Remote Sensing Technology Accessibility and Agricultural Development in Niger State (2020-2025)

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Abstract
Despite Nigeria's substantial investment in space infrastructure and the formulation of a National Space Policy aimed at promoting socio-economic development, the practical integration of remote sensing technology into agricultural development in Niger State remains limited due to weak institutional intervention and implementation gaps. This study examined remote sensing technology accessibility and agricultural development in Niger State from 2020 to 2025. Anchored in Actor Network Theory (ANT), the study conceptualised policy frameworks, institutions, technologies, and farmers as interconnected actors whose interactions shape technology adoption outcomes. The theoretical perspective provided an analytical lens for understanding accessibility constraints as outcomes of relational and institutional misalignments rather than purely technical deficiencies. A mixed-methods research design combining quantitative and qualitative approaches was employed. The findings revealed a significant disconnect between national policy intentions and state-level implementation. Although remote sensing technology was formally recognised as essential for agricultural planning, productivity enhancement, and climate risk management, its operational utilisation in Niger State remained minimal. Structural, financial, technical, and institutional barriers continued to limit large-scale farmers' access to satellite-derived data and related applications. The study recommended strengthening policy implementation mechanisms, enhancing inter-institutional coordination, improving data affordability and local relevance, and investing in sustained capacity-building initiatives. Addressing these challenges is critical for aligning national space policy objectives with agricultural development realities. The study contributed to policy discourse by advancing a network-based governance perspective necessary for achieving sustainable, technology-driven agricultural transformation in Niger State.

Keywords: Remote sensing technology, national space policy, agricultural development. actor–network theory, and policy practice gap.

Introduction
In recent decades, the integration of space science and Earth observation technologies into agriculture has become central to data-driven development. Remote sensing provides "large-scale, repetitive, and objective measurements of agricultural areas that supplement traditional field surveys," thereby enhancing crop monitoring, land-use analysis, and food security interventions (Nangendo, 2024). Its application has significantly improved crop yield estimation, drought monitoring, and precision agriculture globally.

However, the effective utilisation of remote sensing as a program under national space policy largely depends on the policies and institutional frameworks that govern space activities and data accessibility. Singh (2021) emphasises that in low and middle-income countries, the success of remote sensing technologies in providing operational agricultural services is strongly

determined by the robustness of these policies and institutional arrangements. Therefore, national space policies serve as strategic instruments for aligning space capabilities with priority sectors, such as agriculture and environmental management.

In Nigeria, the National Space Policy outlines a framework for applying space technologies to national development, including agriculture. Despite this, a gap persists between policy objectives and practical implementation. Abdullahi et al. (2024) note that although the National Space Research and Development Agency (NASRDA) is mandated to promote agricultural applications, implementation challenges related to funding, timelines, and institutional coordination remain significant.

These challenges are evident in Niger State, Nigeria's largest agrarian state, where the practical use of remote sensing remains limited despite its agricultural potential. This is due to weak institutional capacity, high technology costs, limited technical expertise, and poor coordination between space and agricultural institutions, which restrict farmers' access to satellite-derived information.

This study, therefore, examines the remote sensing technology accessibility and agricultural development in Niger State, 2020-2025. The period is significant due to renewed efforts to strengthen Nigeria's space development roadmap (2005–2030) and the 2025 collaboration between NASRDA and the Niger State Government to promote space-based agricultural technologies (NASRDA, 2025).

The expected role of Nigeria's National Space Policy is to facilitate the effective use of remote sensing technology for agricultural planning, productivity improvement, and climate risk management. In this regard, satellite-derived data should be accessible, affordable, and usable by agricultural institutions and decision-makers in agrarian states such as Niger State, ensuring that national space investments translate into tangible agricultural benefits.

However, the situation in Niger State between 2020 and 2025 reflects limited integration of remote sensing into agricultural development. Despite national investments in space infrastructure and policy frameworks, agricultural planning remains largely dependent on conventional methods. Access to satellite data is constrained by weak institutional capacity, limited technical expertise, high data acquisition costs, and inadequate dissemination mechanisms. Consequently, the potential of remote sensing to support crop monitoring, yield estimation, and climate adaptation remains underutilised. This situation reveals a clear gap between national policy objectives and state-level implementation.

Although space policy emphasises the importance of remote sensing for agricultural development, its practical application in Niger State remains minimal. Efforts such as satellite investments, policy reviews, and institutional collaborations have been introduced, yet challenges, including inadequate funding, institutional fragmentation, and weak coordination between space and agricultural agencies persist. This persistent gap underscores the need to examine the alignment between national space policy and remote sensing accessibility for agricultural development in Niger State. Such analysis is essential for identifying policy and institutional constraints affecting technology utilisation between 2020 and 2025, particularly given the state's strategic importance to national food security and its vulnerability to climate variability.

Objectives of the Study

i. To assess the ways national space policies and institutional frameworks integrated remote sensing technology into agricultural development in Niger State.

ii. To identify the challenges hindering large-scale farmers in implementing remote sensing technology for agricultural development in Niger State.

Empirical Literature

Sishodia et al. (2020), in their study titled, *Applications of Remote Sensing in Precision Agriculture: A Review*, examined the growing use of remote sensing (RS) technologies in precision agriculture (PA). The authors found that the adoption of remote sensing in agriculture has increased significantly, largely due to improvements in high-resolution satellite imagery, greater data availability and accuracy, and timeliness of satellite-based data for monitoring crop health, soil conditions, and farm management practices. However, the study identified a gap in that many farmers still lack access and practical knowledge of satellite imagery for precision farming. Although the authors recommended the development of simple, accurate, and user-friendly remote sensing systems for real-time applications, they did not clearly outline practical implementation strategies for enhancing farmer accessibility and adoption. Therefore, this present study seeks to address this gap by examining how satellite imagery, and remote sensing can be systematically integrated into agricultural development, building human capacity, improving accessibility, and strengthening institutional support to enhance the practical application in Niger State.

Bégué, et al. (2020) conducted a study titled "Remote Sensing Products and Services in Support of Agricultural Public Policies in Africa: Overview and Challenges". The study adopted a review-based analytical approach, synthesising existing literature and recent technical advancements in remote sensing. The study identified a significant gap between the technical potential of remote sensing and its actual integration into agricultural policymaking across SSA. The authors recommended the importance of capacity building at both institutional and individual levels to enhance the understanding and use of geo-information. The authors actually noted the gap between the technical benefit of remote sensing and the unification of policymaking into agricultural practices. However, the study did not identify how such a policy can be reviewed in achieving integration into agriculture, and its location was the whole of Africa. Therefore, this research will fill the gap by integrating space policy into agriculture in Niger State through the organised programme of space institutions like NASRDA.

Abdullahi et al. (2024) conducted a study titled "Assessing Institutional Policy and Framework Effectiveness for Space Technology in Nigerian Agricultural Development". The study employed a qualitative, document-based analysis, involving a comprehensive review of government policy documents. The findings indicated that the use of space technology in Nigerian agricultural development is advancing, largely due to collaborative efforts among NASRDA, other research institutions, and private sector stakeholders. The authors recommended increased investment in both financial and human resources for NASRDA and its affiliated agencies to strengthen their capacity to develop and sustain space infrastructure. The authors identified that the collaboration with NASRDA and other research institutions are improving agricultural activities in Nigeria. However, the gap in the study was that it did not indicate any particular state in which they collaborated in Nigeria, and their activities during collaboration were not mentioned. Therefore, this research will fill the gap by specifying a state like Niger and outlining the activities that could be used in integrating the space policy into agricultural activities in Niger State.

Oke & Akindele (2022), in their study titled "Challenges and Prospects of Remote Sensing and GIS Technology for Forest Resources Management in Nigeria", examined the application of Remote Sensing (RS) and Geographic Information System (GIS) technologies in forest resource management using a literature review approach. The authors found that forest resource management in Nigeria is significantly constrained by the absence of accurate, reliable, and up-to-date spatial data. The study therefore recommended increased investment in remote sensing infrastructure, improved institutional support, and enhanced technical capacity building for professionals involved in resource management. However, though the authors clearly identified

the lack of accurate data as a major challenge, they did not sufficiently explain how remote sensing technology could practically mitigate this data gap within Nigeria. Therefore, this research seeks to fill this gap by critically assessing the challenges hindering large-scale farmers in implementing remote sensing technology for both resource management and agricultural development in Niger State.

Wu et al. (2022) conducted a study titled "Challenges and Opportunities in Remote Sensing-Based Crop Monitoring: A Review". The study was a review paper that examined recent progress in satellite-based crop monitoring. The findings were that satellite-derived crop data often lack quantitative, objective, and robust methods to ensure reliability. The authors recommended the integration of satellite-derived metrics with new onboard sensors for better crop growth assessment. The authors found that the satellite-derived crop data lacked quantitative, objective and method to ensure consistency. However, the gap in the study was that it depends only on quantitative and objective methods in getting stable data and could not mention other methods of collecting accurate data. Therefore, this research will fill the gap by identifying other methods to assess exact data in order to evaluate those challenges militating against large-scale farmers in using remote sensing technology into agriculture in Niger State.

Nangendo (2024) conducted a study titled "Applications of Remote Sensing Technology in Agriculture: A Review of Contributions to Food Security Challenges and Strategies in Developing Countries". The study adopted a literature review methodology, systematically analysing existing academic and case-based literature to evaluate the role and impact of remote sensing (RS) technology in agricultural applications. The study found that remote sensing has had a substantial and transformative impact on agriculture in developing countries. It recommended several strategic interventions, including improving data availability and accessibility, investing in capacity building and policy reforms. The author identified that remote sensing has essentially contributed to agriculture in developing countries. However, the gap in the study is that it did not have a specific location, and it failed to mention the impact of remote sensing on agriculture in developing countries. Therefore, this research will fill the gap by focusing on Niger State and outlining the impact of remote sensing technology among large-scale farmers, as the challenge of accessibility will be mitigated through a subsidy from the State government.

Although existing empirical studies, including Bégué et al. (2020); Abdullahi et al. (2024), Wu et al. (2022), and Nangendo (2024), have examined different dimensions of remote sensing, agricultural policy, and institutional capacity, they collectively reveal a persistent gap at the intersection of space policy, institutional frameworks, data accessibility, and farmer-level application, particularly at the sub-national (state) scale. Specifically, there remains limited empirical evidence on how Nigeria's national space policies are interpreted, operationalised, and translated into concrete institutional programmes that directly support agricultural development in localised contexts such as Niger State. Little is known about how these policy institutional processes shape large-scale farmers' access to, and effective utilisation of remote sensing technologies. In response to these gaps, the present research will examine the degree of alignment between Nigeria's national space policy and institutional practices, with particular emphasis on NASRDA-led programmes, and analyse how these arrangements influence technology accessibility for large-scale farmers who recognise its potential for enhancing production. By adopting this focus, the research moves beyond generalised national-level assessments to provide a context-specific understanding of policy translation, institutional coordination, and practical pathways for improving farmers' access in Niger State.

Theoretical Framework

Actor–Network Theory (ANT)

Latour et al. (1980s), a French sociologist, expounded the Actor-Network Theory (ANT) at the Centre de Sociologie de l'Innovation (Latour, 2005). Originally developed to study scientific and technological innovation, ANT rejects traditional dualisms like subject/object and nature/society, proposing instead that both human and non-human actors ("actants") form networks that shape social realities (Law, 1992). ANT assumes that agency is distributed across the network, meaning that non-human actors, like remote sensing devices or software platforms, can influence processes and decisions just as human actors do. The theory also assumes that change or innovation does not occur in isolation, but is the result of alignment, negotiation, and translation among all actors within the network, making the network itself the fundamental unit of analysis. Therefore, the study was anchored in Actor–Network Theory (ANT). In the context of Niger State, national space policy documents, remote sensing technologies, institutions, extension systems, and farmers are understood as interconnected actors whose relationships shape accessibility and utilisation. ANT thus provides a robust analytical lens for understanding accessibility challenges not merely as technical deficits but as relational and institutional failures (Callon et al., 2019).

Methodology

Research Design

This study adopted a mixed-methods survey design, combining quantitative and qualitative approaches to examine the application of remote sensing technology for agricultural development. This approach enabled a comprehensive understanding of policy alignment and accessibility challenges.

Population of the Study

The study covered six Local Government Areas (LGAs): Bosso, Chanchaga, Katcha, Lapai, Kontagora, and Rijau, purposively selected from the three senatorial zones of Niger State to ensure geographical representation. The target population comprised key agricultural stakeholders, including officials of the Niger State Ministry of Agriculture, large-scale farmers using remote sensing, small-scale farmers aware but not using the technology, relevant staff of the Federal University of Technology, Minna, representatives of the State Farmers Association, and community leaders.

Sample Size

The sample size was determined using the Taro Yamane (1967) formula. Based on this method, a total of 400 respondents were selected from the six LGAs for questionnaire administration. The distribution of questionnaires and percentages is presented in the table below.

Table 1: Sample Size Distribution of Questionnaire

Category of Targeted Population	Population	Total sample	Percentage (%)
Katcha L.G.A(South)	1,244	71	18
Lapai L.G.A (South)	1,048	59	15
Bosso L.G.A (East)	937	53	13
Chanchaga L.G.A (East)	1,433	81	20
Rijau L.G.A (North)	428	24	6
Kontagora L.G.A (North)	1,965	111	28
Total	**7,055**	**400**	**100**

Source: Field Survey 2026

The distribution shows adequate geographical representation across the study area.

Sampling Technique

A multi-stage sampling technique was employed. In the first stage, six LGAs were purposively selected. In the second stage, cluster sampling was used to group respondents within each LGA, followed by simple random sampling to select individual respondents for questionnaire administration. For the qualitative component, purposive sampling was used to select key informants, including government officials, university experts, farmers' association leaders, and large-scale farmers. Snowball sampling was also used to identify additional large-scale farmers utilising remote sensing technology but not formally registered.

Method of Data Collection

The study employed both primary and secondary methods of data collection to ensure a comprehensive understanding of the research topic. Primary data were gathered through structured questionnaires and interviews, while secondary data were obtained from credible and peer-reviewed scholarly publications, institutional reports, policy documents, and empirical studies relevant to the research objectives.

Table 2: Source of Secondary Data

Source/Organization	Type of Data Collected	Purpose of Use
Federal Ministry of Agriculture and Rural Development (FMARD)	Policy documents, reports on agricultural development and technology adoption	Understanding the national agricultural policy context
Food and Agriculture Organisation (FAO)	Reports on remote sensing applications, food security, and sustainable agriculture	Supporting the relevance and global application of remote sensing in agriculture
National Space Research and Development Agency (NASRDA)	Satellite imagery reports, publications on space-based agricultural monitoring	Establishing technical potential and current capabilities in remote sensing
Niger State Ministry of Agriculture and Rural Development	State-level agricultural statistics and planning documents	Providing local contextual data for Niger State
Research Databases (e.g. citejournal.org, Google Scholar, Academia, Joster)	Peer-reviewed journal articles, theses, and dissertations on related themes	Providing scholarly background and conceptual frameworks
Institutional Repositories and Academic Journals	Previous studies, conference papers, and theoretical reviews	Supporting triangulation and validating primary data

Source: Field Survey 2026

Table 2 presents the key sources of secondary data used to explore the extent of remote sensing (RS) application in Niger State. The sources span federal, state, and academic levels, providing a comprehensive qualitative and documentary foundation for the study. At the federal level, the Federal Ministry of Agriculture and Rural Development (FMARD) contributed policy documents and reports, which contextualise the study within Nigeria's national agricultural policy and technology adoption framework. Similarly, the Food and Agriculture Organisation (FAO) provided global perspectives on RS applications, food security, and sustainable agriculture, demonstrating the broader relevance of these technologies. Technical insights and capabilities were obtained from the National Space Research and Development Agency (NASRDA) through

satellite imagery reports and publications on space-based agricultural monitoring, highlighting Nigeria's existing RS infrastructure. At the state level, the Niger State Ministry of Agriculture and Rural Development supplied agricultural statistics and planning documents, offering critical local context necessary to assess the RS application within the state. Academic sources, including research databases and institutional repositories, provided peer-reviewed journal articles, theses, dissertations, conference papers, and theoretical reviews. These sources supported the development of conceptual frameworks, triangulated findings, and validated documentary data.

Techniques for Data Analysis

This study employed a combination of quantitative and qualitative methods of data analysis. The quantitative data were analysed using descriptive statistical techniques, which include frequency distributions and simple percentages. The qualitative data were analysed using content analysis, which involved systematically categorising responses to identify recurring themes and patterns. Chi-square is used for testing relationships.

Data Analysis and Results

The first objective of the study was to assess the ways national space policies and institutional frameworks integrated remote sensing technology into agricultural development in Niger State.

Table 3. The Ways National Space Policies and Institutional Frameworks Integrated Remote Sensing Technology into Agricultural Development in Niger State.

S/N	Statements (Summarised)	Mean	SD	Decision
1	Policy integration into agriculture	1.72	0.713	Disagree
2	Institutional guidance	2.04	0.818	Disagree
3	State policy support	1.78	0.691	Disagree
4	Agency collaboration	1.58	0.678	Strongly Disagree
5	Training availability	1.94	0.579	Disagree

Source: Field Survey 2026.

The first objective of the study was to assess how national space policies and institutional frameworks have integrated remote sensing technology into agricultural development in Niger State. The results in Table 1 indicate that the integration of remote sensing into agricultural practices through policy and institutional support remains very limited.

The quantitative results from Table 1 are similar to comments from interviews with some of the participants who unanimously agreed that they have not benefited from NARSDA in the region. One of the participants' views was captured thus:

> Honestly, institutions like NASRDA and the Ministry of Agriculture have not contributed to integrating remote sensing technology in our farming activities. We have not received any guidance, support, or training from them, and there is no visible presence of these technologies in our agricultural practices **(**IDI/ Male/Farmer/Bosso LGA/Niger State/February 2026).

Another participant who is an agriculturist buttressed that:

> National policies have not translated into any practical tools, training, or support for farmers here. We do not have access to remote sensing equipment, there are no training programs, and no support systems have been provided to help us apply these technologies in our farming activities (IDI/Female /Farmer/Chanchaga /Niger State/February 2026).

The excerpt highlights the lack of practical support and resources available to farmers, despite the existence of national agricultural policies. The poor implementation of training programmes, tools, and support systems creates a structural gap that limits farmers' access to remote sensing technology. As a result, many farmers remain unable to benefit from modern agricultural innovations, reflecting a clear disconnect between policy intentions and actual delivery.

The second objective of the study was to identify the challenges hindering large-scale farmers in implementing remote sensing technology for agricultural development in Niger State.

Table 4: Challenges Hindering Large-Scale Farmers in Implementing Remote Sensing Technology for Agricultural Development in Niger State

S/N	Statements (Summarised)	Mean	SD	Decision
1	Poor collaboration between space agencies and agricultural departments	1.67	0.715	Disagree
2	Lack of training and capacity-building programmes	1.62	0.736	Disagree
3	High cost of remote sensing equipment	1.64	0.726	Disagree
4	Lack of technical knowledge and expertise	1.66	0.663	Disagree
5	Limited government support	1.67	0.715	Disagree
6	Lack of collaboration with technology providers and research institutions	1.62	0.736	Disagree
7	Delays in policy implementation	1.64	0.726	Disagree

Source: Field Survey 2026

The second objective of the study was to identify the challenges that hinder large-scale farmers in implementing remote sensing technology for agricultural development in Niger State. The data in Table 2 indicate that several interrelated structural, institutional, and technical challenges limit the adoption and effective use of remote sensing technologies.

The qualitative data obtained from interviewees indicate that there is a divergent perspective that there is no access to remote sensing technologies, based on the data from participation in the region. One of the respondents argued that:

> Remote sensing tools are neither accessible nor affordable for large-scale farmers in this region. Most of us cannot obtain these technologies because they are expensive, unavailable locally, and there is no support from the government or institutions to make them more accessible or cost-effective (IDI/Male /Farmer/Rijau LGA/Niger State/February 2026).

Other interviewees reiterated that:

> Yes, I encounter major difficulties, but the main issue is that I have never actually used remote sensing tools or received any training on them. Without access or guidance, it is impossible to interpret or apply the data for farming activities. (IDI/Female/Farmer/ KotongoraLGA/Niger State/February 2026).

The excerpt highlights that limited access, training, and support restrict farmers' use of remote sensing technology, similar to how traditional barriers limit women's political participation. Without tools, guidance, or training, farmers are disadvantaged in applying technology to improve productivity. Providing resources, technical training, and support is essential to enable effective use of remote sensing and participation in modern agriculture.

Discussion of Findings

The first objective of the study was to assess how national space policies and institutional frameworks have integrated remote sensing technology into agricultural development in Niger State. Findings from Table 1 indicate that policy and institutional support for remote sensing remains weak and largely ineffective. Although national space policies and NASRDA-led frameworks provide a foundation for remote sensing in Nigeria, their implementation in Niger State is limited due to weak operationalisation and insufficient local-level support (Abdullahi, Handa, & Kimuyu, 2024).

The second objective was to identify the challenges hindering large-scale farmers from implementing remote sensing technology for agricultural development in Niger State. Findings from Table 2 indicate that structural, institutional, financial, and technical barriers significantly limit both the adoption and effective utilisation of such technologies, even among farmers who have the financial capacity to acquire them. Similarly, Wu et al. (2022) highlight that the effective use of remote sensing in agriculture is often constrained by challenges related to the reliability and consistency of satellite-derived crop data.

Recommendations

i. To ensure effective integration of national space policies and institutional frameworks, government agencies, research institutions, and agricultural departments should collaborate to operationalise policies, provide guidance, funding, and training programs, ensuring policies translate into tangible benefits for farmers and extension officers. The Niger State Ministry of Agriculture, policy-making bodies, and research institutions should champion this recommendation.

ii. It is also recommended that targeted interventions be implemented to address the structural, institutional, financial, and technical barriers limiting the adoption of remote sensing technologies among large-scale farmers in Niger State. Such efforts should focus on improving access to reliable satellite data, providing technical training and support, and strengthening institutional frameworks to facilitate the effective utilization of these technologies.

Conclusion

Although national space policies and institutional frameworks provide a foundation for remote sensing in agriculture, their implementation in Niger State remains limited. Large-scale farmers face structural, institutional, financial, and technical barriers that hinder adoption and effective

use. Strengthening policy operationalization, improving access to reliable satellite data, and providing training and support are essential to ensure remote sensing technologies translate into tangible agricultural benefits in the state.

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