NATIONAL DEFENCE UNIVERSITY – KENYA

LEVERAGING SPACE TECHNOLOGY FOR OPTIMISATION OF AGRICULTURAL DEVELOPMENT IN AFRICA: THE CASE OF NIGERIA (2015-2022)

Suleiman Abdullahi

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DECLARATION

I, Suleiman Abdullahi hereby declare that this research thesis is my original work and has not been presented for a degree in any other university.

Signed ..... Date 19/09/2024

Suleiman Abdullahi

ND.601/0086/2023

This research thesis has been submitted for examination with our approval as university supervisors.

Signed ..... Date 25/09/2024

Colonel (rtd) Dr Stephen Okumu Handa

National Defence University, Kenya

Signed ..... Date .....

Colonel (Dr) JJ Kiyimu

National Defence University, Kenya

DEDICATION

I dedicate this work to my father the late Husaini Abdullahi and my mother Hadiza Abdullahi, my wife Hindatu Dangaji, son Manaary Suleiman and daughter Hindatu Suleiman for their support through this rigorous journey.

May Allah bless them all. Amen.

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OPERATIONAL DEFINITION OF TERMS

Agricultural Risk Assessment: In this study agricultural risk assessment is view as a process of identifying, analyzing, and managing the potential risks involved in the agricultural sector to minimize their impact on food production and farm income.

Agricultural Sector: Agricultural sector in this study is refers as the segment of a country's economy that is involved in the production, processing, and distribution of agricultural products, including crops, livestock, forestry, and fishery.

Climate Change: In this study climate change is view as **a** long-term change in the Earth's climate, especially a change due to an increase in the average atmospheric temperature, affecting natural and human systems.

Crop Monitoring: Crop monitoring in the study is refer as the practice of using various techniques, including satellite imagery and ground-based sensors, to observe and manage crop growth and health throughout the growing season.

Crop Planning and Forecasting: In this study crop planning and forecasting is view as the process of predicting future crop yields and production levels based on historical data, current weather patterns, and other relevant factors to optimize agricultural output.

Economic Development: Economic development in the study is view as the process by which a nation improves the economic, political, and social well-being of its people, often characterized by industrialization, an increase in living standards, and an improvement in infrastructure.

Earth Observation: In this study earth observation is consider as the collection, analysis, and presentation of data about the Earth's physical, chemical, and biological systems via remote sensing technologies, including satellites.

Food Security: Food security in this study is view as the state in which all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

Forest Resources: In this study forest resources is consider as natural assets provided by forest ecosystems, including timber, non-timber products, biodiversity, and ecosystem services such as carbon sequestration and water regulation.

Geospatial: In this study geospatial is pertaining to data that is associated with a specific location on the Earth's surface, often used for mapping and analyzing features and events based on their geographical position.

National Development: National development in this study is view as a comprehensive effort to improve the economic, social, and cultural conditions of a nation, involving enhancements in infrastructure, education, health, and welfare.

Precision Agriculture: In this study precision agriculture is refer to an agricultural management concept using digital techniques, such as satellite imagery and GPS, to monitor and optimize agricultural practices and inputs, improving efficiency and reducing environmental impacts.

Precision Irrigation Scheduling: In this study precision irrigation scheduling is consider to be the application of water to crops at the right time and in the right amounts, using data-driven tools to maximize water use efficiency and minimize wastage.

Renewable Energy: Renewable energy in this study is view as energy from sources that are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat, often used in agricultural operations to reduce dependency on fossil fuels.

Satellite Imagery: In this study satellite imagery is view as the images of the Earth or other planets collected by imaging satellites, used for various applications including weather forecasting, agricultural monitoring, and mapping.

Soil Condition: Soil condition in this study is consider to be the state of soil health, including its structure, nutrient content, moisture levels, pH, and the presence of microorganisms, which affects its ability to support plant growth and agricultural productivity.

Sustainable Food Production: Sustainable food production in this research is view as the practice of growing food in ways that are environmentally, economically, and socially sustainable, ensuring that it can continue to meet the needs of the present without compromising the ability of future generations.

Targeted Fertilizer Application: In this research **targeted fertilizer application** is view as the precise application of fertilizers based on soil health and plant needs, utilizing technology to reduce waste and environmental impact while increasing crop yields.

Whole-of-Society Approach: Whole-of-society approach in this research is refers to a method of governance and policy-making that involves all segments of society, including government agencies, private sector, communities, and individuals, in addressing societal challenges and achieving national development goals.

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LIST OF ABBREVIATIONS AND ACRONYMS

AEB	-	Agencia Espacial Brasiliera
AFSA	-	African Space Agency
ASIP	-	Agro Space Integration Project
CNSA	-	China National Space Administration
EO	-	Earth observation
EOS	-	Earth Observation Satellites
ESA	-	European Space Agency
GM	-	Genetically Modified
KPI	-	Key Performance Indicator
MOU	-	Memorandum of Understanding
NASA	-	National Aeronautics and Space Agency
NASDRA	-	National Space Research and Development Agency
NIMASA	-	Maritime Administration and Safety Agency
NSP	-	Nigerian Space Programme
NSPP	-	Nigerian Space Policy Programme
NSTF	-	National Space Technology Fund
NAMS	-	.National Agricultural Monitoring System

PADP	-	Precision Agriculture Development Program
RECs	-	Regional Economic Communities
S-BAES	-	Satellite-Based Agricultural Extension Services
UAVs	-	Unmanned aerial vehicles
UK	-	United Kingdom
UN	-	United Nation
UNOOSA	-	United Nations Office for Outer Space Affairs
US	-	United States
USDA	-	The United States Department of Agriculture

ABSTRACT

The study was conducted on leveraging space technology for agricultural development in Africa: The case of Nigeria (2015-2022). The suitability of NASRDA and allied agencies' policies for leveraging space technology in agriculture is questionable. While these policies recognize the potential of space technology in enhancing agricultural productivity, they often lack specificity and fail to address the unique challenges of the Nigerian agricultural landscape. The institutional frameworks, though well-intentioned, are frequently hampered by bureaucratic inefficiencies and inadequate coordination among relevant agencies. This study addressed the set objectives of the suitability of NASRDA's and allied agencies' policies and institutional frameworks for leveraging space technology for agriculture development in Nigeria, the implementation of NASRDA's and allied agencies' policies and institutional frameworks for effective leveraging space technology for agriculture development in Nigeria and the challenges faced in adopting space technology for agricultural development in Nigeria. The study explores the Institutional Theory to analyze how Nigeria could effectively exploit space technology for agricultural development. The study as well used explanatory mixed methods to collect relevant data, data were gathered from both primary and secondary sources, the primary data were sourced from questionnaires and in-depth interviews, 384 questionnaires were distributed in which 380 questionnaires were retrieved, 380 questionnaires were valid and 4 questionnaires were not valid. In-depth interviews were conducted in the study area; 16 informants were interviewed to support the quantitative data. The secondary data were sourced from relevant existing literature on the topic under study such as textbooks, journals, magazines, seminars, newspapers, that were consulted. Data were analyzed using statistical tools such as tables and simple percentages as well as graph, chart and thematic format using discuss analysis for the qualitative data. The study findings showed that, aligning the National Space Research and Development Agency (NASRDA) policies with the overarching objectives for agricultural development in Nigeria is crucial for ensuring sustainable growth. To assess this alignment, there is the need to first conduct a comprehensive review of both NASRDA's policies and the national agricultural development goals. By comparing key elements such as technology integration, data utilization, and collaborative initiatives, with the aim to identify synergies that promote innovation and efficiency in the agricultural sector in Nigeria. The study recommended that the Centre for Satellite Technology Development should foster international collaborations for data sharing. Also, the Ministry of Science and Technology is recommended to subsidize satellite imagery services and training for small farmers. Finally, the Ministry of Agriculture and Food Security should encourage the adoption of precision agriculture techniques for data-driven decision-making and resource optimization.

CHAPTER ONE: INTRODUCTION

1.0 Overview

This chapter contextualizes the study by giving background information. Furthermore, it provides the statement of the problem, the objectives of the study, the research questions as well as the justification of the study. Finally, the significance of the study, assumptions as well as the scope and limitations of the study are articulated in the chapter.

1.1 Background to the Study

Agriculture is a vital sector in Nigeria, playing a major role in the country's GDP and supporting the livelihoods of millions. However, the sector grapples with various challenges, such as climate change, soil degradation, pests, and reliance on traditional farming methods. These issues are further exacerbated by rapid population growth, which intensifies the strain on food production systems. Nonetheless, Space technology serves as an innovative solution to bolster agricultural productivity and sustainability. It furnishes essential data applicable to precision farming, crop monitoring, and weather forecasting. As a real-time information provider, space technology aids in optimizing resource utilization, enhancing crop yields, and mitigating the impacts of environmental challenges. From 2015 to 2022, Nigeria made notable progress in incorporating space technology into agricultural development. Collaboration between government agencies and private sector players intensified, focusing on the integration of space-based tools into the agricultural sector. The Nigerian Space Research and Development Agency (NASRDA) was instrumental in driving these initiatives forward.

The exploration of space through the use of technology has revolutionized human life through the twentieth and twenty-first centuries. Globally, space technology has found numerous applications in a variety of fields. One such field is agriculture. Generally, states as well as non-state actors in the global north have pioneered and harnessed space-based technology (Johnson, 2019). Thus, multifaceted critical data obtained from space technology such as

satellite-based monitoring can be utilized to enhance agricultural development and address challenges (Nakelembe et al., 2020) such as climate change as well as food insecurity. Accordingly, soil conditions, crop health, weather patterns, fisheries and livestock can be systematically monitored while land productivity and aquatic conditions can be assessed. With this key information, governmental policymakers as well as a broad-range of stakeholders can make crucial decisions and optimally allocate resources towards agricultural development thereby improving food security. Bello-Odifin's (2011) alluded to the significance of space technology in enhancing the wellbeing of human through agricultural development.

There are a number of global frameworks that govern the sustainable use of space which by implication cover agricultural development. Relatedly, the United Nations Office for Outer Space Affairs (UNOOSA) assists countries to leverage the benefits of space exploration ranging from space law to space technology for sustainable development which includes agricultural development (UNOOSA,2022). The United Nations recently reiterated its transformative shift in attainment of its Sustainable Development Goals in its Space Technology for Agrifood Systems Transformation in July 2023 (United Nations Meetings Coverage and Press Release, 2023). The foregoing underscores the priority which the United Nations accords to space technology in agricultural development.

According to the United States National Space Policy, one of its priorities is the increase to the quality of life for all humanity. Thus, the Policy's Goal Number 7 recognizes the importance of space-based assets for agriculture and is supportive of the use of satellite data to enhance food security, resource management, and disaster response. The US Government Agency saddled with space technology, National Aeronautics and Space Agency (NASA), operates earth observation satellites which provide data to support agricultural monitoring, crop forecasting among others. The United States Department of Agriculture (USDA) and NASA have a partnership to further improve agriculture in the country (United States Department of

Agriculture, 2023). Furthermore, the United States Geological Survey uses satellite imagery and other services to support precision agriculture and land management practices (Sugarbaker & Carswell, Jnr 2016). As part of US space for food security, NASA provides funding support for a number of organisations such as the Harvest Consortium. The Harvest Consortium is a collaborative network comprising partners from both national and international domains. This consortium is dedicated to improving the utilisation of satellite data for making informed decisions in the field of agriculture. An integral aspect of Harvest's mission is the smooth transition of research outcomes into practical operational applications (Harvest 2023).

The NASA Food Security Programme, in conjunction with Harvest, undertakes several vital functions (Harvest 2023). This includes the promotion and the integration of satellite and airborne remote sensing data into Earth systems models and various tools aimed at addressing global food security issues. Also, the programme investigates research requirements, the origins of uncertainties, and the technological obstacles that impede the practical use of Earth observations in decision-making processes. Additionally, the programme collaborates with NASA's Earth Science Technology Office to advance cutting-edge technology, which benefits both public and private organisations working to tackle global food security challenges (Harvest 2023). Furthermore, it actively engages with ongoing and forthcoming NASA missions, ensuring that the realm of food security science and its applications are seamlessly integrated into new satellite missions (Harvest 2023). The programme also represents NASA in government-led initiatives, thereby aiding interagency programmes in harnessing NASA's resources to address various challenges. In spite of Harvest Consortium’s extensive work, its list of international support indicates that the Consortium’s assistance to Nigeria is marginal.

Similarly, the United Kingdom Space Agency is the government agency charged with coordinating the country’s space activities and is key in the development and implementation of related policies. As with the US, the United Kingdom (UK) monitors soil health, promotes

precision agriculture and shares data with key stakeholders. Importantly, the UK supports space startups that offer innovative solutions (House of Commons Science and Technology Committee).

As part of its policy, the UK actively supports developing nations in harnessing space technology to bolster food security. This support extends to a range of applications within five critical domains: agriculture, climate change and the environment, disaster resilience, forestry, and urban and transport (Forest 2022). In agriculture, satellite applications play a pivotal role in ensuring stable incomes for farmers through cost-effective mechanisms like rural payments and insurance products. Moreover, these technologies facilitate proactive food security measures and disaster preparedness by providing early warning information and risk assessment (Forest 2022). Furthermore, the UK supplies updated maps of natural resources through Earth observation (EO), aiding in sustainable resource management. Satellite data is invaluable in addressing climate change and environmental concerns. It offers comprehensive insights into climate conditions and the environment, enabling the optimisation of renewable energy production. Moreover, it underpins predictive models for assessing climate change risks, informing strategies for adaptation and mitigation (Forest 2022).

The utilization of satellite data significantly enhances disaster resilience. By offering crucial information related to disaster preparedness, resilience, and response, it contributes to higher survival and recovery rates for both populations and economies in developing countries when confronted with calamities (Forest 2022). Satellite imagery proves indispensable in terms of forestry. It allows for precise, cost-effective surveillance and monitoring of forestry resources at regular intervals. This capability is particularly critical for swiftly detecting changes in land coverage, including illegal logging and the outbreak of pests and diseases (Forest 2022). Importantly, it achieves this at a lower cost than alternative methods of data collection. Another area of support is the use of satellite technologies for addressing the challenges posed by rapid

urbanization (Forest 2022). With Earth observation (EO) capabilities, the UK aids in land use and change detection. Furthermore, traffic data becomes a vital tool in identifying activity hotspots. In addition, location data supports the development of universal geographic reference systems, providing valuable insights for informed urban planning and property database updates (Forest 2022). Thus, these satellite technologies offer multifaceted support to developing countries in their pursuit of food security and sustainable development across various domains. The UK's commitment to utilising space technology in these five key areas plays a crucial role in advancing global food security initiatives and related endeavours. Although the UK and Nigeria signed a Memorandum of Understanding (MOU) in 2014 on exploitation of space technology the progress made in this regard and the extent of coverage of the MOU remains unclear (UK High Commission Press Release, 2014).

Many developing countries leverage space technology to enhance agricultural development. For instance, Brazil's space agency, Agencia Espacial Brasiliera (AEB), uses space technology for deforestation monitoring, precision agriculture and crop health monitoring among other applications. Brazil's Space Act which is implemented through the National Space Programme has assisted the country to transform itself from being a food importer to one of the largest exporters of agricultural products globally. Importantly, the Agencia Espacial Brasiliera collaborates with a host of organizations around the world including the China National Space Administration (CNSA), the National Aeronautics and Space Administration (NASA) in the United States, and the European Space Agency (ESA). Although Brazil does not collaborate with Nigeria on space technology for agriculture, both countries stand to gain in terms of a space technology education training under the auspices of Limitless Space Institute. In Africa, the South African National Space Agency's (SANSA) satellites provide capabilities for crop yield prediction and monitoring of crop health (*The South African National Space Agency Has Developed a System to Monitor Crops |AUDA-NEPAD*, n.d). Similarly, Egypt uses space

technology to monitor the Nile Delta which is critical to efficient water resource management (Samra & Ali, 2021). Also, the country uses space technology for monitoring climate change patterns (Cengiz, 2023). These countries have robust space technologies that are tailored towards optimizing agricultural development. Furthermore, the mentioned African countries' endeavours are in line with the African Union in its African Space Policy which recognizes the significant benefits of space technology for leapfrogging agricultural development on the continent in its Vision 2063.

The African Outer Space Programme, a focal point of the African Union's Agenda 2063, is dedicated to regional integration and socio-economic development. To ensure the successful implementation of the African Union's space programme, collaboration between Nigeria and South Africa is paramount, given their prominent positions in the region in terms of economy, science, and space capabilities. This cooperation encompasses four key thematic areas: earth observation, satellite communication, navigation and positioning, and space science and astronomy. Earth observation, a fundamental area of collaboration, involves capturing and utilizing images of the Earth's surface for analysis, interpretation, and decision-making. Nigeria, equipped with a fleet of Earth Observation satellites, can provide valuable data to South Africa, particularly due to its geographical proximity to the Antarctic. This collaboration allows for the reciprocal exchange of expertise, enhancing the capabilities of both nations.

Both Nigeria and South Africa are signatories to the African Resource Management Constellation, an initiative involving satellite contributions from various countries. Although these satellites have surpassed their expected lifespans, cooperative efforts between Nigeria and South Africa could potentially reinvigorate this initiative. Establishing a functional data access and sharing agreement is essential to unlock mutual benefits. In the realm of satellite communication, an area predominantly served by foreign companies in both nations, cooperation offers significant potential. Nigeria's acquisition of the Nigcomsat-1R

communication satellite aimed at reducing communication costs and expanding rural connectivity. South Africa's plans for its communication satellite have encountered funding delays. Granting Nigcomsat Limited operational licensing in South Africa could reduce communication expenses and bolster connectivity. Navigation and positioning play a crucial role in various applications, such as precision agriculture and surveying. Despite the efforts of China and the European Union to promote their navigation satellite systems in Africa, interoperability and compatibility challenges persist. Nigeria and South Africa, as leaders in space capabilities on the continent, can spearhead the harmonization of satellite services, enhancing navigation reliability and fostering cooperation. Space science and astronomy constitute another promising area for collaboration. South Africa's substantial investments in astronomical facilities present an opportunity for Nigeria to benefit. The use of remotely operated optical telescopes allows astronomers in Nigeria to access South Africa's advanced infrastructure, contributing to the study of space weather and atmospheric research, which has implications for power supply and satellite navigation.

This collaboration can be facilitated by establishing a Nigeria-South Africa Space forum will serve as a platform for professionals to interact and exchange insights. This forum can also advise governments on policy matters related to outer space. Strengthening the cooperative agreement between Nigeria's National Space Research and Development Agency and the South African National Space Agency is vital. Appointing space experts as science attachés in their respective embassies will expedite exchanges and offer necessary support to visiting professionals. Furthermore, developing a comprehensive strategy for space knowledge and workforce development is imperative. This encompasses reviewing school curricula and enhancing training programs in institutions dedicated to space education. These recommendations hold the potential to foster substantial cooperation between Nigeria and South Africa in the field of space technology, leading to mutual benefits and contributing to

the broader African space programme. These are policy issues that both countries could adopt to advance exploitation of space technology for agricultural development in Africa.

In his research, Hammed concentrated on the advantages of space technology within the African context. He highlighted Africa's comparative lag in the field of space technology, which has contributed to a generally lower level of economic development across the continent. Furthermore, he underscored the potential for economic growth through the integration of sectors such as agriculture and communication into space technology initiatives. Additionally, Hammed (2020) conducted an examination of the existing space infrastructure in countries such as Algeria, Nigeria, South Africa, and Tunisia. One of his key findings pointed to the necessity of institution of appropriate institutional frameworks and policies for public-private partnerships for optimal optimisation of space technology for economic growth.

Nigeria is amongst the few African countries that have pursued space technology for agricultural development. The country has exploited space technology since the establishment of the National Space Research and Development Agency (NASDRA) in 1999 (Way,2020). Furthermore, in 2003, Nigeria launched the NigeriaSat-1 being the first of its satellites. Since the pioneer launch, Nigeria has launched a total of six satellites, with three still operational to day (Collins, 2022). The Nigerian government has given renewed vigor to space technology in the last 25 years. In spite of these efforts, country has not optimally attained its goals in exploiting space for various purposes including Agriculture. Nigeria’s National Space Policy indicates in its Vision covers a wide spectrum with the intent to indigenously develop, design and build appropriate hardware and software in space technology towards the socio-economic development and improvement of the well-being of Nigerians. Furthermore, the Mission Statement indicates that the country seeks to develop and manage its agricultural and forest resources through establishment of database for project planning, crop performance assessment, yield production for sustainable food production thereby assuring food security

(National Space Policy, 2015). Specifically, Chapter Two of the policy document states agriculture as one of the short-term and long-term objectives of its application of space technology.

Bello-Odofin (2011) in his study highlights several significant challenges facing space technology and its potential contribution to economic and general development in Nigeria. These challenges encompass the absence of private sector investment, which hampers the commercialization of space technology and efficient service delivery. Another issue is the lack of skilled manpower, impeding the effective implementation of the National Space Programme and capacity building efforts. Inadequate space technology infrastructure, including workshops and ground support facilities, undermines the optimization of space technology applications. Weak research and development capabilities limit Nigeria's ability to become a producer rather than a consumer of space-related products, hindering foreign income generation and job creation. Lastly, the absence of a National Space Technology Fund (NSTF) forces NASRDA to rely heavily on insufficient budgetary allocations, resulting in delays and challenges in advancing space technology for economic development. Overall, these challenges collectively impact Nigeria's ability to harness the full potential of space technology.

1.2 Statement of the Problem

Nigeria's agricultural sector stands to benefit greatly from the application of space technology, yet several challenges hinder the effective leveraging of these advanced tools. The NASRDA and allied agencies have established policies and institutional frameworks aimed at harnessing space technology for agricultural development. However, the suitability and implementation of these frameworks face significant obstacles. The suitability of NASRDA and allied agencies' policies for leveraging space technology in agriculture is questionable. While these policies recognize the potential of space technology in enhancing agricultural productivity, they often lack specificity and fail to address the unique challenges of the Nigerian agricultural landscape.

The institutional frameworks, though well-intentioned, are frequently hampered by bureaucratic inefficiencies and inadequate coordination among relevant agencies.

Implementation of these policies and frameworks has been inconsistent at best NASRDA and allied agencies struggle with limited funding, which restricts their ability to acquire and maintain cutting-edge space technologies. The shortage of skilled personnel capable of operating and interpreting data from these technologies further impedes progress. As well, there is a disconnect between policy formulation and on-the-ground implementation, with many initiatives failing to reach the farmers who stand to benefit most from these advancements

The challenges in adopting space technology for agricultural development in Nigeria are multifaceted. First, there is a significant knowledge gap among farmers and agricultural extension workers regarding the benefits and applications of space technology in agriculture. This lack of awareness leads to resistance in adopting new methods and technologies. Second, the high initial cost of implementing space technology solutions poses a significant barrier, especially for small-scale farmers who form the backbone of Nigeria's agricultural sector. Infrastructure deficiencies, particularly in rural areas, hinder the effective deployment of space technology. Unreliable power supply and poor internet connectivity make it difficult to utilize satellite imagery and other space-based data in real-time decision-making for agriculture. Furthermore, the absence of a robust data management system impedes the efficient collection, analysis, and dissemination of space-derived agricultural information. Despite the potential of space technology to revolutionize agriculture in Nigeria, its adoption have been limited. This study examine the barriers and opportunities from 2015 to 2022, aiming to identify effective strategies to leverage space technology for agricultural development, enhancing productivity, and ensuring food security in Nigeria.

1.3 Objectives of the Study

The study's general objective is to explore the extent to which space technology has been leveraged in Nigeria's agricultural sector from 2015 to 2022, examining both the achievements and the challenges encountered.

1.3.1 To evaluate the effectiveness of NASRDA's policies and institutional frameworks, as well as those of allied agencies', in leveraging space technology for optimal agriculture development in Nigeria.

1.3.2 To evaluate the effectiveness of NASRDA's policies and institutional frameworks, as well as those of allied agencies, in leveraging space technology for optimal agriculture development in Nigeria.

1.3.3 To identify and analyze the key challenges encountered in adopting space technology for optimal agricultural development in Nigeria.

1.4 Research Questions

This study is underpinned by the following research questions:

1.4.1 What is the suitability of NASRDA's and allied agencies' policies and institutional frameworks for leveraging space technology for agriculture development in Nigeria?

1.4.2 What is the level of implementation of NASRDA's and allied agencies' policies and institutional frameworks for effective leveraging space technology for agriculture development in Nigeria?

1.4.3 What are the challenges faced in leveraging space technology for agriculture development in Nigeria?

1.5 Justification of the Study

This sub-section of the research provides the rationale behind the research. The harnessing of space technology for human benefit is pivotal in a world where it is becoming most crucial to employ optimal ways to improve human wellbeing. Agriculture is important for the sustainment of life, thus underscoring its development especially in the face of climate change and dwindling resources. Thus, this study brings to the fore the essentiality of utilization of space technology for agricultural development in Nigeria which is crucial for a multiplicity of stakeholders.

1.5.1 Academic Justification

The study contributes to discourse of policy formulation, implementation and evaluation. It provides insights into the realm of harnessing national and global resources for the attainment of national security in the twenty first century. The study intends to contribute to the existing body of knowledge which the academia could use as a reference point to drive policy change.

1.5.2 Policy Justification

Developing countries are generally grappling with the challenge of efficient utilization of resources in the face of competing demands. Accordingly, optimal utilization of resources is key. This study aimed to provide insights into the current policies and institutional frameworks in place for exploitation of space technology for agricultural development, analyze their suitability and the implementation of the policies. The study is intended to provide inputs for the revision of Nigeria's Space Policy which is due for review in 2025.

1.6 Significance of the Study

The main beneficiary of this study is the Federal Government of Nigeria. The findings of the study will provide the Nigerian government the impetus to pursue a policy change which be most appropriate for the country in this regard. Also, key stakeholders will be better placed to contribute their quota towards the attainment of agricultural development through the

exploitation of space technology. The findings of the study will be beneficial towards the attainment of large-scale mechanized farming in Nigeria for food security. Equally, the outcome of the study will have an impact on crop farming, livestock, fisheries, forestry, aquaculture stakeholders across the food production and supply chain. NASRDA and, Federal Ministry of Agriculture, Federal Ministry of environment among others, will benefit from this study. Additionally, Nigeria's agroeconomic planners and administrators benefit will from the work. Furthermore, the study will add to the existing body of knowledge and elicit further research in the use of space technology for agricultural development. Overall, the research is geared towards bringing about policy and performance improvement.

1.7 Assumptions

The study assumes that the policies and institutional frameworks for will subsist until a review is instituted in 2025. It is further assumed that the implementation of the NASDRA's and other allied agencies polices and institutional frameworks for exploiting space technology will be implemented at their current pace and manner. Additionally, it is assumed that the challenges faced in adopting space technology for agricultural development in Nigeria will remain the same. Finally, it is assumed the current Federal Government of Nigeria's policy direction will remain unchanged thus the research findings will still hold validity on completion.

1.8 Scope and Limitations of the Study

In terms of scope, the study was confined to the areas where the NASDRA and allied agencies are domiciled in Nigeria. Furthermore, only governmental efforts in the area of study were covered in terms of remote sensing and earth observation being the most relevant to agriculture. The period covered is from 2015 to 2022. The period 2015 is chosen as this period was marked with re-invigorated governmental attention to space technology for agricultural development. The period 2022 is chosen because it gives the researcher ample opportunity to collect adequate data for the study and to present an account of more recent findings on the subject matter. The

findings from the qualitative and quantitative analyses are integrated and interpreted together, providing a comprehensive understanding of the research problem. Based on the integrated findings, researchers draw conclusions, develop theories, or make recommendations. There are several common mixed method research designs like convergent parallel design, however this study will use explanatory sequential design where quantitative data is collected and analyzed first, followed by qualitative data collection and analysis to further explain or elaborate on the quantitative findings. The rationale behind adopting this research methodology is for the study to have the ability to address complex research questions, triangulation of findings, and the potential for complementary strengths and non-overlapping weaknesses of qualitative and quantitative methods. Overall, mixed method research methodology is a powerful approach that allows researchers to gain a comprehensive understanding of complex phenomena by combining the strengths of both qualitative and quantitative methods. Theoretically, this study addressed the set objectives of the suitability of NASRDA's and allied agencies' policies and institutional frameworks for leveraging space technology for agriculture development in Nigeria, the implementation of NASRDA's and allied agencies' policies and institutional frameworks for effective leveraging space technology for agriculture development in Nigeria and the challenges faced in adopting space technology for agricultural development in Nigeria.

1.8.2. Limitation. The study was limited by time constraints potentially impacting the depth of data collection and analysis. Previous literature on the research area is broad-ranging covering both space and agriculture in general without targeted focus on policy and institutional frameworks. Thus, the quality and quantity of secondary data was marginally constrained. Nevertheless, accessible data was assessed thematically in line with the objectives. The measurement tools employed were interviews and questionnaires. Focus groups which would have otherwise enriched the research was not used owing to the impracticality of mustering key stakeholders. This marginally limited the findings of the research. Sample sub-groups with appropriate characteristics were selected from the target population with a focus on the main

stakeholders in the space and agriculture sectors. As envisaged, it did not significantly impact the research. Given that the policies to be examined are country-specific, the findings might not be fully generalizable in other countries.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter covers both the theoretical and empirical literature review. The literature is reviewed thematically based on the objectives. However, the review does not make demarcations between the various studies as issues within the literature are cross-cutting. The literature review seeks to identify the gaps to be filled by the research. Furthermore, the chapter presents a theoretical framework for the analysis of the study.

2.1 Review of the Literature

Over the years, number of studies have been undertaken on issues of space technology and agricultural development. At the global level the UN (United Nation) recognizes the transformative potential of space technology within the realms of agriculture. The UN appreciates the growing accessibility and utilization of low-earth orbit and outer space technologies, emphasizing their substantial impact on the realization of the 2030 Agenda *(UN Food Systems Summit+2 Stocktaking Moment)*. Thus, the effective harnessing of space technology's potential stands to foster the development of more sustainable, resilient, and efficient agricultural and agri-food systems. The practical merits of space technologies have already been witnessed through their ability to augment agricultural productivity and efficiency. Data indicate that comprehensive utilization, these technologies could result in yield improvements of over 10 percent while concurrently effecting cost reductions of up to 20 percent *(UN Food Systems Summit+2 Stocktaking Moment)*. Furthermore, the deployment of space-based solutions serves as a linchpin in safeguarding arable land against degradation, enhancing soil quality, and contributing to climate action by means of sustainable resource management. The UN recognized the centrality of embedding food systems strategies within the framework of national policies for sustainable development. Additionally, it called for establishing food systems governance under a comprehensive whole-of-society approach,

thereby fostering the active engagement of all stakeholders *(UN Food Systems Summit+2 Stocktaking Moment)*. It underscores the need for strategic investments in research, data, innovation, and technology capacities to fortify the foundations of agricultural development. The UN thus places a premium on the use of space technology for agricultural development. Principally, it emphasizes the role of national policy in underpinning the transformation.

At the continental level, it is important to review the regulatory framework before taking a look at other body of literature that illuminate the subject matter. Feleti (2021) discussed the African Space Agency (AfSA) Act. The AfSA ratified in 2017 and effective January 2018, assumes a pivotal role as the inaugural and exclusive legal framework regulating space activities across Africa. Instituted by the African Union, the legislation primarily establishes the African Space Agency, charged with the mission of advancing the African space policy and strategy, leveraging space technologies for sustainable development, and enhancing the well-being of African citizens. Addressing recognized gaps in Africa's space initiatives, notably the absence of a coordinated governance structure for continent-wide space endeavours, the Act is designed to rectify these issues by creating the African Space Agency (Feleti 2021).

Concerning the degree to which the AfSA Act aligns with the African Space Strategy, it is imperative to recognize that this legislation essentially serves as a foundational framework. It gave birth to the African Space Agency, delineating its functions and objectives, thus positioning the Agency to serve as a continental overseer, fostering an enabling environment for the advancement of Africa's space sector, both on a national and continental scale, in line with the African Space Strategy. To address the absence of a governance structure for continent-wide space activities, the Strategy emphasizes the establishment of a continental space programme that encourages intra-African partnerships and strengthens the capabilities of member states engaged in national space programme (Feleti 2021). In this context, the AfSA Act mandates the Agency to promote intra-continental partnerships, stimulate regional

coordination and collaboration, and involve member states in space-related activities and research to promote cooperation and prevent duplications. Additionally, the Act creates a framework, encompassing the Agency, national, and international institutions, to orchestrate a continent-wide regulatory framework for space activities. It also entrusts the Agency with the task of coordinating the development of a critical mass of African expertise in space science, technology, and innovation through educational and training programs. This aligns with the Strategy's objective of establishing human capacity development programs that cater to indigenous space sectors and fulfill broader high-end skill requirements in a changing socio-economic landscape (Feleti 2021).Acknowledging economic disparities among African nations, the Act assigns the Agency the responsibility of supporting member states and Regional Economic Communities (RECs) in constructing space programmes, essential infrastructure, and facilitating access to space resources and services. Furthermore, the AFSA Act underscores the pivotal role of the Agency's initiatives in enhancing Africa's economy and the quality of life for its citizens (Feleti 2021). Nevertheless, certain limitations are discernible in the legislation. While it accentuates Africa-centric development, it should also explore opportunities for global collaboration in space science and technology. Moreover, the Act could incorporate provisions for private sector participation, which is crucial for the growth of the African space sector. Additionally, it should address variations in enthusiasm for space activities among African nations to ensure equitable development. Nevertheless, the AfSA Act signifies a substantial step forward in advancing Africa's space programme, particularly in the realm of agricultural development, marking Africa's inaugural practical stride towards space exploration and development (Feleti 2021).

Akinyede et al researched on how sustainable development could be attained through national development. In their study titled ‘‘Nigeria Satellite Technology and its Role in Sustainable Development’’, the used of geospatial information obtained from satellite was considered as a

means of attaining sustainable development. The authors posited that over 80 per cent of socio-economic and environmental management policies are anchored on reliable information on natural resources. They submitted that poor data collection is directly linked to underdevelopment of third world countries which a resultant negative effect on food security environmental degradation among others. In order to address this challenge, the proposed the establishment National Geospatial Data Infrastructure. In this view, this establishment would be the linchpin in the drive towards attainment of sustainable national development. The authors focused on the acquisition of geospatial data through satellite technology without examining the suitability of the existing policies which underpin satellite technology. Moreover, their work was broad without specifically considering data for agricultural development.

Adokwu, in his work, "Nigeria Space Programme and National Development: An Evaluation" analysed the significance of Nigeriasat-1 and NigComSat-1 to national development. The study established that Nigeriasat-1 had only marginal impact in agriculture, among others sectors. The study further linked the inability to fully exploit space resources for national development to funding challenges and inappropriate institutional frameworks. However, a noticeable gap in the study was the inability of the work to establish a nexus between satellite technology and national development. The issue of implementation of frameworks thus not was not adequately covered which would have underpinned their suitability for national development. This would shed light on the challenges of tailoring space technology institutional frameworks in Nigeria to agricultural development among other aspects.

Boroffice's research centred on "Space Technology and Development in Africa and the Nigerian Experience." He delved into the potential of a carefully planned space programme in assisting in the attainment on general development in Africa and highlighted the National Space Programme as a veritable model for achieving this goal. His research primarily concentrated

on the nexus between space programmes and development without specifically centring on agricultural development in Nigeria and policy frameworks.

A study conducted by Chizea (2012) centred on evaluating the impact of Nigeria's space programme on environmental security, in alignment with the programmes's goal stated in the National Space Policy and Programme. Thus, he focused on governmental policies. The research employed a descriptive methodology, incorporating surveys, unstructured interviews, and document analysis. The findings suggested that in spite of substantial government investment in the space programme, its potential to address environmental security issues has not been fully realized due to various challenges, including limited autonomy of the NASRDA, poor inter-agency collaboration, inadequate skilled manpower, power supply issues, orbital misalignment, and insufficient private sector involvement. The study proposed strategies to mitigate these challenges, such as placing NASRDA under the Presidency, improving inter-agency collaboration, enhancing power supply, and launching equatorial orbiting synthetic aperture radar satellites. Ultimately, the study concluded that Nigeria's Space Programme has not achieved the expected impact on environmental security and offers recommendations, including revising the NASRDA Act, establishing Institutes of Space Technology in federal universities, and promoting the manufacturing of space components through small to medium-sized companies. Currently, NASRDA’s Act has not been reviewed and the proposed have not been established.

Uwakara's (2020) study assessed the utilization of satellite technology by the Nigerian Satellite Programme to enhance national development. The research, which employed a descriptive approach combining qualitative and quantitative data, highlighted the nation's untapped potential for growth despite its lagging Human Development Index due to technological shortcomings. At the time of his study, Nigeria possessed two Earth Observation Satellites (EOS) and a communication satellite in orbit. However, the National Space Programme had

yet to effectively harness satellite for the benefit of its citizens. The study identified challenges such as the absence of a policy coordinating body, inter-agency rivalry, satellite backups and ground facility deficiencies, a weak industrial base, and inadequate capital allocation. However, it also noted opportunities such as national satellite platforms, the establishment of a Digital Satellite Assembly, and international satellite technology cooperation. Proposed strategies included activating a national space council, centralized control, launching backup satellites, establishing ground stations, fostering space technology transfer collaboration, and creating a satellite trust fund. The study concluded that effectively utilizing ST could significantly enhance national development and recommended reconstituting the National Space Council, transferring NASRDA and NigComSat Ltd to the Office of the National Security Adviser, and providing extra-budgetary funding for the National Space Programme. The challenges highlighted subsist while most of recommendations have not been implemented. In spite of the fact that the research centred on national development generally, it mirrors the issues and challenges associated with exploiting space technology for agricultural development in Nigeria. A noticeable gap in his work was the erroneous assertion that space programme had not benefitted Nigerian citizens.

Akubue (2020) conducted a study titled "Space Technology and National Security: An Appraisal of the Nigerian Space Programme," which aimed to assess the factors hindering the effective utilization of space technology within the Nigerian Space Programme (NSP) to enhance national security. The research employed a descriptive methodology, integrating both qualitative and quantitative data collected from various governmental entities related to space technology and national security. The study found a direct link between space technology and national security and identified challenges such as the need for improvements in the Nigerian Space Policy Programme (NSPP) 2001, a low technological base for space technology applications, insufficient human capacity, inadequate space technology infrastructure, and

inter-agency collaboration issues within the National Space Programme. It also recognized the contributions of space technology in enhancing food security among other aspects of national security. Recommendations included reviewing the NSPP 2001, increasing research and development investment by relevant agencies, creating a National Space Programme Development Fund, and centralizing control of the National Space Programme to improve its contribution to national security. Overall, the study underscored the potential of space technology in bolstering national security in Nigeria while highlighting the need for strategic improvements.

Undoubtedly, the body of literature reviewed substantially contributed to discourse of the subject matter. The reviewed literature indicates that the approaches employed by the researchers were either broad-based or too narrow to effectively cover space technology and agricultural development polices. While Nigeria has modified, adopted and implemented some of the recommendations proffered, the challenges which this study seeks to address persist. This explains the rationale for the conduct of this literature review.

2.2. Theoretical Framework

This study explores the Institutional Theory to analyze how Nigeria could effectively exploit space technology for agricultural development. Institutional Theory is a prominent and influential perspective within contemporary organizational research. It represents a diverse and expansive body of theoretical and empirical work unified by its central focus on cultural understandings and shared expectations. This Theory is often employed to elucidate the processes of adopting and disseminating formal organizational structures, including written policies, standard practices, and novel organizational forms. The theory rooted in the foundational ideas of Max Weber regarding legitimacy and authority (Lepsius, 2016). However, it truly began to take shape in the 1950s and 1960s through the contributions of

scholars like Talcott Parsons, Philip Selznick, and Alvin Gouldner, particularly in the context of organization-environment relations (David et al., 2019)

Over time, Institutional Theory underwent a pivotal transformation in the 1970s, marked by what is often referred to as a "cognitive turn". This shift brought about a renewed emphasis on the often-unquestioned habits and assumptions that underlie institutional structures. Consequently, this era is recognized as the advent of "neo-institutionalism" within organizational studies. In recent years, scholars working within this theoretical framework have transitioned from primarily studying processes that result in isomorphism (similarity) among organizations to a more pronounced focus on institutional change. This evolution is exemplified by investigations into the emergence of new laws and regulations, innovative products and services, and evolving occupational roles within society (David et al., 2019).

The enduring vitality of Institutional Theory is attributable to its capacity for expansion and adaptation. It has continued to evolve and respond to emerging research questions and trends. Nevertheless, several challenges persist in advancing this theory further. Among these challenges are the need to reconcile inconsistencies within various models of decision-making and action that underlie institutional analysis. Additionally, scholars are actively exploring the complex interplay between socio-cultural forces and entrepreneurial agency, seeking a more nuanced understanding of how institutions both shape and are shaped by human agency (David et al., 2019).

Institutional Theory remains a central and enduring perspective in organizational research, offering valuable insights into how institutions, norms, and cultural expectations influence the behaviour of organizations and individuals. Its evolution from examining isomorphism to institutional change reflects its adaptability and relevance in understanding the dynamics of modern organizations and society.

The Institutional Theory provides a valuable lens through which to analyze the interplay between exploiting space technology and agricultural development in Nigeria. The theory's central focus on cultural understandings, shared expectations, and formal organizational structures is highly relevant to the research objectives.

Institutional Theory can be applied to assess the suitability of NASRDA's and allied agencies' policies and institutional frameworks for the exploitation of space technology for agricultural development. It helps in understanding how these organizations' policies and practices are influenced by broader cultural and institutional norms, and whether they align with the cultural expectations and needs of the agricultural sector. Additionally, the theory can also be used to evaluate the implementation of these policies and frameworks. It allows for an examination of whether the adoption and dissemination of space technology within the agricultural sector align with institutionalized practices and expectations. This evaluation can reveal whether there are any discrepancies between policy intentions and on-the-ground implementation. Furthermore, when assessing the challenges faced in adopting space technology for agricultural development, Institutional Theory offers insights into the role of institutional forces in shaping these challenges. For instance, it can help identify whether resistance to change within agricultural institutions is influenced by deeply ingrained cultural norms and expectations. Moreover, Institutional Theory's evolution towards studying institutional change is particularly relevant. It can shed light on how the introduction of space technology disrupts existing institutional arrangements within the agricultural sector and how these institutions adapt or resist such changes.

The institutional theory’s emphasis on socio-cultural forces and their interplay with agency is crucial for understanding how the agricultural sector perceives and responds to space technology initiatives. It can uncover how cultural expectations and norms influence decision-making and actions within both NASRDA and the agricultural sector. Finally, using

Institutional Theory, the study can offer policy recommendations that take into account the cultural and institutional context of Nigeria. These recommendations can be designed to align policies and practices more effectively with the cultural expectations and institutional realities of the agricultural sector. The Institutional Theory provides a robust framework for examining how the exploitation of space technology for agricultural development in Nigeria is influenced by cultural norms, institutional structures, and shared expectations. It can assist to uncover the complexities of these interactions, offering valuable insights for policy formulation and implementation.

CHAPTER THREE: METHODOLOGY

3.0 Introduction

This chapter covers the methodology that will be used in the study. Thus, it encompasses the research design, area of study, target population and sampling techniques. Furthermore, the chapter expiates on the sample size determination, sample frame and instruments and tools. Additionally, it covers validity and reliability, data collection procedures, as well as data processing and analytics. Finally, the ethical considerations of the research are discussed.

3.1 Research Design

The research employed the descriptive and exploratory research design. This facilitated a detailed explanation of the research topic in order to meet the objective and answer the research questions. The study design covered approaches which used by the researcher to gather and analyze data. This design covered the issues involved in the leveraging of space technology for agricultural development in Nigeria from 2015 to 2022.

3.2 Area of Study

The area of study was Abuja, Nigeria. For respondents in other parts of Nigeria, the researcher corresponded with them virtually via the internet as well as through telephone calls and emails.

3.3 Target Population

The target population in this study comprised key respondents from ministries, departments and agencies. This covered policymaker-level individuals in Ministry of Science and Technology, Ministry of Agriculture & Food Security, NASDRA and Centre for Satellite Technology Development. The chosen target population was considered to have a wealth of expertise and experience in the specific on the research topic. Furthermore, target population is actively involved in or has influence over policy decisions related to the research topic. This ensured that the findings of the thesis have the potential to contribute directly to policy development or modification. Additionally, engaging with stakeholders who have a vested

interest in the study increased the likelihood of the research making a meaningful contribution to the field. Moreover, the target population was considered fairly accessible, hence, it facilitated the smooth execution of the research, allowing for interviews, surveys, and other forms of data collection. Finally, by focusing on this population with unique insights or perspectives, the thesis contributed to filling a void in current knowledge.

3.4 Sampling Techniques

Sampling is a technique of selecting respondents from a study population for the purposes of making statistical inferences and estimating characteristics of the whole population. This study employed the probability sampling design. Particularly, the simple stratified technique was utilized. In this technique, each member of the accessible population stood a chance of selection of the sample. The simple stratified probability technique was chosen because the population that was studied exhibited significant heterogeneity. Stratified sampling allows for the division of the population into distinct strata based on relevant characteristics. This ensured that each stratum was adequately represented in the sample, providing a more accurate reflection of the overall population. Furthermore, simple stratified sampling increased the precision and accuracy of the estimates by accounting for variability within different subgroups of the population. By ensuring representation from each stratum, the findings were more likely to be generalizable to the entire population.

The chosen technique was deemed to lead to more efficient resource utilization. In terms of resource utilization, the researcher's efforts were focused on specific strata, thus leading to effective allocation and obtaining of a representative sample without the need to study the entire population exhaustively. Additionally, this technique facilitated comparative analysis between strata, enabling the researcher to identify patterns, trends, or differences that may exist across different segments of the population. This led to a richer and more nuanced understanding of the research phenomenon. Finally, the technique increased external validity

of the research. The simple stratified sampling enhanced the external validity of the research by promoting a more balanced representation of diverse characteristics within the population. This increased the likelihood that the findings can be generalized to a broader context.

3.5 Sample Size Determination

Sample size is any subset of sampling units from a population. A subset is any combination of **s**ampling units that does not includes the entire set of sampling units that has been defined as population (Nachamias and Nachamias, 2012). Thus,Krejcie and Morgan (1970) model for determining sample size was used in determining the sample size of the study which is 384 (for the quantitative part). While for the qualitative part, sixteen participants were interviewed as captured in the table below.

A sample sub-group with appropriate suitable characteristics was chosen from the target population. Since the policy-level samples are few, the study aimed to cover 16 key individuals from Ministry of Science and Technology, Ministry of Agriculture & Food Security, NASDRA and Centre for Satellite Technology Development.

Table 1.1: Sample Frame

Target Population	**Frequency**
Ministry of Science and Technology	4
Ministry of Agriculture & Food Security	4
NASDRA	4
Centre for Satellite Technology Development	4
Total	**16**

3.6 Instruments and Tools

Data was collected using a variety of tools. These included primary and secondary data. Interviews and questionnaires were utilized. Both structured and semi-structured interviews were conducted in-person and some questionnaires were also served via Google Forms. The use of a variety of data collection tools, including both primary and secondary sources, reflects a comprehensive and multi-faceted approach to gathering information for the research study. The combination of interviews and questionnaires, encompassing both structured and semi-structured formats, served to enhance the richness and depth of the collected data. The decision to conduct in-person interviews and utilize Google Forms for questionnaires was driven by several justifications. Structured interviews provide a systematic and standardized approach to gathering quantitative data. They ensure consistency in responses and facilitate statistical analysis. The semi-structured interviews allow for flexibility and depth in exploring responses. They were be particularly useful when seeking nuanced insights and capturing the contextual richness of the data. On the other hand, in-person interviews foster a personal connection between the researcher and participants. This enhanced trust, encourage open communication, and allowed for the observation of non-verbal cues, contributing to a more holistic understanding of the data.

As for the use of online platforms like Google Forms, this tool enables efficiency in data collection. Respondents completed questionnaires at their convenience, facilitating a wider reach, especially because study involved a geographically dispersed population within Nigeria including those that might be unavailable for interviews for unforeseen reasons. This method was also cost-effective and environmentally friendly. The use of online surveys was time-efficient and resource-effective. It eliminated the need for manual data entry, reduce paper usage, and streamline the data collection process, allowing for quicker analysis and interpretation. The inclusion of structured interviews and questionnaires ensured a balance between quantitative and qualitative data. This approach enabled the exploration of both

numerical patterns and in-depth narratives, providing a more holistic view of the research topic. Employing a mix of interviews and questionnaires allowed for data triangulation. Consistency or disparities in findings across different methods enhanced the credibility and reliability of the study results.

3.7 Validity and Reliability

Ensuring the validity and reliability of data collection instruments involves several key considerations. In terms of content validity, consulting with the supervisor and other experts in the field during the development of data collection instruments was imperative. This ensured that the content remained relevant, comprehensive, and aligned with the research objectives, with expert input validating that the instruments measure precisely what they intend to measure. For criterion-related validity, employing data triangulation through the use of multiple tools such as interviews and questionnaires was crucial. This approach compared results from different methods, providing a comprehensive view of the research phenomenon and reducing the risk of bias associated with a single data source. Construct validity was enhanced by aligning data collection instruments with the theoretical framework of the study, ensuring effective measurement of the constructs or variables under investigation. Pilot testing, involving a small sample, aids in identifying ambiguities, inconsistencies, or issues with question wording, contributing to the refinement of instruments and improvement in validity.

In terms of reliability, maintaining inter-rater reliability was critical when multiple individuals are involved in data collection, requiring training and standardization. Test-retest reliability is assessed through pilot testing, enabling the identification and resolution of inconsistencies or fluctuations in responses over time. Consistency across different data collection tools contributes to reliability, instilling confidence when diverse methods converge on similar results. Clear and precise measurement, facilitated by structured instruments such as well-defined questionnaires, further enhances the reliability of the data. Lastly, a detailed data collection protocol, including comprehensive guidelines for interviews and questionnaire

administration, ensured consistency in procedures, minimize potential sources of error, and l ultimately contributed to the overall reliability of the collected data.

There are several ways to test the validity of a research instrument, however, this research adopt representational Validity which according to Creswell (2019) is a panel of experts exploring theoretical construct and relationship to the questions drafted. The questionnaire and interview schedule were presented to supervisors and academics to ascertain whether the questions meet the demands of theoretical construct and empirical constructs. So many problems can lead to the unreliability of a research instrument such as respondent/ participant bias and stress among others. Therefore, to minimise the occurrence of these problems that often lead to the unreliability of the research a pilot test was conducted to find out possible ways of tackling problems and hence increased the reliability of the study.

3.8 Data Collection Procedures

This study used two major types of data: primary and secondary data. The primary data were sourced from questionnaires and in-depth interviews to be conducted with respondents/ participants/informants in the study area. The reason for using interviews is to generate sufficient data for the study.

The secondary data were sourced from relevant existing literature on the topic under study, from monographs, print and electronic media, journals, magazines, seminars, and newspapers. All the aforementioned secondary sources of data were critically studied, and relevant information derivable from them were used to complement the outcome of the primary data. While the research adopt a blend of primary and secondary data, the latter complement the former, which is the main source for data collection.

3.8.1 Instruments of Data Collection

The instruments that were used to collect data for this study are questionnaire and an in-depth interview the questionnaire and interview guide were designed to answer questions that are related to the variables.

3.8.2 Questionnaire

Multiple options questionnaires were used in the research as an instrument for data collection. This type of questionnaire presents respondents with a series of statements, and they are asked to indicate their level of agreement or disagreement with each statement using a predefined scale. In this study the questionnaire were structured into two sections; the section A consist of socio-demographic information of the respondents while the section B contained the essential issues of the subject matter under study. Multiple options questionnaires is valuable tool for this study, in the sense that it allowed the study to collect quantifiable and reliable data on attitudes, opinions, and perceptions, which contributed to a deeper understanding of the research topic and inform decision-making processes.

3.8.3 In-Depth Interviews

In-depth interviews were conducted in the course of the study. Sixteen Participants/informants were interviewed they include; ministry of science and technology, ministry of agriculture and food security, NASDRA and centre for satellite technology development. The interview was semi-structured. This is to allow participants to express themselves freely about the theme of the study. Through this, the researcher was able to access the depth and raw description of the phenomenon. To cross-check and confirm the information that participants had given during the interview; the researcher used observation as a means of triangulation. Although the interviews were transcribed by the researcher.

3.8.4 Data Collection Procedure

Recording devices was used to record the interviews and later transcribed for research interpretation purposes. This allowed the participants to respond without being restricted or limited in the provision of the required data. Similarly, secondary data were generated through the use of print or electronic media. A research notebook was used for recording when generating data from document analysis. This give a tripartite arrangement which allowed this study to cross-check almost the same information from different participants using different instruments to establish the reliability and validity of the data that were generated. Data generated were validated through a process of triangulation. Aside from this, the researcher relied on personal observation to support participants' claims. The interviews were recorded and transcribed for purposes of analyzing the data.

3.9 Data Processing and Analysis

This research used both quantitative and qualitative methods of data analysis for effective analysis and explanation of the data. The study used a descriptive method which is a descriptive statistical tool to analyze data. Thus the data gathered from questionnaire administration were analyzed quantitatively using tables and simple percentages, bar graphs, pie charts, and narratives were used to present the findings. As well the research used qualitative methods of data analysis for effective analysis and explanation of the data. The methods of analysis of qualitative data for the study include the use of thematic analysis. Thematic analysis provides an avenue for the interpretation and involvement of the researcher, it focuses on the identification of codes as well as the themes. First, the study gathered data from the sources (in-depth interviews), then the organization and interpretation procedure of data follows (that is, elaborating and reduction which is known as coding). Thus the data gathered from interviews were transcribed and analysed qualitatively in a thematic manner using discuss analysis.

3.10 Ethical Consideration

Ethical considerations play a crucial role in academic research, serving as a moral compass that guides researchers toward responsible and principled conduct. Adhering to ethical standards not only upholds the integrity of the research process but also safeguards the well-being of participants and ensures the credibility of the findings. Considering the subject and nature of the research, as well as the research sites and respondents, the researcher take measures to ensure that he protects participants from physical, psychological, or emotional harm and to achieve confidence building among the respondents to obtain reliable data. Participants' anonymity were assured where applicable. More so, the principles of honesty, respect, fidelity, and transparency were adhered to. Any information disclosed were used for the research and not for any other purpose. The researcher was strongly guided by ethics, cultural and religious sensitivities in undertaking the research. The researcher seek consent and highlight the essence of the research to the participants during interview sessions before commencement. Also, the respondents were guaranteed confidentiality of all relevant information as consideration of their feelings and emotions adequately taken into consideration.

Additionally, ethical responsibility extends to the researcher's conduct, and measures were put in place to guard against plagiarism throughout the research process. The researcher exercised diligence in citing sources and providing proper attribution to prevent any form of academic misconduct. To further ensure the integrity of the work, a plagiarism test was conducted as a proactive measure, affirming the originality of the research and upholding the highest standards of academic honesty. These ethical considerations collectively underscored the commitment to conducting the research with the utmost integrity, respect for participants' rights, and adherence to ethical standards in the pursuit of knowledge.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND INTERPRETATION

4.1 Introduction

This chapter presents the analysis and interpretation of the data collected in the course of conducting the research. The data analysis, presentation and interpretation are done thematically. The chapter provides the detailed analysis of gathered data, presentation of findings together with illustrations and discussion. It also presents explanation for the results obtained in the study.

4.1 Data Presentation

4.1.1 Responses Rate

A total of three hundred and eighty-four (384) questionnaires were administered across Ministry of Science and Technology, Ministry of Agriculture & Food Security, NASRDA and Centre for Satellite Technology Development to generate responses in respect of exploiting space technology for agricultural development in Africa a study of Nigeria. After administration and collection, three hundred and eighty (380) were retrieved and four (4) were not returned. Therefore, the analysis is based on the three hundred and eighty (380) completed questionnaires, which were at the disposal of the researcher. The response rate is represented in Table 4.1 and Chart 4.1 below.

Table 4.1 Response Rate

Response	**Frequency**	**Percentage %**
Returned and Fully Filled	380	98
Not Returned	4	2
Total	**384**	**100**

Source: Field Survey, 2024

Chart 4.1 Response Rate

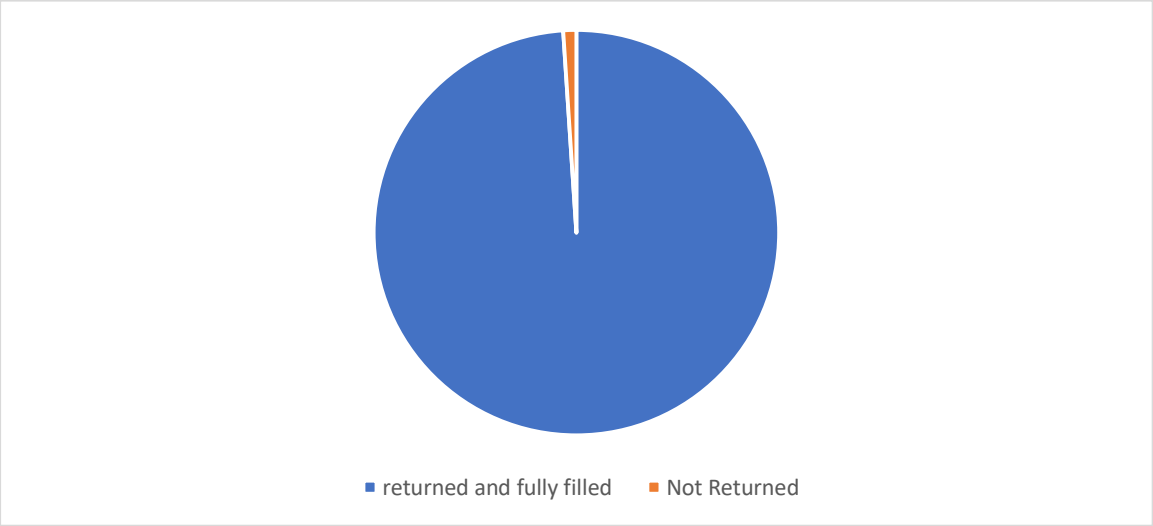


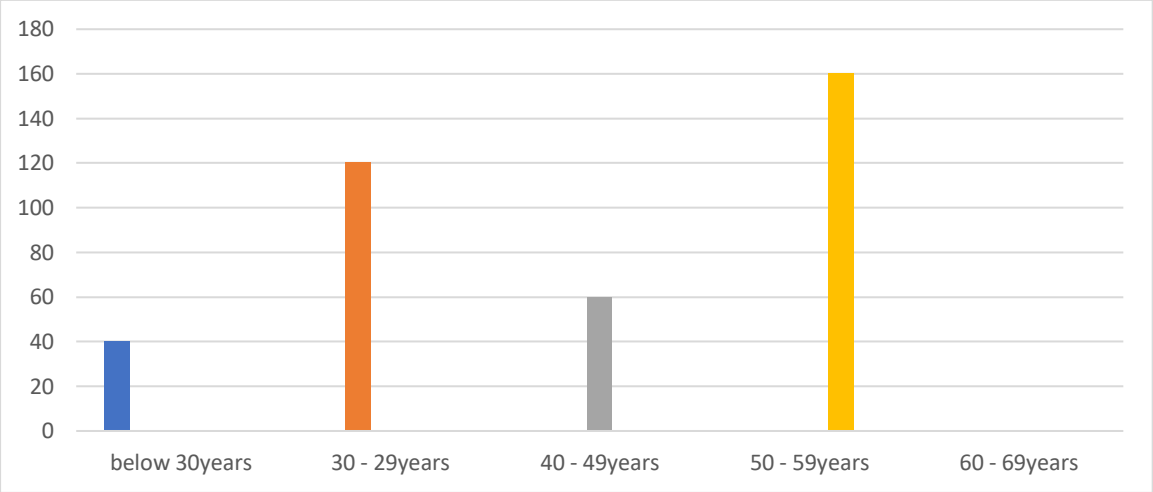
Table 4.1.2 Age Distribution

Table 4.2: Age Distribution

		Frequency	**Percent (%)**	**Valid Percent**
Valid	Below 30 years	40	11	11
	30-39 years	120	31	31
	40-49 years	60	16	16
	50-59 years	160	42	42
	60-69 years	-	-	-
Total		**380**	**100**	**100**

Source: Field Survey, 2024

Graph 4.1 Age Distribution



Source: Field Survey, 2024

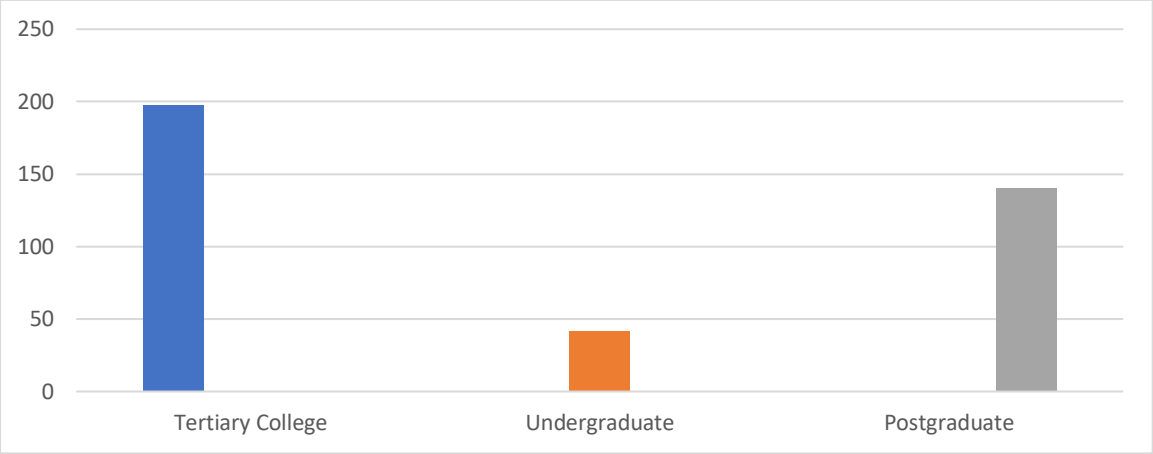
The above Table 4.2 and Graph 4.1 shows that, majority of the respondents fall within the age range of 50-59 which represents 160 (42%) of the respondents, followed by those within the age bracket of 30-39 which represents 120 (31%) of the respondents, the category of respondents within the age bracket of 40-49 is represented by 60 (16%), while respondents within the ages of 30 years below represents 40 (11). Thus, most of the respondents of this study fall within the ages of 50-59 years.

Table 4.1.3 Educational Level
Table 4.3: Educational Level

		Frequency	**Percent (%)**	**Valid Percent**
Valid	Tertiary College	198	52	52
	Undergraduate	42	12	12
	Postgraduate	140	36	36
Total		**380**	**100**	**100**

Source: Field Survey, 2024

Graph 4.2 Educational Level



Source: Field Survey, 2024

Table 4.3 and Graph 4.2 shows the educational background of the respondents, 198 which represents 52% of the respondents attained tertiary college or equivalent, 42 representing 12% of the respondents were undergraduate while the remaining 140 representing 36% of the respondents fall in the category of postgraduate.

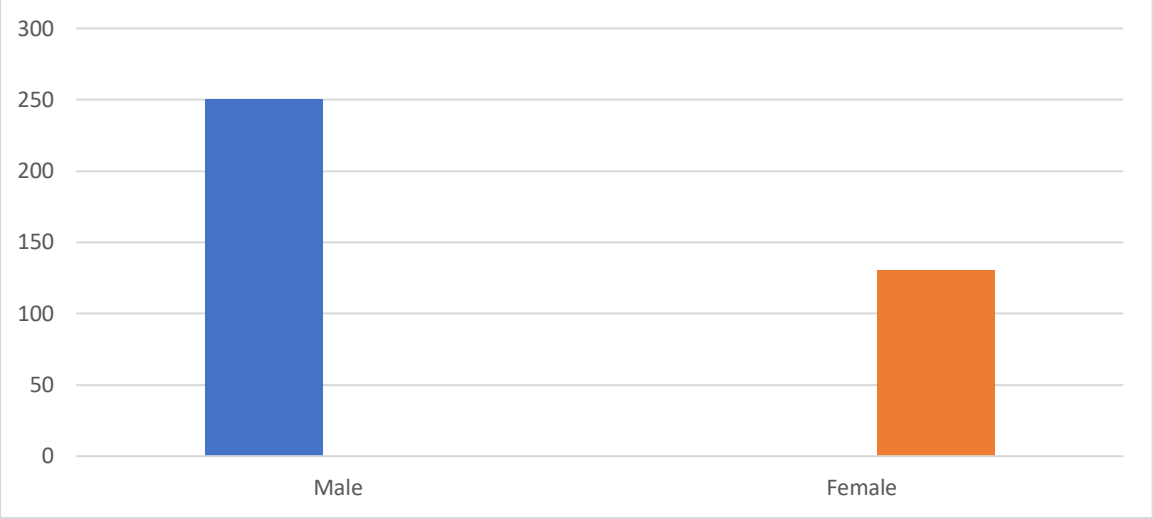
Table 4.1.4 Gender Distribution

Table 4.4: Gender Distribution

		Frequency	**Percent (%)**	**Valid Percent**
Valid	Male	250	66	66
	Female	130	34	34
Total		**380**	**100**	**100**

Source: Field Survey, 2024

Graph 4.3 Gender Distribution



Source: Field Survey, 2024

In table 4.4 and graph 4.3 above as earlier indicated that a total of three hundred and eighty four (384) questionnaires were distributed and three hundred and eighty (380) were retrieved, out of this number 250 representing 66% of the respondents were male while 130 representing 34% of the respondents were female. This indicates that majority of the respondents were male.

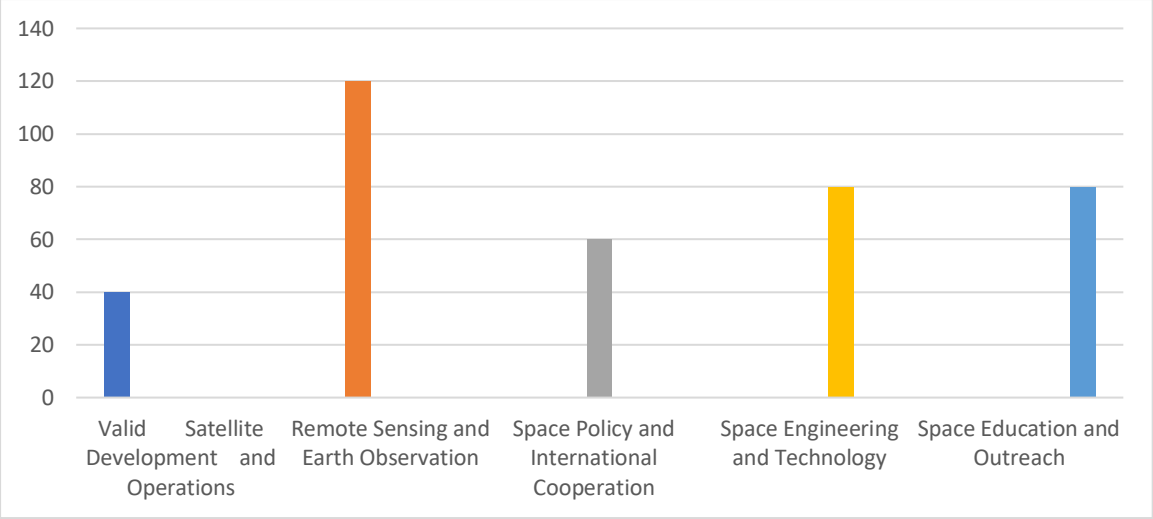
Table 4.1.5 Specialty

Table 4.5: Specialty

	Frequency	**Percent (%)**	**Valid Percent**
Valid Satellite Development and Operations	40	11	11
Remote Sensing and Earth Observation	120	31	31
Space Policy and International Cooperation	60	16	16
Space Engineering and Technology	80	21	21
Space Education and Outreach	80	21	21
Total	**380**	**100**	**100**

Source: Field Survey, 2024

Graph 4.4 Specialty



Source: Field Survey, 2024

The above Table 4.5 and Graph 4.4 shows that, majority of the respondents fall within remote sensing and earth observation which represents 120 (42%) of the respondents, followed by those within space engineering and technology and space education and outreach which represents 80 (21%) respectively of the respondents, the category of respondents within space policy and international cooperation is represented by 60 (16%), while respondents within valid satellite development and operations represents 40 (11%). Thus, most of the respondents of this study fall within remote sensing and earth observation.

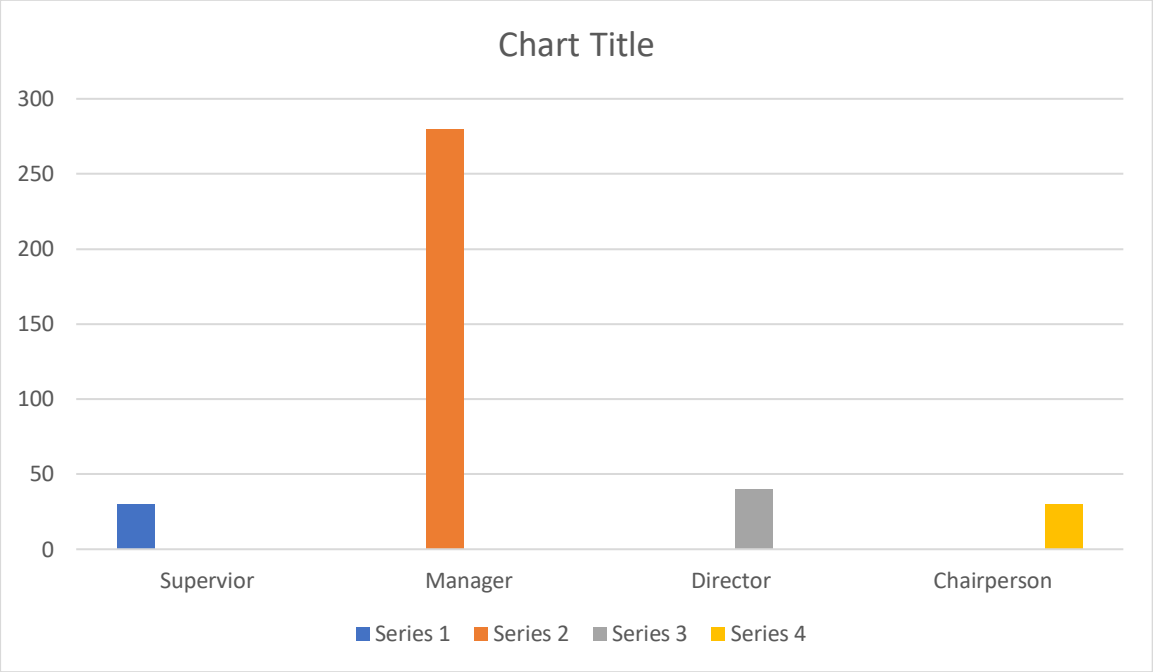
Table 4.1.6 Designation

Table 4.6: Designation

	Frequency	**Percent (%)**	**Valid Percent**
Valid Supervisor	30	8	8
Manager	280	73	73
Director	40	11	11
Chairperson	30	8	8
Total	**380**	**100**	**100**

Source: Field Survey, 2024

Graph 4.5 Designation



Source: Field Survey, 2024

It was discovered from Table 4.6 and graph 4.5 that, 30 respondents representing 8% were supervisors, while 280 respondents representing 73% of those sampled were managers, 40 which represents 11% of the respondents were directors, 30 which represents 8% of the respondents were chairpersons. This indicate that majority of the respondents in this study were managers.

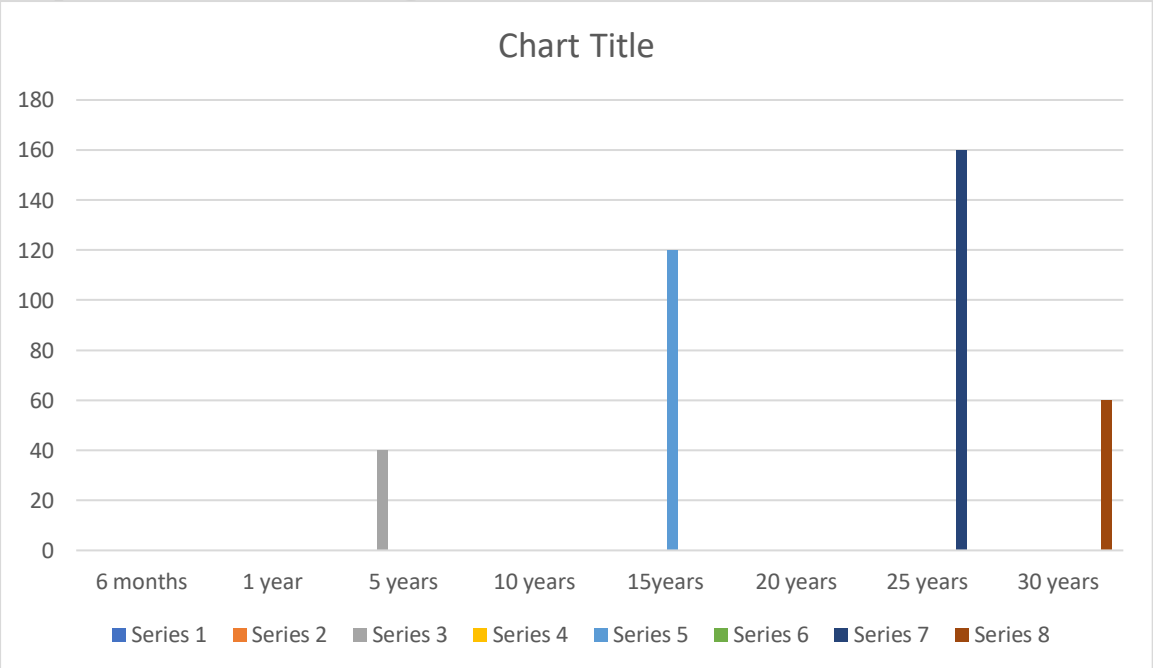
Table 4.1.7 Duration in the Organization

Table 4.7: Duration in the Organization

		Frequency	Percent (%)	Valid Percent
Valid	6 months	-	-	-
	1 year	-	-	-
	5 years	40	11	11
	10 years	-	-	-
	15 years	120	16	16
	20 years	-	-	-
	25 years	160	42	42
	30 years	60	31	31
Total		**380**	**100**	**100**

Source: Field Survey, 2024

Graph 4.6 Duration in the Organization



Source: Field Survey, 2024

The above Table 4.7 and Graph 4.6 shows that, majority of the respondents fall within the range of 25 years which represents 160 (42%) of the respondents, followed by those within the range of 15 years which represents 120 (16%) of the respondents, the category of respondents within the range of 30 years is represented by 60 (31%), while respondents within the range of 5 years represents 40 (11%). Thus, most of the respondents of this study fall within the range of 25 years.

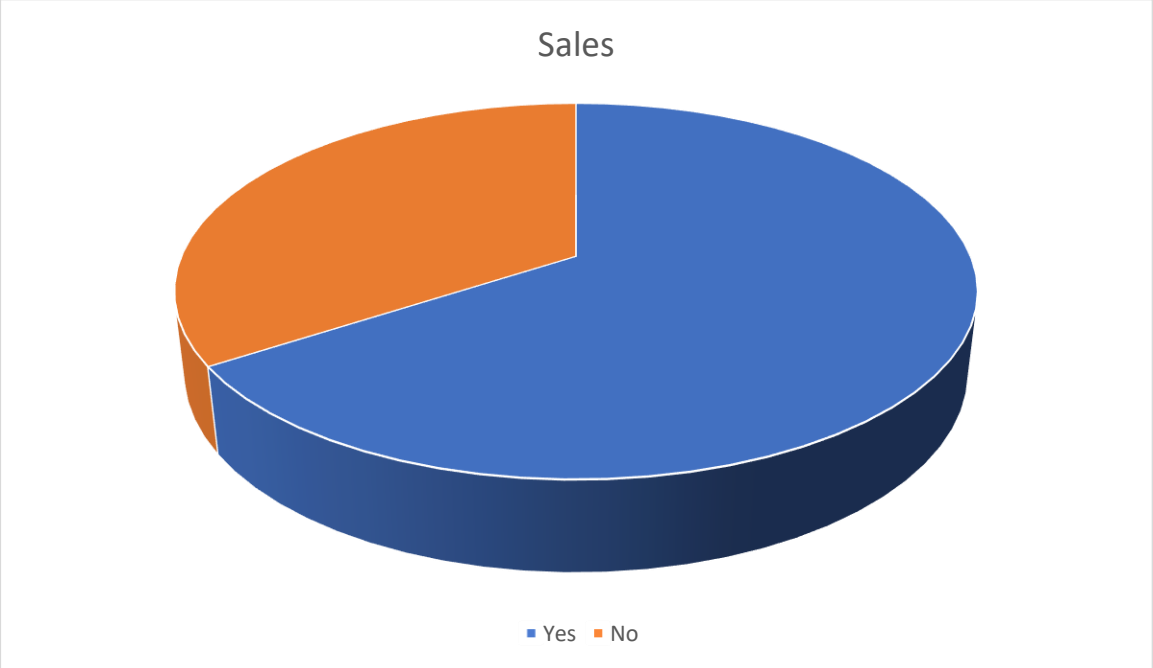
Table 4.1.8 Priority level placed on agriculture by National Space Research and Development Agency (NASRDA)

Table 4.8: Priority level placed on agriculture by National Space Research and Development Agency (NASRDA)

		Frequency	**Percent (%)**	**Valid Percent**
Valid	Yes	250	66	66
	No	130	34	34
Total		**380**	**100**	**100**

Source: Field Survey, 2024

Chart 4.2 Priority level placed on agriculture by National Space Research and Development Agency (NASRDA)



Source: Field Survey, 2024

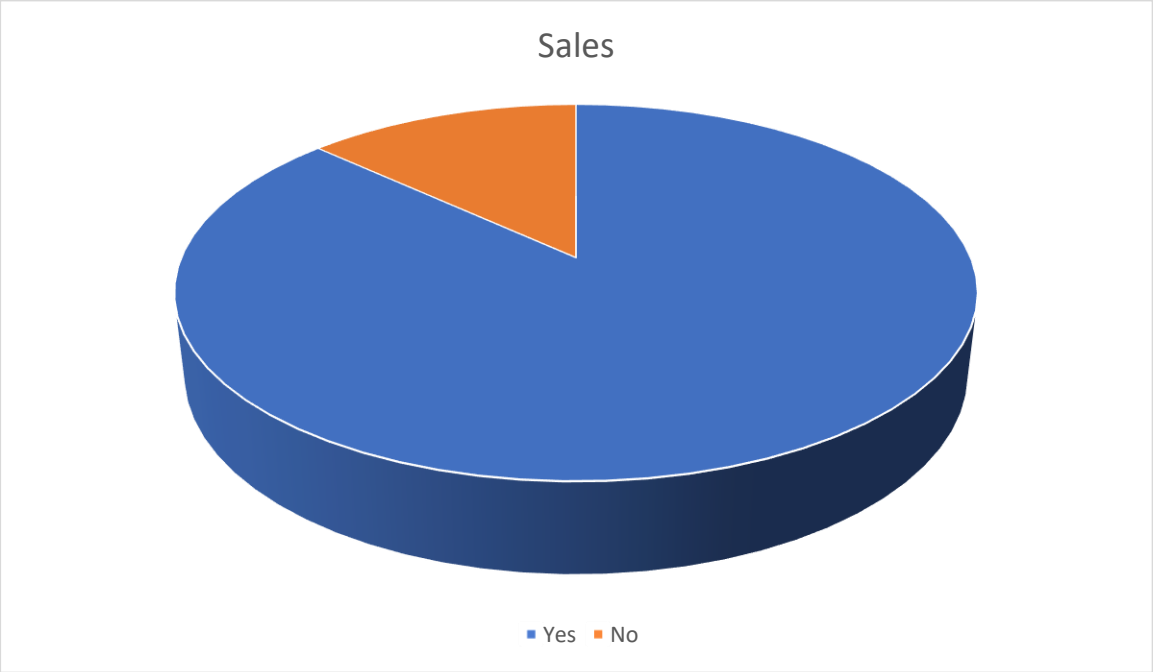
The views of respondents on whether priority level place on agriculture by NASDRA is adequate, shows that, 250 representing 66% of the respondents agreed that priority level place on agriculture by NASDRA is adequate, 130 which represents 34% of the respondents disagreed. This shows that majority of the respondents were of the view that priority level place on agriculture by NASDRA is adequate.

Table 4.1.9 The role of space technology in agricultural development in Nigeria
Table 4.9: The role of space technology in agricultural development in Nigeria

		Frequency	Percent (%)	Valid Percent
Valid	Yes	330	87	87
	No	50	13	13
Total		**380**	**100**	**100**

Source: Field Survey, 2024

Chart 4.3 The role of space technology in agricultural development in Nigeria



Source: Field Survey, 2024

The views of respondents in table 4.9 and chart 4.3 on whether they were familiar with the role of space technology in agricultural development in Nigeria, shows that, 330 representing 87% of the respondents agreed that they are familiar with the role of space technology in agricultural

development in Nigeria, 50 which represents 13% of the respondents disagreed. This shows that majority of the respondents were of the view that they were familiar with the role of space technology in agricultural development in Nigeria.

4.2 The Suitability of NASRDA's and Allied Agencies' Policies and Institutional Frameworks for Leveraging of Space Technology for Been Modified Agriculture Development in Nigeria.

A Ministry of Science and Technology staff interviewed opined that aligning the NASDRA policies with the overarching objectives for agricultural development in Nigeria is crucial for ensuring sustainable growth. To assess this alignment, a comprehensive review of both NASRDA's policies and the national agricultural development goals were conducted. By comparing key elements such as technology integration, data utilization, and collaborative initiatives, the aim was to identify synergies that promote innovation and efficiency in the agricultural sector.

In evaluating the alignment of NASRDA policies with agricultural development objectives in Nigeria, consultations with key stakeholders were initiated, including government officials, agricultural experts, and representatives from NASRDA. This collaborative approach allows for a holistic understanding of the challenges and opportunities, enabling the provision of insights on potential policy adjustments or enhancements to better support the overarching goals of agricultural development. It was further stated that the assessment of the alignment between NASRDA policies and agricultural development objectives in Nigeria involved a detailed examination of the technological infrastructure and satellite data applications in the agricultural sector. Furthermore, it involved the scrutinization of the effectiveness of current policies in harnessing space technology for precision agriculture, weather monitoring, and resource management.

To evaluate the alignment of NASRDA policies with the broader objectives for agricultural development in Nigeria, a comparative analysis of policy frameworks and strategic documents

was undertaken. This includes assessing NASRDA's initiatives alignment with the key pillars of agricultural development, such as food security, sustainable farming practices, and rural development. Additionally, potential gaps were explored and strategies proposed for policy refinement to optimally support the overarching objectives. A comprehensive evaluation of NASRDA's policies in relation to agricultural development objectives in Nigeria required a performance metrics approach. It was stated that measurable indicators and benchmarks are established to assess the impact of space technology applications on agricultural productivity, resource optimization, and environmental sustainability. Through this quantitative analysis, actionable insights are provided to enhance policy coherence and ensure that NASRDA's efforts effectively contribute to the nation's agricultural development goals.

A staff of Ministry of Agriculture and Food Security in an interview conducted during the course of the study on 10/01/2024 in Abuja asserted that NASDRA's policies have been highly effective in addressing the specific needs of the agricultural sector in Nigeria. It was expressed that by emphasizing the use of satellite technology, the Agency enables precision agriculture, allowing farmers to optimize resource utilization, monitor crop health, and enhance overall productivity. This approach has significantly contributed to sustainable agricultural practices and improved yields. NASRDA's policies have demonstrated effectiveness by integrating space-based technologies into weather forecasting and disaster management for the agricultural sector. Farmers in Nigeria face climate-related challenges, such as unpredictable weather patterns and natural disasters. The Agency's focus on providing timely and accurate information through satellite data has empowered farmers to make informed decisions, reducing risks associated with extreme weather events.

The interviewee further asserted that the implementation of remote sensing technologies by NASRDA has played a crucial role in addressing challenges within the agricultural sector. By employing satellite imagery and data, farmers can monitor crop growth, detect diseases, and assess soil conditions. This approach not only enhances the efficiency of farming practices but

also contributes to early detection of potential issues, allowing for proactive intervention and improved crop management. NASRDA's policies demonstrate a holistic approach to addressing the needs of the agricultural sector by investing in capacity building and farmer education programs. The Agency has been effective in providing training to farmers on the utilization of space-based technologies, ensuring that they can harness the full potential of these tools for improved agricultural outcomes. This focus on education enhances the sector's resilience and sustainability.

The NASRDA's policies align seamlessly with government agricultural initiatives, fostering collaboration and synergy between space research and on-ground agricultural activities. The Agency ensures that its efforts complement broader development goals by integrating space-based technologies with national agricultural strategies. This coordination enhances the overall effectiveness of policies in addressing the specific needs and challenges faced by the agricultural sector in Nigeria.

An Interview participant in the Ministry of Science and Technology opined that NASRDA has been actively involved in leveraging space technology to enhance agricultural processes through the implementation of the National Agricultural Monitoring System (NAMS). This initiative integrates satellite imagery and remote sensing technologies to monitor crop health, assess land use, and predict agricultural trends. By providing real-time data to farmers and policymakers, NAMS aims to optimize crop management, increase productivity, and support informed decision-making in the agricultural sector. One notable project initiated by NASDRA to promote the use of space technology in agriculture is the Precision Agriculture Development Programme (PADP). Through PADP, NASRDA integrates satellite-based precision farming techniques, such as GPS-guided machinery and data analytics, to enable farmers to optimize resource utilization. This initiative enhances crop yield, reduces environmental impact, and fosters sustainable agricultural practices, ultimately contributing to food security and economic growth.

The interviewee further opined that NASRDA's commitment to advancing space technology for agricultural benefits is evident in the Agro Space Integration Project (ASIP). ASIP focuses on integrating space-based technologies, including satellite communication and earth observation, with traditional farming practices. This initiative not only improves communication and monitoring capabilities in remote agricultural areas but also facilitates precision farming, leading to increased efficiency, reduced resource wastage, and improved overall agricultural productivity. A key project spearheaded by NASRDA in promoting the use of space technology for agriculture is the Satellite-Based Agricultural Extension Services (S-BAES). S-BAES utilizes satellite communication to deliver timely and relevant agricultural information directly to farmers. This initiative empowers farmers with knowledge about crop management, weather forecasts, and market trends, fostering better decision-making and improving the overall resilience of the agricultural sector to climatic variations and market fluctuations.

A NASRDA staff in an interview conducted during the course of the study opined that in achieving sustainable food production and food security, data collection and establishment play a pivotal role in enabling informed decision-making. Through the leveraging of advanced analytics and monitoring systems, real-time information can be gathered on crop health, weather patterns, and resource utilization. This data empowers stakeholders to make data-driven decisions, optimizing agricultural practices, and ensuring efficient resource allocation. This aligns with the national space policy's commitment to utilizing space-based technologies for sustainable food production. The role of data in sustainable food production extends to precision agriculture, where detailed information collected through satellite imagery, sensors, and other technologies aids in optimizing resource usage. This includes precise irrigation scheduling, targeted fertilizer application, and crop rotation planning. By harnessing space-based data, higher agricultural yields can be achieved while minimizing environmental impact,

contributing to the objectives set forth in the national space policy for sustainable and resource-efficient food production.

Data collection from space-based systems enables the development of early warning systems for potential threats to food security. Monitoring factors such as climate anomalies, pest outbreaks, and natural disasters allows for proactive interventions. By predicting and mitigating these challenges in advance, food production can be safeguarded and distribution systems, aligning with the national space policy's goal of ensuring food security through the application of space-based technologies. Data-based establishment facilitates global collaboration and information sharing in the realm of agriculture and food production. By fostering international partnerships and utilizing space-based data-sharing platforms, countries can collectively address challenges related to food security. This collaborative approach aligns with the cooperative spirit outlined in the national space policy, encouraging the exchange of knowledge and best practices to enhance global food production sustainability.

An interview participant, a staff of Ministry of Agriculture and Food Security, opined that successful integration of space technology into agricultural practices often involves robust public-private collaborations. Partnerships between government space agencies and private companies specializing in agri-tech create a synergy that allows for the development and implementation of cutting-edge solutions. This collaboration provides the necessary resources, expertise, and funding to leverage space-based technologies such as satellite imagery and remote sensing, ultimately enhancing precision agriculture and optimizing resource management.

Institutional frameworks that foster strong alliances between research institutions, universities, and agricultural organizations have proven to be successful in integrating space technology into agriculture. The facilitating of joint research projects and knowledge-sharing initiatives, robust partnerships contribute to the development of innovative technologies and practices. Additionally, academic collaborations provide a platform for training the next generation of

professionals who can effectively apply space-based solutions in agricultural contexts. The interviewee further stressed that success in integrating space technology into agriculture often depends on fostering international cooperation and knowledge exchange. Collaborative initiatives between countries, facilitated by international organizations or agreements, enable the sharing of data, expertise, and best practices. These partnerships create a global network that benefits farmers worldwide, as insights gained from different regions can be applied universally. The collective efforts of various nations contribute to the development of advanced space-based applications for agriculture.

The research found that institutional frameworks embracing multi-stakeholder platforms are instrumental in successful integration of space technology into agriculture. These platforms involve active participation from government bodies, private sector entities, farmers' associations, and non-governmental organizations. By incorporating diverse perspectives and expertise, these partnerships ensure that space-based technologies are tailored to the specific needs of agricultural communities. This inclusive approach not only enhances technology adoption but also fosters sustainable agricultural practices and equitable access to space-enabled solutions.

A Centre for Satellite Technology Development staff in an interview conducted during the course of the study on 29/01/2024 in Abuja, asserted that international collaboration holds immense significance in advancing Nigeria's space technology applications for agricultural development. The sharing of knowledge, expertise, and resources on a global scale can accelerate innovation and bring about cutting-edge solutions to address agricultural challenges. Through fostering partnerships with other nations, Nigeria can tap into a diverse pool of skills and perspectives, ultimately enhancing the effectiveness and efficiency of its space-based agricultural initiatives. It was opined that international collaboration ought to be a cornerstone in Nigeria's efforts to advance space technology applications for agricultural development. By engaging with other countries and space agencies, Nigeria can leverage a broader range of

satellite data, research, and technological capabilities. Collaborative initiatives can lead to the development of more robust and comprehensive solutions for monitoring and managing agricultural activities, ultimately contributing to increased food security and sustainable agricultural practices.

The role of international collaboration in advancing Nigeria's space technology applications for agricultural development cannot be overstated. Collaborative efforts allow for the pooling of resources, both financial and intellectual, which can significantly enhance the research and development processes. Partnering with other nations can open doors to advanced technologies, data-sharing agreements, and joint projects that can propel Nigeria's agricultural sector forward. This collaborative approach not only fosters innovation but also helps in building a global network that strengthens Nigeria's position in the international space and agricultural communities. International collaboration is a key driver for the progression of Nigeria's space technology applications in agriculture. By working hand-in-hand with other nations, Nigeria can access a wealth of experience, best practices, and technological advancements in the field. This collaborative approach facilitates the exchange of ideas and expertise, enabling the development of tailored solutions to address specific agricultural challenges. Moreover, international partnerships can contribute to capacity building within Nigeria, fostering the growth of a skilled workforce that can drive sustainable agricultural development using space technology.

A Centre for Satellite Technology Development staff in an interview conducted during the course of the study on 14/01/2024 in Abuja asserted that public awareness and education were integral in fostering the acceptance and effective use of space technology in agriculture. It was conveyed that emphasizing the tangible benefits to various stakeholders was crucial. It was further opined that clearly communicating how space technology enhances crop monitoring, resource management, and overall agricultural efficiency, supportive public sentiment can be

built. Educating farmers, policymakers, and the general public on the positive impact of these technologies helps create an environment conducive to their adoption.

In the field of space technology and agriculture, addressing misconceptions and concerns is paramount. Through effective communication and educational initiatives, myths can be dispelled and accurate information can be provided about the safety and sustainability of space-based solutions. This not only fosters acceptance but also builds trust among the public, ensuring that they are more likely to embrace these technologies as valuable tools for improving agricultural practices. Public awareness and education play a pivotal role in encouraging collaboration and knowledge sharing within the agricultural community. Through the organization of workshops, seminars, and outreach programmes, a platform can be provided for farmers, researchers, and industry professionals to exchange ideas and experiences related to space technology. This collaborative approach not only enhances the understanding of these technologies but also promotes their effective use through shared insights and best practices.

The interviewee averred that public awareness and education are key drivers in promoting policy advocacy for integrating space technology into agriculture. When the public is well-informed about the potential benefits, they are more likely to advocate for supportive policies. Engaging with policymakers and influencers to educate them on the positive outcomes of leveraging space technology in agriculture can lead to the development of policies that incentivize adoption and investment in these innovative solutions. Public support can be a powerful catalyst for shaping policies that foster the seamless integration of space technology into the agricultural sector.

An Interview participant at Centre for Satellite Technology Development in an interview conducted during the course of the study on 14/01/2024 in Abuja asserted that the current state of space technology utilization for agricultural development in Nigeria is characterized by a mix of challenges and promising opportunities. While there is a growing awareness of the potential benefits of satellite imagery, remote sensing, and GPS technologies in optimizing

agricultural practices, there remain significant barriers such as limited infrastructure, funding constraints, and a need for greater awareness among farmers. However, the increasing availability of satellite data is opening avenues for precision farming, resource optimization, and better crop management, paving the way for a more sustainable and efficient agricultural sector in the country.

Advances in satellite technology, including Earth observation satellites, have enabled farmers to monitor crop health, assess soil conditions, and plan irrigation more effectively. This has resulted in improved crop yields, reduced resource wastage, and enhanced overall agricultural productivity. The integration of space-based technologies is fostering a data-driven approach to farming, empowering farmers with valuable insights and contributing to the modernization of the agricultural sector in Nigeria.

The current state of space technology utilization for agricultural development in Nigeria reflects a collaborative effort between government agencies, research institutions, and private enterprises. Initiatives leveraging satellite data for precision agriculture are gaining momentum, indicating a positive trajectory for the integration of space technology into farming practices. While challenges like infrastructure limitations and awareness gaps persist, there is significant potential for growth. Continued collaboration and investment in space-based technologies can revolutionize Nigeria's agriculture, enhancing efficiency, sustainability, and resilience in the face of environmental and economic uncertainties.

The interviewee further pointed out that Nigeria is at a pivotal stage in integrating space technology into agricultural development. The current landscape highlights the importance of establishing supportive policies and frameworks to harness the full potential of satellite applications in farming. While some progress has been made, there is a need for increased government commitment, financial incentives, and regulatory frameworks to encourage the widespread adoption of space technology in agriculture. Strategic planning and investment in infrastructure and education will be crucial to overcoming current challenges and unlocking

the transformative power of space technology for sustainable agricultural development in Nigeria.

A staff of Centre for Satellite Technology Development in an interview conducted during the course of the study on 29/01/2024 in Abuja posited that in order to enhance coordination and communication among key stakeholders in the utilization of space technology for agricultural purposes, it is crucial to establish a collaborative framework. This involves setting up regular meetings or virtual conferences where representatives from various sectors, such as space agencies, agricultural experts, and technology developers, can share their insights and updates. Additionally, creating a centralized platform for information sharing can help streamline communication and ensure that all stakeholders are on the same page regarding the latest advancements and challenges in space technology for agriculture.

Effective project management tools and platforms play a vital role in coordinating the efforts of different stakeholders. Implementing tools like Asana, Trello, or Microsoft Teams can provide a centralized space for collaboration, task assignment, and real-time updates. By utilizing these platforms, key stakeholders can have a transparent view of project timelines, milestones, and individual responsibilities, fostering better communication and coordination throughout the entire space technology for agriculture initiative. To ensure seamless coordination among key stakeholders in the exploitation of space technology for agricultural purposes, it is beneficial to form cross-functional teams. These teams should consist of members from diverse backgrounds, including space scientists, agronomists, policymakers, and industry representatives. Fostering interdisciplinary collaboration could catalyze the utilization of unique expertise of each stakeholder group leading to a more comprehensive and holistic approach to addressing the challenges and harnessing the opportunities presented by space technology in agriculture.

Nigerian farmers stand to gain significant benefits from the integration of space technology into agricultural practices. This innovative approach often revolutionize farming in Nigeria,

leading to increased productivity, improved resource management, and enhanced food security. Satellite imagery and remote sensing technologies offer farmers unprecedented access to detailed, real-time information about their land and crops. These tools can provide accurate data on soil moisture levels, crop health, and potential pest infestations. By leveraging this information, farmers can make more informed decisions about irrigation, fertilizer application, and pest control, optimizing resource use and reducing waste.

Climate change poses a significant threat to agriculture in Nigeria. Space-based weather forecasting and climate modeling can help farmers better prepare for and adapt to changing weather patterns. This technology enables more accurate predictions of rainfall, temperature fluctuations, and extreme weather events, allowing farmers to adjust their planting and harvesting schedules accordingly. Precision agriculture, enabled by GPS technology, allows for highly targeted application of inputs such as fertilizers and pesticides. This not only reduces costs but also minimizes environmental impact. Nigerian farmers can use GPS-guided machinery to improve planting efficiency and reduce overlap, leading to better yield management.

Continuous learning and understanding of evolving space technology are essential for effective coordination among key stakeholders. Organizing regular workshops and training sessions that bring together experts from the space and agriculture sectors can facilitate knowledge exchange. These events can serve as platforms for discussing emerging technologies, addressing concerns, and identifying collaborative opportunities. By investing in ongoing education, the overall understanding and coordination among stakeholders can be enhanced and involved in the exploitation of space technology for agricultural purposes.

4.3 The Implementation of NASRDA's and Allied Agencies' Policies and Institutional Frameworks for Effective Leveraging of Space Technology for Revised Agriculture Development in Nigeria.

An interview participant who was interviewed in Abuja on 12/01/2024 posited that NASRDA policies have significantly contributed to the enhancement of agricultural productivity in Nigeria by strategically leveraging satellite applications. Through remote sensing and satellite imagery, NASRDA has enabled farmers to monitor crop health, identify pest infestations, and optimize irrigation, leading to improved yields and resource management. NASRDA's policies have played a crucial role in promoting precision agriculture techniques. By harnessing satellite data, farmers can precisely tailor their farming practices, including seeding, fertilization, and irrigation, resulting in higher efficiency and reduced resource wastage. This has positively impacted the overall productivity of the agricultural sector in Nigeria.

The interviewee was of the opinion that NASRDA's commitment to climate monitoring has allowed farmers to adapt to changing environmental conditions. The agency's policies emphasize the use of satellite data to track weather patterns and provide early warnings for extreme weather events. This proactive approach enables farmers to make informed decisions, minimizing losses and ensuring sustainable agricultural practices. NASRDA's policies have facilitated advanced crop planning and forecasting through the integration of satellite technologies. NASDRA's provision of accurate and timely information on soil health, moisture levels, and crop growth stages, farmers optimize planting schedules and make data-driven decisions which contributed significantly to increased agricultural productivity and reduced uncertainties for Nigerian farmers. NASRDA's policies extend beyond technological advancements to include capacity building and technology transfer initiatives. The Agency has been instrumental in training farmers and agricultural extension workers on the utilization of satellite data for improved farm management. This knowledge transfer has empowered

stakeholders across the agricultural value chain, fostering a more resilient and productive sector in Nigeria.

At the Centre for Satellite Technology Development, a staff interviewed on 29/01/2024 asserted that in order to ensure effective coordination between NASRDA and allied agencies for agricultural development, it is imperative to align their objectives. By integrating the goals of NASRDA with those of allied agencies, a synergistic approach that leverages the strengths of each organization can be created. This collaboration will enable a unified focus on key agricultural development priorities and foster a holistic strategy for the benefit of the agricultural sector. Effective coordination hinges on the harmonization of policies across NASRDA and allied agencies. A cohesive framework that eliminates inconsistencies and aligns regulations, standards, and initiatives can be established. This approach ensures that the policies complement each other, facilitating smoother implementation and reducing potential conflicts that may hinder the progress of agricultural development initiatives.

The interview participant further asserted that to enhance coordination, regular communication channels and feedback mechanisms will be established between NASRDA and allied agencies. This will include scheduled meetings, progress reviews, and joint planning sessions. Open and transparent communication will help in identifying challenges early on and allow for quick adjustments to policies, ensuring that collective efforts remain adaptive and responsive to the evolving needs of the agricultural sector. A key aspect of effective coordination is the establishment of collaborative research and development programmes. NASRDA will actively engage with allied agencies to pool resources, expertise, and data. By working together on research initiatives, the strengths of each organization can be leveraged to drive innovation, enhance productivity, and address challenges in the agricultural sector more comprehensively. Coordination will extend beyond policy alignment to include capacity building and training initiatives. NASRDA will collaborate with allied agencies to develop and implement programs that enhance the skills and knowledge of agricultural stakeholders. The way to go is investing

in human capital development, collective efforts that have a lasting impact, empowering individuals and organizations to contribute effectively to the overall development of the agricultural sector can be established.

A NASRDA staff interviewed in Abuja on 7/01/24 opined that international collaboration plays a pivotal role in the successful implementation of space technology in agriculture in Nigeria. By fostering partnerships with leading space agencies and research institutions globally, the expertise can be leveraged to access cutting-edge technologies. This collaboration will enable NASDRA harness satellite data for precision agriculture, enhancing crop monitoring, and resource management, ultimately boosting agricultural productivity in Nigeria. The role of international collaboration in the implementation of space technology in Nigerian agriculture cannot be overstated. Collaborating with other nations allows participants share knowledge, resources, and best practices. This exchange is particularly crucial in the space sector, where advancements occur rapidly. Collaborative experience sharing would accelerate the adoption of novel space-based solutions, leading to more sustainable and efficient agricultural practices. International collaboration is integral to the successful integration of space technology in Nigeria's agriculture sector. Through partnerships with space-faring nations, a broader range of satellite data and technologies can be harnessed to overcome infrastructural and financial barriers. This collaborative approach facilitates the transfer of knowledge and skills, empowering local stakeholders and ensuring the effective implementation of space-based solutions for precision farming, crop monitoring, and natural resource management in Nigeria.

The interviewee further posited that in the context of implementing space technology in Nigerian agriculture, international collaboration is a linchpin for success. By engaging with global space agencies and research institutions, access to advanced satellite technologies can be gained and also there would be diverse perspectives and solutions tailored to different agricultural contexts. This collaboration will foster a rich environment for innovation and

knowledge exchange, positioning Nigeria to harness the full potential of space applications in agriculture for improved yields, resource efficiency, and sustainable farming practices. The role of international collaboration in the successful implementation of space technology in Nigerian agriculture is multifaceted. Global partnership can enable pooling of resources, sharing technical expertise, and addressing common challenges. This approach not only catalyze the adoption of space-based technologies but also engender a culture of continuous learning and innovation. Through these international partnerships, Nigeria can navigate the complexities of integrating space technology into agriculture, ensuring a more robust and sustainable future for the country's farming communities.

A Centre for Satellite Technology Development staff in an interview conducted during the course of the study on 14/01/2024 in Abuja assert that in its formative years, NASRDA, established in 1999, primarily focused on space research and applications. The initial applications in agricultural science were rudimentary, mainly using satellite imagery to monitor crop health and assess land use patterns. While the technology was promising, its integration into practical agricultural solutions was in its infancy. Mid-2000s to 2010s: Integration and Precision Agriculture: As NASRDA continued to evolve, the integration of peace technology in agricultural science advanced significantly. Precision agriculture became a focal point, leveraging satellite data for precision farming techniques. This period saw the development of advanced monitoring systems, allowing farmers to optimize resource usage based on real-time data. The evolution of peace technology in agriculture was marked by increased efficiency and sustainability.

It was further asserted that the 2010s to Early 2020s: Digital Agriculture and Climate Resilience: In the last decade, NASRDA spearheaded the integration of digital technologies into agriculture. Smart farming solutions emerged, incorporating data analytics, artificial intelligence, and Internet of Things (IoT) devices. These technologies not only enhanced productivity but also contributed to climate resilience. The evolution of peace technology in

agriculture during this period showcased a shift towards sustainable and climate-smart practices. The most recent years have seen NASRDA embracing cutting-edge technologies such as block chain and machine learning for agriculture. These innovations aim to address challenges like supply chain transparency and predictive analytics for disease control. Looking forward, the evolution of peace technology in agricultural science through NASRDA is poised to play a pivotal role in ensuring food security, sustainable farming practices, and global agricultural resilience in the face of emerging challenges.

A NASRDA staff in an interview conducted during the course of the study on 13/01/2024 in Abuja asserted that since the launch of NigeriaSat-1 in 2003, there has been a significant transformation in the landscape of space technology application in agriculture. One notable change is the widespread integration of precision agriculture techniques. Satellite imagery and data provided by NigeriaSat-1 and subsequent satellites have empowered farmers with real-time information on crop health, soil moisture levels, and pest infestations. This precision enables farmers to optimize resource use, reduce input costs, and increase overall agricultural productivity.

The advent of satellite technology, particularly NigeriaSat-1, has revolutionized crop monitoring and management practices. With the ability to capture high-resolution images and collect data on a large scale, farmers can closely monitor their fields. This enhanced surveillance aids in early detection of crop diseases, nutrient deficiencies, and other stress factors, allowing for timely interventions. The result is improved crop yields and reduced losses, contributing to the overall resilience of the agricultural sector. The interviewee further asserted that space technology has played a crucial role in transforming water resource management in agriculture. Satellites like NigeriaSat-1 provide valuable information on soil moisture levels and water availability. This data assists farmers in making informed decisions about irrigation scheduling, helping to optimize water usage and conserve this precious

resource. As a result, there has been a positive impact on both water efficiency and agricultural sustainability.

The launch of NigeriaSat-1 has ushered in an era of data-driven decision-making in agriculture. Governments and policymakers now have access to comprehensive satellite data that aids in formulating evidence-based agricultural policies. The integration of space technology has facilitated better planning, resource allocation, and risk management at the national level. This, in turn, has contributed to the overall growth and development of the agricultural sector by fostering a more resilient and adaptive approach to challenges such as climate change and food security.

A Centre for Satellite Technology Development staff in an interview conducted during the course of the study on 9/01/2024 in Abuja asserted that the coordination between NASRDA and the Ministry of Agriculture and Food Security has been notably effective in implementing space technology in agriculture. The collaboration has facilitated the integration of satellite imagery and remote sensing data into agricultural practices, enabling more precise monitoring of crop health, land use, and water resources. This synergy has led to improved decision-making processes and resource allocation, ultimately enhancing the overall productivity and sustainability of the agricultural sector. While there have been commendable efforts in coordinating space technology and agriculture between NASRDA and the Ministry of Agriculture and Food Security, there is still room for improvement. The implementation has faced challenges in terms of disseminating information and knowledge to local farmers, hindering the widespread adoption of advanced technologies. Addressing these communication gaps and enhancing capacity-building programmes could further amplify the positive impact of space technology in agriculture.

The coordination between NASRDA and the Ministry of Agriculture and Food Security in implementing space technology in agriculture has shown satisfactory progress. The collaborative initiatives have contributed to increased efficiency in monitoring and managing

agricultural resources. However, to maximize the effectiveness of these efforts, ongoing investment in research and development is crucial. Additionally, engendering stronger partnerships with the private sector could unlock new opportunities for innovation and technological advancements in the agricultural domain.

From the interviewee's perspective, the coordination between NASRDA and the Ministry of Agriculture and Food Security has been highly effective in achieving comprehensive integration of space technology in agriculture. The collaborative approach has not only focused on monitoring and data collection but has also extended to precision farming techniques, climate modelling, and early warning systems. This holistic strategy has resulted in a more resilient and adaptive agricultural sector, capable of addressing challenges such as climate change and food security. Continued collaboration and strategic planning will be essential to sustain and build upon these positive outcomes.

An interview participant at Ministry of Agriculture and Food Security staff who was interviewed during the course of the study on 16/01/2024 in Abuja asserted that one crucial Key Performance Indicator (KPI) is the measurable impact of space technology on precision agriculture. Evaluate success based on the ability of satellite imagery and other space-based tools to enhance precision in farming practices. Look for improvements in resource allocation, crop monitoring, and yield prediction. Higher precision should translate into increased efficiency, reduced resource wastage, and improved overall productivity. Assess the success of space technology in agriculture by focusing on the early detection and monitoring of crop health issues. KPIs should include the speed and accuracy of identifying diseases, pests, or nutrient deficiencies using satellite data. Success in this area is reflected in the timely implementation of corrective measures, minimizing crop losses, and promoting sustainable farming practices.

It was opined that space technology should contribute to optimizing agricultural resources and promoting sustainability. KPIs in this category include the efficient use of water, fertilizers,

and pesticides based on satellite-derived insights. Success is thus evaluated by considering the reduction in environmental impact, improved water-use efficiency, and adherence to sustainable farming practices, fostering long-term viability. Furthermore, success should be measured by the empowerment of farmers through space technology, enabling them to make informed decisions. KPIs include the accessibility and usability of space-based information for farmers, the integration of data into decision-making processes, and the provision of actionable insights. Successful implementation should lead to improved farm management practices and increased resilience in the face of environmental challenges.

A NASRDA staff interviewed in Abuja on 7/01/24 opined that the involvement of the private sector in agriculture technology implementation in Nigeria can significantly contribute to success through increased investment and innovation. Private companies often have the financial resources to fund research and development, leading to the creation of advanced and tailored technologies for the Nigerian agricultural sector. This infusion of capital and innovation can result in the development of cutting-edge solutions, such as precision farming tools and efficient supply chain management systems, ultimately boosting productivity and sustainability. Private sector involvement can play a pivotal role in enhancing the technological infrastructure required for successful implementation in Nigerian agriculture. Companies can invest in building and upgrading digital infrastructure, such as robust internet connectivity and data management systems. This would enable farmers to access real-time information, market prices, and best practices, promoting a more connected and informed agricultural community. Improved infrastructure contributes to better decision-making, resource optimization, and overall efficiency in the farming processes.

The private sector can contribute to the successful implementation of technology in agriculture by initiating capacity building and training programmes. Companies can collaborate with local educational institutions and agricultural organizations to provide farmers with the necessary skills to effectively utilize modern technologies. Training programs can cover the use of agri-

tech tools, data analysis, and maintenance of equipment. This knowledge transfer empowers farmers, making them more adept at leveraging technology for increased yields and sustainable farming practices. It was further stressed that private sector involvement facilitates the integration of agricultural technology into broader value chains, providing farmers with improved market access. Companies can establish platforms that connect farmers with buyers, processors, and distributors, streamlining the entire agricultural value chain. This integration ensures that the benefits of technology reach farmers directly, leading to increased profitability. Private sector initiatives can also focus on creating market linkages for agri-tech startups, advancing a vibrant ecosystem that encourages continuous innovation and adaptation of technology in the agriculture sector.

An interview participant at Ministry of Agriculture and Food Security interviewed in Abuja on 10/01/2024 posited that to increase synergy between NASRDA and the practical implementation of space technology for optimal agricultural development in Nigeria, there is a need for integration of remote sensing technology. Utilizing satellite data can provide real-time information on crop health, soil moisture levels, and pest infestations. This data can empower farmers with timely and precise information, enabling them to make informed decisions and optimize their agricultural practices.

It was established that implementing comprehensive capacity-building programmes is crucial for maximizing the benefits of space technology in agriculture. It was further opined that NASRDA should collaborate with agricultural institutions and organizations to conduct training sessions for farmers, extension workers, and other stakeholders. These programmes should focus on educating the target audience about the practical applications of space technology in agriculture, enabling them to harness its potential for improved productivity and sustainable practices.

NASRDA can enhance synergy by developing and implementing customized agricultural advisory services based on space technology data. By tailoring information to specific regions

and crop types, farmers can receive targeted recommendations for crop management, irrigation scheduling, and pest control. This approach will ensure that the practical application of space technology aligns with the diverse needs of farmers across different agro-ecological zones in Nigeria. Public-private partnerships for technology transfer, engender collaboration between NASRDA and private sector entities to facilitate the transfer of space technology to the agricultural industry. Encouraging partnerships with technology companies and agribusinesses will not only accelerate the adoption of space-based solutions but also promote innovation in the development of new tools and applications. This collaborative approach can help bridge the gap between research and practical implementation, leading to more effective and widespread use of space technology in agricultural activities in Nigeria.

An interview participant at Ministry of Agriculture and Food Security interviewed during the course of the study on 16/01/2024 in Abuja asserted that one remarkable success story in Nigeria showcasing the impactful application of space technology in agriculture is the precision farming initiative led by AgroTech Innovations. By leveraging satellite imagery and GPS technology, farmers in Nigeria are now able to optimize their crop management practices. This has led to a significant increase in crop yields, reduced water usage, and improved overall farm efficiency. The precision farming approach has not only boosted agricultural productivity but has also contributed to sustainable and resource-efficient farming practices across the country. NASDRA has played a pivotal role in transforming agriculture through space technology. One standout success story is the implementation of satellite-based weather forecasting and monitoring systems. This technology has enabled farmers to make informed decisions regarding planting times, irrigation schedules, and pest control measures. As a result, crop losses have been minimized, and farmers have experienced increased yields. The integration of space technology in agriculture has not only improved food security but has also enhanced the resilience of farmers in the face of unpredictable weather conditions.

The Agricultural Mapping and Precision Nutrient Application project, supported by the NASRDA, has empowered farmers with accurate information about soil health and nutrient levels. By tailoring fertilization practices based on these insights, farmers have witnessed substantial improvements in crop quality and yield. This innovative approach has not only increased agricultural productivity but has also contributed to sustainable farming practices by minimizing the overuse of fertilizers. Space technology has brought about a transformative change in Nigeria's aquaculture sector, with the successful implementation of satellite-based fishery monitoring systems. NIMASA collaborated with space agencies to develop a system that enables real-time tracking of fishing vessels and monitoring of fishing activities in the country's waters. This has not only curbed illegal fishing practices but has also promoted sustainable fisheries management. As a result, fish stocks have rebounded, and local fishing communities have experienced improved livelihoods. The integration of space technology in aquaculture has proven to be a game-changer, ensuring the long-term viability of the sector.

Space technology also enhance crop monitoring and yield estimation. Satellite imagery often provide regular updates on crop growth and health across large areas, helping farmers and agricultural agencies identify potential issues early and respond promptly. This data also assist in more accurate yield forecasting, which is crucial for food security planning and market stability. Furthermore, space-based communication systems improve connectivity in rural areas, facilitating access to agricultural information, market prices, and extension services. This connectivity empower farmers with knowledge and enable them to make better-informed decisions about crop selection, timing of sales, and market access.

The integration of space technology in agriculture also opens up opportunities for smallholder farmers to participate in larger markets. By providing accurate land mapping and crop certification, these technologies usually help farmers prove compliance with international standards, potentially increasing their access to global markets. To fully realize these benefits, it is crucial to invest in training and capacity building for Nigerian farmers. This includes

developing user-friendly interfaces for space-based agricultural tools and providing education on interpreting and applying the data effectively.

4.4 The Challenges Faced in Adopting Space Technology for Included Agricultural Development in Nigeria.

An interview participant, a staff of Centre for Satellite Technology Development, interviewed in Abuja on 15/11/2024 opined that one of the challenges in implementing space technology for agricultural development is the seamless integration of space-derived data into practical on-ground farming activities. While satellite imagery and remote sensing provide valuable information, translating this data into actionable insights for farmers, such as precision farming or irrigation management, requires overcoming technical and accessibility barriers. Another key challenge is the affordability and accessibility of space technology for farmers, particularly in developing regions. High initial costs associated with acquiring and implementing space-based solutions, as well as limited availability of necessary infrastructure, can hinder widespread adoption. Bridging the gap to make these technologies more affordable and accessible is crucial for their practical integration into agricultural practices.

Space technology generates vast amounts of data, and interpreting this information in a way that is understandable and actionable for farmers poses a significant challenge. There is a need for educational initiatives to enhance farmers' capacity to interpret and apply space-derived data effectively. Building awareness and providing training programmes can empower farmers to harness the full potential of these technologies. Implementing space technology for agricultural development requires a supportive regulatory and policy environment. Challenges arise in establishing frameworks that facilitate the responsible and efficient use of space-based data for agriculture. Policymakers need to collaborate with space agencies, agricultural experts, and technology developers to create guidelines that encourage innovation while addressing concerns related to privacy, data ownership, and ethical considerations.

A critical challenge is the lack of adequate infrastructure and connectivity in rural areas where agriculture is a primary economic activity. Many agricultural regions face challenges related to limited internet connectivity and power supply, which are essential for accessing and utilizing space technology effectively. Infrastructure development, including reliable connectivity, is crucial to bridge the digital divide and enable farmers to benefit from advanced space-based solutions.

An interview participant at Ministry of Agriculture and Food Security who was interviewed during the course of the study on 16/01/2024 in Abuja asserted that one of the primary challenges in adopting space technology for agriculture in Nigeria is the limited infrastructure and access to technology. Many farmers, especially those in remote or rural areas, may lack the necessary infrastructure to fully leverage space-based technologies. This includes issues such as inadequate internet connectivity, power supply, and the availability of devices required to access and interpret satellite data. Another significant challenge is the lack of awareness and education among farmers about the benefits and applications of space technology in agriculture. Many farmers may not be familiar with how satellite data can be used to enhance crop monitoring, optimize irrigation, or predict weather patterns. Closing this knowledge gap is vital for successful adoption and implementation.

The cost associated with implementing and maintaining space technology solutions poses a considerable challenge for farmers in Nigeria. The initial investment in acquiring technology, such as satellite imagery or precision agriculture equipment, can be prohibitive for smallholder farmers. Additionally, ongoing costs related to data subscriptions and equipment maintenance may further limit widespread adoption. While space technology provides valuable data, the challenge lies in the effective interpretation and integration of this information into practical, on-the-ground farming practices. Farmers may lack the skills and tools needed to analyze satellite data and translate it into actionable insights for crop management, pest control, and resource optimization. The absence of a robust policy and regulatory framework specifically

tailored to the integration of space technology in agriculture is a significant hurdle. Clear guidelines and support from governmental bodies are essential to facilitate the adoption of these technologies. Policy gaps may create uncertainties around issues like data ownership, privacy, and the use of advanced technologies, hindering their widespread acceptance and deployment. An interview participant at Ministry of Science and Technology interviewed in Kuje on 12/01/24 opined that one key challenge facing NASRDA and allied agencies in achieving the agricultural development goals outlined in the national space policy is the effective integration of satellite data with on-the-ground agricultural practices. While satellite technology provides valuable information such as weather patterns, soil conditions, and crop health, ensuring that farmers can easily access and interpret this data for practical decision-making remains a challenge. Narrowing the gap between space-based observations and local farming methods is crucial for the successful implementation of the national space policy in the agricultural sector. Another significant challenge is the need for extensive capacity building and training programmes for farmers and relevant stakeholders. Utilizing space technology for agricultural development requires a certain level of expertise and understanding, both in terms of data interpretation and the application of innovative practices. NASRDA and allied agencies must invest in comprehensive training initiatives to empower farmers with the skills needed to leverage space-based technologies effectively. This involves not only technical training but also awareness campaigns to spur a greater appreciation for the benefits of space applications in agriculture.

The development of robust infrastructure to support the implementation of space-based solutions in agriculture is a key hurdle. Access to reliable internet connection, proper storage facilities, and efficient transportation networks are essential for disseminating information derived from satellite data and ensuring that technological advancements reach farmers in remote areas. Addressing these infrastructure challenges will be pivotal in realizing the objectives of the national space policy and maximizing the impact of space technology on

agricultural development. Achieving the goals outlined in the national space policy requires effective collaboration and engagement with various stakeholders, including government agencies, research institutions, and private sector entities. Coordinating efforts among these diverse groups is a complex task, and ensuring a seamless flow of information and resources is crucial for success. NASRDA and allied agencies need to grow strong partnerships, encourage knowledge-sharing, and create an environment conducive to collaboration to overcome the challenges associated with implementing space-based solutions in the agricultural sector.

An interview participant at Centre for Satellite Technology Development interviewed in Abuja on 11/01/24 opined that our policies at NASRDA are specifically designed to address the unique challenges and opportunities present in Nigeria's agricultural landscape. It was established that the diverse agro-ecological zones in the country could provide an avenue for tailoring strategies to cater to the varying needs of farmers in different regions. Thus, collaborating with local agricultural experts and engaging in extensive research, will ensure that policies are not only effective but also responsive to the distinct nuances of Nigeria's agricultural sector. NASRDA places a strong emphasis on understanding the socio-economic factors influencing Nigeria's agricultural landscape. It was asserted that policies are crafted with a keen awareness of the challenges faced by smallholder farmers, ensuring that they have access to the necessary resources, technology, and financial support. Additionally, it was stated that NASDRA actively seeks opportunities for innovation and collaboration with stakeholders to enhance the overall resilience and productivity of the agricultural sector, keeping in mind the specific needs of the diverse farming communities across the country.

The policies implemented by NASRDA are a result of a comprehensive analysis of the opportunities and challenges present in Nigeria's agricultural sector. It was noted that the Agency takes into account the unique climate conditions, soil types, and crop varieties across the nation. By adopting a region-specific approach, our policies aim to harness the strengths of

each area while addressing the vulnerabilities. It was further asserted that the Agency is committed to promoting sustainable agricultural practices that align with the local context, ensuring a balanced and inclusive development of the agricultural landscape. NASRDA's policies are intricately designed to align with the specific challenges and opportunities prevalent in Nigeria's agricultural landscape. The interviewee underscored the importance the Agency accords promoting technological advancements that are tailored to the needs of farmers, considering factors such as market dynamics, infrastructure limitations, and climate variability. Our collaborative efforts with agricultural communities, research institutions, and industry stakeholders ensure that our policies are not only adaptable but also contribute to the overall growth and resilience of Nigeria's diverse agricultural sector.

Interview participant at Ministry of Agriculture and Food Security interviewed in Abuja on 10/01/2024 opined that certainly, when examining the intersection of space technology and agricultural development, one glaring policy gap lies in the lack of a comprehensive regulatory framework for satellite data sharing. Currently, there's ambiguity regarding the ownership, access, and utilization of satellite data for agricultural purposes. A well-defined policy in this realm could facilitate easier data sharing among stakeholders, enabling farmers to harness the full potential of space technology for precision farming, crop monitoring, and resource optimization. One significant policy gap affecting the optimal utilization of space technology in agriculture revolves around the absence of clear guidelines on international collaboration. The global nature of satellite data and technology implies that cooperative efforts could yield substantial benefits for agricultural development. However, ambiguities in policies related to data sharing, joint research initiatives, and technology transfer hinder effective collaboration. Addressing these gaps through comprehensive international agreements could unlock a more efficient and coordinated use of space technology for agriculture on a global scale.

The interview participant further stressed that an identified policy gap pertains to the limited incentives and support mechanisms for integrating space technology into agricultural practices

at the grassroots level. While there are policies promoting research and development in space technology, there's a lack of targeted initiatives to encourage farmers, especially in developing regions, to adopt these technologies. Clear policies offering financial incentives, training programs, and technical support for small-scale farmers could bridge this gap and enhance the widespread adoption of space-based solutions for agricultural development.

In the context of space technology and agriculture, a notable policy ambiguity concerns the licensing and regulation of Unmanned Aerial Vehicles (UAVs) or drones for agricultural purposes. Drones equipped with advanced sensors and imaging capabilities have immense potential for precision agriculture. However, unclear regulations on flight paths, data privacy, and licensing requirements create uncertainty for farmers and service providers. A well-defined policy framework addressing these issues would promote the responsible and effective use of drones in agriculture, fostering innovation and efficiency in farming practices.

Interview Participant at Ministry of Agriculture and Food Security interviewed during the course of the study on 16/01/2024 posited that National Agricultural Seeds and Research Agency has shown a proactive approach in adapting its policies and frameworks to address emerging challenges in agriculture. One notable instance is the modification of seed certification procedures in response to evolving climate conditions. NASRDA updated its policies to ensure that certified seeds are resilient to changing weather patterns, thereby supporting farmers in mitigating the impacts of climate change on crop production.

In the realm of agricultural biotechnology, NASRDA has been dynamic in responding to technological advancements. The agency has updated its frameworks to regulate and facilitate the adoption of Genetically Modified (GM) crops. These modifications reflect NASRDA's commitment to harnessing cutting-edge technologies in agriculture while ensuring the safety and sustainability of these innovations. NASRDA recognizes the pivotal role of digital technologies in modern agriculture. In response to the growing importance of precision farming and data-driven decision-making, the agency has adapted its policies to encourage the use of

smart farming technologies. This includes updates in guidelines for the registration and monitoring of agricultural technologies, fostering a more innovation-friendly environment for stakeholders in the sector. Agricultural trade dynamics are constantly evolving, and NASRDA has been agile in adjusting its policies to align with global trade standards. Notable instances include updates in seed export and import regulations, ensuring that Nigeria's agricultural products meet international quality and safety standards. These adjustments aim to enhance the competitiveness of Nigerian agricultural products in the global market, facilitating increased trade opportunities for the country's agricultural sector.

Interview participant at Ministry of Agriculture and Food Security who was interviewed in Abuja on 10/01/2024 averred that NASRDA policy's notable strength lies in its effective integration of space technology for agricultural development. By leveraging satellite imagery and remote sensing, the organization enables precision agriculture, allowing farmers to optimize resource utilization, monitor crop health, and enhance overall productivity. This integration enhances decision-making processes in the agricultural sector, contributing to sustainable and efficient practices. However, a weakness is the limited accessibility of these technologies to all farmers, especially those in remote or economically disadvantaged areas. The NASRDA framework could benefit from a stronger emphasis on capacity building programs, ensuring that farmers across diverse regions have the knowledge and resources to effectively utilize space technology for their agricultural activities.

NASRDA's policy demonstrates strength in promoting data-driven decision-making processes within the agricultural sector. By collecting and analyzing data from space technologies, the organization facilitates evidence-based planning and policy formulation. This enables stakeholders to make informed choices regarding crop selection, irrigation practices, and pest control measures, ultimately leading to more resilient and sustainable agricultural systems. Concerns on the downside, there is a potential weakness related to data security and privacy concerns. As NASRDA gathers vast amounts of sensitive agricultural data, it must prioritize

robust cybersecurity measures to safeguard this information. Additionally, clear guidelines and policies on data access and usage should be established to address potential ethical and privacy issues.

NASRDA's focus on utilizing space technology for climate resilience and disaster management in agriculture is a significant strength. Through real-time monitoring of weather patterns and early detection of natural disasters, the organization helps farmers prepare for and mitigate the impact of adverse conditions. This proactive approach enhances the agricultural sector's resilience to climate-related challenges. A weakness lies in addressing infrastructure gaps and ensuring timely response mechanisms. The effectiveness of the NASRDA policy depends on a well-established communication and infrastructure network. Improved coordination and rapid response mechanisms are necessary to translate early warnings into timely actions on the ground, especially in rural areas with limited infrastructure.

The interviewee further stress that NASRDA's policy excels in providing support for research and innovation in agricultural practices through space technology. By fostering collaborations between scientists, researchers, and agricultural stakeholders, the organization contributes to the development of cutting-edge solutions. This strength positions the agricultural sector to adapt to evolving challenges and technological advancements. A weakness is the potential for funding constraints affecting the continuity of research and innovation initiatives. To maintain momentum and sustained progress, NASRDA should actively seek diversified funding sources and partnerships to ensure ongoing support for research and innovation in the agricultural sector.

A Centre for Satellite Technology Development staff in an interview conducted during the course of the study on 14/01/2024 in Abuja assert one of the primary challenges observed in the adoption and implementation of space technology for agricultural development in Nigeria is the limited infrastructure and connectivity. Many rural areas lack the necessary facilities and reliable internet access required for farmers to effectively utilize satellite data and other space-

based technologies. This hampers the dissemination of crucial information, weather forecasts, and precision farming techniques, limiting the overall impact of space technology on agricultural productivity. Another significant challenge is the insufficient awareness and training among farmers regarding the benefits and application of space technology in agriculture. Many farmers in Nigeria may not be familiar with the potential advantages of using satellite imagery, remote sensing, and other space-related tools for optimizing crop management. Bridging this knowledge gap through targeted training programs and awareness campaigns is essential for successful technology adoption.

Financial constraints pose a significant hurdle to the widespread adoption of space technology in agriculture. The initial investment required for purchasing and implementing space-based solutions, such as precision agriculture equipment and satellite data services, can be prohibitive for small-scale farmers. Adequate financial support, subsidies, or affordable financing options are necessary to make these technologies accessible to a broader segment of the agricultural community.

The absence of a comprehensive policy and regulatory framework tailored to support the integration of space technology in agriculture is another challenge. Clear guidelines and incentives from the government are crucial for fostering an environment conducive to the adoption of innovative farming technologies. A well-defined regulatory framework would address issues related to data privacy, land rights, and the responsible use of space technology, providing a solid foundation for sustainable agricultural development in Nigeria.

4.5 Discussion of Findings

4.5.1 The Suitability of NASRDA's and Allied Agencies' for Included Agriculture Development in Nigeria

The main purpose of the study was to examine space technology for agricultural development in Africa, a study of Nigeria. This culminated to the crafting of three specific objectives. The first specific objective was to analyze the suitability of NASRDA's and allied agencies'

policies and institutional frameworks for leveraging of space technology for agriculture development in Nigeria. The study revealed that, aligning the National Space Research and Development Agency (NASRDA) policies with the overarching objectives for agricultural development in Nigeria is crucial for ensuring sustainable growth. To assess this alignment, there is the need to first conduct a comprehensive review of both NASRDA's policies and the national agricultural development goals. By comparing key elements such as technology integration, data utilization, and collaborative initiatives, with the aim to identify synergies that promote innovation and efficiency in the agricultural sector in Nigeria. NASRDA's commitment to advancing space technology for agricultural benefits is evident in the Agro Space Integration Project (ASIP). ASIP focuses on integrating space-based technologies, including satellite communication and earth observation, with traditional farming practices. This initiative not only improves communication and monitoring capabilities in remote agricultural areas but also facilitates precision farming, leading to increased efficiency, reduced resource wastage, and improved overall agricultural productivity.

The study as well revealed that Climate change poses a significant threat to agriculture in Nigeria. Space-based weather forecasting and climate modeling can help farmers better prepare for and adapt to changing weather patterns. This technology enables more accurate predictions of rainfall, temperature fluctuations, and extreme weather events, allowing farmers to adjust their planting and harvesting schedules accordingly. Precision agriculture, enabled by GPS technology, allows for highly targeted application of inputs such as fertilizers and pesticides. This not only reduces costs but also minimizes environmental impact. Nigerian farmers can use GPS-guided machinery to improve planting efficiency and reduce overlap, leading to better yield management.

The study further revealed that in order to achieving sustainable food production and food security, data collection and establishment play a pivotal role in enabling informed decision-making. By leveraging advanced analytics and monitoring systems, there is the need to gather

real-time information on crop health, weather patterns, and resource utilization. These data empowers stakeholders to make data-driven decisions, optimizing agricultural practices, and ensuring efficient resource allocation. This aligns with the national space policy's commitment to utilizing space-based technologies for sustainable food production. The role of data in sustainable food production extends to precision agriculture, where detailed information collected through satellite imagery, sensors, and other technologies aids in optimizing resource usage. This includes precise irrigation scheduling, targeted fertilizer application, and crop rotation planning. By harnessing space-based data, Nigeria can achieve higher agricultural yields while minimizing environmental impact, contributing to the objectives set forth in the national space policy for sustainable and resource-efficient food production.

4.5.2 The Implementation of NASRDA's and Allied Agencies' Policies and Institutional Framework for Optimal Agriculture Development in Nigeria

The second objective of the study aimed at evaluating the implementation of NASDRA's and allied agencies' policies and institutional frameworks for effective leveraging of space technology for agriculture development in Nigeria. The study shows that, in order to ensure effective coordination between NASRDA and allied agencies for agricultural development, it is imperative to align objectives. By integrating the goals of NASRDA with those of allied agencies, the agency can create a synergistic approach that leverages the strengths of each organization. This collaboration will enable a unified focus on key agricultural development priorities and foster a holistic strategy for the benefit of the agricultural sector. Effective coordination hinges on the harmonization of policies across NASRDA and allied agencies. There is a need to strive to establish a cohesive framework that eliminates inconsistencies and aligns regulations, standards, and initiatives. This approach will ensure that policies complement each other, facilitating smoother implementation and reducing potential conflicts that may hinder the progress of agricultural development initiatives.

The study also indicates that the integration of space technology in agriculture also opens up opportunities for smallholder farmers to participate in larger markets. By providing accurate land mapping and crop certification, these technologies usually help farmers prove compliance with international standards, potentially increasing their access to global markets. To fully realize these benefits, it is crucial to invest in training and capacity building for Nigerian farmers. This includes developing user-friendly interfaces for space-based agricultural tools and providing education on interpreting and applying the data effectively.

The study further revealed that, to enhance coordination, regular communication channels and feedback mechanisms need to be established between NASRDA and allied agencies. This will include scheduled meetings, progress reviews, and joint planning sessions. Open and transparent communication will help in identifying challenges early on and allow for quick adjustments to policies, ensuring that collective efforts remain adaptive and responsive to the evolving needs of the agricultural sector. A key aspect of effective coordination is the establishment of collaborative research and development programs. NASRDA will actively engage with allied agencies to pool resources, expertise, and data. By working together on research initiatives, NASRDA can leverage the strengths of each organization to drive innovation, enhance productivity, and address challenges in the agricultural sector more comprehensively.

4.5.3 The Challenges Faced in Adopting Space Technology for Included Agricultural Development in Nigeria

The third objective of this study aimed to ascertain the challenges faced in adopting space technology for agricultural development in Nigeria. The study found out that, one of the challenges in implementing space technology for agricultural development is the seamless integration of space-derived data into practical on-ground farming activities. While satellite imagery and remote sensing provide valuable information, translating this data into actionable insights for farmers, such as precision farming or irrigation management, requires overcoming

technical and accessibility barriers. Another key challenge is the affordability and accessibility of space technology for farmers, particularly in developing area. High initial costs associated with acquiring and implementing space-based solutions, as well as limited availability of necessary infrastructure, can hinder widespread adoption. Bridging the gap to make these technologies more affordable and accessible is crucial for their practical integration into agricultural practices.

The study also indicated that the cost associated with implementing and maintaining space technology solutions poses a considerable challenge for farmers in Nigeria. The initial investment in acquiring technology, such as satellite imagery or precision agriculture equipment, can be prohibitive for smallholder farmers. Additionally, ongoing costs related to data subscriptions and equipment maintenance may further limit widespread adoption. While space technology provides valuable data, the challenge lies in the effective interpretation and integration of this information into practical, on-the-ground farming practices. Farmers may lack the skills and tools needed to analyze satellite data and translate it into actionable insights for crop management, pest control, and resource optimization. The absence of a robust policy and regulatory framework specifically tailored to the integration of space technology in agriculture is a significant hurdle. Clear guidelines and support from governmental bodies are essential to facilitate the adoption of these technologies. Policy gaps may create uncertainties around issues like data ownership, privacy, and the use of advanced technologies, hindering their widespread acceptance and deployment.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

The study was structured into five chapters; each chapter discussed a particular aspect of the work. This chapter contains summary, conclusions, and recommendations.

5.1 Summary

Agriculture is important for the sustainment of life, hence underscoring its development especially in the face of climate change and dwindling resources. Thus, this study brings to the fore the essentiality of utilization of space technology for agricultural development in Nigeria which is crucial for a multiplicity of stakeholders.

This study employed the probability sampling design. Particularly, the simple stratified technique was utilized. In this technique, each member of the accessible population stands a chance of selection of the sample. The simple stratified probability technique was chosen because the population that was studied exhibits significant heterogeneity. Stratified sampling allows for the division of the population into distinct strata based on relevant characteristics Krejcie and Morgan (1970) model for determining sample size was used in determining the sample size of the study which is 384 (for the quantitative part). While for the qualitative part sixteen participants were interviewed.

Data was collected using a variety of tools. These include primary and secondary data. Interviews and questionnaires were utilized. Both structured and semi-structured interviews were conducted and questionnaires were served via Google Forms. The use of a variety of data collection tools, including both primary and secondary sources, reflects a comprehensive and multi-faceted approach to gathering information for the research study.

Thematic analysis was applied to the qualitative data obtained from interviews, involving the identification of patterns, themes, and recurring ideas within the responses, thereby providing

a deeper understanding of the qualitative aspects of the research. Thematic analysis involves a qualitative analytic method for detecting, interpreting, and reporting themes within data whereas a theme represents same level of structured response. Frequency tables, bar graphs, pie charts, and narratives were used to present the findings.

The study revealed that, aligning the National Space Research and Development Agency (NASDRA) policies with the overarching objectives for agricultural development in Nigeria is crucial for ensuring sustainable growth. To assess this alignment, there is the need to first conduct a comprehensive review of both NASDRA's policies and the national agricultural development goals. By comparing key elements such as technology integration, data utilization, and collaborative initiatives, with the aim to identify synergies that promote innovation and efficiency in the agricultural sector in Nigeria. NASDRA's commitment to advancing space technology for agricultural benefits is evident in the Agro Space Integration Project (ASIP).

One key improvement needed in existing policies is the seamless integration of satellite data into agriculture practices. By leveraging satellite technology, NASDRA can obtain real-time information on soil health, crop conditions, and weather patterns. Policymakers should prioritize creating frameworks that encourage the adoption of precision agriculture techniques, enabling farmers to make data-driven decisions for optimized resource allocation, leading to increased productivity and sustainability.

The study showed that, in order to ensure effective coordination between NASDRA and allied agencies for agricultural development, it is imperative to align objectives. By integrating the goals of NASDRA with those of allied agencies, the agency can create a synergistic approach that leverages the strengths of each organization. This collaboration will enable a unified focus on key agricultural development priorities and foster a holistic strategy for the benefit of the agricultural sector. Effective coordination hinges on the harmonization of policies across

NASDRA and allied agencies. There is a need to strive to establish a cohesive framework that eliminates inconsistencies and aligns regulations, standards, and initiatives.

The study indicates that Nigerian farmers stand to gain significant benefits from the integration of space technology into agricultural practices. This innovative approach often revolutionize farming in Nigeria, leading to increased productivity, improved resource management, and enhanced food security. Satellite imagery and remote sensing technologies offer farmers unprecedented access to detailed, real-time information about their land and crops. These tools can provide accurate data on soil moisture levels, crop health, and potential pest infestations. By leveraging this information, farmers can make more informed decisions about irrigation, fertilizer application, and pest control, optimizing resource use and reducing waste.

The study found out that, one of the challenges in implementing space technology for agricultural development is the seamless integration of space-derived data into practical on-ground farming activities. While satellite imagery and remote sensing provide valuable information, translating this data into actionable insights for farmers, such as precision farming or irrigation management, requires overcoming technical and accessibility barriers. Another key challenge is the affordability and accessibility of space technology for farmers, particularly in developing area. High initial costs associated with acquiring and implementing space-based solutions, as well as limited availability of necessary infrastructure, can hinder widespread adoption.

The main beneficiary of this study is the Federal Government of Nigeria. The findings of the study provide the Nigerian government the impetus to pursue a policy change that is appropriate for the country. This study aims to provide insights into the current policies and institutional frameworks in place for exploitation of space technology for agricultural development, analyze their suitability and the implementation of the policies.

5.2 Conclusion

The first specific objective was to analyze the suitability of NASDRA's and allied agencies' policies and institutional frameworks for leveraging of space technology for agriculture development in Nigeria. The study revealed that, to evaluate the alignment of NASRDA policies with the broader objectives for agricultural development in Nigeria, NASRDA undertake a comparative analysis of policy frameworks and strategic documents. This includes assessing how NASRDA's initiatives align with the key pillars of agricultural development, such as food security, sustainable farming practices, and rural development. Additionally, NASRDA explore potential gaps and propose strategies for policy refinement to better support the overarching objectives. A comprehensive evaluation of NASRDA policies in relation to agricultural development objectives in Nigeria requires a performance metrics approach. NASDRA's commitment to advancing space technology for agricultural benefits is evident in the Agro Space Integration Project (ASIP). ASIP focuses on integrating space-based technologies, including satellite communication and earth observation, with traditional farming practices. This initiative not only improves communication and monitoring capabilities in remote agricultural areas but also facilitates precision farming, leading to increased efficiency, reduced resource wastage, and improved overall agricultural productivity.

The second objective of the study aimed at evaluating the implementation of NASDRA's and allied agencies' policies and institutional frameworks for effective exploitation of space technology for agriculture development in Nigeria. The study showed that, National Space Research and Development Agency's (NASRDA) policies have significantly contributed to the enhancement of agricultural productivity in Nigeria by strategically leveraging satellite applications. Through remote sensing and satellite imagery, NASRDA has enabled farmers to monitor crop health, identify pest infestations, and optimize irrigation, leading to improved yields and resource management. NASRDA's policies have played a crucial role in promoting precision agriculture techniques. By harnessing satellite data, farmers can precisely tailor their

farming practices, including seeding, fertilization, and irrigation, resulting in higher efficiency and reduced resource wastage. This has positively impacted the overall productivity of the agricultural sector in Nigeria.

Space technology also enhance crop monitoring and yield estimation. Satellite imagery often provide regular updates on crop growth and health across large areas, helping farmers and agricultural agencies identify potential issues early and respond promptly. This data also assist in more accurate yield forecasting, which is crucial for food security planning and market stability. Furthermore, space-based communication systems improve connectivity in rural areas, facilitating access to agricultural information, market prices, and extension services. This connectivity empower farmers with knowledge and enable them to make better-informed decisions about crop selection, timing of sales, and market access. Leveraging space technology for agricultural development in Nigeria has the potential to transform the sector, leading to increased productivity, sustainability, and resilience. By embracing these innovations, Nigerian farmers can position themselves at the forefront of modern agriculture, contributing to food security and economic growth in the country.

The third objective of this study aimed to access the challenges faced in adopting space technology for agricultural development in Nigeria. The study revealed one of the challenges in implementing space technology for agricultural development is the seamless integration of space-derived data into practical on-ground farming activities. While satellite imagery and remote sensing provide valuable information, translating this data into actionable insights for farmers, such as precision farming or irrigation management, requires overcoming technical and accessibility barriers. Another key challenge is the affordability and accessibility of space technology for farmers, particularly in developing regions. High initial costs associated with acquiring and implementing space-based solutions, as well as limited availability of necessary infrastructure, can hinder widespread adoption. Bridging the gap to make these technologies

more affordable and accessible is crucial for their practical integration into agricultural practices.

NASRDA's policy excels in providing support for research and innovation in agricultural practices through space technology. By fostering collaborations between scientists, researchers, and agricultural stakeholders, the organization contributes to the development of cutting-edge solutions. This strength positions the agricultural sector to adapt to evolving challenges and technological advancements. A weakness is the potential for funding constraints affecting the continuity of research and innovation initiatives. To maintain momentum and sustained progress, NASRDA should actively seek diversified funding sources and partnerships to ensure ongoing support for research and innovation in the agricultural sector.

5.3 Recommendations

On the basis of the findings of this research, the following recommendations are proposed which will assist in addressing some of the issues raised in the course of the research undertaking.

1. Centre for Satellite Technology Development of Nigeria should work towards fostering international collaborations for data sharing. Creating frameworks that facilitate the exchange of satellite data and technologies among countries can lead to more comprehensive insights into global agricultural trends.
2. Ministry of Science and Technology should provide subsidies for satellite imagery services and training programs on utilizing space technology to meet the specific needs of smaller farmers.
3. Ministry of Agriculture and Food Security in Nigeria should prioritize creating frameworks that encourage the adoption of precision agriculture techniques that will enable farmers to make data-driven decisions for optimized resource allocation.

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APPENDICES

Appendix 1: Research Authorisation-National Defence University Kenya

Appendix 2: Research Tool I - Key Interview Guide

Interview Questions

1. Can you provide insights into the evolution of space technology applications in agriculture since the establishment of NASRDA in 1999?
2. In your perspective, how aligned are the short-term and long-term objectives outlined in Chapter Two of the National Space Policy with the actual application of space technology in agriculture?
3. What key challenges do you think NASRDA and allied agencies face in achieving the goals outlined in the National Space Policy concerning agricultural development?
4. How has the landscape of space technology applications in agriculture changed since the launch of NigeriaSat-1 in 2003, and what impact has it had on the country's agricultural sector?
5. Can you elaborate on specific projects or initiatives that have been undertaken by NASRDA to promote the use of space technology for agricultural purposes?
6. In your opinion, how effective has the coordination been between NASRDA and relevant ministries, such as the Ministry of Agriculture & Food Security, in implementing space technology applications for agriculture?
7. What role do you see data collection and database establishment playing in achieving sustainable food production and food security, as outlined in the National Space Policy?
8. To what extent do you think NASRDA's policies consider the unique challenges and opportunities in Nigeria's agricultural landscape?
9. How would you assess the current level of awareness and understanding among key policymakers regarding the potential of space technology in agricultural development?
10. In your experience, what institutional frameworks or partnerships have proven successful in enhancing the integration of space technology into agricultural practices?

11. Can you identify any specific policy gaps or ambiguities that might be hindering the optimal utilization of space technology for agricultural development?
12. How do you perceive the role of NASRDA and its allied agencies in addressing the challenges faced in adopting space technology for agricultural development?
13. Are there any notable instances where NASRDA's policies and frameworks have been modified or updated to adapt to changing circumstances or emerging challenges in agriculture?
14. In your opinion, what role should international collaborations play in advancing Nigeria's space technology applications for agricultural development?
15. How do you envision the future trajectory of space technology utilization in Nigeria's agricultural sector, considering technological advancements and changing global dynamics?
16. Can you share insights into the funding mechanisms and budget allocations specifically dedicated to space technology applications in agriculture within NASRDA?
17. From your perspective, what are the key performance indicators that should be used to assess the success of space technology applications in agricultural development?
18. How do you think the involvement of the private sector could contribute to the successful implementation of space technology in Nigeria's agricultural landscape?
19. In your experience, what role does public awareness and education play in fostering the acceptance and effective use of space technology in agriculture?
20. What recommendations would you propose to enhance the synergy between NASRDA's policies and the practical implementation of space technology for optimal agricultural development in Nigeria?
21. How would you describe the current state of space technology utilization for agricultural development in Nigeria?

22. What, in your opinion, are the strengths and weaknesses of NASRDA's policies and institutional frameworks for agricultural development using space technology?
23. How do you perceive the level of alignment between NASRDA's objectives, as outlined in the National Space Policy, and the actual implementation in the agricultural sector?
24. What challenges have you observed in the adoption and implementation of space technology for agricultural development in Nigeria?
25. Can you highlight specific success stories or notable achievements resulting from the application of space technology in agriculture within the country?
26. How effective do you think NASRDA's collaborations with ministries, departments, and agencies have been in advancing agricultural development goals?
27. In your opinion, what role does space technology play in achieving food security and economic development in Nigeria?
28. How do you assess the coordination and communication among key stakeholders involved in the exploitation of space technology for agricultural purposes?
29. What improvements or modifications do you think are needed in existing policies and frameworks to optimize the benefits of space technology in agriculture?

Appendix 3: Questionnaire

QUESTIONNAIRE

This study aims to x-ray the policies and institutional frameworks guiding the exploitation of space technology for agricultural development in Nigeria expertise. As a senior-level policymaker and policy advisor, your response is crucial for the success of this study. Your responses will be treated with the utmost confidentiality, and your valuable insights will significantly contribute to the academic understanding.

❑ 1 = strongly agree, ❑ 2 = Agree, ❑ 3 = Un-decided, ❑ 4 = Disagree and ❑ 5 Reasons

Section One: Personal Information

Your age range?

❑ Below 30 years

❑ 30-39 years

❑ 40-49 years

❑ 50-59 years

❑ 60-69 years

Educational level?

❑ Tertiary College

❑ Undergraduate

❑ Postgraduate

❑ Other (specify) _____

Gender?

❑ Male

❑ Female

Specialty?

❑ Satellite Development and Operations

Space Applications
❑ Remote Sensing and Earth Observation

❑ Space applications

❑ Space Policy and International Cooperation
❑ Space Engineering and Technology
❑ Space Education and Outreach
❑ Other (specify) _____

Designation?

❑ Supervisor

❑ Manager

❑ Director

❑ Chairperson

❑ Other (specify) _____

Duration in the organization?

❑ 6 months

❑ 1 year

❑ 5 years

❑ 10 years

❑ 15 years

❑ 20 years

❑ 25 years

❑ 30 years

What is your duration in office to date?

Does National Space Research and Development Agency (NASRDA) accord agriculture appropriate priority as it ought to?

❑ Yes

❑ No

❑ Others (specify) _____

Are you familiar with the role of space technology in agricultural development in Nigeria?

❑ Yes

❑ No

❑ Others (specify) _____

Section Two: Suitability of Policies and Frameworks

1. How do you assess the alignment of NASRDA's policies with the overarching objectives for agricultural development in Nigeria?
2. In your view, how effectively do NASRDA's policies address the specific needs and challenges of the agricultural sector in Nigeria?
3. To what extent have NASRDA's policies contributed to the enhancement of agricultural productivity in Nigeria?
4. How would you describe the coordination between NASRDA's policies and those of allied agencies for effective agricultural development?
5. From your perspective, how well have NASRDA's policies been implemented for the exploitation of space technology in agriculture?
6. Can you identify specific challenges encountered in the practical implementation of space technology for agricultural development?
7. Do you believe modifications or updates to NASRDA's policies are necessary to better suit the evolving landscape of agriculture in Nigeria?

8. How do you assess the role of international collaborations in the successful implementation of space technology in agriculture in Nigeria?
9. In your experience, what are the primary challenges faced in adopting space technology for agricultural development in Nigeria?
10. Any additional remarks or suggestions for improving the exploitation of space technology for agricultural development in Nigeria?

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APPENDIX 4

LIST OF PARTICIPANTS INTERVIEWED IN THE COURSE OF THE STUDY

S/N	Name of Respondents	Designation	Place of Interview	Time and Date of Interview
1.	AA	Ministry of Agriculture & Food Security	Abuja	1:08pm on 10/01/2024
2.	AB	Ministry of Agriculture & Food Security	Abuja	4:30pm on 6/01/2024
3.	AC	Centre for Satellite Technology Development	Abuja	12:20pm on 11/01/2024
4.	AD	NASDRA	Kuje	11:04am on 7/01/2024
5.	AE	Centre for Satellite Technology Development	Abuja	2:10pm on 9/01/2024
6.	AF	Ministry of Science and Technology	Abuja	4:45pm on 10/01/2024
7.	AG	NASDRA	Abuja	10:00am on 13/01/2024
8.	AH	Ministry of Science and Technology	Kuje	2:45pm on 12/01/2024
9.	AI	Centre for Satellite Technology Development	Abuja	1:05pm 14/01/2024
10.	AJ	Ministry of Agriculture & Food Security	Abuja	12:25pm 16/01/2024
11.	AK	NASDRA	Abuja	11:00am 7/01/2024
12.	AL	Centre for Satellite Technology Development	Abuja	2:09pm 15/11/2024
13	AM	Ministry of Science and Technology	Abuja	1:24pm 29/01/2024
14	AN	Ministry of Agriculture & Food Security	Abuja	12:45pm 10/01/2024
15	AO	Ministry of Science and Technology	Abuja	2:01pm 11/01/2024
16	AP	NASDRA	Abuja	4:45pm 12/01/2024

Note:

Names are encoded to uphold the research ethics

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