph, 1991; Maier, 2000; Nnoli, 2008; 2011; Osaghae, 2011; Oyediran et al., 1997; Siolun, 2013). The reign of the military between the 1980s and 1990s also drifted the country toward political and economic failure and collapse as well as international pariah status, to detriment of internal capacity and external support for space among other R&D. The success of Nigeria's led international mobilisation against the apartheid regime in the 1970s and 1980s, and the eventual decline and collapse of the system, equally reduced the drive for catch up and balance of power in space or nuclear capabilities in Sub-Saharan Africa (Adeniji, 2000; Amusan, 2006; Fawole, 2003; Imobighe and Ali, 2012; Ogwu, 2005).

Accordingly, Nigeria's status and power were not threatened by lack of space capability by its peers in the region until the tail end of the 20th century.

There are many factors that drove Nigeria's interests and turned the country into a space player in the early part of the 21st century. Prominent among these is the return of a passionate space lover and supporter of power, in the person of Gen. Obasanjo (rtd) as two-term President between 1999 and 2007. As it will be shown in the subsequent section, he prioritised space among other R&D and considerably mobilised national resources for this purpose, even amidst harsh economic reality of the country (Abiodun, 2017; Isoun and Isoun, 2013; James et al., 2014). Interview with key informants (KIs), who have played leading roles in the operationalisation of Nigeria's space policy in the last two decades, rated Obasanjo's commitments as high as 8/10. The governments of Umaru Musa Yar' adua, Goodluck Ebele Jonathan, and Muhammadu Buhari have sustained Nigeria's space interests and boosted its capabilities. However, many observers are sceptical that the zeal for space has declined in the country (Abiodun, 2017; KIs). A KI observed that government largely lacked continuity and progress with space policy has become inconsistent. Another KI with decades of experience in space policy operationalisation in the country, rated commitment of the current government as 5/10. An academic with decades of experience in policy studies even rated the current attention and commitment to space by government as low as 2/10.

The central objective of space policy in Nigeria, as it will be shown in the next section, is for socioeconomic development of the country. However, public awareness of the policy and its relevance are subjects of debates, which will be returned to later (KIs). Beyond the publicly acknowledged however, power politics is equally a salient driver of Nigeria's space interests. Many regional powers that Nigeria would like to consider as peers across the world boosted their capabilities and joined the exclusive space club, by virtue of owning at least a satellite in orbit, toward the end of the 20th century (Abiodun, 2008; Harvey et al., 2010; Harding, 2013; UCS, 2020). This trend became more alarming for Nigeria when African states started to make headway in this regard. The first orbited satellite from the continent was sponsored by Egypt in 1998, and then followed by South Africa in 1999, Morocco in 2001 and Algeria in 2002 (Abiodun, 2017; Luncedo, and Gottschalk, 2013; Froehlich and Siebrits, 2019; Oyewole, 2017). As a regional power, Nigeria cannot afford to be left out; its first satellite was orbited in 2003. Against this background, subsequent sections in this chapter pays attention to the space policy, strategies, institutions, and capabilities of Nigeria.

4.4. Space Policy and Strategies of Nigeria

Nigeria's space policy and strategies are products of the politics, history, economy, and sociology of the country, which the last section tried to summarise. Alternatively, they are reflections of the past, present, and future efforts and aspirations of the government and people of the country in development and security. Accordingly, the efforts to understand the policy and strategies of the country in space cannot ignore their contexts, most especially the grand strategies and the policy framework. This made it necessary to situate Nigeria's space policy in the context of development and security strategies and extant laws. Hence, this section will be subdivided into two: the first one focuses on the constitutional and legislative framework of the space policy, while the second one focuses on the strategic policy details.

4.4.1. The Constitutional and Legislative Framework of Nigeria's Space Policy

Nigeria's interests in space has considerable constitutional backing. The Constitution of the Federal Republic of Nigeria (FRN), 1999 makes it a "duty and responsibility of all organs of government, and of all authorities and persons, exercising legislative, executive or judicial powers, to conform to, observe and apply the provisions of Chapter II [Sections 13-24]" on the Fundamental Objectives and Directive Principles of State Policy. Section 14(2b) makes "security and welfare of the people" "the primary purpose of government" in Nigeria (FGN, 1999). Therefore, there is no option to development and security for the government of the country in space, given the constitutionally mandated objectives for this and every other issues of policy consideration. Sections 14 - 24 of the Constitution operationalises the national conception of security and welfare, including national unity in diversity, guaranteed fundamental human rights, political freedom, flourishing civil society groups and private investors, re/distribution of wealth, equality, quality education opportunities, living standard, and environment, as well as promotion of national and African interests, while supporting a peaceful and just world order in external engagements, among other things (FGN, 1999).

From Sections 14 – 24 of the Constitution of the FRN, 1999, there are few sections that directly or indirectly justifies the space policy and associated commitments, as well as the framework of this study. For instance, Section 16(1a) mandates the state to "harness the

resources (human and materials) of the nation and promote national prosperity and an efficient, a dynamic and self-reliant economy. This aligns with dependency theory adopted among others as the framework of this study. In agreement with utilitarian principles that are considered in this study, Section 16(1b) states that the state shall "control the national economy in such manner as to secure the maximum welfare, freedom, and happiness of every citizen on the basis of social justice and equality of status and opportunity." Section 17(3d) mandates the state to direct policy to ensure "there are adequate medical and health facilities for all persons." Besides the mandate to ensure "equal and adequate educational opportunities at all levels" in Section 18(1), the following sub-section 2 states that "government shall promote science and technology." Section 20 mandates the state to "protect and improve the environment and safeguard the water, air and land, forest and wild life of Nigeria" (FGN, 1999). Space R&D has become an indispensable aspect of science and technology, which are vital to promoting quality health, food, environmental, and education for all among others.

In addition to constitutional provision that supported space among other aspects of R&D in S&T, the legislature has also passed some laws that are critical to Nigeria's space policy. Earliest among them is the Nigerian Communication Act of 2003, which established the Nigerian Communication Commission (NCC). Prominent among the responsibilities of the commission is development and review of national policy on communication; promotion of investment and R&D in communication; as well as management of relevant resources and regulation of communication services (FRN, 2003). Although the Act was not explicit with this, the mandate of the commission includes governance of space-based communication technologies and services in Nigeria. In addition, the National Information Technology Development Agency (NITDA) Act of 2007 was passed. This Act legislated the existence of NITDA and mandated it to oversee and regulate information network and sharing in Nigeria (FRN, 2007). Although the Act is not explicit on this, it makes the agency a critical agency in the management and regulation of information from space-based technologies.

The NASRDA Act of 2010 is a turning point in space policy legislation in Nigeria. The Act legislated the establishment of NASRDA and allocated 13 functions to the agency. These involve responsibilities for building national capabilities in space S&T; development of satellite technology, applications, services and launch capacity; conducting space R&D to advance the socio-economic development of the nation, coordinate space programmes and

their applications; development of strategy for exploitation of outer space and promoting the participation of private sector in the space industry; establishment and supervision of centres that are required for the implementation of national space programme; establishment of information network for the purpose of facilitating communication and data sharing; promotion of active participation of Nigeria in UN-COPUOS and other UN specialised agencies in space S&T; support academic institutions in R&D that are related to space; serving as repository for all satellite data over the territory, as well as collaborator and consultant for all space related data that involve the country; reviewing national policy and development of strategy on space; and finally, every other activities that are expedient and necessary for the operation of the agency and space S&T promotion in Nigeria (FRN, 2010).

The Defence Space Administration (DSA) Act, 2016 is another major legislative framework for space policy and strategy in Nigeria. The Act legislated the establishment of the DSA with 15 national policy objectives in mind. These involve responsibilities to: (1) facilitate and implement the defence and security aspects of national space policy;

(2) develop and operate military space technology;

(3) support the Nigerian military operation locally and internationally as well as internal security agencies with satellites;

(4) provide affordable and reliable space and cyberspace capabilities for the military as well as other security and law enforcement agencies;

(5) support launching of satellites and other space payload;

(6) establish space control that is capable of ensuring peaceful use of outer space through the use of navigation, surveillance, protection and space intelligence analysis for counter space operation;

(7) establish centres that are capable of providing various satellite application services for force enhancement of the military and the country at large;

(8) strengthening the human resource capacity of the military and other security agencies for implementation of defence space programmes;

(9) encourage the development and operation of space launch vehicle;

(10) coordinate space activities of the services in the armed forces;

(11) develop strategies for exploitation of outer space and promote the participation of the military in space industry;

(12) collaborate with national and international agencies, centres, private industries and NGOs in space and other relevant fields;

(13) promote active participation of Nigerian Armed Forces in UN-COPUOS and other UN specialised agencies in space S&T;

(14) support all military formations, commands, units and institutions in space related R&D;

(15) conduct sustainable training of relevant personnel, and undertake any other expedient and necessary activities, for the operation of the administration and for the promotion of space S&T in the Nigerian armed forces and other security agencies (FRN, 2016).

Besides the foregoing domestic legislative framework, Nigeria has signed and ratified some international conventions and treaties on space and related matters. These include the Outer Space Treaty of 1968, the Rescue Agreement of 1968, the Liability Convention of 1972 and the Registration Convention of 1976 (Erickson, 2019; Momoh, 2008; Van Wyk, 2008; UN, 2002). Although these treaties are legally binding as applicable in International Law, most especially on signatory states to them, they are yet to be domesticated in Nigeria (Erickson, 2019; Momoh, 2008). Equally, Nigeria has ratified the Nuclear Test Ban Treaty of 1963, the International Telecommunications Satellite Treaty (ITSO) of 1973, the International Mobile Satellite Organisation Treaty (IMSO) of 1976 and the International Telecommunication Convention of 1992 (Erickson, 2019; Momoh, 2008; Van Wyk, 2008). However, the country is yet to ratify the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (the Moon Agreement) of 1979 (Erickson, 2019).

4.4.2. The Strategic Policy Framework of Nigeria's Space Programmes

In 2001, Nigeria adopted a Space Policy and Strategy, which reflected the aspiration of the government and the people as evident in the constitution. Besides the executive summary,

the 53-page document covers 10 chapters, scope of the national space programme, and an annex on the structure of the NASRDA. As summarised in Table 4.1, the 10 chapters of the document states the goals, objectives, and approaches of Nigeria in space R&D. The policy goals include development of human resources and capacity in space science and technology (SST), as well as applications of SST for poverty reduction, food security, management of natural resources, disaster prediction, warning and mitigation, defence, national security and law enforcement, communication, understanding of Earth atmosphere for national development, education and training, commerce and spin-off benefits, and international cooperation (FMST, 2001). Several objectives and strategies were identified with each of the goals, although they are considerably repetitive. The last chapter focuses on implementation of space policy, and is followed with a section on the scope of the space programme, and in few cases timeline, and the structure to operationalise it, which will be considered in the latter part of this study.

Table 4.1: Summary of Nigeria's space policy and strategies

Policy goals	Objectives	Strategies
1. Development of human resources and capacity building	Development of: ➢ Pool of Nigerian scientists, engineers and technicians that can design and manufacture hardware and software for various purposes ➢ Skills in various aspects of science and technology ➢ Attractive career opportunities for numerous brilliant Nigerians in STEM ➢ Nigerian technology that can feed local industries and earn-foreign exchange ➢ Highly trained personnel that can train the trainers in STEM	❖ Funding and resourcing mandatory study of space at all levels of education ❖ Develop space infrastructure for public awareness and curriculum for all levels of education ❖ Enhance the capabilities of institutions of higher learning with space related disciplines ❖ Sponsor satellite supported facilities for distance learning to make educational opportunities available everywhere and avoidable for everyone ❖ Create enabling environment that can attract vibrant Nigerian talents in Diaspora ❖ Establish centre for satellite development, aircraft manufacturing, rocketry and

		basic space science, among others, to support space R&D
2. Poverty alleviation, food security, and management of natural resources	➢ Agriculture: assessment of crop performance, yield prediction and determine measures to prevent failure ➢ Land resources: assessment, exploitation, and/or management of oil among other resources, pipeline, oil spill and related hazard; terrain and land resources for military undertaking and land use planning; soil for capability and stability for various purposes. ➢ Water resources: assessment of the quantity and quality of surface and underground water, maritime resources management, rainfall prediction, drought and other disaster forecast, as well as hydrological systems planning and conservation measures. ➢ Ecosystems: Evaluation and monitoring of aquatic ecosystem, land use and vegetation. ➢ Plants: Assessment and determination of plant species in forest systems, aquatic plants for consumption, as well as medical and ornament plants. ➢ Fauna: Assessment and determination of fish distribution to boost yields of trawlers; areas of overfishing and policy measures against consequences of such; inventory of domestic animals and wildlife; provision of weather information and channel conditions for navigation. ➢ Physical environment: Assessment and conservation of air quality and atmospheric indices; provision of short and long terms weather forecast and hazard waring. ➢ Education: transmitting teaching material through time and space to impact knowledge.	❖ Enhance the institutions that involved in remote sensing. ❖ Establish national ground station for receiving data from satellites. ❖ Build and launch Nigerian Earth Observation satellites. ❖ Establish equipped laboratories in each state of the federation for satellite data analysis. ❖ Adequate funding for the various projected initiated by the space agency.
3. Disaster prediction,	➢ Development of capacity to conduct assessment and monitoring of flooding,	❖ Developing enabling environment and integrated

warning and mitigation	land-slides and soil erosion, Whirl wind and thunder storm, heat waves, droughts and desertification, sand and dust storms, locust and other insect infestation, bush burning, hazard from oil exploration, waste management, natural or man-made radio activity, impact of climate change on sea level in coaster areas, Earth tremors, inconsistency of crater Lakes, and effects of mining activities, among others, across the country.	mission for collation, analysis and dissemination of satellite data to stakeholders in environmental management. ❖ Formulation of national disaster reduction and risk management methodologies, and development of disaster forecasting and preparedness. ❖ Development of emergency response system that include disaster, population and resource impacts evaluation and relief administration. ❖ Development of recovery and reconstruction plans and actions for the affected populations and infrastructures. ❖ Mapping out areas of international cooperation in disaster management.
4. Defence, national security and law enforcement	The use of space support/ satellite for ➢ Conflict prevention through pre-emptive measures like advanced communication and remote sensing for early warning, border delineation, resource mapping and monitoring of movements of hostiles. ➢ Enhancement of military capabilities (command and control for tactical and strategic operations) for the fight against criminal elements internally and externally, regional peacekeeping operations, and protection of strategic interests	❖ Establishment of space R&D command units in Ministry of Defence (MOD) and its agencies; fund relevant R&D programmes in collaboration with NASRDA, Nigerian Universities and Research Institutions. ❖ Production of reliable military communication and navigation; development of software and hardware required by the military in space age, training of personnel in space R&D to meet need of defence and national security. ❖ Training for military for disaster operations and participation in search and rescue globally with space support.

		❖ Employing space capabilities for intelligence tracking and forensics by the police, and in the fight against financial crime advance fee fraud.
5. Understanding the Earth and its environment from space for national development	➢ Enable and improve understanding or monitoring of the Earth's atmosphere, biosphere, hydrosphere, and magnetosphere, solar-terrestrial relations, climate and weather forecasting for agricultural and socio-economic development, natural resource inventory, pollution (air, maritime and land), ozone layer depletion and climate change, and the impacts for Nigeria, advance warning of natural and man-made disaster; create employment opportunities for young scientists; and produce international cooperation in Earth science.	❖ Encourage the study of basic space science at all level of learning, and the enabling environment to develop space capabilities and socioeconomic benefits in Nigeria ❖ Develop a pool of scientists that can assess upper atmosphere and the effects on human, aircraft and ground services; measure toxic compounds over Nigeria and determine their effects for the human, agriculture, forests and natural resources, and proffer effective remedies; understand the impacts of stratospheric ozone depletion and radiation on the population; document available natural resources in the country. ❖ Provide ground and space-based monitoring of the Earth and the environment; coordinate national and international monitoring activities to ensure standard and ethical procedure and results.
6. Space communication applications	➢ Accelerate economic growth through affordable telecommunication services; increase tele-density of the country in 10 years; link Nigeria with information infrastructure globally. ➢ Provide telecommunication services in remote/rural areas; satellite broadcasting among other services like data imaging,	❖ Develop and acquire indigenous capacity in satellite and ground receiving technologies; develop and launch affordable and secure satellite communication

	multimedia and global internet access; strengthen the development of distance learning education	
7. Education and training	➢ Develop awareness of the socioeconomic benefits derived from space among other fields of science and technology among the Nigerian youths to prepare them for future leadership role. ➢ Develop human capacity for R&D of high tech from space R&D for sustainable technological and industrial development; ensure success of high tech and derive benefits from such. ➢ Participate in international space R&D, and ensure cooperation with other countries and international organisations	❖ Revive deteriorating facilities for SST; invest in all areas of space research and training (R&T); sustain policy commitment on space R&T and integrate it into national planning and major projects; ensure mass and continuous education of policy-makers and planners to advance all areas of SST; allocate not less than 5% of education tax to space R&T; provide scholarship for students in different areas of SST; funding of relevant space education centres.
8. Commercial aspects and spin-off benefits	➢ Advance from mere consumer to active engagement in research on SST and the spin-off for commercial purposes; attract relevant foreign technologies; create human capacity and employment opportunities for national technological and industrial development; support international cooperation that will promote peace and security of Nigeria and the world.	❖ Provide enabling environment for SST, capacity building, job creation; fund all areas of space R&D; collaborate with established and successful space players with willingness to support the developing countries.
9. Promotion of international cooperation	Peaceful development and use of space resources for the benefits of Nigerians and all mankind; bi/multi-lateral engagements and cooperation based on mutual respects and complement; development of space capabilities of the country; adopt protective measures on space and its environment and resources through international cooperation; support UN space programmes.	support multilateral cooperation on the peaceful uses of outer space in the UN framework; promote with developed and developing nations, sub-regionally in West Africa, and regionally in Africa; support research, business and educational entities to develop international space exchanges and cooperation; build national capacity for bi and multi-lateral collaboration on space programmes, projects and networks, which include ARCSSTE and RASCOM.

10. Policy implementation	Development of indigenous capabilities in major areas of space R&D, and their utilisation for socioeconomic development.	Build capacity in SST, satellites for communications and Earth Observation as well as their applications, indigenous satellite launch vehicles and associated space services in the long run; encourage private sector participation; enhance the education sector in relevant fields; seek international cooperation; establish SST FUND to be managed by NASRDA.

Source: Computed by the author with data extracted from FMST (2001).

The Nigeria's space programmes have been guided by this strategic policy framework for the past 20 years. Even when most of its objectives were expected to have been achieved, the country is yet to revise its space policy and strategy. One of the KIs interviewed at the NASRDA noted that a proposal was sent to government to revise the financial circle of the agency and is expected to be sent to the parliament if accepted. It was only in June 2020 that the new head of NASRDA called for the revision of space policy and strategy. Moreover, the agency does not have any publicly available strategic plan and report of its own. The same thing can be said of the FMST. This is unlike their South African counterparts, which often publish (annual and medium term- two to ten years) strategic plans as well as their assessment report, as it will be shown in the next chapter. KI III recognised that the financial circle operated by the NASRDA like any other civil service institutions in Nigeria make such planning impossible, of which the approval of the submitted proposal will address.

To underscore the importance of space policy and strategy, there is a need to examine this subject in the context of development and security policies and strategies. In this way, one can deduce how space policy thrust and strategic goals have been carried on through or recognised as a subject of national development and security in Nigeria since 2001. Although the Nigeria vision 20:2020 economic transformation blueprint, which was adopted under President Yar'Adua with the aim to catapult the country to the list of first 20 economies in the world by 2020, recognised the importance of R&D in science and technology, the 218-pages document does not identify specific interest in space (FRN, 2009). The same thing can be said of the 168-page document, Nigeria economic recovery and growth plan (2017-2020), which acknowledged the importance of science and

technology generally without any explicit interest in space (Ministry of Budget and National Planning (MBNP), 2017).

Despite the foregoing, the 27-page document on development, the Transformation Agenda (2011-2015) that was adopted under President Jonathan identified NASRDA as a critical agent in monitoring and evaluating the development programmes of the country (FRN, 2011). Moreover, the 80-page document, National Security Strategy that was released under President Buhari identified the promotion of R&D in space technology as a subject of defence and national security, and restated some of the core goals of space policy in the country (FRN, 2019). These among other things speaks of the policy commitments for and priority on space policy programmes in the framework of national development and security aspirations and planning of Nigeria, most especially since the end of pioneering efforts of Obasanjo administration (1999-2007) as mentioned earlier. Out of 10, the commitment of his government to space policy actualisation was rated between 6 and 6 (KIs); while the present government of Buhari was rated between 2 and 5 (KIs). Public knowledge of the space policy and awareness of the programme are believed to be between 3 and 8, with average of 4.6, by those within the agency and affiliated centres (KIs), while those outside believed that it is between 1 and 4 (KIs). It is against this background that the attention of this chapter will be turned to examine the space capabilities of Nigeria in the next section.

4.4. Conclusion

This chapter examines the Nigeria's space policy as well as its political, social and economic determinants and historical development. It provides some insights on the national conceptions of development and security in Nigeria, which all reflected various perspectives that were earlier identified on these concepts in chapters one, two, and three of this study. The developmental goals of the government and people of Nigeria, as evident in this chapter, indicated the desire of the country for economic growth, transformation, catch up, industrialisation, liberalisation and privatisation, resource management, socio-political modernisation, national capacity, human and community flourishing, enlargement of the choices of the people as well as sustainability. The conceptions of security in the country equally reflected elements of national and human dimensions of security, as earlier detailed in chapter one to three. In addition, the conception of space support for these development and security goals align with utilitarian framework of this analysis, while the strategic focus

of the objectives reflected the orientations of the supporting theories (realism, liberalism, dependency and constructivism) adopted in this study, as evident in chapter three.

Against this background, this chapter is important to the assessment of the contributions of space policy programmes to development and security in Nigeria. Moreover, the chapter is an attempt to answer the Nigerian aspect of the first and second research questions of this study, and provides some of the bases for questions three and four. If development and security are the primary objectives for space policy and investment in Nigeria, how much of such benefit has been derived from this process. These concerns will receive attention in chapter six. Prior to this, however, the fifth chapter equally examines the space politics and policy in South Africa, as an attempt to address questions one and two in the study area II.

CHAPTER 5

Study Area II: Space Politics and Policy in South Africa

5.1. Introduction

This chapter examines space politics and policy in study area II, South Africa, just as the previous chapter did in study area I, Nigeria. In doing this, the same model and structure of analysis that were used in the previous chapter are adapted and employed in this chapter. Accordingly, attention is paid to the space policy interests, strategies, and programmes of South Africa as well as their social, economic, political, and historical contexts and determinants. Besides this introduction, this chapter is further divided into four sections. The first section provides brief background information about South Africa, which are necessary to understand political dynamics of its space policy. The second section examines the development of space R&D in South Africa and how they are shaped in the context of history, politics, economy, and society. This is important to understanding the third section, which focuses on the space policy and strategy of the country. It is on these bases that the fourth and the last section of the chapter draws the conclusion that are relevant for the next chapter.

5.2. Study Area I: Background Information on South Africa

This section provides a brief background information on the people and government of the Republic of South Africa (RSA). It covers geographical, historical, sociocultural, economic, political, security development of the country. RSA is situated at the Southern tip of Africa, between 22^0 to 35^0 South Latitude and 17^0 and 33^0 East Longitude. It occupies a surface area, which covers 1,219,602 km^2 (GCIS, 2019 cf. CIA, 2020). In addition to a coastline of 2,798 km (along the Atlantic and Pacific Oceans), RSA shares 5,244 km of land boundaries with Botswana, Lesotho, Mozambique, Namibia and Swaziland (renamed as Estwani) (CIA, 2020; GCIS, 2019). The country hosts a number of internal waters and other physical features like beaches, bushveld, coaster plain, desert, forest, grassland, hill, plateau, and mountains (CIA, 2020; GCIS, 2019; Grab and Knight, 2015). The map of South Africa as evident in Figure 5.1. offers additional insight on the location of major cities and human settlements in the country.

Figure 5.1: Map of South Africa



Source: UN (2020)

The entity that is now known as RSA today is a product of thousands of years of occupation of the affected territory by black Africans and their ancestors before the arrival of the whites from Europe and Indians from Asia. The waves of immigration and settlement in the southernmost part of Africa paved the way for the scrabbling, expropriation, and colonisation of South Africa by different European powers (capitalists and states) between the 17th century and the early 20th century (Feinstein, 2005; Landau, 2010; Thompson, 2000; Stephens, 2003). On May 31, 1910, four British colonies, including Cape Colony, Natal, Transvaal, and Orange Free State, formed the Union of South Africa, which became a republic on May 31, 1961. However, the apartheid regime, a system of socioeconomic and political segregation based on race, was maintained in the country (Beinart and Dubow, 1995; Seekings and Nattrass, 2005). This was the situation where the black Africans, who constitute the majority of the population, were perpetually subjugated by the whites, who constituted the minority, until majority rule was ushered in on April 27, 1994 and a non-racial constitution was adopted on December 4, 1996

(effective from February 4, 1997) (Clark and Worger, 2011; Cornell, 2014; Edigheji, 2010; Guelke, 2005; Lodge, 1989).

RSA's population is estimated to be 56,463,617 as at mid-2020, making it the 26th most populous country in the world (CIA, 2020). Official report, however, shows that the country is populated by 58.78 million in mid-2019 (GCIS, 2019). At the same time, AfDB et al. (2019) reported 58 million, which constitutes 4.4 per cent of the total population of the continent and made RSA the 6th most populous country in Africa. Amidst these, black African constitutes about 80.9 per cent of the population, while the coloured is 8.8 per cent, white is 7.8 per cent, Indian/Asian are 2.5 per cent (CIA, 2020; GCIS, 2019). South Africa's population structure is: 27.94 per cent are 0-14 years, 16.8 per cent are 15-24 years, 42.37 per cent are 25-54 years, 6.8 per cent are 55-64 years and 6.09 per cent are 65 years and above (CIA, 2020; World Bank, 2020). The population of the country is considerably literate, given 87 per cent literacy rate of adult of age 15 and above as at 2017 (World Bank, 2020). Gross primary education enrolment in RSA was 100.8 per cent, while secondary education was 104.7 per cent, and 22.3 per cent for tertiary education. Educational attainment of age 25 and above people include 0.31 per cent doctorate or equivalent and 1.46 per cent with at least master's degree or equivalent (World Bank, 2020). Accordingly, the country's labour force was 22.19 million, which was 29th largest in the world, with 27.5 per cent unemployment rate, in 2017 (CIA, 2020; GCIS, 2019; World Bank, 2020).

With a GDP of US$368 billion, which represents 15.8 per cent of the continental total, in 2018, South Africa is the second largest economy in Africa, a position it has retained since it was surpassed by Nigeria in 2013 (AfDB et al., 2019; World Bank, 2020). The economy depends largely on services, which contributed 68 per cent to the GDP in 2017. Equally, industries contributed 29.3 per cent to the GDP, including 13.4 per cent from manufacturing, while the agriculture only contributed 2.6 per cent (AfDB et al., 2019). The country is rich in diamonds, gold, iron ore, platinum, copper, uranium, and silver among others. However, the total natural resource rents only account for about 5 per cent of the GDP of the country. Amidst these, general government consumption expenditure was 21.28 per cent of the GDP in 2018. In the same year, the external debt of RSA was 46.3 per cent of the GDP, making it the 19th most alarming case in the continent. The GDP per capital of RSA was US$6,414, which makes it the fifth leading African country in this respect, in 2018 (AfDB et al., 2019; World Bank, 2020).

RSA has practiced popular democracy since 1994. The republic is structured as a quasi-federal system with a strong central government and nine subnational governments at provincial level (Fessha, 2010). The country operates a presidential system of government, and a National Assembly that is made up of between 350 and 400 members, which are elected for five years through proportional representation. In addition to these is the National Council of Province (NCOP), which is made up of 90 members (10 from each province) (GCIS, 2019). The political space of the country has been dominated by the African National Congress (ANC) since 1994, although the opposition parties are growing in significance in recent times. However, political stability and integration as well as development and security of RSA have been threatened to various degrees by corruption, poverty, inequality, youth unemployment, HIV/Aids, criminal and xenophobic violence (Amusan & Mchunu, 2017; Amusan, 2016; Bond, 2000; Hanoman, 2018; Pillay, 2014; Schulz-Herzenberg, 2007; Seekings and Nattrass, 2005; Tafira, 2018). These are relevant to understanding the development of space.

5.3. The Development of Space Politics and Policy in South Africa: The Historical, Political, and Socio-economic Perspectives to Space R&D

This section provides some insights into the development of space R&D in the framework of politics and policy in South Africa. It pays attention to the historical, political, and socio-economic contexts, determinants and factors that characterise the development of space R&D of the country. Compared to Nigeria, however, South Africa has richer, more complex and more contested history of active space programmes. In addition to its overt records of civil space programmes, as largely seen in the case of Nigeria, South Africa had a record of a covert space programme, which was integrated with nuclear and missiles programmes, and coordinated for defence policy and military purposes. These are connected to the complex and contested history of the country's socio-political development. To better understand these dynamics, this section will be subdivided into two: the first one will focus on the genesis of civil aspects of space programme of the country, with special attention to astronomy and basic space R&D. The second subsection focuses on the development of space R&D amidst the former missile and nuclear programmes of the country. The analysis covers the period before, during, and after the apartheid regime. Nevertheless, most details of the political and policy developments in relation to space R&D after the apartheid regime are reserved for the next section.

5.3.1. Astronomy and Basic Space R&D

Space R&D in South Africa, like in other African countries, have their distant origin in astrology and cosmological visions of different pre-colonial African societies that occupied the territory as well as cultures and traditions of many centuries before the arrival of the Europeans. In a similar Afrocentric narrative to the earlier identified case of Nigeria, the knowledge of space in this distant past was largely characterised by systems of belief, which included myths and rituals, that revolved around celestial bodies as well as their interactions with the Earth and influence on terrestrial affairs, including the origin, development, and fate of humanity (Holbrook, 2015; Holbrook et al., 2008; Mathenjwa, 1999; Urama, 2008; Urama and Holbrook, 2011). The knowledge produced in this process were largely passed from one generation to another through oral tradition, until contact with Europeans, which started the documentation of these ideas (Smedegar, 2007; Urama and Holbrook, 2011). This process was aided with the introduction of Western Education to South Africa.

Modern astronomy started in South Africa much earlier than in other parts of the continent. The strategic position of the country on the map as well as the favourable weather and the abundant natural resources in the region, attracted the attention, influx of European visitors, settlers, investors, and investigators, including in the area of astronomy and related scientific studies. As far back as the 1700s, several European scientists had visited the Cape of Good Hope and other parts of modern-day South Africa to conduct research, including in the area of geodesy and astronomy (Evans, 1967; Smedegar, 2007). Amidst these, Nicolas-Louis de La Caille, a leading French mathematician sponsored by the Royal Academy of Sciences in Paris (RASP), made the first deliberate expedition for astronomical purposes between 1751 and 1753. In this process, he determined the position of 9,800 southern stars and catalogued them, carried out a series of studies that significantly impacted the development of space sciences, and calculated the latitude and longitude of the Cape (Evans, 1967; Dubow, 2019).

With the defeat and occupation of Holland during the Napoleonic War, political control of Cape passed from the Dutch to the British, a process that was completed with a treaty of 1814 (Evans, 1967). With the rising scientific edge of the British over other European countries and the accruable political and economic benefits from the region, the Royal Observatory was established at the Cape by the government of the United Kingdom in 1820 (Cillie, 1973; Dubow, 2019; Evans, 1960; 1967). In 1834, Sir John Herschel — who was

earlier credited with the discovery of planet Uranus — and his wife and assistant, Margaret, arrived at the Cape, and soon established a private observatory. At the same time, he was elected as the pioneer President of South African Literary and Scientific Institution (LSI) in 1834. With a 20-foot reflector telescope, Herschel identified over 1,700 nebulae and 2,100 double stars, which had notable implications for the development of theoretical understandings of our Galaxy, the Milky Way (Dubow, 2019). Together with Thomas Maclear, the second head of the Royal Observatory at the Cape, Herschel equally studied comets (Dubow, 2019; Lastovica, 1995). These developments laid the foundation of modern space R&D in South Africa.

As at 1910, when the Union of South Africa was formed, the country had already become a notable hotspot in the global map of astronomy and related R&D. The geographical location of the country in the Southern Hemisphere, which is primarily comparable to that of Australia, New Zealand, Argentina, and Chile, is advantageous in astronomy, given the concentration of relevant facilities in the Northern Hemisphere. The dominion status of the country until 1961 also made it an important asset to the British empire. These among others attracted the influx of British among other European and later American space scientists and investment to the country. In this process, local capacity, mainly of the White settlers, was developed in space R&D. Prior to 1961, when the country attained a Republican status under White domination, several astronomical observatories had been established. Beside the Royal Observatory at the Cape, there were the Leiden Southern Observatory; Boyden Observatory at Bloemfontein, which was controlled by a consortium of five European nations; as well as a telescope of 74-inches reflector of the Radcliff Observatory at Pretoria (Cillie, 1973; Evans, 1960). A few American based institutions like Harvard and Yale also collaborated with and supported some of the projects of some of these observatories, as far back as the 1920s and 1930s (Cillie, 1973).

As of the 1950s, South Africa was at the hearth of the conception of Southern Skies in the northern hemisphere and associated international collaboration in astronomy. The launch of Sputnik by the Soviet Union, and associated Cold War implications for the US, also drew NASA close to South Africa in the late 1950s and 1960s. Accordingly, a 26-metre parabolic antenna, which was capable of deep space tracking of satellites and space missions, situated at Hartebeesthoek (HartRAO) was operated by South Africa for NASA from 1961. It equally collaborated with the Centre National D'études Spatiales (CNES), the French space

agency, to operate a satellite tracking station at Paardefontein from 1965 (Dubow, 2019). The strategic partnership boosted the prospects of radio astronomy in South Africa. In this way, the Very Long Baseline Interferometry (VLBI) was installed in HartRAO, with the support of the US and France. Between the 1960s and early 1970s, the British governments and scientific community also played important role to expand South Africa astronomical facilities as well as utilised and maintained the existing ones. These among other collaborations accounted for rapid development in basic space R&D in South Africa (Dubow, 2019; Warner, 2008).

Despite the foregoing progress, the global wave of nationalism and associated international campaigns against the apartheid regime of South Africa undermined the developmental trajectory of astronomy and basic space R&D in the country. In this way, many international partners were forced to withdraw their support for space R&D in South Africa. This was the case of partner universities in Sweden in 1966 as well as those in Western Germany and many in the US and other European countries in 1971 (Dubow, 2019). NASA withdrew its presence in the country thereafter. These among other things, created several vacuums in South Africa, to the benefits of its rival in Southern Skies, that is, Australia and to a lesser extent Chile. In response, the apartheid regime raised local capacity to operate existing facilities while it maintained and entered into new secrete agreement for scientific, cooperation with a few willing countries, of which France and Britain were prominent (Dubow, 2019).

As detailed in the subsequent section, apartheid South Africa's space programme became subsumed into, dominated by, and reduced to the pursuit of, defence and security interests, which is largely operationalised with the quest for space, missile and nuclear weapon capabilities, between the 1960s and 1980s. Nevertheless, the post-apartheid government of South Africa considerably demilitarised space programme in the country, and reinstated its R&D motives (Gottschalk, 2010; Martinez, 2009; 2016; Munsami, 2014; Van Wyk, 2009). These among others have repositioned astronomy of national development, South Africa for competitive advantage in Southern skies and associated international collaboration and investment. These are evident in many ambitious projects, of which SALT and SKA are prominent examples in this context (Dubow, 2019; Gastrow, 2015; Gastrow et al., 2016; Gastrow and Oppelt, 2019; Martinez, 2009; 2012a; 2012c; Twidle, 2019; Van Wyk, 2009; Walker and Chinigò, 2018).

5.3.2. Space, Missile and Nuclear Programmes

Besides astronomical observatories, South Africa also featured in other aspects of space R&D, that is, rocketry for space launch and missile capabilities and artificial satellite, earlier than many other African countries. The space age, which started with the successful orbiting of the first artificial satellite of the Earth by the USSR in 1957, was made possible with the breakthrough in rocket science and engineering, from where missile technology and orbital vehicles were developed. The age of modern rocket science and engineering emerged between the 1940 and 1990s, amidst which the 1930s marked the beginning of major rocket tests and flights in many of the leading countries in this consideration (Air Command and Staff College, 2009; Chertok, 2005; 2006; Chun, 2005; Van Riper, 2004). During the Cold War, this became a quest for trio-capabilities, that is, satellite, missile/space launcher, and nuclear weapons, for many countries. South Africa was not left out of this development. Between the 1960s and the late 1980s, the apartheid regime developed interests, institutions, and policy programmes for missile/space launcher, nuclear weapon and reconnaissance satellites, with varying, but remarkable, degrees of success (Albright and Stricker, 2016; Gottschalk, 2010; Howlett and Simpson, 1993; Purkitt and Burgess, 2005; Van Wyk, 2014a; UNDDA, 1991).

Rocket, space flight, and missile programmes of South Africa can be traced back to private civilian research and test flights that dated back to the late 1940s. Desmond Prout-Jones, the founder of the South African Rocket Research Group (SARRG), established in 1957, started to test-flight rocket in the country in 1947. The South African Interplanetary Society (SAIS) that was established in 1953 was another major player during this period. Between 1959 and 1963, the SARRG launched 528 rockets, which included two-stage, five-stage, supersonic two-stage and liquid-propelled rockets, and 102 firing tests, with varying degree of success. The final rocket launched by the group reached a 40 km altitude, and a 100 km altitude flight was planned before government explosive inspectors banned private rocketry (Gottschalk, 2010; Oyewole, 2017). Following the ban, the apartheid regime commenced a missile R&D programme in 1963, from where the aborted plan to develop space launch vehicle was conceived in the 1980s. During this period, the South Africa space programme was subsumed under defence policy and designed in close connection to the missile and nuclear weapon programmes of the country (Albright and Stricker, 2016; Van Wyk, 2014a; UNDDA, 1991).

As the wave of independence became obvious across Africa in 1960, the apartheid regime in South Africa was confronted with a series of internal and external security challenges. Internally, the regime was confronted with Black resistance to the imposed system of racial domination of the indigenous peoples that were the majority under the White minority rule (Clark and Worger, 2011; Guelke, 2005; Lodge, 1989; Mandela, 1995). The collapse of colonial powers in southern Africa, most especially of Portugal, replaced friendly colonial governments of neighbouring territories with hostile nationalist governments in the region. Accordingly, the internal resistance, which had both civil and military dimensions, drew massive support from multiple post-colonial states in Africa and the rest of the Third World countries, who were largely driven by nationalist government, as well as the Soviet Union and the eastern or communist bloc in the Cold War international system. These among others challenged the security, defence, and regional power projection of apartheid regime in South Africa (Jaster, 1989; Stapleton, 2010; Thomson, 2008; Warwick, 2009). In response to internal resistance, the regime adopted militarised policing against the Black population and counter-insurgency against their political movements, with limited success. These among others informed the ban on privately funded civilian rocket programme in the 1960s. However, the apartheid space, missile, and nuclear programmes were aimed to boost the defence posture of the country and serve as strategic deterrence against the frontline states and their ambitious allies, especially the Soviet Union and Cuba (Albright and Stricker, 2016; Goodson, 2012; van Wyk, 2010).

The foundation of South Africa's nuclear research and weapon programme was laid in the 1940s and 1950s, when the country was contacted for uranium exploration and supply by the UK and later the US, who were then interested in the global mapping and the control of deposits, exploitation and market of this precious product (Albright and Stricker, 2016; Purkitt and Burgess, 2005; Masiza, 1993). Accordingly, South African Atomic Energy Board (AEB) was established in 1948 and national nuclear R&D plan was adopted in 1959. With varying degrees of support of the US, Britain, France, Germany, Netherlands, Norway, and Israel among others, South Africa developed necessary human resources and infrastructure for its nuclear reactors and further research in this area in the 1960s (Albright and Stricker, 2016; Liberman, 2004; Purkitt and Burgess, 2005). These largely involved technological transfer, unknowing that it would be used for military purposes. As the regional security dynamics became more and more hostile to the apartheid regime in the

1960s and 1970s, South Africa initiated a process to militarise and weaponise its nuclear R&D (Albright and Stricker, 2016; Burgess, 2006; Cochran, 1994; Goodson, 2012; Purkitt and Burgess, 2005; van Wyk, 2010). Amidst these, Pieter W. Botha played a critical role, first as South Africa's Defence Minister (1966-1978) and later as Prime Minister (1978-1984) and President (1984-1989).

In 1977, the first South African nuclear gun device was produced, and the Armaments Corporation (Armscor), which had been the statutory department for arm-procurement of the South African Defence Force (SADF), prepared for its test. However, the launch site and the preparation around the facility were uncovered by the Soviet satellites, coupled with details from its intelligence within SADF (Bidgood 2016; Polakow-Suransky, 2010; Masiza, 1993). The USSR shared the details of this intelligence with the government of the US, which also carried out independent efforts to verify the report; and they played critical roles in the international pressure that was mounted against South Africa to denuclearise (Asuelime and Adekoye, 2016; Bidgood, 2016; Moore, 1987; Polakow-Suransky, 2010; Van Wyk, 2007). Despite the international pressure, the apartheid regime made further progress in its R&D of nuclear weapons between 1977 and 1990 (Albright and Stricker, 2016; Burgess, 2006; Masiza, 1993; Thomson, 2008; UNDDA, 1991). In 1993, South African President F.W. de Klerk acknowledged that the country spent about 800 million rand (about US$400 million) on its nuclear weapon programme, and built six nuclear devices and almost completed the seventh device (Masiza, 1993; Purkitt and Burgess, 2005).

Recognising the challenges of air power in delivering nuclear strike generally, and the limited air power capabilities of the country as well as the then rising air defence capacities of Angola and some other frontline states, the regime also prioritised militarisation of rocket R&D for long-range missile and nuclear delivery system (Anderson and Bell, 2019; Baxter, 2012; Bin, 1997; IISS, 1970-1989; Stapleton, 2010; Van Wyk, 2014a). With the initial support from France and enduring close collaboration with Israel, South Africa recorded significant progress in its missile programme. The country started production of short-range tactical missiles in the mid-1960s, from where Valkiri surface-to-surface artillery rocket with 22 km-range and V3 Kukri air-to-air missile that ranged from 4 to 10 km, were inducted to SADF service in the 1980s (UNDDA, 1991). Between the 1970s and 1980s, the apartheid regime in South Africa acquired prototypes and production details of Jericho-2, a missile of 1,300 km range and 1,000–1,500 kg payload capacity from Israel, which was converted to

a space launch vehicle by the Jewish State in the late 1980s (Harris et al., 2004; Liberman, 2004; Gottschalk, 2010; Polakow-Suransky, 2010). Amidst these, South Africa developed a series of ballistic missiles – including intermediate range RSA-1 and RSA-2, with warhead mass of 1,500 kg and trajectories of 1,100 km and 1,900 km respectively — and RSA-3 and 4, which were planned and designed on Israeli models to serve as space launch vehicles for a reconnaissance satellite (Gottschalk, 2010; Van Wyk, 2014a; UNDDA, 1991).

In March 1966, the South African Council for Scientific and Industrial Research (CSIR) was commissioned by the Ministry of Economic Affairs and Technology to carry out a feasibility study of a totally indigenous space programme. When the details of the report were made public in 1989, it was observed that CSIR recognised that the countries have human and technical capacities, but the financial cost was too high to bear for the economy at the time (UNDDA, 1991). Although the programme was downplayed in the 1960s, both external and internal factors restored it to policy priority in the 1970s and 1980s. Externally, the critical roles of the Soviet satellites, and later the US air and space assets, in intelligence that uncovered a series of South Africa's missile test-flights and internationally controversial nuclear weapon test-plans made lasting impression, which were difficult to forget and ignore for the apartheid regime (Asuelime and Adekoye, 2016; Bidgood, 2016; Polakow-Suransky, 2010; UNDDA, 1991). Moreover, the rise in military capabilities, especially air defence systems and power projection of Angola, and associated build-up of alliance with the USSR and Cuba among other states, undermined South Africa's air power capacity that was critical to its national defence, security, and power projection in the region (Baxter, 2012; George, 2005; Joubert, 2019; Leonard, 1983; Minter, 1994; Stapleton, 2010; IISS, 1970-1989). The progress recorded by South Africa's ally, Israel, in launching a satellite into orbit also encouraged the regime for this mission (Gottschalk, 2010; Polakow-Suransky, 2010).

Internal pressure from the Defence Department for locally owned and controlled satellites for C4ISR was salient in South Africa in the 1980s (Albright and Stricker, 2016; Hamann, 2001; Gottschalk, 2010). Although the country was already utilising satellite data purchased from commercial agents like Intelsat, pressure from academic community, space enthusiasts, corporate bodies, and government departments also made independent capacity in satellite programme desirable for weather forecast and communication in the apartheid regime in the 1980s (UNDDA, 1991; Gottschalk, 2010). These among others raised the

strategic importance of a satellite programme in the country in the 1980s and 1990s. Accordingly, the country initiated a Greensat programme, with the plan to launch an Earth Observatory satellite into orbit between the late 1980s and 1990s. This idea evolved from the initial plan to launch a military reconnaissance satellite aboard RSA-3, a solid-fuel orbital launch vehicle, or a solid-propellant RSA-4 (Alberts, 2019; Gottschalk, 2010; Van Wyk, 2014a).

Despite the foregoing, political and security dynamics in and around South Africa changed drastically, with significant implications for its nuclear, missile, and space programmes, in the1990s. In 1989, Botha suffered a stroke and resigned as the leader of the National Party (NP) and President of South Africa, and was succeeded by a liberal reformer, Frederik Willem de Klerk, instead of his favoured successor, Barend du Plessis. Faced with internal resistance, the pressure of international anti-apartheid coalition, the global wave of democracy and the receding Cold War threat of Soviet soon after resuming office, de Klerk initiated the process of transition to majoritarian democracy as well as reintegration and repositioning of the country in the international community from 1990 (Berger, 2009; Mandela, 1995; Sonneborn, 2010). The end of Cold War and the collapse of the Soviet Union allayed the fear of the communist superpower, which necessitated South Africa's nuclear, and to an extent missile, programme and associated deterrence policy. The political transition from apartheid regime to multi-racial and majoritarian democracy in South Africa between 1990 and 1994 eliminated the core basis for internal and regional resistances, which attracted the intervention of external powers and undermined the defence and national security of the country (Clark and Worger, 2011; Dzimba, 1998; Jaster, 1989; Mandela, 1995; Minter, 1994; Thompson, 2000).

Due to the foregoing, the transitional government of South Africa entered into negotiation with relevant actors of international community to display commitment to peaceful co-existence among nations, as well as to redeem the image of, and clear the sanctions against, the country. In this process, the nuclear programme was terminated in 1990 and weapons were unilaterally destroyed. The country's nuclear facilities were opened up to international inspection, and whole denuclearisation was overseen by the International Atomic Energy Agency (IAEA) (Busch and Pilat, 2014; Heinonen, 2016; Howlett & Simpson, 1993; Pabian, 2015; Van Wyk, 2014b). The transition government equally gave up its medium-range missiles as well as the quest for long-range missiles and space launch vehicles

(Gottschalk, 2010; Van Wyk, 2014a). Amidst these, the country only retained capacity to produce tactical missiles. When the RSA programme was cancelled, the prospect of the satellite that was built in this process was also affected, and the efforts to transforme the project into civil and commercial satellite recorded limited progress (Gottschalk, 2010). The transitional and post-apartheid governments signed relevant international treaties to further display their commitment to peaceful use of space and nuclear R&D (Alberts, 2019; Grobler, 1996; Van Wyk and Van Wyk, 2015; Van Wyk, 2008a; 2009).

The denuclearisation and the general demilitarisation of South Africa, including its space programme by the transitional and post-apartheid government was justified as prudent and a source of soft power for the country (Busch and Pilat, 2014; Cock and Mckenzie, 1998; le Roux, 1999; Onderco and Van Wyk, 2019; Pabian, 2015; Van Wyk, 2012 Paul, 2000). Amidst these, the huge cost of military expenditure under the apartheid regime could not be ignored or underestimated. Between 1971 and 1989, South Africa spent over R 63.5 billion (US$ 43.1 billion) on its military. With the average of 3.8 per cent of the GDP, when the general government consumption was 14.6 per cent of the GDP, military expenditure averagely stood at 25.8 per cent of government expenditure during the 19 years period (World Bank, 2020). The post-apartheid South African government is more concerned about national integration and development, poverty alleviation, equality, political stability, peaceful settlement of dispute, and international cooperation (Bond, 2000; Cawthra, 1997; Cock and Mckenzie, 1998; le Roux, 1999; Edigheji, 2010; Fessha, 2010; Hanoman, 2018; Orman, 2008; Shapiro and Tebeau, 2011). Although the post-apartheid government has spent R 79.3 billion (US$ 65.4 billion) on defence between 1994 and 2018, the military expenditure is averagely 1.36 per cent of the GDP during the 24 years (World Bank, 2020).

Despite the demilitarisation of South Africa's space programme and its reversal of associated aggressive quest, the country has developed a new road map and course of action in this consideration. Although the orbital launcher and satellite programmes were halted, suspended or cancelled during the transition, the post-apartheid government inherited relevant history, institutions, infrastructures, and human resources that are required to developed befitting space policy and capabilities. These among other resources have been applied to varying degrees of success by the post-apartheid government of South Africa to advance the national and human development and security interests of the country. The pressure from relevant government departments (as it will be shown later) and the scientific

communities locally, as well as international trends in space S&T and associated geopolitical dynamics, played major roles in setting the space policy trajectories of post-apartheid regime in South Africa (Gottschalk, 2010; Martinez, 2009; 2012a, b & c; 2016; Munsami, 2014; Van Wyk, 2009). Subsequent sections of this chapter will examine the policy interests of the post-apartheid government of RSA. These are important to the subsequent efforts of this study to assess the contributions of these policy initiatives to the development and security of the country.

5.4. Space Policy and Strategies of South Africa

The space policy and strategies of South Africa are products of the politics, history, and socioeconomic development of the country, which are largely presented in the last section. At the same time, they are reflections of the past, present, and future efforts and aspirations of the government and people of the RSA in development and security. As earlier mentioned in the last chapter, the efforts to understand the policy and strategies of this country in space cannot be completed outside the contexts of their grand strategies and policy framework. Accordingly, this section examines South Africa's space policy aim and objectives in the context of development and security agendas and the extant laws of the country. This section will be divided into two sub-sections: the first one will focus on constitutional and legislative framework, while the second one will focus on the strategic policy framework.

5.4.1. The Constitutional and Legislative Framework of South Africa's Space Policy

The 1996 constitution of South Africa provides some clues on the aspirations of the people and government of the country, which must be promoted in all frontiers, including space exploration. Section 7 (2) of the constitution mandated the state to "respect, protect, promote and fulfil the rights in the Bill of Rights", which section 8 (1 and 2) made to be binding on all organs of the state (the legislature, the executive, and the judiciary) and a natural or juristic person within the country (RSA, 1996). Accordingly, sections 9-35 mandates all state and individual actions to respect, protect, promote, and fulfil the right of every one – to equality, human dignity, life, privacy, citizenship, security of the person, labour relations, harmless and secure environment, property, political choice, housing, health care, food, water and social security, children, education, language and culture, cultural, religious and linguistic communities, access to information, just administrative action, access to courts—

as arrested, detained and accused persons, as well as freedom – of religion, belief and opinion, expression, movement and residence, association, assembly, demonstration, picket and petition, trade, occupation and profession, and – from slavery, servitude and forced labour (RSA, 1996). These can be regarded as a considerable representation of South Africa's national conception of development and security interests of the people and government.

Beside the constitution, RSA has a series of space and related legislations that defines the policy and strategic directions of the post-apartheid government of the country in engagements with the final frontier of development and security. Earliest among these legislations is the South African Space Affairs Act (SASAA) of 1993. As evident in Section 2 (1), the Act has two major objectives. First, to meet all the international commitments and responsibilities of the state in respect to peaceful utilisation of outer space, in order to be recognised as a responsible and trustworthy actor in this consideration. Second, to control and restrict the development, transfer, acquisition and disposal of dual-purpose technologies, in accordance with the terms of international conventions, treaties, and agreements entered into or ratified by the government of the country (RSA, 1993). The Act established the South African Council for Space Affairs (SACSA), which is charged with the responsibility to advice the government, as well as encourage, supervise, implement, license, and oversee all space activities in the country. The number and composition of the Council are left for the unspecified relevant Minister to decide. Notably, section 11 banned all forms of launch activities within RSA, or outside of its territory by registered person in the country, without appropriate licencing (RSA, 1993).

In an attempt to satisfy the international pressure and demands on the RSA in the early 1990s, those that were involved in the conception of SASAA of 1993 arguably underestimated the interests and prospects of post-apartheid regime in space exploration and exploitation, as they largely focused on limiting space and related activities more than promoting them in the country. Accordingly, this Act does not provide the country with coherent space policy or a framework to initiate a space programme. The attempts to address these challenges can be said to have started with pressure from different departments of government and scientific communities, which produced some initiatives taken by the executive arms of government since 2000, as it will be shown later (Martinez, 2009; Van Wyk, 2009). In December 2005, however, the cabinet approved the proposal to establish

SANSA, which was later supported with the legislation of South African National Space Agency (SANSA) Act of 2008. The objective of this Act was clearly stated as follows:

> To provide for the promotion and use of space and co-operation in space-related activities, foster research in space science, advance scientific engineering through human capital, support the creation of an environment conducive to industrial development in space technologies within the framework of national government policy, and for that purpose to establish the SANSA; to provide for the objects and functions of the Agency and for the manner in which it must be managed and governed; and to provide for matters connected therewith (RSA, 2008).

The 2008 Act established the SANSA, with the objectives of promoting peaceful utilisation of space; research in space science, communication and navigation; conducive environment for development of space industry; human capital development and infrastructure in space in advance scientific, engineering and technological competences; and international cooperation in space activities (RSA, 2008). The SANSA has the primary responsibility to implement strategy and programme for space activities, which it has to advise the Minister and the government generally on their design, in accordance with adopted national policy. This Act was equally supported by other relevant legislations, including the Astronomy Geographic Advantage Act (Act No 21 of 2007) that was assented to in June 2008 as well as the likes of the Technology Innovation Agency (TIA) Bill of 2007 (Van Wyk, 2009).

Due to the gap between the existing laws and need/reality of the country, the South African Department of Trade and Industry (DTI) commissioned a study in 2012 to review the SASAA. After a series consultation in 2013 and 2014, SACSA established a six-member Ad Hoc Committee to review the Act. The Committee was later dissolved after Inter-Departmental Working Group was established in 2015 with representatives from DST, DOD, SANSA, Department of International Relations and Cooperation (DIRCO), Department of Justice and Constitutional Development (DoJ & CD), Department of Telecommunications and Postal Services (DTPS) and Aerospace Maritime & Defence Industries Association (AMD) (Majaja, 2015; Majaja et al., 2015; Majaja and Maruping, 2017). The Working Group mapped out the areas of inadequacy of the SASAA in its report of the first sitting in April 2015, which was presented to the Portfolio Committee, before it had two more meetings in May and September as well as drafting a new bill in June and

public consultation in July/August. As at early 2020, the process of repealing the SASAA remains yet to be completed (SANSA, 2020a).

As evident in extant laws and relevant strategic policy documents adopted by the country, the government of South Africa put strong emphasis on its international commitments (RSA, 1993; 2008; DTI, 2009; Alberts, 2019; Majaja, 2015; Majaja et al., 2015; Majaja and Maruping, 2017; Van Wyk, 2009). As a result, international conventions and treaties on space signed, ratified, and entered into by the country cannot be ignored in this consideration. Table 5.1 provides a summary of some of these international commitments.

Most especially since 1994, the government of South Africa has equally adopted recognised, identified with, and supported the 11 UN declarations, resolutions, and principles on outer space, which are not legally binding but are persuasive and are increasingly considered as international space norms and custom (Alberts, 2019; Majaja, 2015; Van Wyk, 2009). Prominent among these principles are the International cooperation in relation to the peaceful uses of outer space—Resolutions 1721 A and B (XVI) (1961); Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space (1963), the Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television Broadcasting (1982), the Principles Relating to Remote Sensing of the Earth from Outer Space (1986), the Principles Relevant to the Use of Nuclear Power Sources in Outer Space (1992) (Alberts, 2019; Van Wyk, 2008a; 2009; UN, 2002). These among other things provide the bases for South Africa's space policy and strategies.

Table 5.1: The Status of South Africa in International Convention and Treaties on Outer Space

Treaties	Details of treaties	Status
Outer Space Treaty	Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, entered into force on 10/10/1967.	Signed on 01/03/1967 & ratified on 30/09/1968
Rescue Agreement	Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects launched into Outer Space, entered into force on 3/12/1968.	Signed on 06/08/1968 & ratified on 24/09/1969
Liability Convention	Convention on the International Liability for Damage caused by Space Objects, entered into force on 1/9/1972.	Signed on 29/03/1972 & ratified on 14/12/2011
Registration Convention	The Convention on Registration of Objects Launched into Outer Space, entered into force on 15/9/1976.	Signed and ratified on 27/01/2012
Nuclear Test Ban Treaty	Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and under Water, entered into force on 10/10/1963.	Signed & ratified on 10/10/1963
ITSO	Agreement relating to the International Telecommunications Satellite Organisation (ITSO), entered into force on 12/2/1973.	Signed on 20/08/1971 & ratified on 12/02/1973.

Source: Compiled from Alberts (2019), Majaja (2015), and Van Wyk (2009).

5.4.2. The Strategic Policy Framework of South Africa's Space Programmes

The post-apartheid government of South Africa inherited disparate space institutions, initiatives, and programmes, which are begging for policy direction and coordination. Amidst these, the pressure on the policy makers started to yield results for the development

of national space policy in the early 2000s. A major turning point in this consideration was 2003, when an inter-departmental National Working Group on Space Science and Technology (NWGSST) was established, with representatives drawn from Departments of Communication, Foreign Affairs, Science and Technology, as well as Trade and Industry (Martinez, 2009; Van Wyk, 2009). Another milestone was recorded in 2005, when the DTI released a South African Space Roadmap 2005-2014, with the aims to establish a space agency, develop a space policy and strategy, develop space outreach and capacity building programmes, develop space industry and commercial programme, develop aeronautic and defence strategy, review SASAA, launch a micro-satellite, develop African constellation, among others (Van Wyk, 2009). The DTI also commissioned a consortium to develop National Space Policy Framework in 2006.

In 2009, a 12-page document was published as South Africa's national space policy. The policy statement of the document recognised that the country had several space institutions and programmes that were not well coordinated and managed. Therefore, guiding policy and institutional frameworks were considered as necessity to streamline the development of capabilities, cooperation and utilisation of outer space for maximum benefits (DTI, 2009). The document identified six policy principles, including commitments to the following:

(1) the use of outer space for peaceful purposes and benefit of all human;

(2) development of robust space capabilities, services, and product to support national priorities coordination and cooperation in governance;

(3) responsible behaviours of private and public sectors in space environment in accordance to national legislation and international best practices;

(4) promotion of R&D in space science and technology;

(5) development of domestic industry to achieve greater national self-reliance in space technology;

(6) international cooperation for mutual benefit and peaceful utilisation of space, with emphasis on cooperation with African nations to extend the benefits of space technology to the continent (DTI, 2009).

In addition to the six driven principles of the South Africa's space policy, the document also identified eight policy objectives, which tend to restate some of its principles. As a result, the government of the country set out to improve coordination of space arena, promote the creation and implementation of relevant regulation to support industrial participation in space arena, foster a robust S&T based higher education and research institutions, promote capacity building initiatives, promote the development of appropriate and competitive commercial space sector to provide the required industrial base for the country in space R&D, promote greater awareness of space S&T and associated benefits at all levels of South African society, provide appropriate and adequate space capabilities to support national and foreign policy objectives, as well as to promote improved mutually benefiting international cooperation in peaceful utilisation of outer space (DTI, 2019). Table 5.2 provides a summary of goals and strategies mapped out as general implementation guideline of the space policy.

Table 5.2: The Goals and Strategies of South Africa's Space Policy

No	Strategic goals	Strategic details
1	Development of space capabilities	Addressing national capability requirement in key areas, such as manufacturing, access to space, space science and technology, and human capital.
2	Strengthening of space science and technology base	Maximation of the capacities of research and higher institutions to support space activities.
3.	Development of national space infrastructure	Acquisition and maintenance of various ground facilities, such as facilities required for satellite assembly, testing and integration (ATI), as well as facilities to support flight testing and space launch activities.
4	Promotion of domestic space industry	Development of industrial framework, building capacity in the domestic industry, creating a supporting regulatory environment for national space activities, managing innovation and technological transfer to and from the space

		sector, as well as promoting the competitiveness of space industry.
5	Promotion of enhanced space awareness at all levels	Sustained and integrated efforts of different government departments, agencies and other space actors to communicate to all levels of the society their activities and their contribution to public goods.
6.	Enhance international cooperation	Pursue appropriate and mutually beneficial international co-operation opportunities in space R&D according to consistent with its foreign policy objectives (African agenda, and South-South and North-South cooperation) and international obligations; Areas for international co-operation include space science and exploration, Earth observation, communications and positioning, timing and navigation; Active participation in regional and global multilateral fora for the peaceful uses of outer space.
7	Funding and investment	Public investment in critical space applications that offers broad societal benefits in the interest of the public; public investment in space infrastructure to create conducive environment for the development of private sector, encourage space tourism and better position the country in the regional and global arenas.
8	Monitoring, evaluation and review of the policy	DTI will put mechanism in place to assess the implementation of the policy every ten years, or anytime as deem fit by its Minister.

Source: designed by the author with data from DTI (2009).

Beside the national space policy, the DST developed and released the National Space Strategy, equally referred to as National Space Science and Technology Strategy (NSSTS), which was approved by the Cabinet (SANSA). This undated 19-page document was apparently published between 2007 and 2009. Among other things, the document covers the strengths and weaknesses, opportunities and threats, and strategic contexts of space activities in South Africa; the highly motivated personnel, industrial capacity as well as the experiences and connectivity of various private corporations, research institutions and universities in space activities as the strengths of the country (DST, nd). However, inadequate organisation and coordination of space activities; absence of formalised quality and reliable rules as well as applicable standard in engineering and manufacturing of space products and delivery of related services; and lack of commitments to R&D by private sector are major weaknesses. Amidst these, the level of industrial capabilities for system design and integration; prospects of partnership with MNCs among other international agencies; potential to develop export market from existing facilities and capabilities; and expectation that universities can support industrial development in space sectors are opportunities for the country (DST, nd). The only threats that the sector was considered to be faced with is the investment risk of entering a new business domain like space as well as insufficient and emigration of skilled personnel and the challenges of recruiting required foreign specialists in South Africa (DST, nd).

The National Space Strategy also covers the strategic context for space activities of the RSA, which include details on the vision, mission, goals, and objectives of the country. In this consideration, the strategic vision is to position the republic among the leading nations in the innovative utilisation of space science and technology to enhance economic growth and sustainable development and thus improve the quality of life for all (DST, nd). Moreover, three strategic goals and eleven objectives were mapped out for the country. The following are the three strategic goals in space identified by DST (nd):

1. To capture a share of global market for small to medium sized space systems in order to support the establishment of a knowledge-based economy through development of innovation and industrial competitiveness.
2. To empower the country with better decision-making capacity through the integration of space and ground-based systems that generate accurate and timely information.

3. To utilise space science and technology to develop applications that are relevant for the provision of geospatial, telecommunication, timing, and positioning products and services.

These goals are further deconstructed into 11 objectives. These are to develop or promote (1) local private space science and technology industry sector;

(2) services and products that can respond to user needs;

(3) export market for specific equipment for satellite or services offered from existing facilities;

(4) existing space S&T activities into strategic programmes;

(5) optimum organisation of future space activities to respond to opportunities with international space agencies and industrial partners;

(6) partnerships with established and developing countries in space for the purposes of industrial and capacity development;

(7) appropriate training and technology transfer programmes, including the sharing of experience and expertise;

(8) space S&T in academic institutions and research centres for the provision of opportunities for both short-term and long-term training and education;

(9) responsive capacity to challenges and opportunities in Africa;

(10) advocacy for space S&T and its importance as a priority measure for meeting national development needs; and

(11) capacity to build local awareness of space science and technology and its benefits (DST, nd).

In addition to these, the document identified areas of priority for South Africa's space policy, as summarised and presented in Table 5.3.

Table 5.3: Summary of Key Areas of Priority in South Africa's Space Policy

Key Areas of Priority	Sub-areas of priority
Environmental resource management	I. Environmental and geospatial monitoring II. Ocean, coastal and marine management III. Land management IV. Rural development and urban planning V. Topographic mapping VI. Hydrological monitoring VII. Climate change mitigation and adaptation VIII. Meteorological monitoring
Health, safety and security	I. Disaster monitoring and relief II. Hazard forecasting and early warning III. Cross-border risks IV. Disease surveillance and health risk V. Asset monitoring VI. Regulatory enforcement VII. Defence, peacekeeping and treaty monitoring
Innovation and economic growth	I. Tourism and recreation II. Communications III. Space science and exploration IV. Space technology transfer and spin-offs V. Development of the space industry

Source: developed with data extracted from DST (nd).

The priority areas are expected to be delivered through space programme, which entail basic areas like earth observation, navigation, communication, and space science and exploration; supporting platforms, which include human capital, infrastructure and international partnerships; as well as space awareness. Functional programmes for enabling technologies, mission development, space mission operation and space mission applications are considered to be critical in this consideration (DST, nd). These among other details on space

policy, strategies, and programmes have appeared and have been restated, revised, expanded and updated in many other official documents. Prominent among these are series of sub-sectional strategic documents, annual reports, strategic plans and performance plans that are published by DST and SANSA (see DST, nd2&3; SANSA, 2013/2014; 2015a; 2019a; 2020).

South African national space policy and strategies cannot be fully understood outside the national development and security priorities that it ought to advance. In this consideration, the government of the RSA adopted a National Research and Development Strategy in August 2002. The strategic document lamented the declining state of R&D in the country, most especially in the 1990s. It called for urgent need to address the challenges of R&D, which include appropriate funding of national system of innovation, human resources, areas of strategic considerations, declining R&D in private sector, intellectual property questions, as well as fragmentation of governmental measures on science and technology (Government of the RSA, 2002). In line with this, the document set the following strategic objectives and priorities for the country: to achieve mastery of technological innovation and change in society and economy, increase investment in science-based human capital and national transformation, as well as to create effective government institutions that can align and deliver science and technology system (Government of the RSA, 2002). Amidst these, the document acknowledged the progress made by the US, the former USSR and European countries in space programme among other R&D initiatives in S&T, and the implications of the progress recorded for their various societies (Government of the RSA, 2002).

The South African Defence Review of 2015 equally emphasised the developmental nature of the state and the need to protect it. The review identified four strategic goals and 13 tasks for the national defence of the country. The goals are to defend and protect the RSA, safeguard the RSA, promote peace and security, as well as developmental and other ordered tasks (DOD, 2015). To defend and protect South Africa, the review prioritised deterrence and prevention of conflict, protection of national interests, and defence of the country. To safeguard South Africa, the tasks are to safeguard the borders and critical infrastructures, cooperate with the police services and endure information security. Promotion of strategic influence as well as contribution to peace and stability are essentials to achieve goal three: promotion of peace and stability, most especially internationally. Developmental and other ordered tasks were broadly defined in the review as execution of relevant treaty obligations,

performance of ordered presidential tasks, assist civil authority as well as contribution to the development of South Africa and its people (DOD, 2015). Although without much emphasis, DOD (2015) recognised the relevance of space assets and programme amidst air, land, maritime, and cyberspace assets to achieve the desired defence and security objectives of the country.

5.5. Conclusion

This chapter provides some insights on South Africa's space policy and strategies, their place in the country's conceptions and quest for development and security, as well as how they are shaped by political, historical, and socioeconomic trajectories. It can be observed that the national conceptions of development in South Africa reflected some of the conceptual perspectives recognised in chapters one to three of this study. The ends of development of the RSA reflected economic growth, transformation, catch up, industrialisation, liberalisation and privatisation, resource management, socio-political modernisation, national capacity, human and community flourishing, enlargement of people's choice, as well as sustainability. The conceptions of security in the country also covers elements of national and human dimensions of security, as earlier detailed in chapter one, two, and three. The conception of space support for these development and security goals aligns with utilitarian framework of this analysis, and different objectives in this context reflected the orientations of subordinate theories (realism, liberalism, dependency and constructivism) adopted in this study, as evident in chapter three.

Against this background, this chapter can be considered as an attempt to answer the South Africa aspect of the first and second research questions of this study, and provide some of the bases for questions three and four. Accordingly, this chapter provides the basis for this study to assess the contributions of space policy programmes to development and security in South Africa in chapter seven, and to draw conclusion and recommendations in chapter eight. Prior to this, however, the sixth chapter of this study will first examine the contributions of space policy programmes to development and security in Nigeria.

CHAPTER 6

The Contribution of Space Policy Programmes to Development and Security in Nigeria

6.1. Introduction

This chapter examines the implementation of Nigeria's space policy programmes and their contributions to the development and security aspirations of the people and government of the country. In this process, the chapter relies on established theoretical understanding of development and security as covered in chapters one to three, as well as the operating ideas or national policy and strategic conception of the subject matter in Nigeria, as evident in chapter four. The outcome of these can be summarised into broad perspectives, which will be adopted to guide the structure of this chapter and the next one. On one hand, space policy is an end in itself; in this case, development of space programmes and capabilities constitutes an aspect of national development and security goals. On the other hand, space policy is a means to an end; in this case, space programmes and capabilities are supposed to support critical goals and objectives of national development and security policies and strategies.

Beside this introduction, this chapter is further divided into three broad sections. The first among these sections deals with space policy programmes and capabilities as part of the objectives of national development and security strategies to be achieved in Nigeria. The second section seeks to examine how the existing space policy programmes and capabilities in Nigeria have contributed to the broader national development and security objectives of the country. This is followed by the last and concluding section of this chapter.

6.2. Space Policy as an End in Itself: Space Programmes and Capabilities as National Development and Security Goals in Nigeria

Many studies have shown that becoming a spacefaring nation or climbing space technology ladder, even with basic capabilities, have become a subject of national development, and in some cases, security objectives, most especially for the developing countries (Argoun, 2012; Harding, 2013; 2016; McKenna-Lawlor, 1998; Mistry and Gopalaswamy, 2012; Wood and

Weigel, 2011; 2012a; 2014). The relevance of this position in Africa has been confirmed in many studies (Abiodun, 2008; Froehlich and Siebrits, 2019; Luncedo and Gottschalk, 2013; Martinez, 2012a &b; Munsami and Offiong, 2017; Oyewole, 2017; 2020a; Wangari, 2016). In this case, the utilitarian idea of space is driving an objective that reflects the proposition of the dependency school of thought, that is, for developing countries like Nigeria to develop local and independent capacity in space R&D. As evident in chapter four, Nigeria's national policy and strategies emphasise capacity building as a developmental interest to be achieved first in order to be able to utilise space for its broader development and security objectives.

Space policy cannot be reduced to stated objectives and cannot be fully understood without recourse to its operationalisation, that is, the resources devoted to making it a reality. The extent to which the objectives have been operationalised equally constitutes a considerable aspect of development. Besides, the contributions of space policy to development and security of Nigeria cannot be assessed outside the context of programmes and capabilities that have been developed by the country in this area. Space programmes and capabilities entail the institutions, activities, assets, human resources, funding, and skills among other resources that are made available to operationalise the space policy aspiration of a state. As evident in chapters one to three, these resources are recognised in literatures as elements of national development, and in some cases, human development. Moreover, this section equally offers an opportunity to examine the input, or some of the efforts that are committed to operational realisations of space policy as well as its development and security objectives in Nigeria.

It is against this background that this section is broadly sub-divided into two. The first of these sub-sections deals with institutional development for space policy programmes in Nigeria. The second sub-section focuses on the development of relevant resources that are critical to the mobilisation capacity of established institutions in Nigeria's space policy programmes.

6.2.1. Institutional Development for Space Policy Programmes in Nigeria

Institutionalisation is an important component of development. Some proponents of the liberal school of thought, as evident in the theoretical review of this study (chapter one to three), consider institutions as the building block of development. In this case, many

students of space policy and politics believe that development of space institution is a key step in the developmental path of space R&D for aspiring and developing nations (Martinez, 2009; 2012b; 2016; Shabbir and Sarosh, 2018; Wood and Weigel, 2011; 2012a; 2014; van Wyk, 2009). Without relevant institution, a nation cannot be said to have a space programme, as all space activities emanating from such country can be considered as sporadic, unintended, ad hoc, and un-coordinated for maximum utility. Accordingly, development of space institution cannot be ignored in the assessment of benefits derived by a country in, from, and through space.

A nation's space institution broadly covers publicly owned (by the state or governmental and non-governmental) and private organisations. While NGOs and the private sector can play important roles in a nation's space policy, governmental institutions are critical to create and maintain enabling environment for them to thrive as well as to coordinate their activities among others to advance national interests. In view of these, this section is further divided into two sub-sections: the first one deals with the development of governmental institutions, while the second one focuses on NGOs and private sector development, for space in Nigeria.

6.2.1.1. Development of Governmental Institutions for Space Policy Programmes in Nigeria

Nigeria's space policy is currently operationalised through three broad categories of space programmes: civil, commercial and military programmes. In all these cases, the FGN has institutionalised these programmes, as specialised institutions have been developed for each of them. Accordingly, Table 6.1 offers a summary of government space programmes and the institutions developed for these purposes in Nigeria. It is against this background that this section is further sub-divided into three sections. The first one deals with government owned civil space institutions and some of their leading collaborating local institutions. The second section focuses on the government owned commercial entities, while the third section examines available state institution for military space programmes in Nigeria.

Table 6.1: State-Owned space institutions in Nigeria

Space programmes	Institutions and Centres
Civil space institutions	NASRDA and affiliated centres: NCRS, CSSTE, CSD, CSTP, CGG, CBSSA, CAR, CBSSA, AAEL, ASTAL, COPINE, ISSE, & ZASTA; autonomous centres: CESRA, SEERL & SWAP. Major collaborating institutions locally: UNN, OAU, UNILAG, UNIJOS, FUTA, FUT Minna, RSUST, NMA, UNIBEN, & BUK etc.
Commercial space institutions	NIGCOMSAT Ltd; Geo-App Ltd.
Military space institutions	DSA and affiliated centres

Source: Compiled by the author

6.2.1.1.1. Development of State Institutions for Civil Space Programmes in Nigeria

NASRDA was created in 1999 as the central institution that is mandated to implement and operationalise the Nigeria's space policy and strategy. With this development, Nigeria became the first African country to establish a full-fledged space agency (and not a centre for remote sensing among other things) and resultantly institutionalised its programmes. Similar agencies were only established by Nigeria's regional peers, that is, other leading African nations in space thereafter: Algeria in 2002, South Africa in 2005 and Egypt in 2019 (Martinez, 2009; Oyewole, 2017; 2020a; Van Wyk, 2009). NASRDA has the responsibility to coordinate existing and emerging space institutions, facilities, and programmes in the country. This responsibility was however limited to civil space R&D programmes with the rise of commercial and defence space programmes and associated institutions in the country.

NASRDA is structured into Headquarters (HQs) and development centres (FRN, 2010). The Act that established the agency mandated the HQs to be located in Abuja and subdivided into eight departments. These are Office of the Director-General and Chief Executive, Department of Administration and Finance, Department of Engineering and Space Systems,

Department of Strategic Space Applications, Department of Policy Planning and Research, Department of International Cooperation, Department of Mission Planning and Satellite Data Management, and the Department of Procurement (FRN, 2010; Mohammed, 2011). It also empowered the agency to establish more departments and divisions as the need arises.

The NASRDA Act 2010 and the Nigeria's space policy acknowledged and mandated the space agency to have six development centres. These include National Centre for Remote Sensing (NCRS), Jos; Centre for Space Science and Technology Education (CSSTE), Ile-Ife; Centre for Satellite Development (CSD), Abuja; Centre for Space Transport and Propulsion (CSTP), Epe; Centre for Geodesy and Geodynamics (CGG), Toro; and Centre for Basic Space Science and Astronomy (CBSSA), Nsukka (FMST, 2001; FRN; 2010). On NASRDA (2020) website, there is one additional Centre for Atmospheric Research (CAR), Anyigba. The list of NASRDA's centres on the CBSSA (2020) website further included three more centres, while the Budget Office (FGN, 2018-2020) acknowledged six more centres, which were also given autonomous consideration in budgeting and appropriation. These are the Advanced Aerospace Engine Laboratory (AAEL), Oka; Advanced Space Technology Application Laboratory (ASTAL), Uyo; Cooperative Information Network (COPINE), Ile-Ife; Institute of Space Science and Engineering (ISSE), Abuja; as well as the Zonal Advanced Space Technology Application (ZASTA) centres in Langtang, Kashere, and Kano (FGN, 2018-2020). NASRDA also has a commercial division known as Geo Apps (KI; Mohammed, 2011).

As noted earlier, the NCRS located in Jos, Plateau State is the oldest of all the centres that make up NASRDA. It took off in October 1995. It is primary charged with the responsibility of managing applications of SST for socioeconomic development, with special focus on the acquisition, archiving, distribution, and utilisation of satellite imageries (FMST, 2001; FRN, 2010; NCRS, 2019). The Centre maintains no fewer than nine departments, including the Directorate, Administration and Finance, Strategic Planning, Geo-Information, Geology and Mineral Exploration, Ground Receiving Station, Hydrology and Climate, Land Resources and Urban Planning, and the Ecology and Environment (NCRS, 2019).

Although it appears to be enjoying autonomous consideration in appropriation, COPIN is structured to operate under the coordination of the NCRS as Advanced Space Technology Applications Laboratory- Southwest (ASTAL-SW) (COPIN, 2018). Located in Ile-Ife,

Osun State, it is evident from KIIs that COPIN has been in existence before NASRDA was established as a parastatal or division of the NITDA. ASTAL, which emerged in 2014, with a base in Uyo, Akwa Ibom State, served similar administrative structures and functions as ASTAL-SW in the Niger Delta region (ASTAL, 2020). Similar things can be said of ZASTA centres that emerged in 2017/2018 in Langtang, Plateau State for the North Central geopolitical zone; Kashere, Gombe State for the North East geopolitical zone; and Kano, Kano State for the North West geopolitical zone. These initiatives were aimed to decentralise space popularisation and applications for socioeconomic development across Nigeria (ASTAL, 2020; COPIN, 2018; KIs). As evident with available details on ASTAL, the centres offer consultancy, educational and training services mainly in their areas of jurisdictions. They are structured into six departments. Besides the Directorate, there are Earth Resources Departments (such as the Space Education and Training, the Space Application and Research, the Collaboration and Linkages) and the Decision Support Departments (including the Administration and Finance as well as the Information, Planning and Documentation) (ASTAL, 2020).

CSSTE in Ile-Ife, Osun State is also known as African Regional Centre for Space Science and Technology Education-English (ARCSSTE-E). The centre is mandated to develop, train personnel and professional, and develop curriculum, skills and knowledge in Nigeria (FMST, 2001; FRN, 2010). However, the centre is a product of United Nations General Assembly (UNGA) resolution 45/72 of 1990 and 50/27 of 1995 that the world body should support space R&D in the developing countries (ARCSSTE-E, 2020). Accordingly, Nigeria and Morocco were selected to host the UN CSSTE initiative for English and French speaking African countries respectively. As such, the centre took off in Ile-Ife on November 24, 1998 and was affiliated to the UN-OOSA (ARCSSTE-E, 2020; CPUOS, 2006). The member states of ARCSSTE-E include mostly English-speaking African countries such as Botswana, Cameroon, Egypt, Ethiopia, Gambia, Ghana, Kenya, Liberia, Lesotho, Malawi, Nigeria, Sierra Leone, South Africa, Sudan, Tanzania, Uganda, Zambia, and Zimbabwe. A report of the UN Committee on The Peaceful Uses of Outer Space (UN-COPUOS, 2006) however acknowledged that the centre is placed under the supervision of NASRDA due to the challenges of constituting a functioning regional governing board, which is made up of all member states. Several other sources confirmed the enduring trend in this consideration,

as Nigeria continues to manage and fund the institution (ARCSSTE-E, 2020; FGN, 2020; KI).

CSTP in Epe, Lagos is mandated to develop capacity in rocket science and technology to achieve Nigeria's desire for orbital launch capability (FMST, 2001; FRN, 2010). Very little was known about this centre and its operations perhaps until recently (Oludimu, 2018). The centre has three notable operational units, including Propulsion and Engine System (PES), Structural Integration System (SIS), and Electronic and Simulation System (ESS) (Ibe, 2019a). It is equally involved in collaboration and increasingly building a network of contact laboratories across the country and beyond, especially in the areas of aerodynamics, chemical thermodynamics, gas dynamics, hydraulic, pneumatic, combustion, electronic, computer, vibration, instrumentation control and guidance among others (Fashade, 2008). Closely related to this is AAEL in Oka, Ondo State, which emerged in 2017/2018.

CBSSA was created in 2001 and located at Nsukka, Enugu State. The centre has the mandate to build human and technical capacity in SST with emphasis on astronomy, astrophysics, cosmology, geomagnetism, climatology, rocketry, balloons, and relevant instrumentations for planetary observations (FMST, 2001; FRN, 2010). The centre is divided into five science departments, including Planetary Science, Radio Astronomy, Instrumentation, ICT and Higher Energy Astrophysics, as well as three non-science departments such as Accounts, Budget and Planning, and Administration (CBSSA, 2020). It has developed a network of collaboration and maintains several facilities in collaboration with other universities across the country. The centre is into collaboration with UNN, University of Lagos (UNILAG), University of Jos (UNIJOS), Federal University of Science and Technology, Minna (FUT Minna), Federal University of Science and Technology, Akure (FUTA), River State University of Science and Technology, Port Harcourt (RSUST), and Nigerian Metrological Agency (NMA) among others (UNN, 2020).

CAR was created in 2013 and located in Anyigba, Kogi State. It is also known as CAR-NASRDA and NASRDA CAR (NCAR). It has the mandate to understand the Earth's atmosphere, solar physics, space weather and debris among other things, as well as build capacity in these areas and disseminate atmospheric data and products to relevant users for socioeconomic development of the country. The centre is divided into Administrative departments, including Account, Registry and Record, and Maintenance; the Technical

departments, including Engineering, ICT and Space Research and Initiative; and Organogram (CAR-NASRDA, 2020a). It has collaborated with many Nigerian universities to develop and maintain a network of laboratories across the country. Prominent among them are Space-Earth Environment Research Laboratory (SEERL) within the University of Benin (UNIBEN) campus and a Space Weather and Atmospheric Physics Laboratory (SWAP) within the Bayero University, Kano (BUK) campus (CAR-NASRDA, 2016).

CGG is located in Toro, Bauchi State. It has the mandate to develop capacity in Earth's survey and mapping, geophysics and geodynamics such as monitoring crustal impacts of drilling and resources exploration, and the rising sea level (FMST, 2001; FGN, 2010). CSD is also located in Abuja, FCT. The centre has the mandate to build human capacity in science and engineering for building, launching, tracking, controlling, and managing various kinds of satellites (FMST, 2001; FGN, 2010). Closely related to this is the ISSE, Abuja. Unlike CGG and CSD however, it was only created in 2015 and fully established in 2018. The institute is mandated to develop human capacity in SST through training. Although it was established by NASRDA, it is affiliated to African University of Science and Technology (AUST), which was established in 2007 (ISSE, 2019). AUST is the first of the network of centres of excellence to be established under the auspices of the Nelson Mandela African Institute of Science and Technology (NM-AIST), a pan-African university sponsored by the AU and perhaps the World Bank, on the request of many African Heads of State to support the earlier call for this initiatives by the former South African President Mandela (AUST, 2020).

Beside the institutions that are directly administered by NASDRA, there are many other centres across Nigeria. In 2008, NASDRA invited applications and in the process supported eight universities that were willing to set up their own centre for space R&D. Some of these later became autonomous institutions (KI). Prominent among them are Centre for Space Research and Applications (CESRA), which was sponsored by FUTA in December 2008. The centre was established with the objective of building human capacity as well as conducting R&D in remote sensing and GIS technologies (CESRA, 2017; FUTA, 2018).

6.2.1.1.2. Development of State Institutions for Commercial Space Programmes in Nigeria

Development of state-owned commercial entities in Nigeria is an offshoot of the country's civil space R&D programmes. Geo-Apps Plus Limited and the Nigeria Communication Satellite (NIGCOMSAT) Limited emerged from NASRDA as the major public corporations in Nigeria's space sector. These makes Nigeria one of the very few African countries to have developed state-owned space institutions and programmes for commercial purposes.

Formally known as the NigeriaSat Imageries and Consultancy Services Limited, Geo-Apps Plus Ltd was established in 2003 and made a commercial arm of the NASRDA in 2007. The corporation offers consultancy services and sells data generated from Nigerian Earth Observatory (EO) satellites to relevant buyers (KIs; Space in Africa, 2019b). As evident in the industrial report of Space in Africa (2019b), this corporation is the oldest and perhaps the only state-owned entity in Africa that commercialises EO data from satellites sponsored and operated in the continent. Other entities in this area are mostly privately owned.

NIGCOMSAT Limited was incorporated as communication satellite service provider in Nigeria in 2004 (KI). It was initially under NASRDA in FMST before the struggle for autonomy by the leadership of the corporation led the FGN to move it under Federal Ministry of Communication Technology (FMCT), where it is operating with the regulation of the NCC (Daily Champion, 2011; KI). The corporation also further pushed for its own law, NigComSat bill, which has failed to secure enough support in the National Assembly on different occasions. The bill has been resisted by different stakeholders, including ministries (like FMCT and FMST), agencies (NASRDA and NCC), and many in the private sector in the same industry that believe it will put them in comparative disadvantage (KI; Osuagwu, 2012). Instead, many have advocated for full privatisation of the corporation, and Bureau of Public Enterprises (BPE) has made efforts toward this direction at different points in time, but was retrained by advocates of national security (Adebajo, 2020; Francis, 2019; Elebeke, 2019; Space in Africa, 2020a). NIGCOMSAT Ltd. is the first fully state-owned corporation with a communication satellite in Africa—its closest predecessor is NILESAT, which was established in 1996 as a public-private partnership that involved the Egyptian government as one of the shareholders (Space in Africa, 2019b).

6.2.1.1.3. Development of State Institutions for Defence Space Programmes in Nigeria

Nigeria established the Defence Space Agency on October 9, 2014, although it was later legislated as the Defence Space Administration (DSA) by the National Assembly in 2016 and was signed into law by the President on February 3, 2017 (DSA, 2020). The administration is mandated to operationalise the defence and security aspects of Nigeria's space policy and programmes (FRN, 2016). This development reduced the primarily role of NASRDA to civil space programmes. Although there are indications that South Africa, Egypt, Libya and perhaps Morocco are involved in military space activities prior to this development, this initiative made Nigeria the first African country to develop a publicly known specialised institution for its defence space programmes (Oyewole, 2020a).

Besides two separate offices for the Chief Executive Officer (CEO) or the Chief of the Defence Space Administration (CDSA) and the Deputy Chief of the Defence Space Administration (DCDSA), the institution has nine directorates, including Directorate of Earth Observation (DEO), Directorate of Satellite Communication (DSC), Directorate of Navigation, Positioning and Timing (DNPT), Directorate of Launch Services and Space Operations (DLSO), Directorate of Policy, Planning and Research (DPPR), Directorate of Cyber Security (DCS), Directorate of Support Services, Directorate of Finance and Account (DFA), and Directorate of Procurement (DP). DSA was also mandated to operate five centres: Space Innovation and Development Centre (SIDC), Defence Earth Observation Centre (DEOC), Defence Satellite Communication Centre (DSCC), Defence Cyber Operation Centre (DCOC), and the Defence Space School (DSA, 2020; FRN, 2016).

6.2.1.2 Development of NGOs and Private Sector in Nigeria's Space Policy

NGOs and private sector are important in the consideration of institutional development for space programmes. As evident in the arguments of some liberal scholars in chapters one to three, NGOs and the private sector are important for political and economic liberalisation of space and associated benefits respectively. They are essential platforms for wider education or popularisation, mobilisation, and participation in space policy processes. At the same time, their expansive services make space, its technologies, and associated benefits more accessible and, in competitive environment, more affordable to a greater majority of the world population. Accordingly, the development of such important institutions,

platforms or sector cannot be ignored in the assessment of Nigeria's space policy, its operationalisation and their contributions to the development and security of the country. Table 6.2 offers a summary of known space-related NGOs and private companies in Nigeria. This section is subdivided into two: development of NGOs and private sectors in Nigeria's space policy and industry.

Table 6.2: Space-related NGOs and private companies in Nigeria

Major non-state space actors	Major Organisations
NGOs	SGAC, EarthSpace, AWB Nigeria, NAS, GSN
Private Corporations	Space in Africa, Atlantic Factorial, BeepTool

Source: Compiled by the author.

6.2.1.2.1. Development of NGOs in Nigeria's Space Policy Processes

Nigeria has few known NGOs that make space their core and perhaps only areas of interest. Prominent among them is the Nigerian Astronomical Society (NAS). It is an umbrella body for professionals that are involved in teaching and research in astronomy, space science, and other related disciplines (Space in Africa, 2018a). The organisation promotes space science education and research through teaching and engagements with academic community, university students included, as well as public enlightenment and mobilisation. It maintains a strong connection with CBSS among other government space institutions and facilities as well as relevant NGOs and private firms. It holds annual conference, which started in 2011.

The national branch of the Space Generation Advisory Council (SGAC) is another major NGO with space focus in Nigeria. The Council is an INGO with the aim of representing university students and young space professionals between 18 and 35 years of age and their interests in engagements with the UN, space agencies, industry, and academic community (SGAC, 2020). Established in 1999, the organisation has HQ in Vienna and branches in more than 150 different countries, including Nigeria. SGAC as well as its Technical Subcommittee (TSC) and Legal Subcommittee (LSC)enjoyes a permanent observer status at the UN COPUOS, and consultative status at the UN Economic and Social Council

(UNESC) (SGAC, 2020). One of the KIs claimed that Nigerian representations in the organisation dated back to its formative year. The representation of the country is headed by a programme manager, who works in collaboration or assists the regional coordinator, and is answerable to the executive committee of the organisation. As evident from KIs, the national and regional branches of the Council have strong relations with the NASRDA, especially at its formative years.

EarthSpace is a Lagos-based NGO with primary focus on space in Nigeria. It was founded by Dr Fayetola Ayodele and incorporated in Nigeria in 2003 as a limited liability company, but maintains a sort of NGO (foundation) arm. A review of the activities of the organisation simply suggests that it operates more like an NGO than a private company. Prior to this development, Dr Ayodele initiated the Space Science Popularisation Programme in Nigeria (Space SPiN), between 2001 and 2007, in collaboration with Babatunde Rabiu, now Professor and Director of one of NASRDA's centres. The primary objectives of both initiatives are to popularise space through training and educational outreach (KI). The organisation has collaborated with the National Geographic Society (NGS), the American Geophysical Union (AGU) as well as some American-based universities and Lagos-based telecommunication companies (KI).

The Astronomers Without Borders (AWB), Nigeria was established in October 2013 and incorporated as an NGO under Companies and Allied Matters Act (CAMA) of the Corporate Affairs Commission (CAC). The organisation was founded by Olayinka Fagbemiro with the aim of promoting STEM and making astronomical observations accessible to all Nigerians (AWB, 2020a). The organisation is affiliated and in partnership with Office of Astronomy for Outreach (OAO), Office of Astronomy for Education (OAE), Office of Astronomy for Development (OAD), International Astronomical Union (IAU), West African Regional Office of Astronomy for Development (WAROAD), AWB International, NASRDA, DSA, Mount Wilson Observatory (MWO), Los Angeles Astronomical Society (LAAS), African Astronomical Society (AAS), Sterren Schitten Voor Ledereen (Stars Shine for Everyone) (AWB, 2020b). The office of the organisation in Nigeria is based in Abuja, FCT.

There are many other NGOs with implicit focus on space. Prominent among them are the Nigerian Meteorological Society (NMETS), the Geoinformation Society of Nigeria (GSN), the Nigerian Society of Physical Sciences (NSPS), and the Nigerian Society of Engineers

(NSE). The NMETS was established in 1986 as an umbellar body for Nigerian professionals who are involved in teaching, research, and public campaigns on weather and climate. The organisation is strongly connected to the Nigerian Meteorological Agency (NIMET), the World Meteorological Organization (WMO) and the NASRDA (NMETS, 2011; TheNews, 2019). The GSN is the foremost Nigerian professional association on geospatial analysis, which is established with the aim of educating the public on, and promoting the, subject matter (GSN, 2020). The NSPS was incorporated in Nigeria on January 9, 2019. It was established with the aim of promoting research and study of physical sciences in Nigeria and develop effective programmes to support these ends (NSPS, 2020). The NSE was established in February 16, 1958 and incorporated in Nigeria as a limited liability company in 1967. The organisation works closely with the government, academic community, and industries with the aim of setting engineering standard, to develop human capacity as well as facilitate and promote technological adaption, acquisition, and development in Nigeria (NSE, 2020).

6.2.1.2.2. Development of Private Sector in Nigeria's Space Industry

Nigeria has very few known private companies in space industry. Prominent among them are Space in Africa, which was founded by Temidayo Oniosun in 2018. Mr Oniosun is a meteorology graduate from FUTA, the former African regional coordinator for SGAC, and a young entrepreneur in his mid-20s. With HQ in Lagos, the organisation has a developed physical presence in five African countries. Space in Africa is a media company that provides news as well as market and business assessment of space industry in the continent, covering 54 countries (KI; Space in Africa, 2019a). It is into partnership with the AU and various national space agencies, NGOs and private companies across the continent and beyond.

Other major space related companies in Nigeria are Atlantic Factorial Limited (AFL) and BeepTool. Atlantic Factorial was established as a limited liability company in 2010 with a base in Lagos. It uses satellite data among others to provide tracking services to public and private establishments in Nigeria. The company is in partnership with the NASRDA (AFL, 2020; Space in Africa, 2019b). BeepTool Communications and Integrated Ltd. was founded by John Enoh in 2014. The company deals with affordable smart satellite phone. It partners with the Avanti Communications, Kepler, NigComSat, OneWeb, Telesat, and Sky and

Space Global (Space in Africa, 2019b; BeepTool, 2020). The Lafiya Telehealth App Ltd. is one of the popular subsidiaries of BeepTool group of companies (Space in Africa, 2019c).

6.2.2. Development of Mobilisation Capacity for Space Policy Programmes in Nigeria

Institutions cannot operationalise space policy and strategy beyond the resources that are made available to them. Human and material resources are required to develop the capacity of an institution in the efforts to build the space capabilities of a country for development and security. However, the development of these resources and their management are an essential part of any organisation as well as its success and failure in delivering its objectives. This section therefore examines the human and material resources that are available to achieve the development and security aspirations of the people and government of Nigeria in space.

6.2.2.1. Human Resource Development in Nigeria's Space Sector

Human resource is the most important aspect of every organisation. It involves the quality and quantity of personnel, workforce, and labour that make up an organisation. The quality of personnel includes the skills, commitments, procedure and motivations of personnel that make a high-performance workforce (Armstrong 2006; Locke, 2009; Noe et al. 2011; Senyucel 2009; Sims, 2002). This implies that the quantity of personnel is one aspect of human resources, the quality of their training and skills as well as material wellbeings and resources made available for job satisfaction and motivations are another thing. Some of these elements will be considered here, while later discussion on material resources will provide more insight on the subject. Besides, this subject of concern is equally relevant to human capital development, which constitute one of the contributions of space policy programmes to the general human development in Nigeria, as evident in the latter part of this chapter.

This study is unable to determine the exact number of human resources that are available to operationalise the Nigeria's space policy. A report by Space in Africa (2019a) shows that 8,500 people were employed in space industry, including public and private facilities, across the continent. Amidst these, over 3,000 personnel are employed by NASRDA (Space in Africa, 2019a; KI). In 2018, NASRDA was reported to have sponsored 600 Nigerians in acquiring postgraduate degrees, including 200 PhD and 400 Master's degree holders, in

different fields of space sciences and engineering, and planned to train up to 1,000 persons by 2025 (Ibe, 2019b). Moreover, one of the KIs within the organisation recognised that the agency has up to 200 PhD holders trained across the world, and over 400 currently on training. Another KI claimed that the agency has up to 300 PhD holders, which was believed to be higher than that of many universities in the country. Nevertheless, another internal source claimed that the agency has over 180 PhD holders, which makes it the highest concentration of doctorates in any government agency and department in the country.

However, some of the KIs recognised that government space institutions are considerably overstaffed, in the sense that they have more personnel than the facilities available for them to work. Amidst these, there are concerns about how politicians have influenced the recruitment processes to undermine merits and flooded some of the institutions with their candidates, which are in possession of varying degrees of competence. However, a source revealed that this development is recent, given how recruitment into the agency was very rigorous with several stages of tests, which only produced the very best during the formative years. The politicisation started with some elements of ethnic, religious and regional mobilisation, as the subject of leadership succession of the institutions arose. In addition to these are the growing issue of party loyalty, especially for the leadership. These and the concerns associated with resource management will receive more attention in the next section on material resources that have been committed to space in the country.

Beside NASRDA and affiliated centres, there are a few other actors in Nigeria's space industry with their own personnel. NigComSat was reported to have between 201 and 500 personnel (Space in Africa, 2019b). A KI within the corporation claimed that 50 personnel were trained abroad in different areas of satellite communications, and they have in turn trained over 100 more. These are in addition to supporting staffs. At the same time, GeoApp Ltd was reported to have 58 staffs (Space in Africa, 2019b). Equally, the personnel strength of DSA can be estimated to be less or around 100 staffs. These are made up of some civilians with required expertise, who were recruited directly or transferred from NASRDA, as well as specially trained personnel drawn from the Nigerian Army (NA), Nigerian Air Force (NAF), Nigerian Navy (NN) and the Nigerian Police Force (NPF). However, military and paramilitary personnel are deployed or transferred in and out of DSA regularly. Hence, the number of those that have trained and worked with the administration are hard to determine.

Private companies employ less workforce in Nigeria's space sector. As at 2019, AFL and BeepTool were reported to have employed 15 and 13 staffs respectively (Space in Africa, 2019b). As evident from KI, Space in Africa operated with a staff of between 10 to 20 within and outside the country. KI also shows that EarthSpace utilises an ad hoc staff of less than 10 volunteers, mostly students that are trained and paid stipend, whenever it has a major programme.

The membership strength of space-related NGOs can also offer some insights into human capital development in this sector. SGAC has more than 15,000 members in more than 150 countries (SGAC, 2020). Amidst these, a KI claimed that Nigeria has close to a thousand members, and was at a point in time the 5th largest and most represented country in the organisation. These are in addition to the membership strength of AWB Nigeria, NAS and GSN among others.

Despite the foregoing, the staff strength of these institutions is not enough to determine the human resources that are operationalising the Nigeria's space policy and strategy or that are available for this purpose. There are many lecturers and researchers with PhDs as well as postgraduate and undergraduate students across hundreds of higher institutions (universities, Polytechnics, Colleges of Education and Technical Colleges), and graduate, in different areas of sciences and engineering, in Nigeria. For instance, more than 64,000 students were admitted into various engineering courses across Nigerian universities in 2015 alone (NBS, 2017). These are in addition to tens of thousands of Nigerian scientists, engineers, and technicians in diaspora. In essence, Nigeria has huge human resources that can be mobilised to actualise its aspiration through space among other subjects of concern in science and technology.

6.2.2.2. Material Resources

Although human resources are the most important aspect of any organisation, the output or performance of the workforce largely depends on the material resources, including funding, facility, equipment and work environment that are made available for their operations. The contribution of space policy to development and security in Nigeria cannot be fully realised or assessed without paying adequate attention to operationalise all the relevant elements of the inputs, including the material resources that are available to the institutions and the

associated workforces that are commissioned to implement the policy and its programmes. In this consideration, this section will pay attention to the available funding and facilities.

6.2.2.2.1. Development with Space Expenditure

Funding is a critical aspect of any organisation and determinant of its institutional capacity. Nigeria has committed hundreds of billions of naira to its space programmes since its inception. Inadequate access to the full annual reports of Euroconsultant and Space in Africa makes it challenging to determine the space spending of the country. However, Nigeria often appears in Euroconsultant's global map of countries spending US$10 million and above on space. Some of the available details from these reports show that Nigeria's space spending was US$70 million in 2013, US$66 million in 2014, US$61 million in 2016 and US$48 million in 2018 (Bochinger, 2016; Euroconsultant, 2017; Lal et al. 2015; Seminari, 2019). In this way, Nigeria's space spending was the second largest in Africa (after Morocco) in 2013, first in the continent in 2014 as well as fourth (after Algeria, Morocco, and Angola) in 2016 and (after Egypt, Morocco and Algeria) in 2018 (Oyewole, 2020a). While the methodological details behind Euroconsultant data is not fully available for proper scrutiny, data from the Nigerian budget office and Appropriation Act, as well as their conversion to the US$ from naira (N) using the average exchange rate for each as documented by the World Bank's World Development Indicators, questioned the figures given on the space budget of Nigeria. This will receive further attention shortly.

In 2018, a Business & Market Analysis by Space in Africa (2018b) showed that Nigeria voted N13.7 billion (US$37.8 million) to civil space programmes, which was 18.1 per cent of the total budget of the FMST. The same report showed that Nigeria budgeted N2.9 billion (US$8 million) on military space programmes, which was 0.5 per cent of the total military budget. However, the list that captured the breakdown of Nigeria's civil space institutions and their budgets only covers 11 of them and excluded CSTD and COPINE. The report also ignored N5.169 billion (US$16.89 million) budgeted for NIGCOMSAT Ltd, which is a government-owned commercial space programme, in 2018. These among other things questions the authoritativeness of the given quantification of Nigeria's space spending by the report. The limited access to the data of Euroconsultant and Space in Africa as well as the inconsistency of the available ones make it challenging to understand the history or draw a trend analysis of financial resources that have been committed by the government of

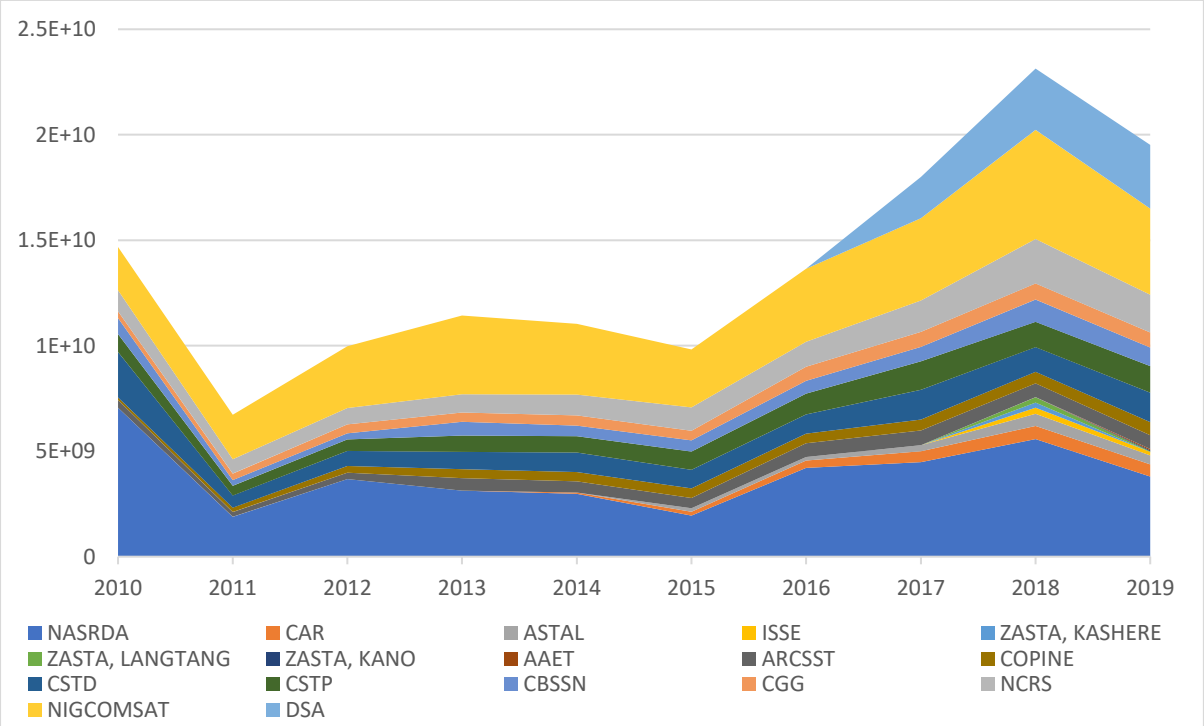
Nigeria and perhaps the few existing NGOs/private corporations to different aspects of space programming.

Nigerian Budget Office has archived FGN budget on its website since 2009. Amidst these, an independent effort was made to track the budget allocation to different space institutions in Nigeria in the last decade. Figure 6.1 provides a summary of the findings. Nigeria budgeted N137.987 billion (US$640.6 million) to its space programme between 2011 and 2019. It is amidst these that NASRDA HQ and NIGCOMSAT received the lion share of 28 per cent and 24 per cent respectively. Some of the long-established institutions like NCRS, CSTD and CSTP also received a significant share of the space funding with 8.69 per cent, 7.96 per cent and 6.55 per cent. It is also evident that the newly established DSA is receiving significant budget attention, as it accounted for 15.4 per cent of the Nigeria's space spending in 2019. However, it is important to note that Nigeria's space spending is insignificant in the total government spending, as it accounted for 0.034 per cent in 2019. Moreover, it is notable from Figure 6.1 that space spending always falls during election years from what it was in the preceding years. This is the case during the 2011, 2015 and 2019 election years.

Despite the foregoing, there are many concerns about known details of Nigeria's space expenditure, which is often assessed based on budget. Prominent among these concerns are the fact that not all budget allocations are usually released on time or utilised judiciously. One of the KI raised a concern that sometimes the agency does not receive funds for necessary projects in the early months of the year due to regular delay in appropriation processes and release of fund for capital projects in the country. In this way, many of the staff are often redundant and project schedules are often disrupted. More alarming is the fact that unutilised funds of ministries, agencies and parasters have to be returned to treasury at the end of the year. Hence, a project that ought to run for 10 months, and the funding is released later than the first two months of the year will have the remaining money return to FGN's coffer and reallocated the next year. These among other things delay many projects and give room for diversion of funds. Besides some of the concerns raised by few KIs, there are some publicly available records of allegations and counter-allegations of corruption, diversion and mismanagement of fund, and non-performing allocation and investment that are associated with the Nigeria's space programmes (Adebajo, 2020; Anderson, 2007; Blueprint, 2020; Pen Pushers, 2020; Punch, 2016; The Nation, 2018; The Whistler, 2019; Sahara Reporters, 2020; Space in Africa, 2020b).

Many of the Nigerian space NGOs are funded with grants, donations, aids, and sponsorships from local and international organisations. Accordingly, AWB, Nigeria has been supported by OAD, AWB International, IAU, UNAWE, VIXEN company, SSVI Telescope, and the Nigerian Army, among others (Fagbemiro, 2020). The EarthSpace has also received similar international grants and donation, most especially from USA. Professional associations like NSA, GSN and NSPS rely on annual dues from members and support from relevant government agencies and institutions. However, private companies rely on market forces and foreign investment as sources of their funding (this will be considered later in this chapter).

Figure 6.1: Nigeria's Space Budgets, 2011-2019



Source: Data extracted from Budget Office (2010-2019).

6.2.2.2.2. Ground Facilities and Infrastructural Development for Space R&D in Nigeria

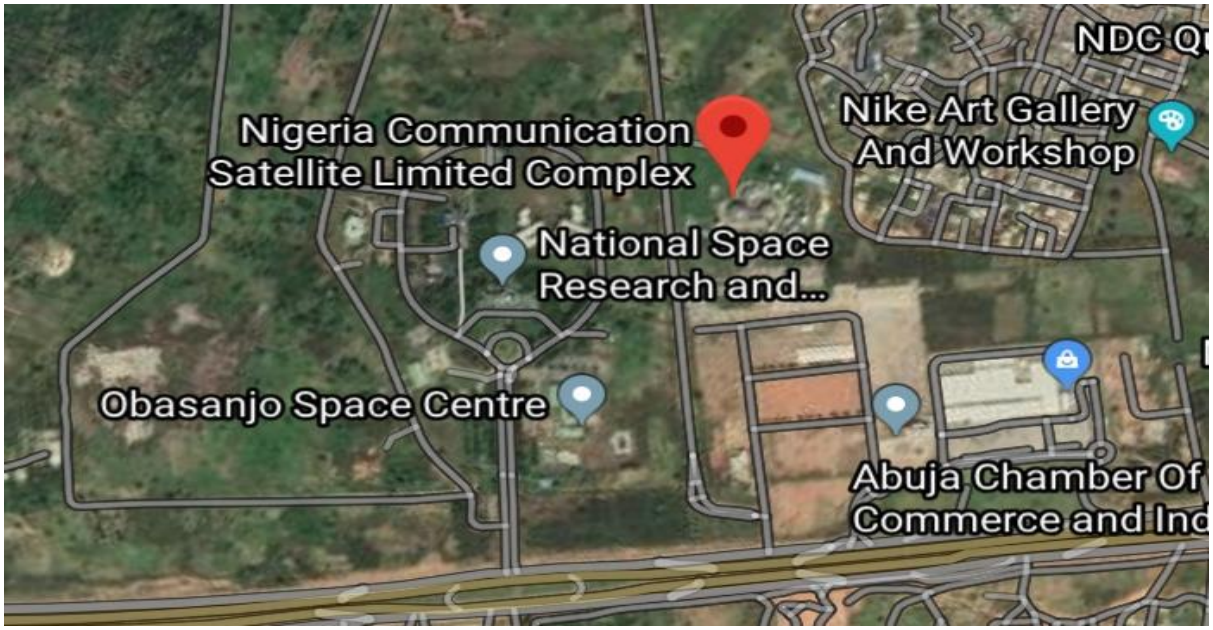
Ground facilities and related infrastructural capacities for space R&D can be considered as an aspect of infrastructural development for national growth, development, and security. Facility is a critical aspect of material resources and a major determinant of the performance

of the workforce in relation to the targeted policy goals. Besides the question of funding, the facilities that are available for the operationalisation of the Nigeria's space policy cannot be ignored in the consideration of key capabilities that determine the extent of the contribution of space funding to development and security in the country. Facilities generally include land, building, and equipment. In this consideration, this sub-section briefly examines the facilities of some of the institutions that operationalise the space programmes in Nigeria.

Figure 6.2 broadly shows a satellite imagery of Nigeria's space facilities in Abuja, the FCT. These include headquarters (HQ) of the NASRDA, CSTD, ISSE, and DSA, which are all located in a property called Obasanjo Space Centre (OSC), in close proximity to NIGCOMSAT. Figure 6.3 provides a closer view of NASRDA HQ, DSA, CSTD and ISSE. This property was said to host a ground receiving station for the Earth Observatory satellite inventory of the country. Also, it was supposed to host a facility for Satellite Assembling, Integration and Testing (AIT). Although this project has received budgetary attention running into hundreds of millions of naira over the years, it has not been completed or equipped. While there is public insinuation of diversion of funds from the project, it has also been revealed by insiders, including a few of the KIs that government has not released enough funds to complete the project (also see The Whistler, 2019). Although the DSA HQ is located in Abuja, there are evidence that they are constructing other facilities elsewhere. The property is also in close proximity of NIGCOMSAT HQ (see Figure 6.4) and a host of other facilities, including a ground receiving station for communication satellite.

Figure 6.5. offers a satellite imagery of the NCRS facility in Jos. The facility was supposed to host remote sensing satellite ground receiving station for utilisation and distributions of satellite imageries to relevant users as well as archiving for socioeconomic development. The centre has received significant budget attention as evident in the last section. Although this suggests that centre has developed appreciable capacity, the quality of the facility cannot be fully determined. Figure 6.6 is a satellite imagery of ARCSST, which is located within the campus of OAU in Ile-Ife, Osun State. The CBSSA, Nsukka, Enugu State hosts facilities that include astronomical observatory, which is equipped with 0.25-m and 0.15-m telescopes, as well as radio telescope (UNN, 2020). There were indications that the CSTP have equally completed the construction of its facility with fixed and mobile launch pads for rockets.

Figure 6.2: Satellite imagery of Obasanjo Space Centre and NIGCOMSAT, Abuja, Nigeria



Source: Tracked and captured by the author using GPS, Google Map.

Figure 6.3: Satellite imagery of Obasanjo Space Centre, NASRDA & DSA, Abuja



Source: Tracked and captured by the author using GPS, Google Map.

Figure 6.4: Satellite Imagery of NIGCOMSAT facility, Abuja



Source: Tracked and captured by the author using GPS, Google Map.

Figure 6.5. Satellite imagery of the NCRS facility, Jos, Nigeria



Source: Tracked and captured by the author using GPS, Google Map.

Figure 6.6. Satellite imagery of the ARCSSTE-E facility, Ile-Ife, Nigeria



Source: Tracked and captured by the author using GPS, Google Map.

The agency is also affiliated with to other agencies and centres as well as universities, which also maintain facilities that are directly or indirectly relevant to space R&D. Prominent among these is the satellite ground station owned and operated by the CESRA in Akure. These are in addition to international cooperation maintained with different countries across the Africa and beyond. South Africa, UK, China, Japan, and Russia are prominent among the partners that are engaged by Nigeria, some of which have opened their facilities to the latter for human capacity development, services, and other collaborative space activities.

6.2.2.2.3. Development in Space Access and Assets: Satellites and Launch Capabilities

With or without a space agency, sponsoring, owning, and operating at least one space asset, that is, orbiting a satellite, and developing capacity for space launch, are considered as some of the major steps that qualify a nation as a spacefaring country (Argoun, 2012; Harding, 2013; Kornilenko, 2007; McKenna-Lawlor, 1998; Othman, 2003; UCS, 2017a; Wood and Weigel, 2011; 2012a&b; 2014). Accordingly, the progress made by Nigeria in satellite and space launch capabilities are important in this discourse. To address these concerns, this section is sub-divided into two: the first one deals with the development of space-based

capabilities in Nigeria, while the second one focuses on the nation's space launch capabilities.

6.2.2.2.3.1. Development of Space-based Capabilities in Nigeria: Satellites

Nigeria, by African standard, has developed significant space-based capabilities. The country has sponsored or co-sponsored the orbiting of six satellites as evident in Table 6.3. With this, Nigeria sponsored approximately 15 per cent of the 41 satellites that were sponsored or co-sponsored from Africa as at early 2020. At the same time, Nigeria is in the same category with Algeria in terms of the number of satellites sponsored, and slightly surpassed by South Africa and Egypt, which as at then sponsored eight and nine satellites respectively (Oyewole, 2020a). Following the record of Egypt in 1998, South Africa in 1999, Morocco in 2001 and Algeria in 2002, Nigeria became the fifth African country to sponsor or co-sponsor a satellite with the orbiting of NigeriaSat-1 in 2003 (Oyewole, 2017; Froehlich and Siebrits, 2019).

Table 6.3: Development of Nigeria's Satellite Inventories and Capabilities

Satellite names	Mass of satellites (kg)	Manufactural	Purposes	Launch & operational dates	Launch facility & locations	Cost (US$ million)
NigeriaSat-1	100	SSTL	Earth Observation	26/9/2003-2012	Plesetsk Cosmodrome, Russia	13
NigComSat-1	5,150	CGWIC	Communications	13/3/2007-11/11/2008	Xichang Satellite Launch Centre (XSLC), China	300
NigComSat-1R				17/12/2011		
NigeriaSat-2	300	SSTL	Earth Observation	17/8/2011	Dombarovsky Air Base (DAB), Russia	112
NigeriaSat-X	100	NASRDA engineers in SSTL lab				
EduSat-1	1	FUTA engineers in KIT		3/7/2017-13/5/2019	Kennedy Space Centre (KSC), USA	0.1

Source: Compiled by the author with data from UCS (2020); Oyewole (2017); Gunter's Space Page (2020)

As evident in Table 6.3, four of the six satellites sponsored by Nigeria are for EO, while two are for communications. Two of the EO satellites were fully constructed by the UK based Surrey Satellite Technology Ltd (SSTL) with an agreement that entails technology transfer, which includes training of Nigerian engineers. NigeriaSat-1 with 100kg mass cost $13 million to manufacture in 2003, and was launched from Plesetsk Cosmodrome, Russia. Before NigeriaSat-1 went out of service in 2012, two other EO satellites were launched into orbit for its replacement in 2011. NigeriaSat-2 and NigeriaSat-X with 300kg and 100kg weight mass respectively were designed and manufactured at the SSTL, and launched from the Dombarovsky Air Base (DAB), Russia, at the total cost of US$ 112 million. As part of the technology transfer agreement with the SSTL, NigeriaSat-X was fully designed and built by Nigerian engineers after the completion of their training using its satellite AIT facilities.

In 2004, the FGN contracted China Great Wall Industry Corporation Limited (CGWIC) to design, manufacture, launch, and provide in-orbit services and insurance of a communication satellite as well as construct its ground station and train host engineers. It was the first of such broad services and technology transfer by China to any country. Launched in March 2007, the 5,150kg mass NigComSat-1 that was designed to last for 15 years ran out of power due to technical anomaly, and eventually failed in orbit in November 2008. A new contract that led to the construction and successful launch of a replacement communication satellite NigComSat-1R in December 2011 was signed by the two parties in early 2009, making it the third satellite launched for Nigeria that year. It was revealed that the new satellite was replaced by the insurance cover with no additional cost to Nigeria. Hence, the total cost of these two communication satellites, which were both launched from the Xichang Satellite Launch Centre (XSLC), China, was US$300 million. However, these projects were largely funded by Chinese state-owned bank loan to fast-track their deliveries.

In 2015/2016, the Japanese government sponsored what was known as the “Bird project” as a space technology transfer initiative to the developing countries, and has since then had it hosted by the Kyushu Institute of Technology (KIT). This project has benefited many countries, including Bangladesh, Ghana, Kenya, Nigeria, Mongolia, Thailand and Taiwan. Nigeria is one of the first set of countries to benefit from this initiative, which allows the engineers of the selected countries to develop capacity in satellite manufacturing under the supervision of KIT. Edusat-1, a research EO micro-satellite of 1kg mass, is a product of this initiative. This satellite was built by Nigerian engineers from FUTA in the KIT AIT facility,

and launched aboard SpaceX Falcon 9 from Kennedy Space Centre (KSC) in the USA. Edusat-1 was operated in constellation with other satellites under Bird project and tracked from Nigeria and other partner countries before it was deorbited in May 2019. This project was cosponsored with a counterpart fund of US$100,000 paid by FUTA with the support of the NASRDA (CESRA, 2017).

In the last five years, the Nigerian government has at several times announced plans and ongoing efforts to launch more satellites soon. In early 2016, the FGN announced its plan to obtain a US$600 million loan from China for the construction of NigComSat-2 and 3 (Oyewole, 2017). A KI in the organisation acknowledged that the project of manufacturing these satellites was ongoing in China. Evidence from, KIIs equally shows that DSA is planning to have a research satellite produced and launched into orbit. For years, officials have also talked about ongoing NigeriaSat-3, which was initially scheduled to be fully made in the country. However, one of the KIs revealed that the delay in the completion of Nigerian satellite AIT had changed the plan, and the government then had to produce part of the components required for the new satellite locally. Moreover, the Nigerian 2021 appropriation bill shows that the NASRDA is sponsoring the production of two satellites. Amidst these, Nigeria tends to be underutilising available human resource capabilities in local production of satellites.

Besides satellite inventory, Nigeria also has other interests in space-based capabilities, which are currently underdeveloped. The national space strategy roadmap entails the desire of the country to orbit a Nigerian scientist. This goal was initially set to be realised in 2015 but was later postponed to 2030, after the failure to meet the first targeted timeline. While some KIs are optimistic about the realisation of this desire within the new timeline, others are not. Currently, there are little or no indication that the country is preparing for this kind of mission beyond a series of declarations by relevant government officials as well as the enduring optimism of some enthusiastic members of the scientific community. However, some KIs disclosed that the country's space programme is better without this project, at least in the immediate future, which suggest that it may now be off plan. It is on this basis that the attention of this study will be turned to examining the development of space access, with emphasis on rocketry and space launch programmes in Nigeria.

6.2.2.2.3.2. Development of Space Access Capabilities in Nigeria: Space Launch Vehicles

Nigeria currently lacks space access capabilities or capacity to launch an object into the orbit. As evident in the previous section and Table 6.3, all the satellites sponsored by Nigeria were launched into orbit for the country from elsewhere. Nigeria is not alone in this; no African country currently has the capacity to launch satellite into orbit. Nigeria, like other African countries, had contracted Russia, China and the US for orbital launch services in the past. Some other African countries have equally contracted France and India for the same purpose. This trend is not likely stop soon, most especially for Nigeria. However, this does not mean that Nigeria does not have interest and commitment to develope the required capacity to launch its own satellite from its own territory. Conversely, Nigeria is developing its space launch programme, which some government officials believe will be cost effective, given the location advantage of the country's closeness to the equator.

The CSTP is the institution that is principally charged with the responsibility to develop Nigeria's capacity in space transportation. The DSA equally has the responsibility to support national interests in this project. The national space strategic roadmap considers the desire of the FGN to launch a satellite into orbit from its territory by 2030. Very little is known about the progress that has been made in this project, perhaps until recently, and many KIs avoided discussion on it. A report by Space in Africa shows that CSTP launched 30 experimental rockets, which were all below 10km altitude, before 2019 (Ibe, 2019a). As at 2020, however, a KI revealed that an experimental rocket that surpassed this altitude had been launched. The country has entered into partnership with some Asian and European countries to develop its capacity in this consideration. Besides the state sponsored rocket programme, several cases of amateur rocket flights that were sponsored by private individual, mostly rocket enthusiastic students, have been reported in Nigeria over the years. Nevertheless, Nigeria has a long way to go to realise its objective in space access.

6.3. Space Policy as a Means to an End: Space Support for Development and Security Goals in Nigeria

The development of Nigeria's space policy programmes is evident with the growing profile or capabilities of the country in this sector. As shown in the last section, this offers a sectorial

perspective to national development in Nigeria. However, this trend further raises a number of questions for this study to contend with in the bigger picture of development and security in the country. The big question is: how has the development in the space sector advanced the broader development and security aspirations of the people and government of Nigeria? One can also ask why the government decided to prioritise space for institutional building, human capacity development, and investment, in the face of pressing terrestrial challenges. This section seeks to address these and other related concerns. In doing this, this section is sub-divided into two: the first one deals with space support for national development and security in Nigeria, while the other focuses on sustainable human development and security in Nigeria.

6.3.1. Space Support for National Development and Security in Nigeria

As evident in chapter four and the preceding section of this chapter, the Nigeria's space programmes were designed to promote and support the aspirations of the government of the country. This section is interested in the extent to which this objective has been achieved. For this purpose, this section is subdivided into two: the first one focuses on space support for national development, and the other focuses on space support for national security in Nigeria.

6.3.1.1. Space Support for National Development in Nigeria

Between chapter one and three, this study identified different conceptions and theoretical perspectives on development, some of which focus on national development. These ends include: economic growth and transformation, resource management, catch up, and local or independent capacity among other things that are considered as objectives of development. These among other things reflect some aspects of national space policy objectives and development conceptions of the government of Nigeria, as reviewed in the chapter four of the study. Some of these objectives will be considered in details as follows:

6.3.1.1.1. Development as competitiveness and catch up

As evident between chapter one and three, the international competitiveness of a state, catching up with advanced states, or staying comparable with other states that are considered to be contemporaries constitute a perspective to development. In this framework, Nigeria is

recognised generally and in the context of space as a developing country and emerging global power or player, and regional power in Africa. Globally, Nigeria, like many other developing countries, is pursuing space policy to catch up as well as close the development gap with the developed countries. In this consideration, the country has prioritised the need to acquire required capabilities, including human and technical capacities, to derive benefits from space and attendant technologies. This is responsible for the growing capacity of the country to access space products and convert them to its consumable need. Nevertheless, Nigeria largely remains a consuming nation in terms of space technologies, with little or no facilities, assets, inventions, productions, and market share of a major global space player.

Among the developing countries and emerging or regional powers or players in space, Nigeria is interested in staying comparable, catching up with those ahead and staying ahead of those behind. This is equally connected to Nigeria's regional leadership status and aspiration in the continent of Africa. Many KIs see no reason why Nigeria should not lead the continent and stay competitive among developing countries. Nigeria's policy aspirations and public institutionalism in space can be better rated than many other emerging space players globally. However, the country remains an average player among emerging space powers, with little industrial capacity to support its space programmes. Compared to other regional powers outside Africa or emerging space powers like India, Brazil, Pakistan, Israel, Argentina, Indonesia, Iran, United Arab Emirates (UAE), South Korea and North Korea, it is apparent that Nigeria falls behind in terms of space access, facilities, assets, inventions, productions, and market share (cf. Al-Ekabi and Ferretti, 2018; Al-Ekabi et al., 2017; Burger and Bordacchini, 2019; Harding, 2013; Harvey, Smid and Pirard, 2010; Lopez, 2015; Mistry and Gopalaswamy, 2012; OECD, 2014; Space Foundation, 2015b).

In the continent of Africa, Nigeria is recognised as one of the most advanced space players, which is only comparable to South Africa, Egypt, Algeria and recently Morocco. As at late 2020, these are the only countries that have sponsored more than one satellite as well as have owned and operated them for about two decades or more (Froehlich and Siebrits, 2019; Luncedo and Gottschalk, 2013; Oyewole, 2017; 2020a). Amidst these, Nigeria is leading in terms of space policy aspirations and public institutionalism. It was the first African country to establish a space agency in 1999 and publish its national space policy and strategies in 2001. The Algerian Space Agency was established in 2002, SANSA came into existence in December 2010, and the Egyptian Space Agency was established in August 2019, while

Morocco is yet to create an agency for this purpose – its space programme is largely coordinated by a centre for remote sensing. Since 2015, Kenya, Ethiopia, Zimbabwe, Rwanda and Uganda have equally joined the list of few African countries that have advanced the institutionalism of their space programmes from a mere centre of remote sensing to an agency status.

Despite the foregoing, the Nigeria's space programme also started with the desire to catch up with other regional powers in the continent. The launch of the first orbited satellite from Africa in 1998 was sponsored by Egypt, which was followed by a South African satellite in 1999, Morocco and Germany co-sponsored satellite in 2001, and Algerian satellite was launched in 2002, before the Nigeria's own was launched in 2003. This considerably informed Nigeria's ambitious space policy programmes between 1999 and 2007, including the desire and launch of the first African sponsored communication satellite. It is also important to note that Nigeria's defence space programme started in 2014, the same year that the first African sponsored military satellite by South Africa was launched. South Africa and to a limited extent Egypt are equally ahead of Nigeria in astronomical observatories and some other facilities for basic space sciences, capacity building for space access, and commercialisation of space products. As at late 2020, Nigeria had only sponsored six satellites, while Egypt had sponsored nine satellites and South Africa eight satellites. However, Nigeria may catch up with these records with planned two EO satellites and two communication satellites. Generally, Nigeria remains one of the leading African space players, although this status is increasingly eroding as other countries are catching up and closing up the development gap.

6.3.1.1.2. Development as Economic Growth and Transformation

Nigeria's space programming has proved relevant to national development, as it concerns economic growth and transformation. Space has been employed to transform different sectors of the economy. However, the extent of the impact of space programme has not received adequate attention in most cases. Prominently, the space programme has supported communication, digitalisation, urban planning, construction, resources management, and education, which have all boosted the economy and created wealth for many, in Nigeria.

Nigeria has recorded progress in adopting communication technologies and digitalisation of its economy in the last two decades. This is considerably evident with the rapid adoption and access to mobile phone and internet penetration, which has greatly revolutionised the country. Mobile cellular subscriptions in Nigeria rose from 0.024 per 100 people in 2000 to 88.18 per 100 people in 2018. In 2000, only 0.06 per cent of the population had access to internet services in Nigeria. In 2017, however, 42 per cent of the country's population had access to internet (World Bank, 2020). This development, which is a product of a series of policy choices in relation to terrestrial and space infrastructures, has revolutionised different sectors of the economy, including agriculture, manufacturing, and services. Most notably, the banking sector has been revolutionised with the growing adoption of e-banking and mobile banking. The growing access to the internet has spinned off e-commerce, e-learning, e-governance, precision agriculture, and telemedicine. In this case, satellites are playing some considerable roles, most especially to connect the unconnected and the under-connected peoples of the country. However, the NCC recently revealed that satellite only contributes as low as 0.2 per cent to Nigeria's internet connectivity (Akinyemi, 2020).

In addition to the trend of internet access and its revolutionary impact in Nigeria, the huge and growing access and subscription to satellite TV and radio in the country is another aspect of space support for economic growth and transformation. These platforms are transforming access to information, innovation and e-commerce. Prominent among the impacts of these platforms is the transformation of Nigeria's entertainment industry, which is now worth billions of naira. However, there were indications that most satellite TV and radio service providers in Nigeria prefer foreign data, a trend that has undermined the profitability of NigComSat. With the launch of direct to home platform by NigComSat Ltd, most private firms that are involved in satellite TV platform services consider the corporation as a competitor rather than collaborator. Consequently, they prefer alternative sources of satellite data, and have supported the enduring campaigns for NigComSat privatisation.

Through more availability and accessibility to remote sensing data from satellite, Nigeria's space policy and programmes have transformed and supported construction, agriculture, resource management, and other sectors of the economy. One of the KIs, revealed that it usually took months or years to develop a visibility report for federal road construction two decades ago, but similar exercises were carried out and completed in days or weeks now due to space support. Space support provides fast and reliable mapping of terrains in a

manner that are very helpful to assess visibility and monitor progress during construction of roads, rail, bridges, dams, ports, and other notable infrastructural projects in Nigeria. But while the impact of space assets is revolutionary for this sector, it does not eliminate some of the societal ills that are associated with public infrastructural developments in the country. These include corruption in pricing, politicisation of bidding and contracting, inadequate quality or failure in delivery, and other questionable human factors or dealings in the sector.

The impacts of space support are equally noticeable in the agricultural sector. The space agency has provided the Ministry of Agriculture and associated departments and agencies with satellite data that are relevant to policy planning and assessment in Nigeria. Satellite data that are made available to universities and research centres across the country have also boosted agricultural research and development in the country. The space policy programmes have equally encouraged or sustained the rise and activities of some consulting firms and satellite service providers that provide supporting services to farmers. However, these services have remained largely limited to few large-scale farmers, while they are mostly less accessible and unaffordable for majority of Nigerians in this sector.

The space programme has supported Nigeria's struggle to improve its capacity in natural resources management. Nigerian satellites have helped the country to compile inventories of its natural resources, mining sites and its environmental impacts. The FGN mandated the NASRDA to develop a resource inventory of the country in 2007. In response, the agency used NigeriaSat-1 to produce several high-resolution satellite images that were worth 4 billion Naira (US$ 11 million) in its first phase of resource mapping of the country. Following the launch of NigeriaSat-2 and X in 2011, the agency commenced the second phase of the survey, which was conducted at the scale of 1:50,000 in most cases. This project was estimated to be worth 5 billion Naira (about US$ 13.8 million) upon completion (Space in Africa, 2019c). These are important in a resource dependent economy like Nigeria, a country with natural resources rent of 15.08 per cent of the GDP on the average between 1970 and 2017 (World Bank, 2020). The efforts of space programming for environmental impacts assessment in the mining sector of the country will receive better attention later in this study.

Despite many worrisome trends, especially in relation to inadequate utilisation of most of the available assets, the space policy programmes have made significant impacts and

contribution to the economic growth and transformation of Nigeria. As it will be shown later, the contribution of the space programming to the quality of education and health in Nigeria is financially significant. However, the revenues generated by space assets, firms and agency offers more insight into the contribution of this sector to economic growth in the country. In total, the NigeriaSat-1 directly contributed over 10.5 billion Naira (about US$ 29 million) to Nigeria's economy within its first 9 years in orbit. Accordingly, this satellite considerably appears to be profitable, given that the total cost of manufacturing it was US$13 million. The annual revenue of the Lagos-based Atlantic Factorial with 15 employees was estimated between US$500,000 and US$1,000,000. With 13 employees, Beeptool raised US$600,000 investment in 2019. The company was recently evaluated to be worth US$ 12.5 million, even with less than US$ 100,000 annual revenue. Equally, GeoApps was reportedly declared by its leadership to be worth US$ 1 million (Space in Africa, 2019b). While NigComSat have not disclosed its revenue publicly, the corporation is believed to be one of the biggest corporations in African space industry. These among others show the contribution of space programming to economic growth and transformation in Nigeria.

6.3.1.1.3. Development of local/independent capacity and self-reliance

The Nigeria's space policy strategies echoed some of the objectives of development that are known to students of dependency theory. Prominent among these is the need to develop local capacity and self-reliance in different aspects of space capabilities. As evident above, Nigeria has acquired some space technologies and developed institutional capacity to convert those resources into utility for the advancement of its development and security. Prior to the advent of the space programming in 1999, Nigeria was largely a mere consumer of space products. In this case, the country lacked the capacity for direct access to space products and convert them as required for its need. With the launch of Nigerian satellites and the development of their ground stations, the country has maintained capacity for direct and unrestricted access to various satellite services and utilised them as deemed suitable for its national interests. The country has equally acquired considerable capacity in satellite design and manufacturing, although inability to complete its AIT facility has undermined its potentials, considering the quality and quantity of human resources that are available to the country in terms of space R&D. Despite the progress made by the country in rocketry as well, its quests for independent orbital launch capabilities remain a long-term goal.

However, the progress made in space assets acquisition and their utilisation, policy articulation and operationalisation, institutional development and resource conversion are significant indicators of local capacity developed in Nigeria.

6.3.1.2. Space Support for National Security in Nigeria

Space capabilities, most especially the use of satellites for communication, remote sensing, and navigation have been employed to advance Nigeria's national security interests. These are in the area of defence, power projection, law enforcement, and disaster management. Nigeria's space capabilities have contributed to the efforts of the country to neutralise or minimise internal and transnational threats against the country. These include threats of terrorism, insurgency, banditry, piracy, smuggling, kidnapping, oil theft and bunkering, illegal mining and refining, and many other forms of political or criminal violence. These capabilities have further contributed to Nigeria's peacekeeping, peace enforcement and military power projection across Africa and beyond. Space support has also featured in Nigeria's strategic planning and management of natural and man-made disasters.

6.3.1.2.1. Space Support for Internal Security Operations

One of the greatest security threats that has confronted Nigeria in the 21st century is the emergency of Islamist militancy and insurgency. The Islamist Boko Haram insurgency emerged from northern Nigeria and expanded into neighbouring countries in the Lake Chad region, including Cameroon, Chad, and the Niger Republic. The movement has a developed network with Al Qaeda central and its affiliate groups like the Al Qaeda in the Islamic Maghreb (AQIM) and Al Shabab, as well as the Islamic State in Iraq and Syria (ISIS) and its affiliates in Sahel and North Africa. This development has become the biggest challenges to defence, internal and transnational security that have confronted the country in the last decade. Boko Haram insurgency and terrorism are characterised by (suicide) bombing, assaults, hostage taking and ransoming, assassination, sexual violence, attacks against border communities, military and police targets, as well as land grabbing. At the peak of its campaign of violence between 2014 and 2015, its membership strength ranged from 15,000 to 50,000. The group has killed more than 30,000 people, kidnapped about 10,000, and displaced over 2 million people. The group was in control of 20,000 square miles of territory

in Nigeria - an area the size of Belgium- in January 2015 (Onuoha and Oyewole, 2018; Oyewole, 2017).

The Nigerian government has responded to the threats of Boko Haram through economic, military, diplomatic, political and socio-cultural engagements. Politically, the government of Nigeria at different levels have engaged the Boko Haram insurgents and other relevant stakeholders in dialogues, offer of concessions, and initiation of some policies to strengthen the support base for the states in the region. These allow for socio-cultural engagements, which include mobilisation of traditional rulers and religious leaders against Boko Haram ideology in the region. Amidst these, economic responses entail improved investment to advance the development of the region, tracking the sponsors of the insurgents and offering incentives to repentant Boko Haram members. These are in addition to diplomatic efforts to build regional front against the insurgents and their network in the Lake Chad region, Sahel, West Africa, the continent of Africa and the world. Besides, the armed forces have been deployed with the law enforcement agencies (police, customs, immigration, Department of State Service (DSS), the Nigeria Security and Civil Defence Corps (SCDC), and the Civilian Joint Task Force (CJTF) among others), as a Joint Task Force (JTF) to contain Boko Haram insurgency, as well as restore stability and improve security in the affected region.

The roles of the army and the air force have made land and air frontiers the most prominent in the military campaign against Boko Haram insurgents in Nigeria and the Lake Chad region (Omeni, 2018; Oyewole, 2017). The NA maintains about two of its divisional strengths, which is estimated between 40,000 and 50,000 personnel, in this theatre of operation. The NAF equally maintains one of its six Command in the region. Although it has received less attention, the relevance of the maritime frontier is necessitated by the strategic location of Lake Chad, where the NN has also operated in the theatre. Despite their relevance, the role of the space institutions (NASRDA, NIGCOMSAT and DSA) and capabilities have received inadequate attention in the war.

The counter-insurgency (COIN) operation of the Nigerian military in the Lake Chad region has been supported by space assets. For instance, when insurgents' targeted attacks crippled the tele-communication facilities in the region, the military and other security forces in the region relied on satellite supported communication, which are provided by NIGCOMSAT with little or no charges. The space agency and administration also supported the military

with comprehensive survey and mapping of the operational theatres. These are important in military tactical and operational engagements against the insurgents. Satellite data are relevant in the search for and rescue of hostage in the theatre of operation. For instance, when the Chibok schoolgirls were abducted by Boko Haram in April 2014, the military was provided with detailed satellite data of the region to support planning of search and rescue mission.

Satellite data have been relevant to the air and surface (ground and maritime) forces in their search and destroy operations against insurgent camps and logistics in the vast area covered by Sambisa Forest Reserve and other forests as well as fringe islands across the Lake Chad region. In addition to air and human intelligence, satellite data are relevant in mapping and planning general sweep operations to recover losses from the insurgents. When insurgents' use of anti-aircraft missiles tends to undermine air power capabilities and delivery of the NAF in 2014, this service of the military and space agency collaborated in R&D of satellite guided missiles, which enable the aircraft to fly at higher attitude with better precision strike (Oyewole, 2020a). In this manner, Institute of International Security Studies (IISS, 2020) recognise that Nigeria is the only Sub-Saharan African country with an air force that maintains Inertial Navigation System (INS)/ GPS guidance capabilities for aerial bombing. This development is suspected to have increased the air strike capability and efficacy of NAF (Oyewole, 2021). The space agency also provided the NAF with topographic map to support investigation into the Nigerian fighter jet that crashed in active operation against the insurgents in the Niger Republic in 2013 (Space in Africa, 2019c).

Space support is also evident in other internal security operations of the Nigerian military. The military has been deployed in support of the law enforcement agencies against the bandits in Nigeria. Amidst these, military deployment and operations against bandits is salient in the north, most especially in Zamfara, Benue, Katsina, Sokoto, Taraba, Niger, Jos, Adamawa, Nasarawa and Kano States. In some of these cases, space-based survey and mapping have helped the military forces in planning and familiarising themselves with operational terrain. In addition to human and air assets, satellite data have equally supported the troops in the efforts to locate and neutralise bandits, their camps and logistics. Military operation against militants, illegal miners and refiners, oil bunkers and saboteurs, pirates and armed robbers, kidnappers, militants in the Niger Delta and other coaster communities of Nigeria have sometimes benefited from space-based C4ISR. Besides, the war against

smuggling benefitted immensely from space capabilities. When the Nigeria's boarder with Benin Republic was closed and a military-led JTF was formed and launched against smuggling, the security forces relied on satellite for their communication.

6.3.1.2.2. Space Support for External and Situational Security Operations

The Nigerian military has considerably enjoyed space support in its external engagements. As one of the leading military powers in Africa, Nigeria has been involved in a series of peacekeeping and peace enforcement operations and power projections in the continent. Between 1990 and 2018, Nigeria contributed 741,398 troops to various peace-keeping missions globally, which represents 12.2 per cent of such contribution from African nations (Oyewole, 2020b). Some of these missions have benefited from space support. Even before the nation's space policy and programme took a coherent shape, the Nigerian military-led ECOWAS Monitoring Group (ECOMOG) and UN supported operations in Liberia and Sierra Leone in the 1990s benefited from space supported command and communication. Satellite phone was critical for the military commands in Monrovia and Freetown to maintain communications with the authority in Lagos as well as a link between troops and their families (Adesina, 2002). Some of the KIs also revealed that the space agency supplies the military forces with relevant satellite imageries to support their operations in Mali, Sudan and Central African Republic. Nigeria and ECOMOG allies benefited from space support in their peace keeping operations in Mali in 2012. The country also brought space support to bear on its military deployment to AU and UN mission in Sudan. These have contributed to Nigeria's capabilities to project military power as well as defend its interests, allies, commitments, and status internationally.

Situational security that involves disaster management has equally benefited from space support. This is notable in environmental crisis management, including natural and man-made disasters. The Nigerian satellites have been instrumental in mapping dams, rivers and other water bodies to provide early warning and real time situation awareness for floods in the country and beyond. It has also provided early warning for tremor, landslides, earthquake, volcanic eruption and bush fires across the world. Nigeria provided satellite data to support the South East Asia in response to tsunami, US in its response to hurricane Katrina, Brazilian response to wide fires in Amazon Forest, and response to locust invasion of Algeria. Cameroon, Chad, Niger, DR Congo, Australia, and Sudan among other countries

have also benefited from Nigeria's space support in their responses to various natural disaster. In these and other ways, space capabilities have contributed to Nigerian security interests at home and abroad. However, early warning and real time information that are necessary to address or manage a threat is one thing, time and effective action is another in assessing policy efficacy.

6.3.2. Space Support for Sustainable Human Development and Security in Nigeria

Beyond traditional conception of development and security, space has supported human development and security in Nigeria. It is important to restate that the development of space capabilities and their contribution to national development and security have advanced human development and security goals. This is evident in ways that space has supported job opportunities, wealth creation, poverty alleviation, education, competitiveness of the nation and dignity of its people, and disaster management. However, there are subjects of human development and security that deserve more attention in this consideration. This section will look into space support for human rights, good governance, food, water, and environmental security, quality health system, quality education system, poverty alleviation, employment opportunities, and youth empowerment, as well as international cooperation.

6.3.2.1. Human rights and the struggle for human freedom

Nigeria's policy, which includes programmes run with indigenous and foreign capabilities, have supported the quest for human rights and good governance in the country. Satellite TV and radios as well as (terrestrial and space supported) internets have greatly revolutionised public space in Nigeria. These platforms have enhanced public access to information, and empowered the people to mobilise for better political representativeness in governance. Satellite radio and internet platforms played important role in the mobilisation of the Igbos for better political representation, integration, and secession, especially between 2014 and 2017. Prominent among the actors in this mobilisation are the Movement for the Actualisation of the Sovereign State of Biafra (MASSOB) and the Indigenous People of Biafra (IPOB). Besides, the #BringBackOurGirls campaigns between 2014 and 2018, and the #EndSARS campaigns between 2017 and 2020 relied heavily on internet platform to mobilise public support for the struggle for human freedom in the face of state power.

A growing number of media outlets and civil society groups in Nigeria are embracing the use of satellite images to prove cases of human rights violation against state and non-state actors, most especially against the military in the less accessible North East, where Boko Haram's campaign of terror have endured for more than a decade. One of the bloodiest attacks ever recorded by Boko Haram was in Baga on January 3, 2015, where over 2,000 people were killed, 3,700 buildings were destroyed, about 15,000 people were forced to become refugees in Chad and many more were displaced internally within Borno State in Nigeria (Oyewole, 2015). However, the government and the military downplayed the attack and the impacts on the affected communities. Local and international media, NGOs and INGOs were able to raise public attention for the plight of the affected communities using a combination of human and space assets. Satellite data of the destroyed communities were widely published. These among other publicity of security failure and attendant public campaign for transparency in security crisis handling affected the then siting government, making Goodluck Jonathan the first incumbent President to lose at the poll in Nigeria in 2015. Satellite data also contributed to available public information and attendant campaign against the accidental January 2017 aerial bombing of Rann-based IDP camp, where 234 people died. Similar data were equally useful in assessing NAF bombing of communities, which were thought to be insurgent camps, in Denmsa and Numan LGAs of Adamawa State in December 2017 (Amnesty International, 2018a&b; Oyewole, 2021).

6.3.2.2. Democratisation, Policy Efficacy, and Good Governance

Beyond human rights campaigns, space capabilities have further supported other elements of democratisation and good governance. This is salient in policy planning, implementation and assessment. Prominently, space capabilities have been employed to support election management in Nigeria. Between 2010 and 2015, Nigeria made significant efforts toward digitalisation of election planning and processes. In the wake of the 2011 General Elections, the then head of the Independent National Electoral Commission (INEC), Prof Attahiru Jega requested for the assistance of NASRDA in producing the updated map of the country to guide the commission in revising the geostrategic considerations for the distribution and location of electoral materials. Satellite data produced by the space agency helped INEC to identifie many (new) settlements that were not captured in the initial elections, and reassess the demographic growth across the country. These measures contributed to the efforts to

increase political participation, representativeness of government, and entrench democracy in the country.

To reduce irregularity in electoral management in Nigeria, INEC also initiated e-platform that allows for instant transmission of all results from different parts of the country to the election situation monitoring room in its HQ, Abuja. This e-platform like many other public platforms is supported by both terrestrial and space assets, although the former is dominant. This initiative tends to entrench transparency in electoral management, and checkmate some of the fraudulent dealings and manipulation that characterised the traditional, manual and offline transmission of results in previous elections, most especially in the Fourth Republic.

Space support for public policy planning, implementation, and evaluation have contributed to improvement in government efficiency. The Nigerian satellites have been used to produce a series of surveys of land use and land cover, which has been supplied to the Federal Capital Authority and many state governments to support urban and regional planning across the country. These data among others have improved town planning and modernisation in some parts of Nigeria, where state and local governments have developed institutional capacities to design and implement relevant strategic plans. However, department of town planning in many parts of Nigeria lack the institutional capacity to design and implement community and urban development plans, even with space support. Satellite data have equally supported ministries of transportation, agriculture, education, and health among others, as well as their various departments as a contribution to policy efficiency and good governance in Nigeria.

6.3.2.3. Food, water and environmental security

Space capabilities have been employed to support research and policy quests for food, water, and environmental security in Nigeria. The water and the environment are critical factors in food production. Hence, their availability is important in food security calculation of a country. Nigeria has sponsored a series of space supported R&Ds in this area. Satellite data have helped the country to determine the growing desertification in the North, as well as forecast and prepare for period of drought. A series of space supported studies have been conducted to determine Nigeria's basement complex, as well as availability and accessibility of freshwater across the country (see for example Olusola and Fashae, 2019). These among

others have supported policy planning on agricultural, domestic and industrial utilisation of water, with significant implication for food production and importation, in the country.

It is notable that the percentage of freshwater used out of the available internal resources of the country rose from 2.529 per cent in 1987 to 4.665 per cent in 2002 and 5.642 per cent in 2012. Amidst these, the available data show that the proportion of freshwater withdrawal for agriculture in Nigeria has declined over the years, as population growth continues to increase domestic withdrawal. Freshwater withdrawal for agriculture declined from 70.13 per cent of the total in 1987 to 53.44 per cent in 2000 and 47.62 per cent in 2005, while domestic withdrawal rose from 20.13 per cent in 1987 to 31.45 per cent in 2000 and 35.43 per cent in 2005. Within this period, industrial withdrawals were between 9 per cent and 16 per cent. In 2010, agriculture, domestic and industrial withdrawal of freshwater were 44.19 per cent, 40.1 per cent and 15.76 per cent of the total withdrawal respectively (World Bank, 2020). These among other things can help us to explain the reason why food importation into the country was alarming in 2011, when food imports were 30.56 per cent of the total national mechanise imports, the highest ever since 1960 (see World Bank, 2020). In these among other critical situations, space support for relevant policy cannot be totally ignored.

Nigerian government is faced with a challenging task of determining cultivated land, planted crops and expected yield in a vast country that is characterised by small scale farming and weak institutional capacity of the local government to generate relevant and reliable data that are necessary for policy planning for agricultural and food production, importation and exportation. In this case, satellite data are very useful basis for policy planning. Although satellite data that are relevant to forecasting weather, soil fertility, water, and pests among other things that can enhance food production and ensure precision agriculture are increasingly available in Nigeria, they remain largely inaccessible for majority of the farmers, who have largely continued to maintain their small holdings and employ primitive farming strategies. Similar data on maritime ecosystem have adequately been used by government, most especially at the state and local levels, to develop coherent policy to prevent or reduce overfishing. At the same time, relevant satellite data remain largely inaccessible to majority of the people that are involved in fishing to enhance productivity and protect endangered maritime species.

Space support for terrestrial communication infrastructures has enhanced the connectivity of the rural and coastal communities, which are very critical to farming and fishing as well as food security of the country. This is important to keep these food producers in remote locations up-to-date about government policy (especially on support for farmers and tariff policy) and the general market values of their products. In this manner, the federal government under President Jonathan adopted an e-wallet platform to register and support fair distribution of subsidised fertilizer to farmers, with the aim of reducing the role of middlemen and attendant room for corruption, in Nigeria in 2014 (Manyika, 2016; Oyewole, 2017).

The utilisation of space support for environmental security generally in Nigeria has recorded its progress and challenges. Satellite data have supported research and policy responses against deforestation and soil erosion in Nigeria, with most emphasis in the South. Research and policy responses against desertification of the North, as well as depletion of Sambisa Forests have benefited from Nigeria's space policy, programme, and capabilities. The shrinking of Lake Chad and other water bodies, most especially Kanji and other dams that provide the country with hydroelectric power, have been studied with space support. Satellite data have equally supported Nigeria's search for oil reserve in the Lake Chad as well as River Benue and Niger Basins. The same assets have been employed to assess oil spillage and gas flaring as well as their environmental and health implication in the Niger Delta region. In all these and many more cases, space support is relevant for research as well as policy advocacy, consideration, adoption, implementation and assessment of environmental security in Nigeria (for example, see Ajonye et al., 2016; Anifowose, 2019; Ayodele et al., 2013; Bahago et al., 2019; Ikpaya et al., 2016; James et al., 2007; James et al., 2013; Mahmoud et al., 2016; Olusola and Fashae, 2019). Nevertheless, policy research and advocacy does not always translate to adequate policy attention, adoption, and implementation in the country.

6.3.2.4. Quality of Health System

Space policy and attendant capabilities have contributed to the quality of health system in Nigeria. At the basic level, many Nigerians across the country can now get some tips for healthy living, which include public information on food, water, drugs, and environment, from satellite TV and Radios as well as internet. In this manner, those in remote locations

now have the opportunities for timely access to information on food, drink, and drugs that have been declared unsafe for public consumption. It is easier as well to warn members of the public of the environment that have been declared as contaminated areas. Among public responses to the threats of Ebola in Nigeria, these platforms were critical in the efforts to educate those living in rural and remote communities, especially in warning them against consumption of bush meat, which may be contaminated. These platforms are also useful in a series of public engagements with basic education on health and resilience living in communities that are affected by oil spillage and gas flaring in the Niger Delta as well as lead poisoning in the North West.

Telemedicine is an important area, where space supports quality health system. One of the KIs revealed that Nigerian civil space institution and assets were first employed to support telemedicine as a pilot project in early 2000s. As at that time, however, the issue of telemedicine was not operationalised beyond the pilot stage. Nevertheless, public and private interests and investment in this programme have been revived in recent years. One of the most important private actors in this area is the Lafiya Telehealth App Ltd., which is a subsidiary of BeepTool. However, the outbreak of coronavirus (Covid-19) in Nigeria made the development, deployment, and utilisation of telemedicine a necessity, as the government of the country like others across the world struggle to enforce social distancing to contain the spread of the virus (Obikunle, 2020; Oludimu, 2020). During this period, NASRDA and Lafiya Telehealth App Ltd launched space supported telemedicine programme (NASRDA, 2020b; Space in Africa, 2020c). This initiative contributes to the efforts of the country to contain the spread of Covid19 and determine those that are already infected with the virus.

Satellite data have equally supported research and policy responses with large scale mapping to determine outbreak and concentration of diseases. They were used by many researchers to map out the spread of Ebola in West Africa in 2014. Similar data have been useful for mapping spatial distribution and concentration of swamp and other conducive environments for mosquitos in malaria research as well as related policy advocacies and considerations in Nigeria and beyond. Moreover, satellite maps and, in most cases, GPS have supported health workers with details to track the location of those in emergency medical situations with appreciable precision. These have been very useful in responses to Covid19.

6.3.2.5. Quality of Education for all

Nigeria's space policy and capabilities have supported the quest for quality education for all in the country. Terrestrial and space infrastructures have supported e-learning through internet, TV, and Radio. Public education has been sponsored by the government and NGOs through these platforms across the country. During the Covid19 lockdown in Nigeria, some states and private institutions utilised these platforms for basic education. Many public primary and secondary school programmes ran on dedicated local and satellite TV and Radio stations, while many private schools embraced internet supported e-learning across the country. Prior to these, the high degree programmes of the National Open University of Nigeria (NOUN) and many regular universities, especially those with distance learning programmes, have been based on e-learning platform. These have brought the opportunities to enrol for higher education to many people, including those in the remote parts of the country. In these and many other ways, education has become more accessible to the population of the country. Alas, very few universities and other tertiary institutions, which are mostly privately owned, are able to operate on e-learning in Nigeria during Covid19.

The space programme has equally boosted the quality of education in Nigeria. The number of trained personnel with PhD and MSc in the industry have supported the capacity of the country in STEM, and particularly in space S&T education. Besides, the space agency has supported R&D and the improvement in the quality of education in Nigeria with grant to develop their capacity in space S&T. It was revealed that between 12 and 15 universities received this kind of grant between 2004 and 2008. Among these is FUTA, which created CESRA with its first grant. The university and its centre equally received another grant from the agency, which it utilised to support the construction of Nigerian EduSat-1 satellite. With these among other initiatives, FUTA is proud to have produced many space scientists and engineers, including the founder and director of Space in Africa. The space agency and its centres also offer internship opportunities to Nigerian students, as well as training and re-training of academics and professionals from across the country and the continent.

Nigerian space assets have equally provided research centres, universities and other high institutions of learning with space-related data for R&D across the country. It is important to note that satellite data has been supplied to universities and research institutes across the country without charges. NASRDA donated more than 4,000 satellite images taken by its

first satellite NigeriaSat-1 to Nigerian universities and research institutions. These images were estimated to be worth 3 billion Naira (about US$ 8.3 million). It also donated 4.5 billion Naira (US$ 12.4 million) worth of images from NigeriaSat-X to 35 universities across the country. These among others represent space support for education to ensure quality of the system. The end products of these developments are evident in Nigeria's growing contribution to the body of knowledge on space S&T as considerably presented in Table 6.4.

Table 6.4: Nigeria's Contribution to Knowledge on Space Science and Technologies, 1996-2019

Fields	No of publications	Citations	Ranking in Africa	Ranking globally
Aerospace engineering	335	1,718	5/43	56/187
Astronomy and astrophysics	386	2,679	3/38	58/177
Atmospheric Science	618	7,179	2/53	42/217
Control and System Engineering	654	2,668	6/47	71/188
Global and Planetary Change	279	4,126	4/55	47/217
Physics and Astronomy (miscellaneous)	2,076	9,622	5/55	61/206
Space and Planetary Science	496	4,232	3/48	58/205

Source: Compiled by the author from Scimago (2020) database

As evident in Scimago ranking, Nigeria contributed 355 scholarly publications, which attracted 1,718 citations, to knowledge on aerospace engineering between 1996 and 2019, making the country 56th out of 187 globally and 5th out of 43 in Africa in this consideration. At the same time, Nigeria contributed 385 scholarly publications, which attracted 2,679 citations, to the body of knowledge on Astronomy and Astrophysics, making the country 58th out of 177 globally and 3rd out of 38 in Africa. Nigeria contributed 618 publications, which attracted 7,179 citations, to knowledge on Control and System Engineering, making

the country 71th out of 188 globally and 6th out of 47 in Africa. With 279 publications in the field of Global and Planetary Change that attracted 4,126 citations, Nigeria was 4th out of 55 countries in Africa and 47th out of 217 globally. The country came 5th out 55 countries in Africa and 61th out of 206 globally with 2,076 publications in Physics and Astronomy (miscellaneous). In the field of Space and Planetary Science, the country contributed 496 publications that fetched 4,232 citations to rank 58th of 205 globally and 3rd of 48 in Africa.

Despite the foregoing claims on the nexus between space and education, there are enduring concerns that the knowledge of space, its attendant technologies and their utilisation are limited in Nigeria. This is evident in many KIs rating of public, and to an extent, academic attention to space policy and education. The attention of social scientists, and political scientists particularly, on the subject matter are even rated to be poor in most cases.

6.3.2.6. Poverty alleviation and employment opportunities

Space support for development in Nigeria has directly and indirectly created employment opportunities for some Nigerians and alleviated their poverty. Thousands of Nigerians are directly employed in the space industry, especially in the public institutions. Satellite supported telecommunication, most especially subscription-based TV and Radio, have created a chain of employment opportunities. Space support for agriculture and food production is expected to have reduce poverty in Nigeria. This is a sector that is responsible for 36.38 per cent of the total employment of the country in 2019 (World Bank, 2020). Space support for food, water, and environmental security as well as health system is also relevant for healthy leaving and poverty alleviation in Nigeria. This is important in a country, where 3.5 per cent of the population were pushed below international poverty line of US$1.90 per day due to out-of-pocket health care expenditure (World Bank, 2020). Besides, food poverty in Nigeria was officially reported to be as high as 75.7 in 2009/2010 (NBS, 2019). In these and other ways that were earlier identified, space support has contributed indirectly to poverty alleviation across Nigeria.

Despite the foregoing, there is a concern for the enduring trend of unemployment and human poverty in Nigeria. More than 8 per cent of the labour force were unemployed, and 39 per cent of the population were below poverty line of US$1.90 by headcount, in 2018 (World Bank, 2020). These among others question the contribution of space and attendant

technologies to employment and poverty alleviation in Nigeria. Although this is currently less salient, there is also a concern that space supported AI will create a socioeconomic condition that will necessitate smart workforce and less job opportunities, most especially for the unskilled and semi-skilled labours, in Nigeria. This is a potentially dangerous trend for human development and national security that are threatened by youth unemployment.

6.3.2.8. International cooperation

Beyond the struggle for competitive advantage, Nigeria's space policy has fixed the country in the liberal Universalist dream of using space and the attendant technologies to advance international cooperation and for the benefits of humanity. In this framework, the people and government of Nigeria have benefited from the space capabilities of other countries, as well as used their capabilities to benefit others. The space policy and programmes of the country have benefited from the support of many countries that have helped in technological transfer and services. Several companies from the USA, the UK, France, the UAE, Netherlands, Sweden, and Luxembourg have secured satellite landing permits in Nigeria (NCC, 2020). These companies are offering space support services in Nigeria. However, some local stakeholders consider the involvement and activities of some of these companies in Nigeria as unfair competition for internal capacity building.

The efforts of Nigeria in space institutional capacity and local technological development have been supported by many countries across the world. In training of personnel and human capital in space R&D, countries like the UK, China, Japan, Russia, the US, Ukraine, and South Africa are prominent supporters of Nigeria. Previous satellites that were sponsored by Nigeria were developed by different companies or institutions or using facilities in the UK, China and Japan. All these satellites were launched into orbit with the support of Russia, the US, and China. While Japan has supported Nigeria with a grant for the development of research satellite and astronomical facilities, China offered the country a loan to acquired communication satellites for commercial purposes. These among other things have shown the beneficiary dimension of international cooperation in space R&D in Nigeria. However, the actual extent of technology transfer and adoption in these processes remain debatable.

Nigeria is involved in data sharing cooperation with members of the Disaster Management Constellations (DMC), which are made up of countries (Algeria, China, Turkey and the UK) with satellites built by SSTL (Curiela, 2005; Mohammed, 2011). This is similar to the data sharing arrangement from constellation of satellites with Algeria, Kenya, and South Africa under the ARM, which was agreed in 2003 (Mostert and Jacobs, 2008; Oyewole, 2017). Nigeria is also one of the leading supporters of space cooperation in the continent of Africa that have produced African Space Policy and its institutionalisation with the establishment of the ASA. Nigeria is equally a member of RASCOM and UNOOSA. These among other platforms have allowed the Nigerian space programme to benefit many other countries and their peoples. Imageries generated by the Nigerian satellites have been delivered to many countries to support them in disaster management without charges. Beneficiaries of these data include members of DMC and ARM, as well as the US, Australia, and South Eastern countries. The Nigerian satellites have supported peacekeeping and disaster management in many African countries. ARCSSTE-E, which were also funded by Nigeria, are instrumental for training personnel of many English-speaking African countries in space R&D.

6.4. Conclusion

This chapter examined the capabilities that operationalise Nigeria's space policy, considering the institutions as well as the resources, including human and material (funding and facilities) resources that are committed to the realisation of the set goals. These are vital to the development of space policy programme and its contribution to the development and security in Nigeria. Accordingly, this chapter shows records and gaps in space support for different indicators of (national and human) development and security in Nigeria, with attention to national competitiveness, economic growth and transformation, local technological capacity, defence, security, power projection, disaster management, human rights and freedom, democracy and good governance, food and water security, sustainable environment, quality of health and education systems, and international cooperation. It is on this basis that chapter eight will draw conclusion and recommendation, following chapter seven that focuses on the contribution of space policy to development and security in RSA.

CHAPTER 7

The Contribution of Space Policy Programmes to Development and Security in South Africa

7.1. Introduction

This chapter examines the programmes that operationalise the South Africa's space policy and their contributions to the development and security aspirations of the government and people of the country. While connecting to various theoretical perspectives on development and security as reviewed between chapters one and three, this chapter relies on the national conception of space policy and its strategic objectives in South Africa, as evident in chapter five, with a design that is similar in structure to that which was adopted in the preceding chapter on Nigeria. Consequently, this chapter is divided into three broad sections in addition to this introduction. The first section examines space policy programmes and capabilities of South Africa as some forms of the objectives of national development and security to be achieved. The second section interrogates how the South Africa's space policy programmes and capabilities have contributed to the development and security aspirations of the government and people of the country. The third section provides a concluding thought for this chapter.

7.2. Space Policy as an End in Itself: Space Programmes and Capabilities as National Development and Security Goals in South Africa

As earlier stated in the last chapter, starting a space programme and record of progress with it has, globally, been a form of developmental goal since the advent of space age. This is even more important in developing countries and emerging powers like South Africa. As evident in chapter five, the policy and strategic goals of South Africa in development and security, and particularly for the space frontier, include the development of necessary institutional, human resources, and industrial and technological capacity and capabilities. Consequently, the progress that have been made by the country in space policy programming and capacity developed cannot be ignored. Moreover, it will be impossible to fully appreciate the contribution of space policy programme to development and security in

South Africa (output) without adequate knowledge of the resources that were committed and capabilities that were developed for this purpose (input).

This section examines the institutions, activities, assets, human resources, funding and skills among other resources that are made available to operationalise the space policy aspiration of South Africa. To achieve this objective, however, this section is divided into two broad sub-sections. The first sub-section assesses the institutional development for space policy and programmes in the country. The second sub-section examines the resources that are made available or mobilised to operationalise institutions that are relevant to the attainment of the space policy objectives of the government and people of South Africa.

7.2.1. Institutional Development for Space Policy Programmes in South Africa

As earlier argued, institutions are important building block and component of development, including space R&D. Space policy and strategies are designed and operationalised by relevant institutions, which are expected to transform sporadic, unintended, ad hoc and less or un-coordinated interests and activities into coherent and substantive programme to maximise the utility derived from available resources. As indicated in the previous chapter, a nation's space institution broadly covers publicly owned (by the state or governmental and non-governmental) and private organisations. NGOs and private sector are increasingly playing critical roles in national space policy globally, although governmental institutions remain central to creating and maintaining the required environment for them to thrive as well as coordinating their operations in line with national interests. It is against this background that this section is sub-divided into two. The first sub-section examines the development of governmental space institutions in South Africa, while the second sub-section surveys the development of NGOs and private actors in the space sector of the country.

7.2.1.1. Development of Governmental Institutions for Space Policy Programmes in South Africa

South Africa can be said to run three broad categories of space programme, which are: civil, commercial, and military space programmes. In some of these cases, the republic has institutionalised these programmes, as a number of institutions have been developed over the years for them. Table 7.1 provides a summary of government space programmes and the

major institutions developed for these purposes in RSA. Accordingly, this section is divided further into three sub-sections. The first sub-section examines one, government departments and agencies, as well as some of the collaborating local academic institutions, which are central to operationalise civil space programme in the country. The second sub-section deals with the state owned and sponsored commercial entities that are involved in space affairs, while the third sub-section involves state institution for military space programmes in the RSA.

Table 7.1: State-Owned space institutions in South Africa

Space programmes	Institutions and Centres
Civil space institutions	SANSA + relevant Departments (DST & DHET: DHESI & DTI) and agencies/institutions (CSIR, SACSA, & NRF). Major collaborating academic institutions locally: CPUT, UCT, UWC, University of Stellenbosch, TUT, UNISA, UKZN, University of Free State, University of Pretoria, & Wits.
Commercial space institutions	Spaceteq, Sentech Soc Ltd.
Military space institutions	DOD: Armscor & SANDF (SAAF, SAA, SAN, DI); & SSA

Source: Compiled by the author.

7.2.1.1.1. Development of State Institutions for Civil Space Programmes in South Africa

As evident in chapter five, modern day space S&T in South Africa can be traced to 1700s. Accordingly, many institutions have emerged for this purpose over the years. However, it was only in early 2000 that concrete steps were taken to coordinate the disparate institutions and their activities. This gave birth to the establishment of SANSA in December 2010. The politics behind this development has been considered in chapter five. As a result, this section is only interested in the organisation and functionality of this and other institutions.

Unlike the Nigerian space legislation that created a decentralised space agency with multiple centres, the South African space legislation created a relatively centralised space agency. Although they later recognised the need for the space agency to create or partner with a company as well as establish, coordinate, and manage any programme considered necessary, SANSA is made the central institutional unit of space policy implementation in South Africa (RSA, 2008). In the case of Nigeria, NASDRA has several centres that are created by law, funded directly from the National Appropriation, and exercise some level of administrative and operational autonomy from the central institution (see chapter six for more details). In the RSA, however, the SANSA has facilities with limited institutional autonomy that are managed centrally or remotely, in case of distance ones, by partnered organisations.

The operations of SANSA cover four major programmes, which include EO, space engineering, space operations, and space science. The EO programme entails collection, processing, archiving, and dissemination of various EO data mainly generated from satellites to support decision-making, economic growth, and sustainable development in the RSA. The space engineering programme is designed to develop, build and test satellite systems and sub-systems. The space operation programme focuses on various ground station facilities and services for launch activities, including satellite tracking, telemetry and command (TT&C), launch support, in-orbit testing, mission control, and space navigation. Space Science operated programme is designed for the study of the Earth's magnetic field, the Sun and the near-space environment (SANSA, 2020b). The SANSA head office is located in Pretoria, from where the EO and space engineering programmes are also coordinated. The SANSA space operations programme is coordinated from Hartebeesthoek, while the space science is coordinated from Hermanus in Western Cape (SANSA, 2020c).

Although SANSA is the primary state institution in the implementation of space policy in South Africa, it operates closely and collaboratively with several government departments, agencies, and institutions. The agency maintains close working relationship with other departments, such as the Department of Higher Education, Science and Innovation (DHESI), the Department of Communications and Digital Technologies (DCDT), DTI, DOD, and the DIRCO. As an agency under DST, which is also known as the Department of Science and Innovation (DSI), SANSA operates closely with the central administration of the Department as well as associated agencies or related institutions within it. Prominent among these institutions are the Academy of Science of South Africa, the CSIR, the National

Advisory Council on Innovation (NACI), the National Research Foundation (NRF), and the TIA.

The Academy of Science of South Africa was established by President Mandela in May 1996. The Academy currently operates within the legislative framework of Academy of Science of South Africa Act (Act 67 of 2001), which was passed and amended by the Parliament, and came into operation in May 2002. The Academy has a physical presence in Pretoria. The mandate of the organisation entails using science to investigate national problems and provide evidence-based solutions; inspire pure and applied sciences for the benefit of the society; connect the country to the highest level of knowledge globally; and facilitate public understanding of the character, scope, and value of scientific and technological enterprise (Academy of Science, 2020). The focus of the Academy covers various fields of science, including space science.

The CSIR is another relevant player in space R&D in RSA. The CSIR was established by an Act of Parliament in 1945. Its office is based in Pretoria. The mandate of the organisation, as stated by the Scientific Research Council Act 46 of 1988, amended by Act 71 of 1999, is to promote and direct multi-disciplinary research and technology for the advancement of national interests. It is also mandated to work with private and public sectors to promote critical fields of science, industrial research and development to improve the quality of life of the people of the RSA (CSIR, 2020). As evident in chapter five, this organisation played important roles in the formulation and implementation of the space policy of the country, especially before the 1990s. Thereafter, the activities of the CSIR have directly or indirectly supported space R&D in South Africa.

The NACI is another state-owned organisation that is relevant for space R&D in South Africa. The organisation operates with the legislative framework of The National Council on Innovation Act, 1997 (Act No. 55 of 1997). It has the mandate to promote STEM research and studies to improve and sustain quality of life, develop human capital for science and technology, and building the economy of South Africa, as well as strengthen the competitiveness of the country in the international system (NACI, 2020). This makes it possible for the activities of NACI to support space R&D directly or indirectly in the RSA. This organisation maintains a physical presence in Pretoria.

The NRF is another government establishment that is involved in promotion of science and technology R&D. Following a major review of the Department of Art, Culture, Science, and Technology (DACST), NRF was established in 1998 to take over the functions and services of the pre-existing research funding entities such as the Centre for Science Development (CSD) that was dedicated to Human Sciences Research Council (HSRC) as well as the Foundation for Research Development (FRD) and its affiliated research facilities (NRF, 2020a). The entity is mandated by the National Research Foundation Act (Act No 23 of 1998) to fund advanced research, promote human capacity development, as well as provide support and maintain research facilities in all fields of science and technology without excluding humanities, social sciences, and indigenous knowledge. The foundation also has the mandate to bridge the gap between the scientific community and the society through public awareness, as well as support government and its policy priorities with scientific R&D (NRF, 2020b). The NRF maintain a physical presence in Pretoria. As an entity under the DST, the foundation works closely with other agencies in the department and Higher Education Institutions (HEIs) across the country.

The TIA is another entity in the DST that is relevant to technological R&D, including the space sector. The Agency was established and operates within the legislative framework of Technology Innovation Act (Act 26 of 2008). The mandate of the Agency is to stimulate and promote innovative R&D, discoveries and exploitation in public interest. For these purposes, the Agency maintains physical presence in Pretoria, Cape Town, and Durban. The TIA has developed pre- and post- investment initiatives to support technological research and development in South Africa from proof of conception to pre-commercialisation. These among other things led the agencies to establish various funds, which include the seed fund, the technology development fund, and the commercialisation support fund (TIA, 2020).

The DHET and affiliated higher institutions are state entities that have played critical roles in the formulation and implementation of South Africa's space agency. The DHET was established in 2009 when the former Department of Education (DE) was divided into two new ones: Department of Basic Education (DBC) and the DHET. The Department has the mandate to undertake policy measures to provide, support, and promote education, training and skill development beyond basic schooling. It operates under the constitutional provision of Section 29 on Educational rights of all as well as the legislative framework of the Higher Education Act, the Continuing Education and Training Act, 2006 (Act No 16 of 2006) (SET

Act), the Further Education and Training Act (AET Act and FET Act), the National Student Financial Aid Scheme (NSFAS Act), the National Qualification Framework Act (NQF Act), and the Skill Development Levies Act (DHET, 2020). The Department develops the policy framework, accredit and supervise universities in the RSA. In 2019, DST was subsumed into DHET to form the DHESI.

South African universities played important roles in space policy processes, most especially the implementation and assessment, in the country. The government of RSA and the space agency have engaged institutions, experts, and students of the University of Stellenbosch, UCT and CPUT as recognised in chapter one. Other major universities in this consideration are the Tshwane University of Technology (TUT), the University of Western Cape (UWC), the University of KwaZulu Natal (UKZN), the Nelson Mandela Metropolitan University (NMMU), the University of Free State, the University of Pretoria, the University of Witwatersrand (Wits) and UNISA. The Faculties of Science and Engineering of these universities and their products among others are playing critical roles in managing many space facilities and corporations, as well as acting as catalysts of innovations and inventions in this sector. Amidst these, University of Stellenbosch, UCT and CPUT have made some of the most important landmarks in space policy implementation of the country, considering their instrumentation in satellite construction. Notably, the French South African Institute of Technology (F'SATI), which is jointly developed by the French and South African governments, works with the CPUT's Department of Electrical, Electronic, and Computer Enginnering (DEECE). Similarly, the UCT maintained a Spacelab until 2020/2021, while the University of Stellenbosch maintains an Electronic Systems Lab (ESL). Some of these details will receive further attention later in this chapter.

The SANSA also work closely with the DCDT in the implementation of South Africa's space agency. The DCDT was created in June 2019, following the merger of the Department of Communication (DOC) and the DTPS. Among other things, the department has the responsibility to promote, coordinate, and manage interest and investment in Information and Communication Technologies (ICT), and ensure that they are utilised to enhance the socioeconomic development of the people of South Africa (National Government, 2020). The mandate of the department cuts across both terrestrial and satellite communications, as well as ICT support for other forms of space assets. These among others gave DCDT some implicit and explicit roles in the formulation and implementation of space policy in the RSA.

The DTI and DoD are also major institutions in the commercial and defence dimension of space policy in South Africa, and they will be considered in the appropriate sections later in this chapter. The relevance of space assets and facilities to the activities of some other departments of government also makes them institutionally important for implementation of South African space policy, most especially in utilitarian consideration. Prominent among these departments are the Department of Environment, Forestry and Fisheries (DEFF), the Department of Agriculture, Land Reform and Rural Development (DALRRD) and the Department of Transportation (DOT) as well as their various agencies and institutions that rely on space assets and facilities to support their policy processes and operations.

It is against this background that SANSA and its relatively centralised structure, especially when compared to NASDRA, cannot be taken out of context. These and other government departments and their agencies as well as affiliated research and academic institutions are considerable state-institutions that are involved in the South African civil space programmes. Accordingly, the state institutional development for the civil space programmes of South Africa cannot be reduced to SANSA, even though the organisation remains central in the whole process. Instead, the subject of state institutional development for civil space policy and programmes in the country can be approached from two perspectives. One of these approaches is focused on SANSA as the central unit of analysis, while the other tends to recognise network of many other entities in state institutional development for civil space programmes in South Africa.

7.2.1.1.2. Development of State Institutions for Commercial Space Programmes in South Africa

Development of state-owned commercial space entities in South Africa is an offshoot of the country's civil and military space programmes. It is important to note that these entities are to various degrees subjected to the regulatory, supervisory, partnership, and oversight roles of SANSA, DST, DOD, DCDT and DTI. Prominent among the state institution developed for commercial purposes in the space sector in the RSA are Spaceteq and Senntech Soc Ltd.

The Spaceteq is a business unit of Denel Dynamics, which is a division of government-owned Denel SOC Ltd. The parent company has its root in missile research, design, and development that started in 1964 with the Institute for Rocket Research (IRR), which later

became the National Institute of Defence Research (NIDR), under the CSIR. This cumulated to the establishment of Kentron (Pty) Ltd as a division of Armscor in 1978 with the aim of providing defence system and support for the military. When the Denel (Pty) Ltd was established as a group of companies in 1992 and commissioned for arms exportation, Kentron became a division of this industrial group. In 2004 and 2006 restructuring of Denel, Kentron was renamed Denel Aerospace Systems (DAS) and Denel Dynamics respectively. As a unit of Denel Dynamics, Spaceteq became operational on July 1, 2013 (Denel Dynamics, 2020). It also important to note that the Sun Space, the spinoff of SU's ESL, sold its intellectual property to Danel spaceteq, which also absorbed its staffs.

Spaceteq's business interests broadly cover tactical missiles, precision-guided weapons, Unmanned Aerial Vehicles (UAVs), satellite, and integrated system solutions (IAF, 2020a). Its most important space products and services include design and development of satellite systems and (both soft and hard-ware) subsystems or components, missions control systems, AIT assistance and testing services, as well as professional advice on space systems design and training (Spaceteq, 2020). Spaceteq is located in Grabouw. It has been a member of the IAF since 2013. The entity equally operates in partnership with the NewSpace Systems, CSIR, DTI, DST, SANSA, UCT, University of Stellenbosch, Astroafrica Technologies, F'SATI, and Space Advisory Council (Spaceteq, 2020).

Sentech SOC Ltd. is another prominent state-owned enterprise (SOE) that is involved in space-related activities in South Africa. The origin of this company can be traced to the technical division that was tasked with signal distribution of the state-owned South African Broadcasting Corporation (SABC). Sentech was incorporated as a subsidiary of SABC in 1992, and was converted into a separate public enterprise in 1996. The Sentech Act of 1966 tasked the company to provide broadcasting signal distribution services, that is, Electronic Communications Network Services (ECNS) and Electronic Communications Services (ECS), to licensed television and radio broadcasters in accordance to the South African Electronic Communications Act (Sentech, 2020). The company offers television and radio broadcasting services with both terrestrial and space-based infrastructures and assets. Sentech maintains a physical presence at Honeydew in Roodepoort, Gauteng.

7.2.1.1.3. Development of State Institutions for Defence Space Programmes in South Africa

As earlier discussed in chapter five, the government of South Africa has developed space-related military interests and programme since the 1960s. However, these interests and attendant programmes were suspended between late 1980s and early 1990s, as the national security threats perception of the country changed with the political transition of the period. Yet, the first decade of the 21st century witnessed renewed interests and programmes for military space capabilities in the country. Unlike Nigeria, where space-related military interests and programme have been institutionalised with formation of DSA, South Africa does not have a specific institution at the level of agency in the DOD or service of the armed forces that are publicly known to be dedicated to operationalising its defence aspect of space policy. Nevertheless, this does not mean that there is no institution for this purpose.

Although there is limited public information on the defence space programme of the RSA, it remains the area of responsibility of DOD. The DOD is responsible for defence policy planning, and provides the framework for its implementation by its agencies and different services of SADF as well as collaborative arrangement with other public or private entities. This includes the area of defence space policy and programme. In this case, an agency in the DOD like ARMSCOR cannot be ignored. The ARMSCOR and its affiliated entities and partners, are critical in research, design, development, acquisition, and adaption of defence technologies, including space related ones, and relevant training for personnel (Armscor, 2020). Denel emerged as a division of Armscor to become a component of the separate state-owned company established in 1992. However, the agency maintains the Defence Decision Support Institute (DDSI), and the Institute for Maritime Technology (IMT) among other facilities, some of which will be examined later in this chapter.

Different services of the South African Defence Force (SANDF), most especially the South African Air Force (SAAF), the South African Army (SAA) and the South African Navy (SAN) are key to operationalising defence space assets and facilities in the RSA. Amidst these, the SAAF maintains a Joint Air Reconnaissance Intelligence Centre (JARIC), which operates ground radars with air and space ISR assets. These among other things led some KIs to believe that the SAAF plays more important role in operationalising the South African defence space policy programme. Nevertheless, there are indications that the

Defence Intelligence division of the SANDF (SANDF-ID), which is also known as the military intelligence play a central role in space-related C4ISR of the RSA. Other relevant divisions of SANDF in defence space policy and programme of the country are Policy and Planning, and the Joint Operations Division (JOD).

Beyond SANDF, there are indications that some other institutions are involved in the defence and security aspects of the South African space policy and programme. These include the State Security Agency (SSA) of South Africa, which was established in 2009, when the National Intelligence Agency (NIA), the South African Secret Service (SASS), the South African National Academy of Intelligence, National Communications Centre and the Electronic Communications Security (Pty) Ltd (COMSEC) were brought together under one big structure. The SSA is responsible for all civil-related or non-military intelligence of the Republic. Within this structure, SASS is a division, which continues to be responsible for foreign intelligence and counter-intelligence. In addition, the South African Police and Customs tend to be relevant in defence space policy and programme mostly as consumers.

7.2.1.2 Development of NGOs and Private Sector in South Africa's Space Policy

NGOs and the private sector are important in the consideration of institutional development of space programmes. As evident in the arguments of some liberal scholars in chapters one to three, NGOs and the private sector are important for political and economic liberalisation of space and associated benefits respectively. They are essential platforms for wider education or popularisation, mobilisation, and participation in space policy processes. At the same time, their expansive services make space, its technologies, and associated benefits more accessible and, in a competitive environment, more affordable to greater majority of the world's population. Accordingly, the development of such important institutions, platforms, or sector cannot be ignored in the assessment of South Africa's space policy, its operationalisation, and their contributions to the development and security of the country. Table 7.2 offers a summary of known space-related NGOs and private companies in South Africa. This section is subdivided into two: development of NGOs and the private sectors in South Africa's space policy and industry.

Table 7.2: Space-related NGOs and private companies in South Africa

Major non-state space actors	Major Organisations
NGOs	ASSA, SGAC, FSDSA, SASA
Private Corporations	Aerobotics, Amaya Space, Astrofica Technologies, ATE, Brolaz Projects, Cobham, Carl Zeiss Optronics, Convergence Partners, Cubespace, DeltaV Aerospace, EMSS Antennas, ETSE Electronics, Geosmart Space, Marcom*, Marnic Precision Engineering, Mzansisat, Newspace Systems, Neotel, Pinkmatter Solutions, Reutech, SCS Space*, Simera Sense Pty, SAC, Stone Three, Stratosat Datacom, SpesCom, Spectrem Air, SunSpace, Tellumat & Telkom.

*Now out of business

Source: Compiled from the Tauri Group (2011); Space in Africa (2019b).

7.2.1.2.1. Development of NGOs in South Africa's Space Policy Processes

Several NGOs have emerged in South Africa with space policy as well as R&D as their explicit or implicit interests. Prominent among these organisations is the Astronomical Society of Southern Africa (ASSA). The society was born out of the merger of the Cape Astronomical Association (CAA) and the Johannesburg Astronomical Association (JAA) to form a national association known as the Astronomical Society of South Africa in 1922. The CAA was established in 1912, while the JAA was established in 1918. The Society adopted its current name, with South Africa changed to Southern Africa, in 1956. The objective of the Society is to stimulate and encourage the study of astronomy, and astronomical observation and research, as well as disseminate relevant information to the community of astronomers. The Society is an umbrella association for astronomical centres

and societies in the country. The major centres of the Society are located in Bloemfontein, Cape Town, Durban, Hermanus, the Garden Route, Johannesburg, and Pretoria (ASSA, 2020).

The national branch of the SGAC is another major NGO with space focus in South Africa. Much has been discussed about this INGO and its African regional arrangement in the last chapter. However, it is important to note that South Africa is well represented in the INGO. The importance of the country is evident in how it hosted the 10th annual conference of the organisation, held in Cape Town, in 2011; it was attended by 130 delegates from 42 countries (SGAC, 2020b). The national branch of this organisation maintains close relations with space-related government institutions and other NGOs in the country.

The Foundation for Space Development, South Africa (FSDSA) is another major NGO in the country with space focus. It was established in 2009 with a base in Cape Town. The objective of the Foundation is to drive space awareness through: outreach, education, and activities (FSA, 2020a&b). The South African Space Association (SASA) is also an NGO that focuses on the subject matter. This association is a forum for the professionals to exchange ideas. It maintains physical presence in Cape Town. The SASA has collaborated and partnered with local and international players in space. The association is recognised by the IAF (2020b) to have maintained a membership of this INGO since 2012.

There are many other NGOs with varying degrees of interests in space and attendant technologies in South Africa. Prominent among them are the South African Society for Atmospheric Sciences (SASAS), the Wildlife and Environment Society of South Africa (WESSA), the Centre for Environmental Rights, the World Wide Fund for Nature (WWF) South Africa, and the Wildlands Conservation Trust (Wildtrust). These among other NGOs are primarily concerned with the sustainability of the environment, and to varying degrees, how they can use space to advance their core interests.

7.2.1.2.2. Development of Private Sector in South Africa's Space Industry

South Africa has the highest concentration of private companies in the space industry than any other country on the continent. The operationalisation of space policy and programmes of the country is considerably supported by the existence of a vibrant and thriving private sector. No fewer than 23 space-related companies in South Africa were identified in a report

by The Tauri Group (2011). These include two state-owned companies (that were discussed earlier in this chapter) and 21 private companies, such as Aerosud, Ansys, Advanced Technologies and Engineering Co. (ATE), Brolaz Projects, Cobham, Carl Zeiss Optronics (Pty) Ltd, Convergence Partners, EMSS, New Dawn Technologies (NDT), Neotel, Radio Holland South Africa, Reutech Radar Systems (RRS), Reutech Communications, Space Advisory Council (SAC), SpesCom, Spectrem Air, Tellumat, and Telkom as well as the now defunct Marcom, Space Commercial Services (SCS), and SunSpace (The Tauri Group, 2011).

A recent report by Space in Africa (2019b) recognised 18 space companies in South Africa, which include several companies that are not identified by The Tauri Group. These include Aerobotics, Amaya Space (Pty) Ltd., Astrofica Technologies, Cubespace, Deltav Aerospace, EMSS Antennas, ETSE Electronics, Geosmart Space, Marnic Precision Engineering, Mzansisat, Newspace Systems, Pinkmatter Solutions, Reutech Radar Systems, Simera Sense Pty, SAC, Stone Three, and Stratosat Datacom as well as now defunct SCS Space (Space in Africa, 2019b). It is important to note, however, that there is no exhaustive list of companies that are directly or indirectly involved in the space industry in South Africa. Accordingly, the aim of this section is only to examine some of the prominent and most relevant private actors in the sector.

The Advanced Technologies & Engineering Co (Pty) Ltd. is one of space-related private companies in South Africa. It popularly known as the ATE South Africa. The company is a key industrial subsidiary of the ATE Group of Companies, which was established by the French Aeronautical Engineers. It was established and registered in South Africa in 1984 (ATE, 2020). This company is located in Halfway House, Gauteng. It is a specialist system integrator that is involved in designing, integrating and testing of avionics systems for military aircraft; ballistic algorithms and firing control systems for weapons platforms; as well as development and production of remote sensing platforms (The Tauri Group, 2011).

Aerobotics is an MNC with business presence in 18 countries, including France, Germany, Italy, Mozambique, Russia, South Africa, the US and Zimbabwe. In South Africa, the company maintains physical presence in Cape Town. It employs data (imageries) generated from drone and satellite to support farmers with precision agriculture, especially in the areas

of plantation management. The company offers services that include farm survey, problem identification, yield forecast, and management (Aerobotics, 2020; Space in Africa, 2019b).

Aerosud is another space-related company in South Africa. It maintains a physical presence in Pretoria. The company engages in aviation engineering for civil and military purposes. It is involved in researching, designing, prototyping, developing, manufacturing, supplying, fitting and servicing aviation products, which include aerostructure and interior components of aircraft, as well as robotics and automated solutions (Aerosud, 2020; The Tauri Group, 2011).

Amaya Space (Pty) Ltd. is a leading South African company that is involved in space manufacturing and commercial services with special focus on nanosatellite. Established in 2018, the company is a spin-off of over ten years involvement of the CPUT and its affiliated F'SATI in space programme, and particularly satellite research, design, development, and production. The objective of the company is to commercialise nanosatellite systems and subsystems as well as associated services and knowledge locally and globally. Amaya Space maintains a physical presence in Cape Town. Its key partners include the CPUT, F'SATI, Cycle Space (the Scottish distribution partner), Stone Three, SANSA, DST, Etse electronics, CSIR, and the University of Stellenbosch (Amaya Space, 2020; Space in Africa, 2019).

Ansys Limited is another private company that is relevant and involved in South Africa's aerospace industry. It ISO 9001 and CIDB certified South African company, which maintains a physical presence in Pretoria. The company engages in design, development, production, integration, and distribution of technology-driven engineering solutions in the defence, information security, industrial, mining, rail, and telecommunications sectors. The company is a founding member of the South African Electrotechnical Export Council (SAEEC) and is equally affiliated to the Aerospace, Maritime and Defence Industries (AMD) and the Fibre To The Home (FTTH) Council (Ansys, 2020; The Tauri Group, 2011).

Astrofica Technologies Pty Ltd was established in 2018. The name was coined from Astro and Africa. The company, born from the dreams of Jessie Ndaba and Khalid Manjoo, was slowly conceived from 2006, when they were involved in the SumbandilaSat project of the DST. Its services revolve around satellite technology solutions, particularly in the areas of assembling, integration, and testing of satellite systems. The company maintains its head

office in Cape Town and an AIT facility in Grabouw. Astrofica's partners and clients include the DST, SANSA, CPUT, Amaya Space, Newspace System, Cocalibra Engineering, Simera Sense, Cube Space, and Spaceteq (Astrofica, 2020; Space in Africa, 2019).

Brolaz Projects (Pty) Ltd. is a member of Brolaz Group of Companies. It was established in South Africa in 1989 with a base in Midrand, Gauteng. The Company has developed and expanded over the years, as evident with its growing number of subsidiaries across major African countries. The Brolaz is a leading infrastructure service provider in the areas of Telecommunication, Broadcasting and electronics. It offers tailor-made services to meet the requirement of its customers in different areas of turnkey solutions for infrastructural projects. It specializes in the design, development, production, and supply of relevant infrastructural components such as towers, masts, conventional and alternate power, cooling systems, equipment shelters, as well as camouflaged antenna and the supporting structures. Its clients and partners comprise of blue-chip companies, broadcast operators, equipment vendors, fixed and mobile telecommunication operators, government bodies, oil companies as well as many other investors locally and internationally (Brolaz South Africa (Pty) Ltd. 2011; Apollo, 2020; The Tauri Group, 2011).

Cobham Aerospace Communication is another South African company that is involved in the aerospace sector. Although the company is known as the Omnipless Manufacturing (Pty) Limited, it is trading as the Cobham Aerospace Communications. The company maintains physical presence in Western Cape. It offers services to clients in commercial, defence and security aerospace sectors. Its operation covers a range of services, including aircraft clocks, light, satellite communications system, antennas, audio and radio management, avionics and supporting systems, as well as UAV connectivity among other tailor-made services required by customers (Cobham, 2020a &b; The Tauri Group, 2011).

CubeSpace is one of the key players in South Africa's space industry. It was born from the success recorded in academic research and innovation of the ESL of the University of Stellenbosch and the Innovus programme of its Nedbank LaunchLab business incubator on attitudinal determination and control systems (ADCS) in 2014. CubeSpace was officially recognised as a spin-off of the University in 2017. The company is located in Stellenbosch. Its products and services revolve around micro-satellite sub-systems, with special focus on ADCS, including onboard CubeSat computer, sensor, control, and experimental satellite

cameral sensor. Its clients and partners include the NASA, the ISIS, Hawaii Space Flight Laboratory, Open Cosmos, and Alén Space (Cubespace, 2020; Space in Africa, 2019b).

The Convergence Partners is another company in South Africa with space-related focus. It was established in 2006. The company maintains a physical presence in Johannesburg, South Africa and some other African countries. It provides skills, experience, and capital to accelerate technological development in the areas of communications access and ICT infrastructure development, with special focus on initiatives that raise the availability of communications and broadband services as well as new technology in Africa (Convergence Partners, 2020; The Tauri Group, 2011).

DeltaV Aerospace is another emerging space-related company in South Africa. It was established in 2014 and located in Cape Town. The company provides services in the areas of propulsion engineering, aerospace engineering, systems engineering, test engineering and related programme management. Accordingly, DeltaV is into research, design, simulation, development, assembling integration, testing and supply of propulsion devices, launcher vehicle, satellite and UAV systems and subsystems (DeltaV, 2020; Space in Africa, 2019b).

The EMSS group of companies is another major player in South Africa's space industry. It was established in 1994 by Dr. Frans Meyer and Dr. Gronum Smith to render services in electromagnetic consulting. Over the year, the company developed a series of additional services and products, which matured into independent status that made it a group of companies. Amidst these are computational electromagnetic software that was associated with FEKO, which was sold to Altair in 2014. The EMSS Antennas was also established as one of such new entities in 2002. This entity is based in Stellenbosch. It provides antenna hardware and software, and supported local and international industry with electromagnetic engineering services and solutions. Since 2006, the company has focused on developing receiver solutions for radio telescopes and offering services in the area of reflector design, which include both analysis and synthesis. When EMSS group of companies rebranded as Alphawave Group in 2017, the EMSS Antennas equally became one of its subsidiary entities (EMSS Antennas, 2020; Space in Africa, 2019b; The Tauri Group, 2011).

The ETSE Electronics is another subsidiary of Alphawave Group (formerly EMSS group of companies). It was established in 1997 with a base in Stellenbosch. The company has

developed products and offered services for space, military, agriculture, and commercial applications. It is involved in research, design, development, manufacturing, and consultancy in the areas of radio frequency (RF) and microwave electronic design (including at the levels of component, module, and system solutions). Its experience covers implementation of technologies such as embedded systems and software, Field Programmable Gate Array (FPGAs), Global System Mobile (GSM), GPS, RF modems, microprocessors, low-power systems, sensors and measurement devices (ETSE, 2020; Space in Africa, 2019b).

GeoSmart is another South Africa's space-related company that emerged from R&D efforts of the University of Stellenbosch. It was established by Prof Adriaan van Niekerk as a spin-off company of the University's Innovus LaunchLab business incubator, and is based in Stellenbosch. The company maintains close ties, partnership and collaboration with the university as well as its affiliated entities like the Innovus and the Centre for Geographical Analysis (CGA). It employs various cutting-edge technologies, such as the geographical information systems (GIS), earth observation satellites, global navigation satellite systems (GNSS), mobile devices, cloud computing, and artificial intelligence to provide geospatial solutions to geographical problems in the country (Geosmart, 2020; Space in Africa, 2019b).

Marcom Aeronautics and Space (Pty) Ltd. was another major player in South Africa's space industry. It maintained a physical presence in Johannesburg. Marcon's strategic partners included AISI, CSIR, SANSA and SACSA (Marcom, 2020). However, a KI reealed that company relied most on small contracts from the DST. The company was involved in research, design, simulation, development, assembling, integration, testing, manufacturing, and supply of launcher systems and subsystems. Its products and services covered a broad spectrum, including liquid rocket engine design and testing; guidance, navigation, and control systems; attitude control system design; orbital mechanics, trajectory optimization; thrust vector control systems; structural dynamics; and aero-thermodynamics (Marcom, 2020; The Tauri Group, 2011).

Marnic Precision Engineering started a family business founded by Pottie Potgieter in 1988. It grew from a backroom business to its facility in Johannesburg, and was incorporated as a company in 2016. The company provides precision engineering products and services for aerospace and defence, medicine, agriculture, mining, power and energy, petrochemicals,

and food and beverage industries. Its products and services include computer numerical control (commonly referred to as CNC) milling, turning, conventional milling, wire cutting, welding, grinding, fabrication, reverse engineering, and product development (Marnic, 2020a&b; Space in Africa, 2019b).

Mzansisat is another major player in South Africa's space industry. It was established in 2013 with a base in Stellenbosch. The company provides satellite broadband services and connectivity for a wide range of industries, from finance and education, to mining and agriculture, as well as the government entities, including the military, police and disaster management agencies. It boasts of providing connectivity from a sovereign satellite, that is, the space asset that is controlled and operated within the country (Mzansisat, 2020; Space in Africa, 2019b).

New Dawn Technologies (NDT) is a South Africa's ICT company that was established in 1999. It maintains a physical presence in Midrand. The NDT's strategic partners include Oracle, Microsoft, SAP, Vodacom, IBM and CITRIX. The company provides systems integration and business consulting solutions across various industries, which include communication, education, energy, entertainment, government, financial, health, hospitality, information, leisure, manufacturing, mining, retail, tourism, utilities and other sectors (NDT, 2020a &b; The Tauri Group, 2011).

Newspace Systems (Pty) Ltd. (NSS) is also a major space company in South Africa. It was a product of a joint venture that involved the South African company, SCS Aerospace Group, and the Dutch SSBV Group. The company maintains physical presence in Cape Town, South Africa as well as in the United Kingdom. Its strategic partners and clients include AstroDigital, AstroScale, Berlin Space Technologies (BST), Aerospacelab, Conae, Hemeria, KMI, Lapan, Leo Stella, Gomspace, Nexeya, OHB, Okman Aerospace, Sierra Nevada Corporation, Sitael, Spaceflight, and Syspective. The NSS is involved in research, design, development, assembling, integration, manufacturing, and supply of spacecraft components and sub-systems, and famous in the area of ADCS. The products and services offered by the company include CubeSat attitude control solutions, closed-loop ADCS, GPS receivers and antenna, magnetometers, magnetorquer rods, reaction wheels, sun sensors, stellar gyros, star mappers and waveguides (NSS, 2020; Space in Africa, 2019b).

Pinkmatter Solutions is a space-related company in South Africa. It maintains a core physical presence in Pretoria, South Africa and Berlin, Germany. The company specialises on R&D of earth observation satellite, ground station and data management software. Its products and services include ground station and data management software, the FarEarth software suite, encompasses antenna, satellite downlink scheduling, high volume data processing, data archiving and cataloguing, automated services for the processing and visualization of earth observation imagery, such as high resolution elevation models for encroachment detection, vegetation analysis as well as flood and fire monitoring. Its clients and partners include several space and remote sensing agencies or centres across Africa, Asia, Australia, Europe, and North-America (Pinkmatter, 2020; Space in Africa, 2019b).

Reutech Pty Ltd. is a group of companies that produce and supply space-related products and services. Prominent among its subsidiaries are Reutech Radar Systems, Reutech Mining, Reutech Solutions, Reutech Communications, Reutech Electronics, Reutech Rouge International, Fuchs Electronics, Nanoteq, Omnigo, Dopptech, Terra Firma Solutions, and Bluenova. Reunert Limited. As a group, these companies design, develop, manufacture, provide, and supply high-precision products and services for defence, mining, industrial, and other commercial applications. The Stellenbosch-based Reutech Radar Systems (Pty) Ltd. (RRS), which was established in 1987 and now owned by Reunert Ltd., is involved in research, design, development, supply and installation land and sea-based and solar radar systems and tracking devices, as well as telescope products. Reutech Solutions provides statics and mobile tactical ICT support for C4. Reutech Rouge International deals with remote control systems. Reutech Communications provides secure communication for SADF and some international clients. Other Reutech subsidiaries are equally relevant in the production or provision of supporting products and services for space systems and sub-systems (Reutech, 2020a &b; Space in Africa, 2019b; The Tauri Group, 2011).

Space Advisory Council (SAC) is one of the spin-off companies from the South Africa's satellite demonstrations: SunSat and SumbandilaSat. It was established in 2009 with a base in Stellenbosch. The company specialises in research, design, development, assembling, and testing of spacecraft and payloads, with emphasis on nano and micro satellites engineering. It offers system and sub-system solutions to clients on EO satellite programming. SAC's products include optical payloads Gecko Imager, Chameleon Imager and Tegu Imager; optical satellites like phoenix (25kg) CubeSat, Lightweight High Resolution and High

Performance (1m) Satellites and Very High Resolution (50cm) Satellite; as well as Synthetic Apreture Rader Satellites like uStar, FalconSAR and Dragonsar. Its clients include China and Netherlands (SAC, 2020; Space in Africa, 2019b; The Tauri Group, 2011). As SAC was crumbling in financial crisis in 2019/2020, Bryan Dean (the CEO of the new firm) and four other employers of the company established Southern Space, which was later renamed Dragonfly Aerospace (Space in Africa, 2020d).

Space Commercial Services, otherwise known as the SCS Space (Pty) Ltd is another private actor in South Africa's space industry. It was established in 2008 and maintains physical presence in Cape Town and Stellenbosch. The company provides advisory and consulting services on satellite programming. Its strategic partners are SAC and the NewSpace Systems (SCS Space, 2020; Space in Africa, 2019b; The Tauri Group, 2011).

Simera Sense Pty Ltd is a space-related company in South Africa. It was established in 2018 as a subsidiary of Simera Group. It maintains physical presence in Somerset West, Western Cape. The company specialises on end-to-end optical payload for EO satellites. It designs, develops, manufactures and supplies different systems and subsystems or elements of a remote sensing payload, including optical front-end, control, sensor, processing power, structure, robustness and calibration. Its products include different variant of xScape100 and xScape200. The company is into partnership with Amaya Space, Clyde Space, CubeSpace, ISISpace, GOMSpace, Open Cosmos, Nano Avionics, Space Inventor, and Satsearch (Simera, 2020; Space in Africa, 2019b).

Spescom (Pty) Ltd is a South African ICT company that was established in 1977. It maintains physical presence in Stellenbosch, Durban and Johannesburg. The company is made up of five divisions, including Spescom DataFusion, Spescom DataVoice, Spescom Telecommunications, Spescom Media IT and the recently created NewTelco South Africa. Spescom specialises on delivering integrated communication solutions for businesses connect and communicate with their customers with voice, video, and data technologies. It offers integrated contact centre platforms and applications, as well as telecommunications and broadcast solutions (Spescom, 2020; The Tauri Group, 2011).

Stone Three is another major space company in South Africa. It was established in 2000 and based in Somerset West. The company specialises on IoT and AI-augmented solutions. It

develops software-defined radio (SDR) products, maritime VHF data exchange systems (VDES) as well as automatic identification system (AIS) space receivers for microsatellites (Stone Three, 2020; Space in Africa, 2019b).

Stratosat datacom is another company in South Africa's space industry. It is a subsidiary of the German based Schaueburg International Group, which equally maintains subsidiaries in some other African countries like Angola, DR Congo, Mozambique, and Nigeria. Stratosat was established in 2002 with a base in Gauteng. Its interests and investment in South Africa broadly cover mining, government, transportation, enterprise, NGO, construction, defence, oil and gas, finance, health, agriculture, and ICT. The company provides turnkey satellite and microwave wireless converged communication network solutions, which entails design, production, supply, systems integration, installation, training and operational services to clients and partners, such as Internet Service Providers (ISPs), Mobile Network Operators (MNOs), broadcasters, satellite network operators and system integrators (Stratosat, 2020; Space in Africa, 2019b).

Other notable space related companies in South Africa are Carl Zeiss Optronics (Pty) Ltd, SunSpace, Spectra Air, Neotel, Telcom and Tellumat. The Pretoria-based Carl Zeiss focuses on rangefinders, thermal imagers, handheld targeting systems, stabilized multi-sensor platforms for use in helicopters, special aircraft and drones, and submarine periscopes. The Stellenbosch-based SunSpace produces satellite systems and sub-systems. Spectral Air specialises in air and space supported survey. Neotel and Telcom are leading communication companies in South Africa that provide a broad range of services with terrestrial and space infrastructures across the country. Neotel maintains its head office in Johannesburg, while that of Telcom is based in Pretoria. Based in Cape Town, Tellumat specialises in defence, electronics and communication technology (The Tauri Group, 2011).

7.2.2. Development of Mobilisation Capacity for Space Policy Programmes in South Africa

As earlier argued, institutions can only give life to space policy and strategy within the scope of their mobilisation capacity. The extent of development and security objectives that are achieved with space policy and strategy are functions relevant to institution capacity. In this case, human and material resources are critical to the development of mobilisation capacity

of institution/s that are required to develop, display and utilise space capabilities for the development and security aspirations of a country. These are essential resources for the management of organisational goals. This section is further subdivided into two subsections, which focus on the human and material resources that make up up South Africa's space sector.

7.2.2.1. Human Resource Development in South Africa's Space Sector

Human resources are critical to the operationalisation of space like any other policy and strategy as well as the realisation of national and organisational objectives. These include the totality of individuals that are directly or indirectly involved in space policy implementation, R&D, and industry as well as their operational environment, skills, motivations, and performance. However, this section largely focuses on and attempts a survey of personnel that are involved in space R&D, policy implementations and industry, and to a limited extent, relevant skills, in the RSA.

It is important to note that this study is unable to fully determine the aggregate number of people that are involved in this sector. Besides, previous efforts towards this direction by Space in Africa (2019a &b) are based on extensive profiling of major public institutions and private corporations that are involved in the sectors. However, the list of profiled public and private entities are inexhaustive, they excluded many entities that are indirectly involved in, and those that provide supporting services for the sector. They equally excluded academic communities that are directly or indirectly involved in space R&D. Nevertheless, these and other efforts provide useful insight into personnel strength of different space entities in South Africa, the space sector of the country as a whole, and elsewhere across the continent. Table 7.3 offers a summary of some of the major space entities and the known total number of their employees in South Africa.

Table 7.3: Major Space entities and their total number of employees in South Africa

No	Entity	Total employees	
		As reported by Space in Africa 2019/20	Officially reported or other sources, 2019/20
State owned			
1	SANSA	-	177
2	Denel Spaceteq	26-50	-
3	Sentech Soc Ltd	>500	200
Private Corporations			
4	Aerobotics	56	48
5	Amaya Space	11-25	-
6	Astrofica Technologies	10	-
7	Cubespace	10	17
8	DeltaV Aerospace	63	-
9	Dragonfly Aerospace	15	
10	EMSS Antennas	11-25	-
11	ETSE Electronics	11-25	13
12	Geosmart Space	1-10	-
13	Marnic Precision Engineering	26-50	35
14	Marcom		6
15	Mzansisat	1-10	-
16	Newspace Systems	22	-
17	Pinkmatter Solutions	11-25	-
18	Reutech	51-100	-
19	SCS Space	1-10	-
19	Simera Sense Pty	15	-
20	SAC	47	-
21	Stone Three	40	-
22	Stratosat Datacom	30	-
23	Xinabox Ltd	10	-

Source: Space in Africa (2019b) and author's own research.

Unlike NASRDA that has little publicly available information on its human resources and their management, SANSA provides a detailed annual report on the subject matter. Between 2013 and 2019, SANSA maintains between 148 and 183 permanent staffers (SANSA, 2014b; 2015b; 2016; 2017; 2018; 2019). As at March 2019, SANSA has 177 personnel, which fell short of approved 203 personnel for the agency, leaving it with 26 (12.8 per cent) vacancy (SANSA, 2019a). Although it represents an increase from a staff of 148 in 2014, it was a decline from a staff of 183 in 2018. As at March 2019, the number of SANSA's employees as categorised by salary levels are one person at the position of top management, six at senior management level, 56 professionally qualified, 93 skilled, 20 semi-skilled, and one unskilled. In terms of employment by programme, the agency was staffed by 37 employees for administration and space engineering, 31 staffers for Earth Observation, 55 personnel for space science and 54 employees for space operations as at 2019 (SANSA, 2019a).

The SANSA equally maintains some public records that are relevant to assessing its level of personnel diversity, discipline, retention, training and morale (SANSA, 2014b; 2015b; 2016a; 2017a; 2018a; 2019a). In term of gender, the personnel strength of the agency is made up of 105 (59 per cent) male and 72 (41 per cent) female. In term of race, SANSA maintains 112 (63.3 per cent) African employees, 16 (9 per cent) coloured, 11 (6.2 per cent) Indian, and 38 (21.5 per cent) White. Although the Indian appears to be the least in number in the agency, they can be found in the positions of top management and senior management. Moreover, 66.7 per cent (48) of the female employees of the agency are Africans, while 20.8 per cent (15) are Whites, 9.7 per cent (7) are coloureds and 2.8 per cent (2) are Indians (SANSA, 2019a). These among others considerable show the level of diversity of the agency.

SANSA's records of retention are also instructive. Between 2013 and 2014, the agency terminated the appointment of 8.8 per cent (13) of its 148 permanent employees (SANSA, 2014b). Between 2014 and 2015, the appointments of 13.1 per cent (21) of its 184 personnel were also terminated. Between 2013 and 2015, temporary or contract staffs also declined from 36 to 23, as permanent staff increased from 138 to 160. Between April 1, 2018 and March 31, 2019, there were equally 12 appointment and 19 (10.7 per cent) termination of appointment in the agency. Amidst these, the termination of appointment is connected to nine resignations, seven expirations of contract, two retirements and one dismissal between

2018 and 2019. At the same time, the agency responded to misconduct with three written warning, three final warning and one dismissal (SANSA, 2019a). These among other offer some insight into labour relations: retention or turnover and discipline within the agency.

Personnel welfare, morale and training are equally important in agency's human resource development and management. The SANSA spent 48.6 per cent of its total expenditure on personnel in 2018/2019. On average, R653.674 million are voted for personnel cost per person, per annum during this period. Amidst these, 0.89 per cent of the personnel cost was voted for training. SANSA trained or retrained 93.8 per cent (166) of its total personnel in 2018/2019. Accordingly, R8.239 million was used in training individual personnel trained on average per annum (SANSA, 2019a). These among other things suggest the existence of a robust welfare package and training programmes, which are expected to boost personnel morale for optimum performance, in SANSA.

Beyond SANSA, there are many other organisations that make up or support space industry, implement relevant policy, and conduct related R&D. The state-owned Denel Spaceteq is reported to have between 26 and 50 employees in early 2019. Another state-owned company, Sentech was reported to have over 500 personnel by Space in Africa (2019b), although Dun & Bradstreet (2020) estimated that the company has 200 employees. Table 7.3 provides a summary of the private actors in space industry and the number of their employees as reported by Space in Africa (2019b). However, there are cases where officially given information in late 2020 differs from these data. For instance, Cubespace was estimated by Space in Africa (2019b) to have between 1 and 10 employees, while the company officially recognised 17 personnel as member of its team (Cubespace, 2020). Space in Africa (2019b) also reported that ETSE Electronics has between 11 and 25 employees. However, the company officially recognised 13 personnel as of 2020 (ETSE, 2020). Equally, Space in Africa (2019) reported that Marnic Precision Engineering has between 26 and 50 employees. Yet, the company officially recognised 35 employees in 2020 (Marnic, 2020a).

Beyond these, tens of thousands of people are associated with space and related NGOs in South Africa. These are in addition to thousands of scientists and engineers that are engaged in space R&D and related fields across South African universities as well as other high degree awarding institutions and research centres. Moreover, these systems are producing

hundreds of thousands of scientists and engineers annually, with the potentials to contribute directly or indirectly to space policy processes (advocacy, formulation and implementation), R&D, and industry. These are separate from thousands of space and other scientific enthusiasts with background in art, social sciences, law and business management in the country. These among others provide considerable insight into available human resources that are available for the mobilisation of the republic in the quest for space capabilities and associated policy goals.

7.2.2.2. Material Resources

Besides human resources, material resources are also critical to every organisation and their performance. Accordingly, the material resources that are available to relevant institutions to operationalise space policy in South Africa cannot be ignored in this analysis. This section therefore examines the material resources that underscored space policy and industry in the RSA, with special attention for the financial resources and relevant facilities.

7.2.2.2.1. Development with Space Expenditure

Funding is an important element of material resources that determine institutional capacity, including the areas of personnel strength, skills and morale as well as facilities that can be afforded for their operations. Since the end of the apartheid regime, South Africa's civil space programmes have emerged out of its military shadow, which makes it more possible to assess its expenditure. Although the country retains a military space programme, of which details remain less accessible for many research attempts, including this one, its civil programmes have become more defining in public and academic focus on its space policy.

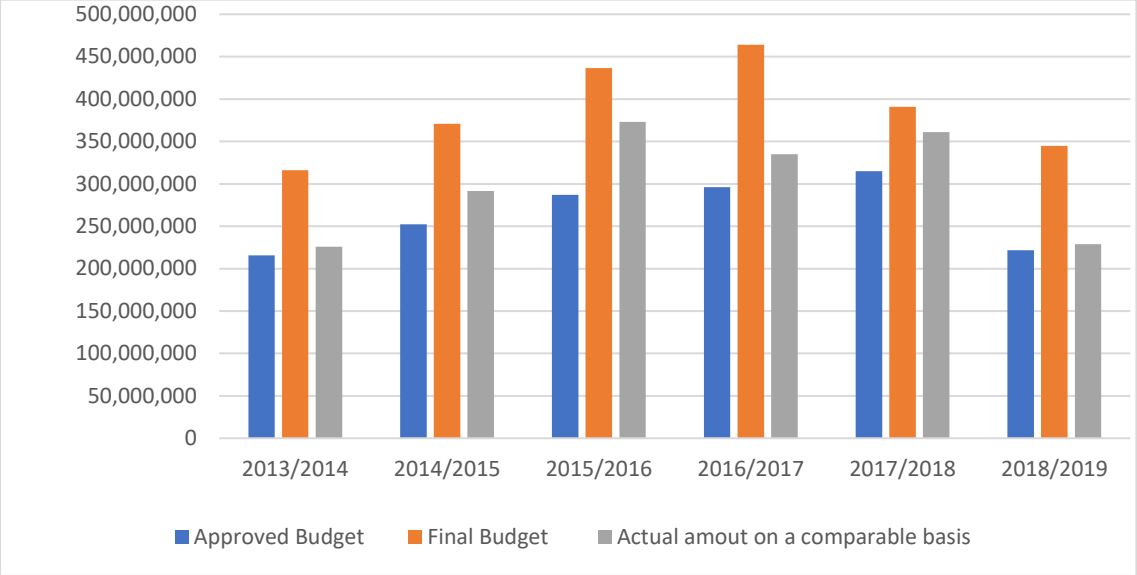
There are multiple sources of data on South Africa's space expenditure. For instance, data from Euroconsultant offers some insights on the civil space expenditure of countries that spend more than US$ 10 million across the world, including the RSA. In this case, South Africa spent an aggregate of US$ 110 million on space in 2013, 2014, 2016 and 2018 (Oyewole, 2020a). The country spent US$ 23 million in 2013, US$ 31 million in 2014, US$ 20 million in 2016, and US$ 36 million in 2018. These made the country the 6^{th}, 5^{th}, 7^{th}, and 6^{th} highest space spender in Africa in 2013, 2014, 2016 and 2018 respectively (Bochinger, 2016; Euroconsultant, 2017; Lal et al. 2015; Oyewole, 2020a; Seminari, 2019). In all these cases, the government of South Africa spent less than its counter-parts in Algeria and

Nigeria, and in some cases, lesser than Egypt, Congo, Morocco and Angola (Oyewole, 2020a).

In 2018, a Business & Market Analysis by Space in Africa (2018b) shows that South Africa voted R138 million (US$ 9.7 million) to SANSA, which was 1.7 per cent of the total budget of the DST. In addition, R709 million (US$ 50 million) was voted to the SKA project. These made a total of R847 million (US$ 60 million) budgeted for civil space activities, which represented 10.9 per cent of the DST's total budget. The report observed that SANSA's 2018 budget was a significant increase from the R131 million (US$ 8.6 million) budget for the agency in 2017 (Space in Africa, 2018b). However, the absence of a specialised institution for space in the defence department is recognised in the report as the cause of the challenge in tracking the funds that is specifically designed for defence space programme of the country.

The financial reports of SANSA also offer another perspective to funding that is available to space activities in the country. Figure 7.1 shows SANSA's expenditure, paying attention to the approved budget, final budget, and the actual amount on a comparable basis from 2013 to 2019. The entity, like others in the country, maintains a final year that covers April 1 to March 31. This makes it a challenging task for those reports that generate space expenditure of the country on the basis of calendal year. In all cases presented in figure 7.1, the approved budget for the entity is less than its final budget, which is also not the same as its actual expenditure. Unlike the case of the NASRDA whose financial reports are not available for verification of disparity between approved budget and allocation, available data between 2013 and 2019 capture these disparities for the SANSA. These raises some questions about the reliability of using approved budget to assess government expenditure on space activities in South Africa and beyond.

Figure 7.1: Space Expenditures in South Africa: SANSA's budget, 2013-2019 (R)

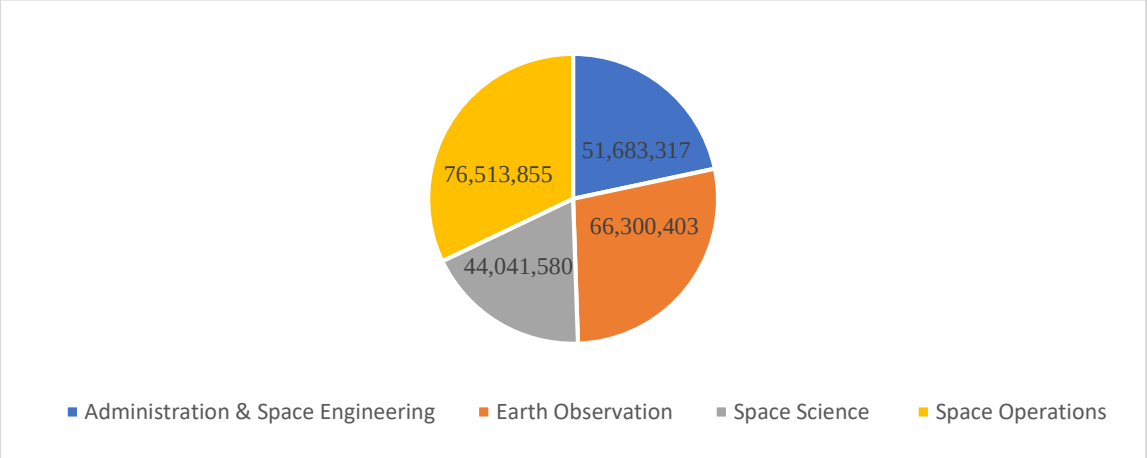


Sources: Data extracted from SANSA (2014b, 2015b, 2016-2019).

Available data on SANSA's expenditure as evident in Figure 7.1 show that there was an increase in approved budget from R 215.6 million in 2013/2104 to its peak of R 315 million in 2017/2018, before declining to R 221.56 million in 2018/2019. The final budget for the entity rose from R 316 million in 2013/2014 to its peak of R 464 million in 2016/2017, before declining to R390.8 million in 2017/2018 and R 344.8 million in 2018/2019. Actual amounts on a comparable basis rose from R 225.876 in 2013/2014 to its peak of R 373 million in 2014/2015, it declined to R 335 million in 2015/2016, rose again in R 360.957 million in 2017/2018, and declined again to R 228.76 million in 2018/2019 (see Figure 7.1).

The report of SANSA (2019) offers some unique perspective to the funding of the entity, as it paid some attention to its expenditure based on programmes. This detail was captured under human resource management and not financial or audit report. This detail, however, introduces some confusion, as the expenditure of the entity was reported in billions and not millions. The total expenditure of the entity between April 1, 2018 and March 31, 2019 was reported to be R 238.5 billion, of which R 115.7 billion (48.6 per cent) is personnel expenditure. Thirty-two (32) per cent of the total expenditure was voted to Space Operations, while Earth Observation, Administration and Space Engineering, and Space Science received 28 per cent, 22 per cent, and 18 per cent respectively (see figure 7.2).

Figure 7.2: SANSA's expenditures by programmes in 2018/2019 (R'000)



Source: Data extracted from SANSA (2019)

Beyond SANSA, there are many other public institutions whose funding have direct or indirect contributions to space in South Africa. These broadly cover civil, military, and commercial entities owned by the government. Financial and audit reports of the earlier mentioned and other relevant state-owned institutions that are directly or indirectly involved in space activities in South Africa may offer us a fresh perspective into the space expenditure of the country. This called for a revaluation of the prevailing model or metric of assessing the space expenditure of the country. In doing this, research efforts can be channelled to determining the aggregate or relevant aspect of disaggregate expenditure of concerned entities.

Assessment of space expenditure in South Africa will not be complete without special attention for private capital in the industry. Private companies that are involved in space activities in the country have generated funds for their operations through multiple sources, including personal saving/earning of the founders, grant, loan, investment and stock market. For instance, equity investment in South Africa's space industry in the last decade include the US$ 4.6 million raised by the Aerobotics, the US$ 2 million raised by Simera Sense Pty Ltd, and the US$ 500,000 raised by GeoSmart (Space in Africa, 2019b). These among others are indicators of private investment and expenditure in space activities in the RSA.

7.2.2.2.2. Ground Facilities and Infrastructural Development for Space R&D

Ground facilities are important aspects of space and other scientific R&D capabilities as well as general infrastructural development for national growth, development, and security. The facilities are products of funding or financial investment committed to the realisation of space policy. However, facilities like land, building or office spaces, and relevant equipment are critical for deriving optimum utility from human resources in operationalising the policy. Accordingly, this subsection examines some of the available facilities, especially the location of office spaces and relevant equipment installed, for space R&D in South Africa.

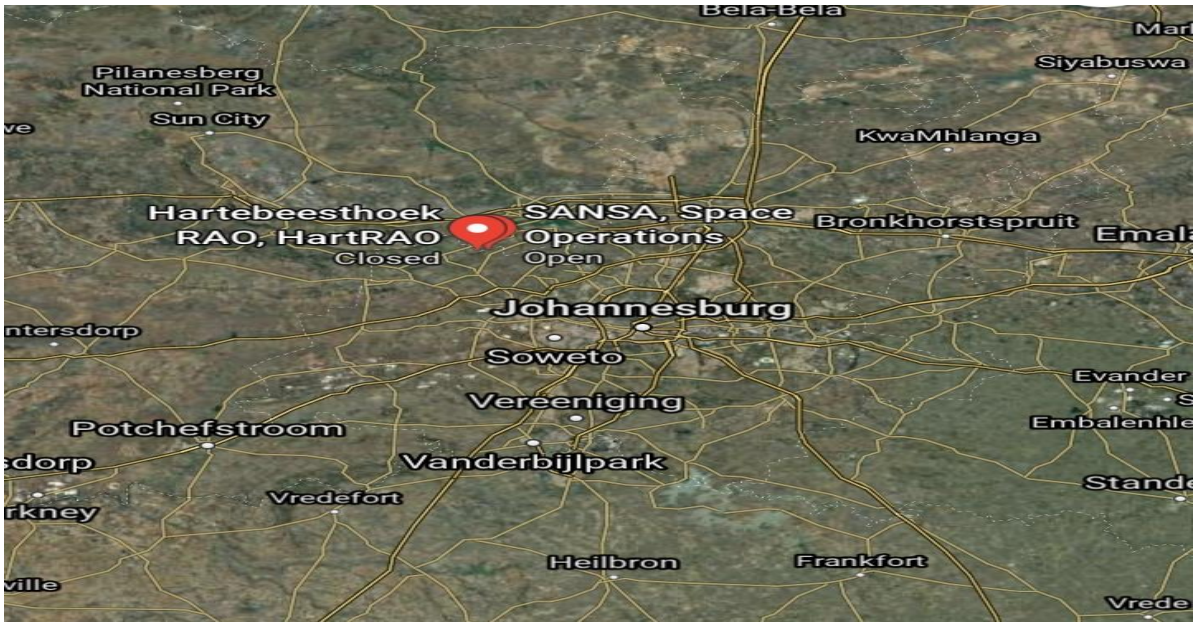
South Africa is home to several facilities for space R&D, which are dispersed across the country. These include facilities owned by state institutions and private corporations as well as those jointly held with international partners or consortium. As the primary space actor in the country, SANSA maintains three major facilities. One of them is located at Enterprise Building, Mark Shuttleworth Street, Innovation Hub, Pretoria 0087, Gauteng, South Africa (see figure 7.3). This is the site of the agency's administrative head office as well as Space Observation, and Space Engineering Programmes. The SANSA has another facility for its Space Operations Programme, which is located at Farm No 502 JQ Hartebeesthoek, District Krugersdorp (see figure 7.4, 7.5 and 7.6). The third facility is maintained for Space Science Programme at Hospital Street, Hermanus 7200, Western Cape, South Africa (see figure 7.7). Figures 7.3, 7.4, 7.5 and 7.7 present selected satellite imageries of the locations and structures or buildings that make up these facilities. Figures 7.8 and 7.9 also present the satellite imageries of the Danel Overberg Test Range near Arniston and the AIT facilities at the Spaceteq site along High Rising Road in Grabrouw.

Figure 7.3: Satellite imagery of SANSA's facility in Pretoria



Source: Tracked and captured by the author using GPS, Google Map.

Figure 7.4: Satellite imagery of the locations of SANSA's Space Operations and HartRAO, Hartebeesthoek



Source: Tracked and captured by the author using GPS, Google Map.

Figure 7.5: Satellite imagery of SANSA's Space Operations, Hartebeesthoek



Source: Tracked and captured by the author using GPS, Google Map.

Figure 7.6: Satellite imagery of HartRAO, Hartebeesthoek



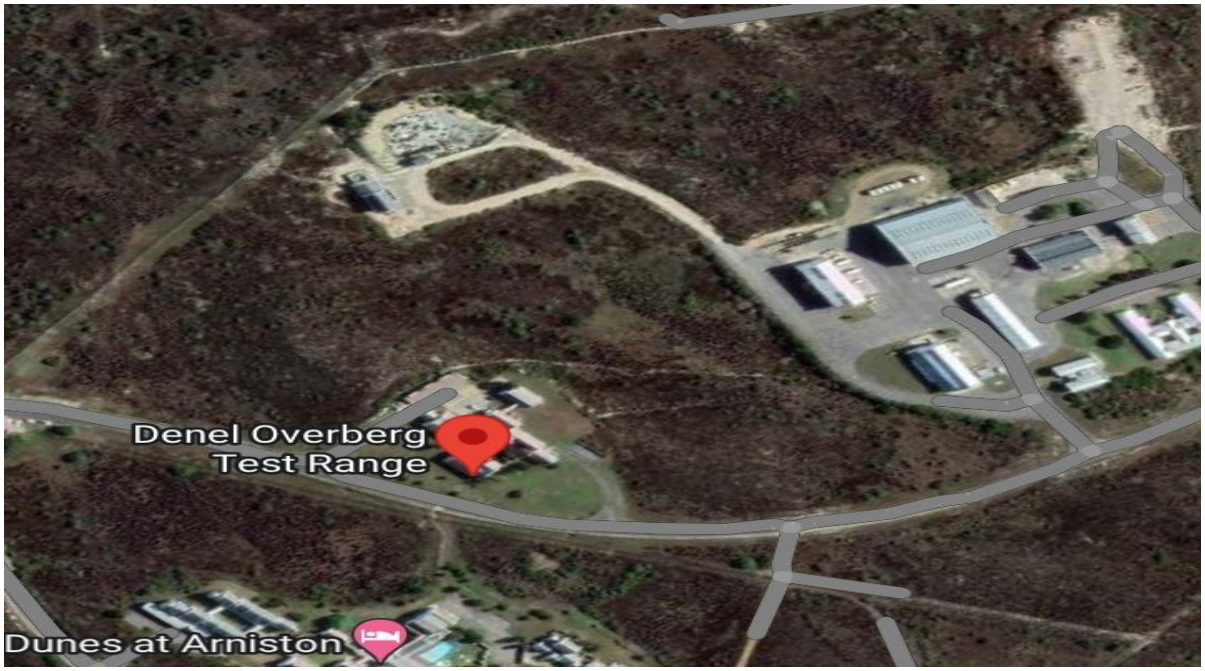
Source: Tracked and captured by the author using GPS, Google Map.

Figure 7.7: SANSA Space Science, Hermanus 7200, Western Cape.



Source: Tracked and captured by the author using GPS, Google Map.

Figure 7.8: Danel Overberg Test Range near Arniston



Source: Tracked and captured by the author using GPS, Google Map.

Figure 7.9: Danel Spaceteq, High Rising Road, Grabrouw



Source: Tracked and captured by the author using GPS, Google Map.

For the purpose of Space Operation, Hartebeesthoek facility is very important for SANSA. The facility is equipped with antenna systems that are sited across 40 locations on the 4000 ha of land. These include L, S, C, Ext C, X, Ku, DBS, and Ka frequency bands. There are S-band for mobile support, and several other antennas for full-motion TT&C. These facilities have the capabilities of providing antennas services, launch support services, TT&C services, antennas hosting and maintenance services, as well as teleport services (SANSA, 2020b). For the purpose of Space Science, SANSA maintains facilities and equipment like the Space Weather Centre (SWC), Magnetic Clean Facility (MCF), Helmholtz Coil, Temperature Chamber, Non-magnetic Screening Chamber, Absolute House, Superconducting Quantum Interference Device (SQUID), as well as Science Center and Mobile Space Lab (SANSA, 2020b).

Several astronomical facilities are maintained across South Africa by public, private and/or international institutions. Bloemfontein, Cape Town, and Sutherland host the majority of South Africa's telescopes. Bloemfontein hosts the Boyden observatory with 0.41- m Nishimura reflector, Watcher Robotic reflector of 0.41 m, Alvin Clark Refractor of 0.33 m, Metcalf Photographic Triplet Refractor of 0.25 m, Coelostat Telescope of 0.20 m. The likes

of Elizabeth Telescope with 1.0 m; McClean Refractor with 0.61 m; Dall-Kirkham Reflector with 0.45 m; Parks Telescope of 0.41 m, which are mostly used for pulic outreach, are based in Cape Town. In Sutherland, there are SALT, which is 11.1 meter (m) by 9.8 m; Radcliffe Observatory, which is a 1.9 m telescope; Infrared Survey Facility (IRSF), SuperWasp, BiSON Telescope, Kilodegree Extremely Little Telescope (KELT), 1.4; 0.75 and 0.5 m Telescopes (AfAS, 2020; Dubow, 2019; Froehlich and Siebrits, 2019; Oyewole, 2017; 2020a). These are in addition to the VLBI, geodesy, and radio telescope in Hartebeeshoek. The construction of SKA, with the bulk of its facilities to be located in the RSA, is another major addition to astronomy in the country.

South Africa equally has several manufacturing and AIT facilities for spacecraft systems, subsystems and sub-subsystems. Besides AIT of satellite systems, most satellite subsystems or components are manufactured in the country. For instance, Cubesapce maintains an AIT facility for satellite subsystem and components like ADCS in Stellenbosch, while the NNS maintains a facility that serves similar purposes in Cape Town (Cubespace, 2020; NNS, 2020). Marnic Precision Engineering equally maintains 2600m2 manufacturing plant in Johannesburg, which provides the platform to deliver quality precision parts for different products, including spacecrafts (Marnic, 2020a). More importantly, Astrofica and the SAC maintains AIT facilities for satellite systems in Grabouw and Stellenbosch respectively (SAC, 2020; Astrofica, 2020). DeltaV Aerospace Ltd also has AIT facility in Somerset West. These are, connected or in addition to the AIT and related facilities, maintained for R&D capacities in satellite systems and sub-systems by the University of Stellenbosch, UCT and CPUT. Besides, some of these universities equally own and operate satellite ground stations.

Many facilities for rocket, missile, and space launcher research facilities can also be found in South Africa. Somerset West-based DeltaV Aerospace owns an 800sqm test facility and a 500sqm laboratory for research, design, simulation, development, assembling integration, and testing of aerospace systems and subsystems, including launcher vehicle, satellite and UAV (Space in Africa, 2019b). Marcom Aeronautics and Space (Pty) Ltd also maintained facility for research, design, simulation, development, assembling, integration, testing, and manufacturing of launcher systems and subsystems in Johannesburg (Marcom, 2020). The of Engineering of UKZN and its Aerospace Systems Research Group (ASReG) equally own and maintain facility for Phoenix Hybrid Sounding Rocket Program (HSRP). Besides, Denel

owns and maintains (orbital) launch pads and tracking systems at its Overberg Test Range near Arniston, Western Cape. Armscor equally maintains Alkantpan Test Range, which is a strategic ISO 9001 certified all-purpose ballistic test range for medium and large calibre of weapons and munition (Armscor, 2020), although a source claimed that it is not connected to space. These among other facilities are important to the operationalisation of South Africa's space policy and the realisation of its objectives.

7.2.2.2.3. Development of Space Access and Assets in South Africa

This section focuses on the level of space access and assets as elements of capabilities or resources that are available to South Africa to operationalise its space policy and realise associated development and security objectives. Therefore, this section is sub-divided into two subsections: the first one deals with the development of space-based capabilities in South Africa, while the second one focuses on the nation's space launch capabilities.

7.2.2.2.3.1. Development of Space-based Capabilities in South Africa

South Africa has, by African standard, developed significant space-based capabilities. The country has sponsored or co-sponsored the orbiting of no fewer than eight satellites as at mid-2020 (see Table 7.4). This made South Africa to account for approximately 19.5 per cent of the 41 satellites that were sponsored or co-sponsored from the continent as at early 2020. With nine satellites orbited to its credit at late 2020, Egypt is the only country in Africa that has sponsored a greater number of satellites into orbit than South Africa. At the same time, Algeria and Nigeria are behind South Africa, with six satellites each. With its first satellite launched in 1999, South Africa became the second African country to sponsor, own, and operate a space-based asset, following the record of Egypt in 1998 (Oyewole, 2017; 2020a; Froehlich and Siebrits, 2019; Space in Africa, 2019d). Table 7.4 provides a summary of satellite capabilities sponsored, owned and operated by South Africa and their details.

Table 7.4: Development of South Africa's Satellite Inventories and Capabilities

Satellite names	Mass of satellites (kg)	Manufactural	Purposes	Launch & operational dates	Launch facility & locations	Cost (US$ million)
SunSat	64	University of Stellenbosch	EO/ Education	23/2/1999-19/1/2001	VAFB, California	2
Sumbandila	82	SunSpace & University of Stellenbosch	EO/ Technology demonstration	23/9/2009-8/2012	Baikonur Cosmodrome	3
ZaCube-1 (TshepisoSAT)	1.2	CPUT	EO/ Technology Development/ Educational	21/11/2013-	DAB, Russia	-
Condor-E2	-	NPO Mashinostroyeniya	EO/ Military	19/12/2014-	Baikonur Cosmodrome	108
Nsight-1	3	SCS Space	EO/ Commercial	26/5/2017-	ISS	-
Za-AeroSat	4	Stellenbosch University	EO/ Educational	18/5/2017-	ISS	-
Za-Cube-2	4	CPUT	EO/ Educational	27/11/2018-	Vostochny Cosmodrome	-
XinaBox ThinSat	<1	High Schools	Educational	17/4/2019-4/2019	Mid-Atlantic Regional Spaceport, Wallops	-

Source: Compiled by the author with data from UCS (2020); Oyewole (2017); Gunter's Space Page (2020), Space in Africa database, and author's own research.

As evident in Table 7.4, South Africa has sponsored satellites of different forms and size for different purposes. In consideration of size, the country is known to have sponsored microsatellites (10-100 kg) like SunSat and Sumbandila; nanosatellites (1-10 kg) like Za-Cube-1&2, Nsight-1, and Za-AeroSat; as well as a picosatellite (0.1-1) such as XinaBox ThinSat. Although almost all satellites sponsored by South Africa are designed for EO, they have notable similarities and differences in their purposes. With the exception of Condor-E2 and, to a limited extent, Nsight-1, other South African satellites are designed for educational purposes at different levels and to demonstrate the technological capacity of the country. It is not surprising that local academic and research institutions and spinoff companies are central to the research, design, development, assembling, integration, and testing of these satellites. However, South Africa, unlike Nigeria, Egypt and to an extent Angola, is yet to sponsor, own or operate a communication satellite in orbit.

Unlike other space nations in Africa, South Africa has displayed the capacity to produce its satellites locally at least on seven different occasions between the 1990s and 2010s. Besides Condor-E2 that was produced by the Russian NPO Mashinostroyeniya, every other satellite sponsored by South Africa were largely manufactured locally. University of Stellenbosch with its Sun Space and the CPUT with F'SATI were directly involved in 62.5 per cent of all satellites acknowledged to have been sponsored by South Africa. SunSat was produced by the University of Stellenbosch, while Sumbandila and Za-AeroSat were produced by spin-off companies of the University, that is, SunSpace, and CubeSpace respectively. The CPUT-based F'SATI equally produced the Za-Cube 1&2. The UCT and the NMMU have equally contributed to the success of some of these and other satellite projects in South Africa. The involvement of 16 High Schools from Western Cape in XinaBox ThinSat have driven space R&D and STEM generally further to the next generation (Space in Africa, 2019e; Wener, 2018). SunSpace equally manufactured microsatellite for a Middle Eastern country, reportedly Saudi Arabia.

Spin-off companies from satellite R&D in universities have further expanded the coast of commercial space industry in South Africa. In this manner, the South Africa's Nsight-1 is considered as the first satellite sponsored, owned, and operated by African-based commercial entities. The satellite is a joint investment of the SCS Aerospace Group and Pinkmatter Solutions. Some of the outsourced components of the satellite like the ADCS was produced by the CubeSpace, a spin-off of University of Stellenbosch, while NMMU developed the Radiation Mitigation VHDL Coding Technique. The satellite system was assembled in the NewSpace System's cleanroom as well as integrated and tested in SAC's AIT facility. These two companies are parts of SCS Aerospace Group of Companies (Space in Africa, 2019f).

The local content of most South African sponsored satellites, among other things, is largely responsible for the cheap cost of producing them, when compared to those operated by Nigeria and other African countries, without accounting for the technical variations (see chapter six; Oyewole, 2017). Notably, SunSat cost US$ 2 million, while Sumbadila cost US$ 3 million. It was also reported that the nanosatellite programme of CPUT, which produced Za-Cube 1&2, cost the DST R16.5 million (Space in Africa, 2019g). At the surface level, these are cheaper than the Russian made Condor-E2, without accounting for the technological variations in them. However, it is important to also note that most of the

satellites sponsored and manufactured in South Africa lasted in orbit for a few weeks/months and at most few years, which is typical of low-budget nanosatellites designed for educational and technological demonstration purposes. However, these are shorter in lifespan when compared to 10 to 15 years' serving inventory of microsatellites purchased by Algeria, Egypt and Nigeria. This suggests that South Africa requires constant replacement for these satellites in a drive for self-reliance in satellite data and their utilisation, especially in comparison with other leading African nations.

It is also remarkable that the first African satellite for military use, that is Condor-E2, was sponsored by South Africa. This satellite was manufactured by the Russians and launched in 2014. It was a product of a US$100 million contract negotiated by the South African government with its Russian counterpart, and signed on May 19, 2006. The spy satellite was largely conceived, designed and executed in secrecy, and was codenamed "Project Flute" and "Consolidated Flute", until January 2014 when it was uncovered by David Maynier, a member of the opposition party (Democratic Alliance) in the national parliament.

Beyond EO satellites, South Africa is yet to sponsor or co-sponsor any other space-based capabilities, most especially interplanetary mission or space station. However, South African based ground facilities or space infrastructures, most especially TT&C facilities have supported many interplanetary or extra-terrestrial missions. A national of the country had visited the ISS. Mark Shuttleworth, with dual citizenship of Britain and South Africa, became the first African citizen and the second space tourist to be launched to orbit and occupied ISS in 2002. The privately funded space tourism cost Mr Shuttleworth about US$ 20 million (Oyewole, 2017). Nevertheless, there is little or no indication by the South African government to sponsor astronauts or any other scientists or tourists to space.

7.2.2.2.3.2. Development of Space Access Capabilities in South Africa: Space Launch Vehicles

South Africa currently lacks space access capability or capacity to launch a satellite into the orbit. As evident in the previous Table 7.4, all the satellites sponsored from South Africa, other African countries, were launched into orbit for the country from elsewhere. South Africa relied on Russia and the US for orbital launch services. SunSat was launched on board a Boeing Delta II launch vehicle from the US Vandenberg Airforce Base (VAFB) in

California. Sumbandila and Condor-E2 were launched from Russian leased and operated Baikonur Cosmodrome in Kazakhstan, while Za-Cube-1 & 2 were respectively launched from DAB and Vostochny Cosmodrome in Russia. Nsight-1 and Za-AeroSat, were released into orbit from the ISS, after they were launched aboard Atlas V from the US. The Virginia Space, which owns and operates the Mid-Atlantic Regional Spaceport that is located on Wallops Island, was also contracted to provide launch service for the XinaBox ThinSat. To have idea of the cost, Sumbandila was launched at the of cost R8.3 million (Martin, 2012).

Despite the foregoing, South Africa has committed some efforts to developing its launcher capacity. As earlier mentioned, the country has a rich space tradition; it includes the area of medium-range missile and launcher system development. However, the end of apartheid regime has seen a significant downward review of this programme, which is now limited to production of tactical missiles and maintenance of facility for orbital launcher like Overberg Test Range. In the last two decades, however, South Africa has revived its interest in rocketry and launcher systems. Unlike the initial rocketry and space launcher programme that was motivated, controlled, and managed by the military for security purposes, the recent one is motivated, controlled, and managed by civilians for R&D purposes. The interests and investment are driven by the DST, SANSA, academic/research institutions, and private organisations.

Prominent among the academic institutions that are involved in space launcher programme is UKZN. The university-based ASReG, which is connected to Faculty of Engineering. The group is equipped with laboratory-scale test facility and Mobile Rocket Launch Platform (MRLP). The group has tested three sounding rockets, including Phoenix 1A, Phoenix-1B, and Phoenix 1B II. The last launch of the group reached 24.8 km range (ASReG, 2020), which was behind the achievements of amateur rocket tests recorded in the country about six decades ago. Prominent among the private organisations that are involved in rocket R&D in South Africa is Marcom. The organisation has proposed on CHEETAH-1 CSLV, a two stage, liquid propelled, expendable launch vehicle capable of delivering small and medium sized payloads to low Earth inclined, polar and sun-synchronous orbits (Marcom, 2020). An informant disclosed that the company developed a sub-scale engine prototype, which was never fire, but put through a cold test. These among other organisations and activities, couple with existing infrastructures, may define the future of rocket R&D in South Africa.

7.3. Space Policy as a Means to an End: Space Support for Development and Security Goals in South Africa

The growing public advocacy, policy priority, public and private investment, as well as institutional, human capital, and infrastructural developments for space R&D in South Africa, as evident in the previous section of this chapter, have generated public and academic interests in the objectives served in this process. Beyond an end in itself, the development and security aspirations of the people and government of South Africa, like many other countries across the world, necessitate the need to examine and re-examine space and the attendant policy, investment, institutions, programmes, as well as capabilities as a means to an end. Accordingly, this section focuses on space support for development and security goals of the people and government of South Africa. In this process, this section is broadly divided into two. The first among the sub-sections interrogates space support for national development and security objectives of South Africa, while the other sub-section deals with space support for human or people-centric development and security goals in the country.

7.3.1. Space Support for National Development and Security in South Africa

As earlier discussed in this study, the space policy and programmes of South Africa were designed with the aim of promoting and supporting national interests, that is, the aspirations of the government of the country. This section examines the extent of achievement recorded in relation to some of the objectives. In doing this, this section is broadly subdivided into two: the first one interrogates space support for national development, while the other one examines space support for national security in South Africa.

7.3.1.1. Space Support for National Development in South Africa

This study earlier discussed different conceptions and perspectives on development, amidst which those that focus on national development were identified. Accordingly, the objectives of development in this case include economic growth, liberalisation, and transformation, resource management, catch up or competitiveness, local or independent capacity among others. These equally reflect some of the objectives of national space policy, science and technology policy, as well as development conceptions of the government of South Africa, as earlier identified in the chapter five of the study. Some of these objectives of development

will be examined in relation to space support under three subsections. The first subsection focuses on development as competitiveness and catch up, the second subsection focuses on development as economic growth, liberalisation and transformation, while the third subsection considers local or independent capacity and self-reliance.

7.3.1.1.1. Development as competitiveness and catch up

As earlier identified in this study, securing competitive advantage against other nations, staying comparable to peer group of nations, and catching up with advance nations, in international political economy can be considered as a perspective in the conception of development goals. This perspective is well recognised in the conception and framing of South Africa's space policy and associated end. For instance, the South African Astronomy Geographic Advantage Act of 2007 that was assented to in 2008 formalised and legalised the long-held belief and aspiration of the country to be a leading player from the Southern Hemisphere, and destination with competitive advantage for, astronomical R&D of southern skies. The South Africa's space policy and strategy equally emphasises the desire to develop competitive space industry that can drive international competitiveness of the country, most especially in promoting export and capturing a share of global market in this sector. In this consideration, South Africa is recognised generally and in the context of space R&D as a developing nations and emerging power or player globally, and as regional power in Africa.

At the global level, South Africa, like many other developing nations, has adopted space policy and developed considerable capacity in this area in an attempt to catch up, as well as close the development gap with the advanced nations. From its location and aspiration in the global-South, the country has developed considerable capacity for competitiveness and competitive advantage as well as attraction for internationally sponsored projects, especially in astronomical R&D. These are evident in the ways that the development of astronomical facilities in South Africa has benefited from the country's strategic attraction of sponsorship, collaboration, technological transfer, consulting, funding, staffing, training, and other support globally. Most of the telescopes in the country owe their existence to geostrategic competitive advantage and the attraction of the country to scientific communities and their policy-makers across Europe, North America, and recently China. The success of South Africa against Australia in the bid for siting the majority of the construction of the SKA, a

project sponsored through international collaboration, is a testimony to the competitiveness of the country.

South Africa has equally developed considerable industrial capacity to capture a share of the global space market, most especially by the global-South and African standard. For instance, Hartbeeshoek facility offers a competitive TT&C service for clients from across the world. It has supported more than 600 spacecraft in low-Earth orbits and high-altitude geostationary orbits (SANSA, 2020b). Armscor and Denel have equally exported made in South Africa guided tactical missiles internationally. A growing number of South African companies have exported satellite subsystems and components to many countries across the world. For instance, in not more than 30 years of its existence, NNS has over 60 clients, including more than 9 reseller and 14 national space agencies across the world (NNS, 2020). Moreover, some South Africa's companies, especially those that are involved in communications, with a combination of terrestrial and space infrastructures, have developed into multinational giants. These among other things offer insight into the growing competitiveness of South Africa as well as the position of the country in the global map of space market.

Despite the foregoing, South Africa's share of the global space economy is still low and less significant in the general picture of things (Euroconsultant, 2017; OECD, 2014; Space Foundation, 2015b). For instance, South Africa only accounted for 0.03 per cent and 0.05 per cent of global space expenditure in 2016 and 2018 respectively (Euroconsultant, 2017; Seminari, 2019). Besides, all the satellite systems that are produced in South Africa largely remain in the realm of technological demonstration, although some of the subsystems have entered the commercialisation stage. More policy commitments and investment are still required to make South Africa's satellite and general space industry globally competitive and export viable. In this consideration, the space, among other technological undercurrent of technological hub initiative of the South African government, is commendable. However, these concerns are relevant in locating the country among other emerging space players. As such, South Africa is largely considered as a second-class developing nation or emerging player in space, with few countries ahead of it in the global-South (Harding, 2016; Martinez, 2016). In this case, absence of orbital launcher capability as well as the scope and size of the space investment, industry, and market are issues that affect the global rating of the RSA.

Despite the foregoing concerns against the competitiveness of South Africa at the global level and drive to catch up with the advance nations in space, the country retains competitive advantage in many areas in Africa. The country is setting the pace in many areas of space R&D, industry and militarisation. For instance, South Africa is home to 71 per cent of all astronomical facilities in the continent (AFAS, 2020; Oyewole, 2020a). As at mid-2020, the country accounted for all satellites manufactured in Africa by citizens of African nations. A report of Space in Africa (2019b) shows that South Africa accounted for 87.5 per cent of all known space companies in the continent. The same report shows that total number of space companies that are based in Cape Town and Stellenbosch alone are more than those in the rest of Africa. Besides, while majority of space companies across Africa only target national and regional markets, many space companies in South Africa are in the global league. With the launch of Condor-E2 in 2014, South Africa became the first African country to sponsor, own and operate a satellite designed for military purpose. These among other things show that the Republic retains competitive advantage in many areas of space R&D, industry, and passive militarisation, in which other African countries have to struggle to catch up.

7.3.1.1.2. Development as Economic Growth, Liberalisation and Transformation

The space policy and programmes of South Africa have considerably contributed to national development, especially in the areas of economic growth, liberalisation, and transformation. To examine these in details, this section will be divided into two. The first subsection here focuses on the contribution of space policy, institutions, programmes, investment, and capabilities of South Africa to desired economic growth and liberalisation, while the second subsection examines them in relations to economic growth and transformation.

7.3.1.1.2.1. Development as Economic Growth and Liberalisation

More wealth has been created as investment in space sector has continued to increase the size and growth of South Africa's economy in its own ways. For instance, records of SANSA between 2013/2014 and 2018/2019 financial years show that the agency's revenues always surpass its expenditures, from where surplus and not deficit of actual amount on a comparable basis were generated annually. The surplus was approximately R 101.6 million in 2013/2014, R 79.4 million in 2014/2015, R 66.1 million in 2015/2016, R 135.6 million in 2016/2017, R 72.2 million in 2017/2018 and R 130.7 million in 2018/2019 (SANSA,

2014b; 2015b; 2016a; 201a7; 2018a; 2019a). In most cases, between 25 per cent and 40 per cent of the agency's revenue are derived from non-government subsidy sources, such as contracts with public, private and foreign entities. At least, 37.6 per cent of the agency's revenue in 2018/2019 were from such non-government subsidy sources (SANSA, 2019a). With about 200 employees across its facilities, the state-owned Sentech equally generates US$ 115.56 million in sales (Dun & Bradstreet, 2020). These are indicators of commercialisation and liberalisation of public entity, and their contribution to economic growth in South Africa.

As desired by advocates of liberalism and emphasised as one of the objectives of South Africa's space policy, the country has made significant progress to make the interests, efforts, and investments of private individuals and organisations a major driving force of its policy, programmes, investment, and capabilities in the space sector. As evident in the previous sections of this study, there is a growing number of private entities in South Africa's space sector. This has considerably shared or shifted a part of the burden of space R&D to the private sector, allowing government to accommodate more and more public interests in its list of policy priorities. Besides, by reducing the influence of politics and bureaucracy in investment decision, liberalisation is believed to be also more economically effective and efficient, in space exploration and exploitation (Anderson, 2013; Pelton, 1992; Sadeh et al., 2015; Utrilla, 2017). Accordingly, privatisation and commercialisation have attracted more local and foreign investment into the space sector, and created more wealth in South Africa.

The space-related private sector has considerably contributed to economic growth in South Africa. First, it has made it possible to retain most of the public investment in space locally. Second, it raises fund locally through stock market and other private sources as well as attracts foreign investment. Although many of them did not disclose details of their revenue and investment, the report of Space in Africa (2019b) offers some useful insight into the contribution of the sector to the economy through the investment raised and net worth of some of the space companies in the country and beyond. For instance, Aerobotics had raised US$ 4.6 million in total investment as at 2019. Similarly, Astrofica raised US$ 300,000 in total investment. Amaya Space and Simera Sense were reported to have secured contracts of US$ 2 million and US$ 1.5 million respectively in early 2019. Mzansisat was evaluated to be worth US$ 54.7 million, while XinaBox and Newspace is worth US$ 10 million and

US$ 2.5 million respectively. Geosmart was evaluated to be worth US$ 500,000 with close to US$ 100,000 annual revenue, while Stratosat makes between US$ 50 and 100 million annually.

Beyond foreign investment raised by the private sector, the government of South Africa has equally succeeded in attracting similar investment for space facility and infrastructural development, with significant implication for economic growth. For instance, South Africa only contributes a third of the US$ 35 million cost of constructing SALT, while Britain, Germany, Poland, New Zealand, and the United States paid the rest of the bill. Similarly, South Africa is only expected to pay a fraction of the cost of the ongoing multinational efforts on the construction of SKA, which is scheduled to cost about US$ 3.94 billion (Oyewole, 2017; 2020a). These are similar to the experience of the country on other major space projects.

Against this background, it is evident that space policy, programmes, and projects are largely liberalised in South Africa, with significant implications for economic growth and wealth creation in the country. Nevertheless, some KIs are worried that government's role is complicated and challenging for the private sector, as they are largely unpredictable with less stable policy orientation in South Africa as in other developing countries. In this case, the challenges of slow economic growth and dwindling budget cannot be ignored in government investment in space sector. However, most of the existing space companies are believed to rely and survive on state-funded programmes and projects, which are marked with policy inconsistency and instability in funding. Private companies cannot invest money where there are few or no customers, while non-governmental customers only want to do business with companies that they are sure will continuously be in business. These are the reasons why some companies have closed down, exited, or redirected their investment into other sectors. Prominent among the exit cases are Omnipless Pty Ltd., Capricorn Satellite Communication, iKubu Ltd., Maxwell Satellite Technology Pty Ltd., SunSpace, Marcom, SCS and 03N Networks Ltd (Space in Africa, 2019b; KIs). In the words of one of the KIs, these among others have produced a trend, which only "create a new generation of frustrated space professionals every decade or two who then emigrate to work elsewhere and contribute to brain drain." In this way, government commitment and consistency are essential for private sector survival.

7.3.1.1.2. Development as economic growth and transformation

Space policy and attendant technologies have contributed to the economic transformation of South Africa, like many other countries across the world. First, the implementation of the space policy among other policies on science and technology, communication, industry, and commerce have recorded considerable success in creating and sustaining a space sector among other sectors that are responsible for the country's high and medium-tech industries. As at 2018, South Africa exported 5.3 per cent of its manufactured high-tech in exchange for US$ 2.2 billion. Earlier in 2017, South Africa exported 46.7 per cent of its manufactured high and medium-tech in exchange for US$ 24.4 billion (World Bank, 2020). Beyond the transformational impacts of these high-technologies, which include space-related ones, they are sources of foreign exchange, with economic contribution and prospects in South Africa.

Second, space support is evident in the transformation of different sectors of South Africa's economy, including communication, digitalisation, urban planning, construction, resources management, and education, which have all boosted the economy and created more wealth.

Over the last three decades, South Africa has recorded progress in adopting communication technologies and digitalisation of its economy. Within this period, more internet penetration was recorded, with growing space and terrestrial infrastructural support. The importance of rapid adoption and access to mobile phones in the country can also not be overstated. Available data from the World Bank (2020) shows that the percentage of the population with internet access in South Africa rose from 0.013 in 1991 to 6.347 in 2001, 33.97 in 2011 and 56.167 in 2017. These have revolutionised different sectors of the economy with the rise of the e-commerce, e-learning, e-governance, precision agriculture, and telemedicine. In connection to these, Mzansisat and Stratosat datacom among other space companies provide broadband services to support mining, government, transportation, enterprise, NGO, construction, defence, oil and gas, finance, health, agriculture and ICT. As a result of these among others, online retail was projected to be 1.4 per cent of the estimated R 1 trillion to be spent on traditional channels in 2018 (GCIS, 2019). However, the economic transformation is not evenly shared in the country. While internet is high in some provinces like Gauteng (74.6%), Western Cape (72.4%) and Mpumalanga (70.2%), they remain lower in others like Limpopo (46.2%) and Eastern Cape (55.3%). Equally, internal access in rural areas (45.0%) is low compared to metros (67.5%) and urban areas (63.7%) (GCIS, 2019).

Besides internet, the impacts of satellite broadcasting for TV and radio is also revolutionary in South Africa's social-cultural, political, and economic spaces. The state-owned SABC and other entities like Multichoice, Top-TV, e.sat tv, Newzroom Afrika as well as some of the state-owned and private radios operate on this platform. The operations of these entities, which are space supported, are critical to political and strategic communication, nation-building and integration, entertainment, businesses, job opportunities, and poverty reduction. Without its own communication satellite, however, South Africa has continued to pay for exclusive reliance on foreign entities, especially American and European multinational corporations, to access satellite data that it utilises for broadcasting and internet, among other things. In the early years of 2000s, it was reported that various users of satellite facilities in South Africa, such as Telkom, Sentech, and Transtel, spent between R 450 million and R 550 million annually to lease satellite time (Purkitt and Burgess, 2005; Oyewole, 2017).

There is also a growing resort to air and space support for agriculture, urban planning, construction, and resources management in South Africa. Accordingly, drone and satellite data are having revolutionary impacts in many sectors of the economy. It was reported in early 2015 that SANSA's Earth observation directorate revealed that the French Spot-6 and Spot-7 satellite data used by government entities, such as the departments of human settlements, agriculture, forestry and fisheries, and statistics, are purchased at a cost of R 35 million per year (Wild, 2015). These data are critical to guiding the decisions and strategic planning of policy-makers as well as tactics and operations of civil servants and corporate organisations that implement them on agriculture, human settlement, forestry and fisheries. Because of the growing business opportunities, some companies have developed varying capacity to deliver different space supported services in these areas. Aerobotics and GeoSmart are prominent among companies that deal with satellite imageries for various clients. It is instructive that Marnic Precision Engineering, ETSE Electronics and other companies also spread their interests from space to agriculture and mining, among others.

7.3.1.1.3. Development as Local/independent Capacity and Self-reliance

The objectives of South Africa's space policy include the desire to develop and promote the capacity of the country in space R&D, industry, and commerce. Although the policy priority and investment that space has received, as evident from the financial resources that are made

available, are inadequate, especially in comparison with some other African countries that have managed this in ways that have produced considerable results. At the basic level, South Africa has recorded considerable progress in the development of manpower that is required for research, design, development, manufacturing, assembling, integration, testing, patenting, commercialisation, popularisation, and operation of space technologies. The country has equally witnessed increase in the number of facilities and associated opportunities in space R&D and industry. These among other factors are driving South Africa's progress towards local, and in some cases, independent capacity in some areas of space programming.

South Africa has developed considerable local capacity to access some space resources as well as convert and utilise them. With available astronomical facilities in South Africa, it has been possible for the country to advance in STEM, with a level of independence in capacity to demystify space science and contribute meaningfully to the body of related knowledge. The country has equally developed notable local capacity to access space support and convert it to advancement of national interests. The level of independence that the country has achieved in the production of satellite is an indicator of its advancement towards self-reliance. Besides, many public and private institutions have developed the capacity to convert or integrate space support into basic services and products that are made easily accessible to the larger population. Consequently, space supported bandwidth and imageries as well as guidance/ navigation are provided in a competitive market in the RSA.

The most remarkable aspect of local capacity development by South Africa in space entails satellite systems and subsystems. As earlier mentioned, South Africa is the only African country at least as at 2020 to have produced locally made satellites from scratch to finish. The country has seven of such satellites to its credit (see Table 7.4). Equally, the production, commercialisation and in some cases exportation of South African satellite subsystems are major achievements in consideration of the desire of the country to develop local capacity that can produce self-reliance and international competitiveness. With the first flight of Cubespace's ADCS products in 2014, the company had delivered more than 70 ADCS units and over 250 Wheels as at late 2020. The company also boasted of having more than 40 missions in orbit using its products (Cubespace, 2020). At the same time, another South African company that produced ADCS solution, NewSpace System revealed that more than

60 clients are using its products (NSS, 2020). These among others show the level of capacity that South Africa has developed locally in R&D of satellite system and subsystems.

Despite the foregoing claims on the progress made by South Africa in the development of local capacity in space and attendant technology, the country still relies on other countries or foreign entities for many things. As earlier mentioned, the country relies on other countries for launcher services, despite its rich history and renewed interests in missile and rocket R&D. At the same time, South Africa exclusively relies on foreign satellite data providers for telecommunication and navigation. Moreover, the progress made by the country in R&D of EO satellites have not eliminated or significantly reduced its reliance on foreign providers of these services. In as much as the world has become interconnected, these are subjects of concerns for students of development studies with background in dependency theory.

7.3.1.2. Space Support for National Security in South Africa

South Africa's space policy, programmes, and capabilities have considerably advanced its national security interests. These areas include defence, power projection, law enforcement, and disaster management. Although South Africa, unlike Nigeria, does not have specialised defence and security institutions with overt space functions, its space policy planning and programme implementation involve relevant security departments, agencies, services, and corporations. Consequently, the national defence and security interests and programmes of South Africa have benefited considerably from space support.

Some of the defence objectives of South Africa are to deter and prevent conflict, protect national interests, and defend the territorial integrity of the country, safeguard its borders and critical infrastructures, endure information security, promote strategic influence, as well as contribute to peace and stability in the region (DOD, 2015). Space capabilities have in some ways contributed to the advancement of these objectives. Some KIs considered the South African sponsored first military satellite, Condor-E2 to have contributed to promoting the national security interests of the country. However, some KIs are critical of this position on the ground that military threats against the country, especially from the frontline states and their allies, have declined or vanished since the end of the apartheid regime. Amidst these are those that consider it to be an irrelevant and wasteful project that sought to advance

the personal ego of its promoters. These cannot be total disconnected from the controversy that surround the secrecy of the project (see Joubert, 2014; Helfrich, 2014).

Despite some of the critiques of the defence space project, this and other space technologies have enhanced the capacity of the RSA for deterrence, territorial defence, border security, critical infrastructure's protection, strategic influence, and contribution to peace and stability in the region. Although the threats of inter-state wars have reduced significantly, local and transnational armed non-state groups pose considerable security challenges to the country's internal and maritime domains, and regional interests. The DOD and the intelligence services have been engaged in deterrence and campaigns against smuggling, transnational terrorism, and their network, and other transborder crimes as well as IUU fishing, piracy (especially in the Indian Oceans) and other maritime crimes. In almost all these cases, space supported C4ISR contributed to the South Africa's defence and security postures, deterrence, and campaigns. In connection with these, there were indications that the DOD initiated a process of fitting military vehicles and other assets with satellite tracking systems (DOD, 2013). Shortly after the launch of Condor-E2, it was also reported that the Joint Air Reconnaissance Intelligence Centre was upgraded with space integrated and supported ACTionable INTelligence (ACTINT) reconnaissance evaluation devices, supplied by Denel Integrated Systems & Maritime (Denel ISM) and the Airbus Defence and Space (ADS) (SAAF, 2015). Meanwhile, a source also revealed that the Spaceteq is involed in this case, given that its Grabouw premises were originally built under the name Houwteq to house branches of desktop monitors for photo-analysis of the planned reconnaissance satellite intended to be launched aborad RSA-3 in the 1980s.

As one of the leading regional powers in Africa, South Africa is also a major contributor of military forces for peace-keeping and enforcement in the region. The country has deployed troops to Burundi, CAR, DR Congo, Ethiopia, Eritrea, Mozambique and Sudan. It deployed a total of 334,176 military personnel for peace-keeping in Africa between 1990 and 2018 (Oyewole, 2020b). In almost all these cases, space supported C4ISR contributed to the South Africa's military capabilities, strategic influence, deterrence, interventions, and campaigns.

South Africa's space and related industries are also important in strategic consideration of its defence and security postures, strategic influence, and deterrence. Denel, Armscor, Ansys, Cobham, Marnic, Reutech, Stratosat and Tellumat are prominent among companies

with interests and investment in defence and space related products and services. The capacity of the country to manufacture high and medium technologies that are relevant for military space programming and defence generally, which broadly include products like spacecraft (satellite), aircraft, Armored tank, Armored Personnel Carrier (APC), ship, radar, guided missiles among other things, is major boost to the defence posture of the nation in the region and beyond. The commercialisation of some of these products, their subsystems and related services have equally added to the geostrategic influence of the country. For instance, South Africa exported US$ 2.44 billion worth of weapons to 71 recipients, including 68 countries (31 of which are in Africa), two international organisations and one liberation movement between 1950 and 2018. This amounted to the largest record of weapon exportation by an African nation. It is more than the net worth of weapon exported by Algeria, Angola, DR Congo, Egypt, Morocco, Nigeria and Sudan combined within the period (Oyewole, 2020b).

Institutions that are responsible and central to internal and situational security situation management in South Africa have also been supported with space capabilities. The South African Police Service (SAPS) and the Directorate for Priority Crime Investigation (DPCI) or the Hawks are central to internal law enforcement. These institutions among others have drawn space support, especially utilising satellite imageries, navigation and communication to enhance their operational capacity and delivery of policing functions in South Africa.

Space support is further evident in South Africa's disaster management strategy as a matter of national security. The operations of the National Disaster Management Centre (NDMC), which is designed for emergency management in South Africa, has been supported with space policy, programmes, and capabilities. For instance, space support was evident in South Africa's responses to tsunamis and lightning that occurred in Marion Island on September 23, 2020 (SANSA, 2020c). Responses to fire disasters of Worcester in February 2016 and Knysna in June 2017 also benefited from space support (SANSA, 2016b; 2019b). Space technologies have equally supported the country's responses to floods disasters locally— as evident in Gauteng in 2016, KZN and Eastern Cape in April 2019 and elsewhere (SANSA, 2016c&d; 2018b; 2019c). South Africa also supported other countries with satellite data for disaster monitoring, as evident with response to floods in Malawi, Mozambique and Madagascar in 2015 as well as Cyclone Idai in Mozambique, Malawi and Zimbabwe in 2019 (SANSA, 2015c, 2019d). In these and other ways, the space policy,

institutions, programmes, and capabilities of South Africa have contributed and advanced its defence, security, law enforcement and disaster management capacities.

7.3.2. Space Support for Sustainable Human Development and Security in South Africa

Space support for development and security in South Africa has extended beyond the state-centric conceptions to people-centric understanding of policy objectives. Accordingly, the contribution of space to job opportunities, wealth creation, poverty alleviation, education, environment, food and water security, human rights and dignity, and disaster management cannot be ignored. This section interrogates space support for human development and security goals, such as human rights, good governance, food, water, and environmental security, quality health system, quality education system, poverty alleviation, employment opportunities, and youth empowerment, as well as international cooperation.

7.3.2.1. Human Rights, Democratisation and Good Governance

South Africa's space policy, programmes and capabilities have supported the struggle for human rights and freedom in the country and beyond. Satellite TVs and radios as well as (terrestrial and space supported) telephony and internets have had considerable impacts on South Africa's socio-political space. These platforms have enhanced public access to information, and empowered the people to mobilise for better political participation and representation in government. They allow individuals, especially from a remote part of the country, to swiftly share their experiences of human rights violation or threats to freedom, with limited restriction, and then receive public attention, mobilisation and support for protection and possibly redress and compensation. Relevant policies have equally supported some South African communications giants like MTN and DSTV among others to rise to prominence in Africa, where they are providing services that are in turn supporting some of the platforms that enhance globalisation of human rights and freedom across the continent.

Satellite imageries and navigation are relevant for protection of human rights and freedom (Froehlich and Tăiatu, 2020; Bromley, 2010; Knoth & Pebesma, 2017; van Wyk, 2008b). Satellite imageries have become increasingly tenable and acceptable in court and securing justice in territorialised infractions and disputes. They are equally relevant to protect the fundamental rights to life of the people threatened by natural and some man-made disasters

or accident, through space supported early warning, which can produce decisive effects when combined with quick mobilisation and proactive response to prevent, deter, or reduce the impact of the threats as well as rescue the affected members of the population. In this manner, the support of South Africa's air and space among other capabilities are noticeable in saving lives in flooded communities. Police also make use of these technologies to aid responses to crime, and thereby advance its role in the protection of human rights and freedom.

Beyond the course of advancing and protecting human rights, space policy and capabilities have equally supported other elements of human freedom, democracy, and good governance in South Africa. The governance of agricultural, urban, water, food, environmental, health and security policy processes, especially in terms of advocacy, planning, implementation and assessment are supported by space capabilities. While some of these points will receive more attention in subsequent sections, the role of space support for urban governance is emphasised here.

Urban governance focuses on town planning with details like infrastructural development, housing, transportation, and waters. Amidst these, satellite data are playing notable roles in town planning and assessment of infrastructural development in major cities in South Africa. For instance, in mid-2020, SANSA sponsored a competitive modelling of location of informal settlement in KZN, using AI on the SPOT satellite imagery supplied by the agency. The competition attracted the participation of 184 scientists from across Africa, from where the winner won US$ 1,000 (SANSA, 2020d). In addition to air and sea transportation, navigation satellites have further gained usage among road users and are supporting in regulation of traffic in the country. In these and other ways, some of which will be discussed later in this chapter, space policy and capabilities are supporting policy research and processes to enhance governance and public services in delivering public goods that are key to human development and security.

7.3.2.2. Food, Water and Environmental Security

Space institutions, programmes, investment and capabilities have supported research, policy, and development in food, water and environmental security in South Africa. For the purpose of food security, SANSA has engaged relevant government departments, most

especially the DEFF and the DALRRD, by supplying them satellite data to make informed decisions on agriculture, land reform, forestry and fishing. The agency has also collaborated with private sector and NGOs to support farmers with space capabilities. In early 2017, for instance, the data from Sentinel-2B satellite, which was launched in 2015, and associated analysis was recognised by SANSA to have contributed significantly to policy decisions on agriculture and food security in the country (SANSA, 2017b). Equally in early 2019, the agency joined other organisations in the implementation process of the African AgriCultural Systems with the support of Remote Sensing (AfriCultuRES) in Free State and KZN (SANSA, 2019e). Private service providers like Aerobotics and Goesmart are involved in air and space support for precision agriculture to enhance food production in South Africa. The growth of e-commerce, with the support of space and terrestrial infrastructures, has also aided distribution and accessibility to food products, thereby advancing human development and security.

With many of the ingredients of precision agriculture imbibed, including elements of space technologies, it is instructive to note that South Africa is the foremost African country in food security. Out of 100, South Africa's rating in food security rose from 41.44 in 1960 to 79.57 in 1990 and all-time height of 126.7 in 2014 (World Bank, 2020). As at 2014, food was 10.9959 per cent of the mechanised exports, and 6.28 per cent of mechanised imports of the country. The value added of agriculture, forestry and fishing for South Africa's economy rose from approximately US$ 807.8 million in 1960 to US$ 4.9 billion in 1990 and its peak at US$ 9.5 billion in 2011, was US$ 8 billion in 2018. Meanwhile, the growth of the sector is not comparable to other sectors like industry and services. Notably, the contribution of the agriculture, forestry and fishing sector to the GDP of the country declined from 11 per cent in 1960 to 4.2 per cent in 1990 and 2.1 per cent in 2018. Besides, the percentage of the population that is employed in the sector declined from 9.3 per cent to 3.6 per cent between 1991 and 2019. However, the country was able to raise value added per worker in the sector from US$ 6,173 in 2000 to its peak of US$ 14,433 in 2014, and was US$ 11,816 in 2018 (World Bank, 2020). These among other things underscored the significant modernisation of the sector with various precision technologies, which include elements of space strategies.

The food security situation of South Africa cannot be examined in isolation. It is connected to water and environmental security. The annual total of freshwater withdrawal in South

Africa rose from 12.73 billion cubic meters in 2000 to 15.5 billion cubic meters in 2013. The annual total of the withdrawal was 28.4 per cent and 34.6 per cent of the internal resources in 2000 and 2014 respectively. In 1990, 71.98 per cent, 17.14 per cent, and 10.88 per cent of the annual total of freshwater withdrawal in South Africa for agriculture, domestic and industrial purposes respectively. As of 2013, agriculture accounted for 62.52 per cent of the total freshwater withdrawal, while 27 per cent and 10.48 per cent remaining were consumed for domestic and industrial purposes respectively (World Bank, 2020). These call for careful management and policy governance of freshwater withdrawal in the country. In this context, satellite data has been utilised to support research on the quantity and quality of water that is available across South Africa. For instance, in 2014/2015, Spot-6 satellite data was used in a research to determine the quality of the Vaal Dam, with emphasis on the concentration of algal bloom (SANSA, 2015d). With advent of AI like the Mzansi Amanzi tool, SANSA (2020e) recognised South Africa's capacity to monitor and keep track of dams with satellite data rose from 250 to 30,000. These among others are supporting the country in the management and governance of freshwater for human development and security.

Environmental security is essential to food and water security. Environmental research and policy in South Africa have considerably benefited from space support. Satellite data are playing considerable roles in diagnosing and assessing the extent of ecological challenges faced by South Africa, like many other countries. For instance, in mid-2020, the agency supplied the satellite data that supported a study of air quality in the country. As such the TROPOspheric Monitoring Instrument (TROPOMI) on board of Sentinel-5P satellite, which was launched in 2017, was used to examine the concentration of sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) gases over the country (SANSA, 2020f). The agency has also supported relevant departments and agencies on land, urban planning, agriculture, water, maritime affairs, fishing, forestry, and disaster management with relevant satellite data, training, and other forms of capacity building to aid effective environment management. These efforts and those of other government agencies and departments have equally found the support of the private sectors and the academic community very critical in this process.

Despite the foregoing claims on the progress and prospects of space support for food, water and environmental security in South Africa, there are still some notable gaps between policy strategies and realities. It was emphasised by some of the KIs that air and ground instruments

are more considerable, accessible, and utilised for these purposes. These alternatives are in most cases considered to be cheaper and easier to access and utilise. Others considered the knowledge of space support in many areas to be limited in the country. The interests of the general public in space and its relevance are mostly considered to be very low in many other countries, while the interests of the academics and private sectors are rated between modest and low. Some observers believed that many of the scientists that are in the space and related fields are not really in touch with wholistic policy interests, strategies, and reality.

7.3.2.3. Quality of Health System

South Africa space and related policy, institutions, programmes, investment, and capabilities have contributed considerably to the advancement of the quality of health system in the country. As earlier mentioned in the case of Nigeria, and applicable to many other countries, satellite TVs and Radios as well as internet have expanded the quantity and quality of health and other relevant information that are available for people to live healthy. Space has supported the terrestrial infrastructures to raise the prospects of telemedicine in South Africa. This is most pronounced in the area of bandwidth that provide those in the remote parts of the country the opportunity to locate, connect, and access better medical facilities and experts that are based in the cities easily. Equally, e-commerce makes relevant drugs in cities more accessible for those in remote locations. Generally, telecommunication expand accessibility to medical insurance and ambulance services among other things.

Space support for health research and policy are also critical to improving the quality of health system in South Africa. This is mostly noticeable with the use of satellite data to support policy research, decisions and implementation during Covid-19. SANSA supplied relevant satellite to different department and agencies of government, private sector, and research institutions to support their responses to the challenges of Covid-19. Satellite data were used to support contact tracing initiatives, in order to identify the location of infected persons, test, and monitor those in close proximity, and contain further spread of the virus. Space support was employed to monitor lockdown compliance, as movement of vehicles along all major routes in the country were observed from satellites. In similar manner, transborder movements were also monitored with space support. Satellite data were also important to location and mapping of warehouses and distribution of relief materials to different areas. They were equally utilised for researching the impact of the lockdown on

the environment, as well as the effects of the weather and climate on health (see SANSA, 2020g, h, & i).

7.3.2.5. Quality of Education for all

South Africa's space policy, institutions, programmes, and capabilities have supported the quality education and the quantity of those that have access to it in the country. Terrestrial and space infrastructures have supported e-learning through internet, TV and Radio. Public education has been sponsored by the government, NGOs, private sector as well as academic and research institutions through these platforms over the years. These have expanded the quantity of people that have access to quality education in South Africa. During the Covid19 crisis, e-learning platforms became further critical for public and advanced school educations.

STEM educations have been greatly enhanced by space policy, institutions, programmes, investments, and projects in South Africa. In 2019, for instance, SANSA engaged more than 10,000 secondary school students across the country in capacity building in the area of space application, including in GPS navigation training, to advance STEM educations (SANSA, 2020j). More importantly, the agency and the DST among other government departments and agencies have partnered and supported academic and research institutions, and in some cases, high schools, in R&D of satellite systems and its subsystems or components. Similar partnership and support are noticeable in R&D of astronomical instruments and rocketry, to the advancement of STEM educations in the country. This was the way and manner that the country developed seven satellites locally and created a space industrial sector. Besides, the data obtained from these satellites, those made available by SANSA and open sources have further advanced R&D in the fields of science, which translates to better quality of education. In relation to these, Table 7.5 shows the contributions and positions of South Africa in the metrics of knowledge production globally and regionally in selected fields of space S&T.

Table 7.5: South Africa's Contribution to Knowledge on Space Science and Technologies, 1996-2019

Fields	No of publications	Citations	Ranking in Africa	Ranking globally
Aerospace engineering	1,245	13,173	1/43	36/187
Astronomy and astrophysics	5,183	145,428	1/38	24/177
Atmospheric Science	1,838	45,615	1/53	29/217
Control and System Engineering	3,388	40,532	4/47	42/188
Global and Planetary Change	1,278	35,192	1/55	23/217
Physics and Astronomy (miscellaneous)	6,893	108,935	1/55	42/206
Space and Planetary Science	5,483	163,783	1/48	27/205

Source: Compiled by the author from Scimago (2020) database

As evident in Scimago ranking, South Africa contributed 1,245 scholarly publications that attracted 13,173 citations to knowledge on aerospace engineering between 1996 and 2019, making the country 1st out of 43 African countries and 36th of 187 countries globally. In Astronomy and Astrophysics, South Africa contributed 5,183 scholarly publications, which attracted 145,428 citations, to the body of knowledge, making the country 1st of the 38 regionally and 24th of 177 globally. South Africa contributed 1,838 scholarly publications with 45,615 citations to knowledge on Atmospheric Science, making the country 1st out of 53 in Africa and 29th out of 217 globally. In the field of Control and System Engineering, the country is the 4th out of 47 regionally and 42nd out of 188 globally with 3,388 scholarly publications that attracted 40,532 citations. With 1,278 scholarly publications that fetched 35,192 citations in the field of Global and Planetary Change, South Africa is the 1st out of 55 countries regionally and 42 out of 217 countries globally. The country is ranked first in Africa and 42nd in the world for its contribution of 6,893 scholarly publications that have attracted 108,938 citations in the field of Physics and Astronomy (miscellaneous). In the field of Space and Planetary Science, South Africa contributed 5,483 publications that

attracted 163,783 citations, and was ranked 1st out of 48 countries in Africa and 27th out of 205 countries globally.

Despite the foregoing claims on space support for education, there are enduring concerns that the knowledge of space, its attendant technologies and their utilisation are limited in South Africa. This is evident in many KIs rating of public, and to an extent, academic attention for space policy and education. The attention of social scientists, and political scientists, particularly, on the subject matter are even rated to be poor in most cases.

7.3.2.6. Poverty alleviation and employment opportunities

Space support for research, policy, and different sectors of the economy has directly and indirectly affected poverty situation and employment opportunities in South Africa. The space industry directly employed about 2,000 persons, and many more indirectly, in South Africa. Besides, space supported telecommunication, most especially satellite TVs and Radios as well as internets, have created a chain of employment opportunities in the country like many others across the world. Space supported agriculture and food security, water security, urban governance, environmental management, telemedicine, e-commerce, e-learning, e-banking, e-governance among others have further created job opportunities for skilled workers, as well as increased effectiveness, per capital productivity and the standard of living of the affected persons. This is evident in how these and other technologies have revolutionised agriculture, and then raised the value added per worker in the sector from US$ 6,173 in 2000 to US$ 14,433 in 2014 as earlier identified (World Bank, 2020). However, these among other things also raised concerns for job security and opportunities, most especially for the unskilled and semi-skilled labours, with the growing resort to AI. This is evident in the earlier identified decline in the percentage of the population that are employed in agricultural sector, while the productivity of the sector continues to rise. These are potentially alarming trend for a country that is already threatened by unemployment.

7.3.2.7. International cooperation

The international dimension of South Africa's space policy goes beyond the competitiveness of the nation against others to accommodate cooperation. In some ways, South Africa has institutionalised its desire and support for international cooperation with membership of relevant multilateral arrangements, especially in IGOs. Prominently, the

country is one of the leading advocates of regional and global space cooperation. As such, South Africa is a member of the ARM, which was established in 2003 with Algeria, Kenya and Nigeria (Mostert and Jacobs, 2008). It is one of the over 40 members of RASCOM. The country was one the leading advocates of African Union's hosted ASA and its founding members. It is also a member of UNOOSA. On these bases, South Africa has benefited and sponsored international assistance, partnership, and support in space and attendant technologies.

The space policy, programmes, capabilities, and investment in South Africa have benefited from the support of many foreign governments, industries, as well as academic and research institutions. This is evident in the technical and financial support that the country received for the construction of most of its astronomical observatories. As such, HartRao and some of its infrastructures benefited from South Africa's collaboration with the US and France. Two-third of the US$ 35 million cost of SALT was paid for by Britain, Germany, Poland, New Zealand, and the United States (Oyewole, 2017). The SKA is currently funded by several countries, including Australia, Canada, China, France, Germany, Japan, India, Italy, Netherlands, Portugal, the UK, South Africa, South Korea, Spain, Sweden, and Switzerland.

South African satellite programmes and industry have also benefited from the international collaboration of the country. It is instructive that South Africa relied on purchased and open data from satellites sponsored, launched, maintained and operated in Europe and America. Intelsat, Spot, and Sentinel satellites and supporting infrastructures by ADS are prominent in this case. The military satellite of the country was also designed, developed, and launched by Russia. South Africa also proposed to jointly build EO satellite with Brazil, but the allocated ran out before it was completed. South Africa relied on the US and Russia for launch services. Moreover, some of the industries that support indigenous capacity of the country in space sector are foreign investment, while others survived on transnational operations and exportation of satellite subsystems and components. As such, Aerobotics, Brolaz Projects, Convergence Partners, Pinkmatter Solutions and Stratosat datacom are prominent MNCs that are involved in space sector in Africa. CubeSpace, NSS, and SAC among other space companies in South Africa have also resorted to exportation. These allow them to add the benefits of foreign trade and investment to their survival, even while contributing and supporting other countries in space.

Many countries have benefited from South Africa's space programmes as well, especially in Africa. SALT and some other astronomical observatories like space related programmes in universities and research centres in the country are considerably open to foreigners to utilise and develop their capacity. South Africa also provided the leadership that has made it possible for many African countries to benefit from the siting of SKA. The partners include Botswana, Ghana, Kenya, Madagascar, Mauritius, Mozambique, Namibia, and Zambia. The country is also a key promoter of African Very Long Baseline Interferometer Network (AVN). South Africa has further supported disaster management in other African countries, especially in the Southern Africa, with relevant satellite data. These are in addition to the opportunities for trade and technological transfer in the areas of space R&D, especially satellite system or subsystems/components and guided tactical missiles, from South Africa to other countries on the continent. These, among other things, show the desire and commitments of South Africa to cooperation among nations, especially in Africa, on space technologies.

7.4. Conclusion

This chapter examined the institutional capacity as well as resources, including human and materials (financial and infrastructural) that were developed in South Africa to realise its space policy and strategies, and how they advance the developmental and security objectives of the government and peoples of the country. As a result, the chapter interrogates space support for the national competitiveness, economic growth, and transformation, local technological capacity, defence, security, power projection, disaster management, human rights and freedom, democracy and good governance, food and water security, sustainable environment, quality of health and education systems, and international cooperation in South Africa. It is on this basis that the next chapter draws conclusion and recommendation on the contribution of space policy and programmes to development and security in the study areas.

CHAPTER 8

Summary, Conclusion and Recommendations

8.1. Introduction

This chapter provides the summary of key findings, recommendations, and conclusion of this study on space policy and its contribution to development and security in Nigeria and South Africa. For this purpose, this chapter is further subdivided into three sections. The first among these sections deals with the summary of the study, while the subsequent section provides the concluding thoughts on the subject matter and the last one provides some recommendations.

8.2. Summary of the Study

In the last seven chapters, this study has explored and attempted an assessment of the space policy, institutions, programmes, investments, and capabilities of Nigeria and South Africa as well as their contributions to the development and security aspirations of the governments and peoples of these countries. The chapter one of this dissertation provides brief background to the study, aim and objectives of the study, research questions, justification for the study, the conceptual framework of the analysis, scope and limitation of the study, ethical consideration, and organisation of the study. The brief background relates space and attendant R&D to subject of interests in social sciences and the field of International Relations, even as the section tries to locate Nigeria and South Africa in the figurative map of Africa and the world in space policy priority, programmes, investments, and capabilities. The chapter also provides clarification of key concepts, with attention on variation and utilisation of social and astronomical dimension of geometric space in its relative application. Development and security are equally taken to broadly cover means and ends that are salient in people and state-centric perspectives.

This inquiry is largely motivated by two major reasons as identified under the statement of problems in chapter one of this study. First, the study was motivated by the need to go beyond the then prevailing historical and institutional reductionism of space politics and policy studies in selected countries among others in Africa, through an assessment of what they sought out to achieve and their records of achievement. Second, space policy programmes and investment in the study areas, as in other African and developing countries, are motivated by their developmental and security promises. However, the experiences and perspectives of these

countries are underexplored or understudied, and at best covered in the space popularisation project of the advanced space players. These among others account for the underrepresentation and marginalisation of the experiences and perspectives of Africans and other developing countries in space politics and policy as an emerging field of study as well as a subject of study in the fields of International Relations, Development Studies, and Strategic Security Studies.

This study is considered to be significant for four major reasons. First, it interrogates the experiences of Nigeria and South Africa to contribute to African perspectives to space politics and policy studies, which are brought into the context of African, governance, development, and security studies. Second, it offers an opportunity to assess the realisation and efficacy of space policy in Nigeria and South Africa. Third, given the leadership status and influence of Nigeria and South Africa in the continent, this study provides insight into the development paths of space policy in the two countries and their implications for Africa. Finally, it contributes to the efforts to Africanise African narrative on space politics and policy against some misinformation and misrepresentation on the extra-terrestrial aspirations of the region at the global level.

Chapter two of this study provides extensive review of literature and identified notable gaps on the subject matter, with special attention to rationales for space exploration, policy and their assessment, as well as how and what to assess in space policy. In connection to these, the quest to advance human knowledge (academic-related interests) and accumulate terrestrial benefits (policy-related interests) are broadly recognised rationales. Amidst these, this study recognised the trend and need to go beyond science and engineering reductionism of space studies to accommodating art and humanities redux and social sciences, with emphasis on policy studies, in the academic interests. The review also shows the growing need and trend of transcending state-centric reductionism to accommodation of various non-state actors in space politics and policy. Besides, this review identifies development, security, and prestige as common interests that motivates states that are involved in space, although there are variants that mirror unique understanding and conceptions of these interests, based on geostrategic consideration. Based on this, capabilities are an important factor to be considered in assessing the space policy of a nation, as they determine differentials in the rating of nations by various parameters. In this study, however, space policy and its developmental and security impacts for Nigeria and South Africa are considered in a framework of three levels of analysis, that is, as emerging space players globally, leading space players regionally, and as space nations in their own rights.

As a matter of research design, this study adopts multilayers triangulation, as detailed in chapter three. This entails triangulation of theory, data, space (research sites), method, and technique. To assess the contribution of space policy to development and security in Nigeria and South Africa, this study adopts utilitarianism as a general theory, which emphasises consequences of all action, with the aim to maximise the benefits of the concerned party. To deconstruct the idea of benefits in space policy assessment, however, this study relied on specific theories like realism, liberalism, dependency and social constructivism. This triangulation of theory is only followed by methodological and analytic triangulation. Both qualitative and quantitative data were collected from primary and secondary sources, coded accordingly and analysed using mixed method. The techniques of analysis were designed with elements of quantification – descriptive statistics for congruent testing— and qualification – content analysis, historical analysis and structural phenomenology. These are evident between chapters four and eight.

Space politics and politics in the two study areas, Nigeria and South Africa received detailed attention in chapter four and five respectively. These are unbundled into two chapters to allow for detailed analysis of the unique contents of the space policy and strategies of each of these countries as well as the historical, social, political, and economic conditions that produced them. While modern space R&D in Nigeria can be traced to the 1960s, that of South Africa dated back to the 18th century. Amidst these, national space programmes took off in Nigeria in the late 1990s and in South Africa in the early 1960s. The take off was largely directed for civil purposes in the former, but militarised in the latter until early 1990s. However, these countries only adopted a publicly known space policy and strategic document much later: Nigeria in 2001 and South Africa in 2009. They equally created space agency around these periods: NASRDA in 1999 and SANSA in 2010. The space policy, strategies and institutions are supported by the constitutions and relevant legislations in the two cases. Besides the attempt to understand the economic, historical, political, and socio-cultural situations of each of these countries, chapters four and five reviewed the objectives of their space, development, and security policies. These provided the bases that were connected to the theoretical framework of analysis for chapters six and seven to examine the contribution of space to development and security in the study areas.

Chapters six and seven focus on the contribution of policy and programmes to the development and security aspirations of the government and peoples of the study areas: Nigeria and South Africa respectively. In this case, this study recognises the need to treat space policy as an end

in itself and as a means to an end. As an end in itself, space policy is designed to develop institutional, capacity, human resources, financial resources, and infrastructures that can support space programmes and capabilities, as a matter of national development, security and prestige. As a means to an end, however, space policy is expected to be operationalised in form of programmes that support institutions' capacities and policy initiatives that promote development and security aspirations of the people and government of its sponsor. In this case, attention is paid to the contribution of space policy to national and human conceptions of development and security.

As a matter of national development concerns, this study examined the contribution of space policy and programmes to the international competitiveness. It also examined the capacity of affected nations to catch up with advanced nations or maintain competitive advantage over others. Such contributions include: economic growth, liberalisation and transformation, as well as internal or independent capacity. Chapters six and seven equally examined the contribution of space policy, programmes, institutions, investments, and capabilities to defend and power projection, law enforcement and internal order, and disaster management capacity of Nigeria and South Africa respectively, as a matter of national security objectives. In reference to human development and security goals for the peoples of Nigeria and South Africa, the same chapters paid attention to the relevance of space policy and programmes to human rights, policy efficacy, democratisation, good governance, food and water security, environmental security, quality of health system, quality of education for all, employment opportunities and poverty alleviation, and international cooperation. These objectives reflected indicators of adopted conceptual orientations and theoretical frameworks of this study, which are complemented by methodological choices made of data and techniques of analysis. It is against this background that the next section offers some concluding thoughts.

8.3. Conclusion

This study contributes to evolving knowledge on space politics and policy in Nigeria and South Africa, as an element of the experiences, perspectives and narratives of Africa by African on the subject matter. It paid attention to underexplored convergence and divergence between what Nigeria and South Africa hoped to achieve through space policy and their records of achievement, with special attention to the contribution of relevant policies, programmes, institutions, investments, and capabilities to the development and security aspirations of the

peoples and governments of these countries. In this case, it is important to note that as at late 2020 when this study was finalised, some relevant studies had emerged that were not available when it started in 2018. Prominent among these is a series on Space Support in Africa for SDGs among other works by Annette Froehlich, which have encouraged the emergence of Springer published Southern Space Series (see for example Froehlich, 2019; Froehlich and Siebrits, 2019).

Despite the emerging development on the subject matter, the in-depth country-focus analysis in this study, offers a unique perspective on space policy in study areas, which provides insights into the region's experiences and perspectives. The diversity in disciplinary, theoretical, and conceptual orientations of this study afforded this analysis the opportunities to take the form of famous description of "few cases, many variables" as identified in chapter three (see Porta, 2008). As evident in chapter two and three, these allow this study to provide bridges across disciplines, especially between pure and applied sciences on one hand and art, humanity and, social sciences on the other hand. These made it possible to transcend the prevailing academic focus on space and its application to its politics, policy, development, security, and International Relations frameworks. The triangulation of theory equally made it possible to work on different conceptual perspectives and test multiple assumptions with several indicators on space policy (programmes, investments, human and material resources, among other capabilities) and their relevance to development and security, which ranged from state-centric to people-centric goals. With this broad scope of analysis, this study offers a unique view with some fresh, refreshing, and integrated perspectives of space policy in the study areas - Africa and the developing world.

Between the theoretical propositions and empirical conclusion of this study, the triangulation of method played important roles. The planned fieldwork for this study was greatly affected by Covid-19 pandemic and associated lockdown. Only about 41.7 per cent of the targeted facilities were visited and KIs were engaged when this crisis started. Amidst these, about 13.3 per cent of targeted KIs turned down interview requests, withdrew from, or ignored planned engagements. These are in addition to 15 per cent of targeted KIs that never displayed interest to participate in the research from the onset. These KIs could not be persuaded against their wishes and rights to voluntary participation as identified in the ethical consideration of this study. However, the rest of the targeted KIs agreed to virtual interactions, which aligned with the choice of multiple media of engagements as identified in chapter two. The study also adopts

space support for observation of relevant facilities, as shown in chapters six and seven. Other sources of data, especially online archives or data repositories of relevant institutions and subjects, played important roles in filling the rest of the gap, in line with data triangulation arrangement of this study. Finally, structural phenomenology allows for analytical flexibility of the research design to code data pieces that were merged into categories and refined through several iterations of cases and thereafter explores for the relationships or patterns across categories, so as to identify major themes that are relevant to understand the context and the object of study (Ary et al., 2014:519).

Beyond the research design (especially theoretical framework of analysis and methodology), which deals with the academic interests in terms of contribution to knowledge, this study also concludes with some empirical policy thoughts. On a general note, both Nigeria and South Africa have made significant progress in space R&D and associated policy. It is remarkable that Nigeria has prioritised and recorded progress in state institutional, human, and infrastructural capacity development to operationalise its space policy aspirations over the last two decades. Besides, this study shows how Nigeria has employed space technologies to support economic transformation, internal security, power projection, election management, as well as struggles for human and environmental rights, and freedom and security. At the same time, South Africa has prioritised and recorded progress with state institutional, human and infrastructural capacity development for academics and private sector to operationalise its space policy. It is therefore remarkable that this country has developed impressive capacity to produce and commercialise some space-related high technologies as well as support its development and security goals.

In comparative perspective, it is observed that the space policy and strategies of Nigeria are largely designed and developed around applications of space technologies by the government and universities with limited production and commercialisation. In South Africa, however, the space policy and strategies revolve around production and commercialisation of some relevant technologies by the academics and the private sectors, with applications by government and NGOs. In another words, pattern of space institutional development in Nigeria is largely government driven with academic support and growing military dimension, with limited private sector. For South Africa, however, the institution is largely academic and private sector driven with government support and a covert military dimension. These are important for the development paths of these countries in terms of space-related human and material resource

management. Compared to South Africa, Nigeria's space programmes are observed to be characterised by more sophisticated but fewer space-based assets, less sophisticated but impressive ground facilities, which are maintained with more human and financial (but under-utilised) resources. These development paths are models that are likely to reflect on many other African countries.

Despite the record of progress reviewed, this study has raised a series of concerns on space policy, its operationalisation, and utilisation in the study areas. For instance, there were concerns on space-related human resource management, especially on the quantity and quality of recruited personnel in relevant state institutions, as well as financial mis/management, in Nigeria. The underutilisation of Nigeria's human and material resources in space-related development and security is also worrisome. This is evident in the underdevelopment of the capacity of the country in design, production, and commercialisation of space technologies as well as their inadequate application for law enforcement, economic transformation, urban planning, forest and maritime governance, water and environmental management, and precision agriculture and food security. Besides, the potential implications of space support for the armed forces and other security forces with the enduring record of the militarisation of public space have become a subject of concern for human rights and democracy, despite the growing use of the same space to support the struggles for human and environmental freedom in Nigeria (cf Oyewole, 2020).

South Africa's space policy is not without its challenges as well. There are concerns that the government has been inconsistent or failed to sustain policy priority and investment for space R&D. This concern is also notable in the case of Nigeria, where relevant institutions are often left handicapped and human resources are made redundant due to unavailability of funds. In the case of South Africa, however, this development has forced many promising space-related high-tech companies to liquidate. In both cases, many bright minds that made up the highly skilled human resources of these countries have been forced to emigrate, thereby causing brain drain, a pattern of unequal and unfavourable labour mobility between the South and the North. Nevertheless, the limited economic growth, and in some cases, stagnation and contrast of the two countries in recent years have caused budget constraint with implication for space policy and investment in the study areas. These among other things have equally caused underutilisation of human, and in some cases, material resources that are available for South Africa to realise its potential in space R&D and their application for development and security.

The covert nature of South Africa's military space programmes constitutes another subject of concern about transparency and regional security. This is important in light of an absence of a coherent institutional framework for defence space programme and the shadiness of the military satellite project of the country. In a series of attempts to absolve themselves from wrongdoing and public scrutiny, almost all the institutions involved in Condor-E2 or Flute project engaged in finger-pointing and name calling of others as being responsible (see Joubert, 2014; Helfrich, 2014). With these and related developments, the exact value of the project remains in the realm of politicised debate in South Africa. Besides, the military satellite is considered as the main catalyst for the second and emerging wave of military space programming in Africa since the 2010s (Oyewole, 2020). Without any pronounced connection, it is instructive that Nigeria established the DSA to institutionalise its military space programme in 2014, the same year that information about South Africa's secret military satellite was leaked and launched. As at late 2020, Egypt and Morocco were observed to have acquired space assets for military purposes, and Nigeria announced its commitment to joining them by 2021.

As shown between chapter four and seven, Nigeria and South Africa, like other leading African countries that maintain some sort of space programmes and capabilities have displayed their commitments to international cooperation in space exploration and exploitation at the global, regional, and sub-regional levels. However, the drive for space capabilities for military-security has the potentials to generate competition among these countries and other regional powers in Africa. Although the potential for direct hostility is very low, this may militarise space policy and programmes for political and security purposes, in some cases, at the expense of relevant development objectives. Besides, the quest for international competitive advantage and catch up in political economic realms remain another concern for international cooperation between Nigeria and South Africa. It is not surprising therefore that non-African space-related products and services are more patronised at the expense of African-owned in Africa. This is evident from the purchase of satellite system, subsystems/components, and data.

It is against this background that Nigeria and South Africa are creating development models and paths in space policy and politics with the prospects that many other African countries will consider, follow, adopt, adapt, refine, internalise and re-popularise. Moreover, it is important to note that the space policy-decisions, programmes, institutions, investments, and capabilities

of these countries are essential components of the experiences, perspectives, and narratives of Africa, developing countries, and emerging space players in space politics and policy studies.

8.4. Recommendations

In response to the challenges and prospects of space policy, programmes, and investment that have been examined, this study calls for more cautious research, development and security-oriented attention to the subject matter. In consideration of academic interests to gain and advance knowledge, there is a need for more researches on space R&D from all fields, especially in the study areas. In addition to the efforts of those in pure and applied sciences, more space-related research in art, humanity, and social sciences are required to document the records of these among other nations as contribution to development of the experiences, perspectives, and narratives of Africa by African, developing countries and emerging players in space. As social scientists, students of political science, International Relations, and policy studies need to embrace multidisciplinary perspectives and multiple theoretical frameworks to enrich studies in space politics, policy, programmes, investments, and capabilities as well as their prospects and challenges for national and human development and security interests.

The study observes the need to balance attention between national-centred space programmes and regional-centred or aggregate space policy assessment in Africa. There is a need to advance space politics and policy in the study areas and the continent with various theoretical perspectives as well as different forms of data and their sources, with research methods and techniques. Amidst these, more quantitatively-driven research is required to assess the contribution of space policy programmes to different but specific development and security goals. Accordingly, specific research efforts need to be devoted to each or limited indicators of space policy and attendant development and security goals in order to allow for better and more exhaustive case by case interrogations. Besides, universities in the study areas and the region should commission and sponsor relevant databases as well as subscribe to some of the existing ones to make such data available for academic interrogation and enhance African narratives by Africans in space policy and attendant politics, development, and security debates.

Future research is encouraged to devote more attention to the extent that other African countries may perceive and reference Nigeria and South Africa as models in space policy and politics in the continent. More attention is also required to raise the prospects and minimise the challenges

of space policy in the study areas and beyond. In this case, the importance of space popularisation cannot be overstated in advancing academic and policy interests. There is a need to devote research attention to bridge the gap between academic community and the population where decision-makers with little or no knowledge of the subject matter are drawn. Space S&T should be promoted among other STEM educations, with emphasis on capacity building and quality of education that is available in traditional fields of pure and applied sciences. At the same time, non-traditional fields such as art, humanity, management, and social sciences need to be revised to promote space popularisation and STEM educations. Amidst these, astropolitics, astro-sociology, space policy studies, space commerce, and economics, among other fields need to give better attention to building space-conscious societies in the study areas and the region generally. For a sustainable space programme, it is important for a nation to develop its population to support space policy and be committed to realising its development and security potentials.

At the national level, there is a need to revisit the priority placed on space policy, programmes, and institutions in development and security planning. There is a need to maximise the utility of available space capabilities to the fullest of their potentials in order to advance the development and security aspirations of the peoples and governments of the affected countries. More funding and prudent management of resources are essential in this case. Besides, more policy efforts are required to further integrate the space sector with other sectors of the economy in order to ensure interconnectivity that can sustain the industry. Commercialisation of some aspects of space programmes are equally essential to boost funding and sustenance of the sector. At the same time, political will, openness, transparency, innovation, and general state institutional capacity building are essential to optimising the development and security potentials of space policy, programmes, institutions, investments, and capabilities in the study areas and beyond.

Nigeria and South Africa need to take cautious policy measures to strengthen relationships with each other and other African countries. This is important for maintaining mutual confidence and trusts as well as partnership, which are essential to peace, political stability, socioeconomic development, and security in Africa. In this case, space is another frontier for the two countries and others in the region to display their commitments to leadership and mutual respects with the spirit of pan-Africanism, brotherhood, collaboration, collectivism, and regionalism. Their space policy and programmes cannot be disconnected from their foreign policy in this case.

Therefore, these countries need to take the lead in supporting other African countries and advocating for international cooperation that will benefit the smaller economies in the region. While this calls for some sacrifices on their parts, it does not necessarily need to be flamboyant and wasteful display of space power.

As models for many countries in the region, Nigeria and South Africa need to manage their competitive advantage, strength, and capabilities so as not to escalate its harmful effects and challenges internally and internationally. The two countries can work together to transform ARM from data sharing to building joint satellites. They can also work together to explore the potential of Overberg Test Range for launching African satellites into Low Earth Orbit. Their support is further required to realise the dream of African space strategies. Moreover, these and other countries need to support the narratives of African experiences and perspectives by Africans, in space politics and policy as well as in other fields of study, in order to increase African representation and reduce the marginalisation of the region on the global map of knowledge production. Finally, the international community needs to support these countries and others in the region to ensure globalisation of knowledge, shared global prosperity and human security.

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Appendix 1

Interview Guide

Project Topic: Assessing the Contribution of Space Policy to Development and Security in Nigeria and South Africa
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Introduction

National space policy is the conscious and specific use of space and its attendant technologies to promote the security and socioeconomic interests of the state (Harding, 2012:5). Accordingly, this study seeks to assess the development of space policy and its benefits for the enduring developmental and security aspirations of the peoples and governments of Nigeria and South Africa. This is important for the following reasons:

1. Academic rationales: To assess the experiences and perspectives of Nigeria and South Africa in space. This will contribute to the experiences and perspectives of emerging space players in Africa on the subject of space politics and policy. To bring space issues into crucial components of African Studies, such as development, governance, policy and security.
2. Policy rationales: To identify the utilities of space policy and investment in space, and how to maximise them, in Nigeria and South Africa. To understand the prospects of other Sub-Saharan Africa countries in space policy priority, investment and associated benefits as well as regional cooperation, institutional building and possibly competition in this area. To put space policy of emerging space players in Africa and its motivations in utilitarian

perspective as against its mischievous misrepresentation at the international level.

Personal information

1. Please briefly introduce yourself and describe your (role in your) department/ organization/ field of study within the context of space policy in your country.

Space policy objectives

1. What are the objectives of space policy in your country? What are the factors that shape the conception of space policy interests in your country?
2. How can you assess the contributions of different department of government/ academic community/ civil society/ private corporation to space policy advocacy/ formulation/ implementation/ assessment in your country?
3. To what extent does space policy in your country reflect the development and security aspirations of the people and government of your country? To what extent does space policy in your country reflect its position as a regional power in Africa?

Space policy priority

1. How will you rate policy/ public/ academic/ corporate attention for space policy in your country? Can you please rate the level of attention between 1 and 10? What aspects of space policy are most popular in your field of study/ policy circle/ private corporation/ general public?
2. How will you rate government and corporate investments in space science and technology, and how significant are they to the realization of space policy objectives in your country? Please rate the investment in satellite system in your country?
3. How can you rate the space capabilities of your country vis-à-vis the national space policy objectives/ other African countries/ globally? How can you rate satellite inventories of your country?

Space Policy Assessment

1. To what extent has the objectives of space policy been achieved in your country/ sector/ field of study/ corporate interests. How can you rate the utility/ relevance of space technology in your country/ field/ sector/ department/ corporate interests?

2. How have you and your colleagues in your field of study/ department/ company/ organization contribute to the realisation of space policy objectives of your country? What are the outstanding contributions of your field of study/ department/ organization/ company to the development of space technological capacity (most especially satellite) and its application in your country?
3. Please explain the contributions of space technologies (most especially satellite system) to development and security in your country, and the role played by you and your colleagues in your field of study/ department/ sector/ corporation/ organisation in this framework, if any.
4. Please explain specific ways and cases of how your country/ organisation/ department/ field of study/ corporation has employed space technologies (most especially communication and earth observatory satellite) for selected national interests, such as economic growth, poverty alleviation, employment generation, industrialisation and national self-reliance, election and its integrity, media and journalism, political participation and mobilisation, urban and regional planning, agriculture and food security (from production to distribution and accessibility), provision of health services, quality and quantity of education, early warning and disaster management, policing and law enforcement, intelligence gathering, military capabilities and (strategic, tactical and operational) purposes, foreign policy and international peacekeeping.
5. Please explain how other countries (with emphasis on Africa) have benefited from the space activities of your country/ department/ organisation/ academic community/ corporation. In your opinion, how do you think other African countries view your country's capabilities and achievement in space and attendant technologies.

Space Policy Feedback

1. What can you observe as pressing challenges against the realization of set objectives of your country/ department/ organization/ academic field/ corporation in space? Which area(s) will you like your country/ department/ organization/ academic field/ corporation to pay more attention to and invest more or less in space?
2. To what extent do you think space activities should be state/ private interest-driven in your country? Will you be willing to support the increase in space spending in your country? How many per cent of government expenditure will you like to be voted to space activities

in your country? Which outstanding space-related legislation (bill/ act) will you want the parliament to pass into law or amend in your country?

3. To what extent do you think your country/ corporation should compete/ lead/ dominate the space politics/ economy in Africa? To what extent do you think your country/ corporation should cooperate and support aspiring/ emerging/ established space players in Africa? To what extent do you think your country should support regionalization of space activities in Africa (AU's vision and policy)? To what extent should your country collaborate with major space powers—the established players in the West (US and Western Europe), Russia, Japan and China, and the emerging players like India, Brazil, South Korea, North Korea, and Iran?

Final questions

1. Please indicate if there are other topics and information that are relevant to this interview.
2. Are there important documents that you can share with me that can be of help to my work?

Many thanks for your time and contribution