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Geomatics tools for agricultural and farm disaster risk management and reduction: A survey of farmers in South-South coastal communities, Nigeria

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ABSTRACT

This paper examined how geomatics, a technology, reduces and manages agricultural risk disasters in the coastal areas of South-South, Nigeria. A total of 450 farmers was randomly selected from 18 coastal communities of the South-South, Nigeria, known to have experienced disasters. Questionnaire and oral interview were used to elicit information from the farmers. Descriptive tools were used to analyze and interpret data obtained. Results showed the common agricultural risks/hazards in the area include flooding (100%), soil erosion (69.3%), oil spillage (99.7%), drying up of rivers and streams (91.1%), resource conflicts (98.8%) among other risks. Tools such as Geographic Information Systems (GIS), remote sensing (88.8%), digital elevation models (67.5%), and land use planning (58.4%), oil spill risk mapping (99.3%) among others, are in use the study area. Geomatics reduce disaster by mapping out agricultural lands (M=3.37), helps to identify soil types (M=3.87), monitor rainfall (M=3.06), helps to identify flood-prone areas (M=3.66), pests/diseases surveillance (M=3.38) among others. The challenges that limit use of geomatics include weak disaster coordination (84.4%), inadequate manpower (68.2%), high cost of technology (77.7%), financial sustainability (84.3%), and lack of awareness (73.3%). Solutions to the problems include developing agro-based risk & hazard maps, promotion of farmer-friendly geospatial information use, building institutions for effective governance.

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INTRODUCTION

Agriculture is a vital component for economic advancement, food safety, and the sustenance of livelihoods in Nigeria, especially within the South-South coastal area, known for its vast wetlands, mangrove ecosystems, and river systems. Nonetheless, the agricultural output in this region faces mounting threats from various environmental challenges, including flooding, coastal erosion, soil degradation, oil pollution, and fluctuations related to climate. These challenges not only diminish crop production but also disrupt the livelihoods of rural communities, increasing poverty levels and food insecurity (Bello *et al.*, 2025). In recent times, the use of geomatics tools—such as Geographic Information Systems (GIS), Remote Sensing (RS), Global Navigation Satellite Systems (GNSS), and Unmanned Aerial Vehicles (UAVs)—has proven to be an effective strategy for managing agricultural hazards and crises. Geomatics refers to the gathering, analysis, interpretation, and handling of spatial information, which empowers stakeholders to track environmental changes and make well-informed decisions. For instance, technologies like GIS and remote sensing are extensively utilized for tasks including mapping land usage, monitoring crop health, evaluating flood risks, and forecasting the effects of disasters (Bello *et al.*, 2025). The deployment of geomatics in managing disaster risks spans all stages of the disaster management cycle: mitigation, preparedness, response, and recovery. For example, remote sensing data can assist in pinpointing areas at high risk of flooding, while GIS-based frameworks can analyze the spatial interactions among environmental factors and agricultural resilience. These innovations facilitate the creation of early warning systems and risk assessment maps that are crucial for mitigating disaster effects (Amatebelle *et al.*, 2025).

In Nigeria, geomatics technologies have found applications across various environmental and agricultural domains, such as erosion risk mapping, flood vulnerability assessments, and land-use monitoring. Research indicates that Geographic Information Systems (GIS) and remote sensing are

effective tools for evaluating soil erosion, mapping flood risks, and monitoring land degradation (Makinde and Oyebanji, 2018; Alimi *et al.*, 2023). Nevertheless, the uptake and application of these technologies among farmers, particularly smallholder farmers in rural coastal areas, remain quite limited. The South-South region of Nigeria faces pronounced vulnerability to climate-related threats, including seasonal flooding, rising sea levels, and saline intrusion, which negatively impact agricultural productivity. Given that rural communities heavily depend on agriculture, there is an urgent need to incorporate geomatics tools into local farming practices to bolster resilience and sustainability. However, the success of these geomatics solutions is closely tied to farmers' awareness, accessibility to tools, and their ability to effectively use such technologies. A significant number of farmers lack the technical expertise, financial means, and necessary institutional support to embrace these innovations. As a result, a disconnect exists between the accessibility of geomatics technologies and their practical utilization at the community level. Agricultural practices in South-South coastal Nigeria are increasingly at risk from environmental challenges like flooding, erosion, and climate variability, which severely jeopardize food security and rural livelihoods. Despite the presence of sophisticated geomatics tools that could enhance disaster risk management, their use among farmers is still notably low.

A principal issue is the limited awareness and technical knowledge that farmers possess regarding GIS, remote sensing, and other geospatial tools. Many continue to depend on traditional farming techniques and disaster response strategies, which often prove insufficient amidst rising environmental uncertainties. Furthermore, restricted access to geomatics tools and supporting infrastructure presents a considerable hurdle. The high costs associated with acquiring geospatial technologies, combined with inadequate institutional support and poor extension services, hinder their implementation in rural settings. Consequently, farmers miss out on

the advantages of early warning systems, risk mapping, and data-driven decision-making strategies.

The significance of this research is rooted in its ability to enhance agricultural resilience and minimize disaster risks in vulnerable coastal communities. With the escalating impacts of climate change, there is a pressing need for innovative, technology-driven methods in agricultural management. Geomatics tools offer a scientific, data-based framework for understanding and tackling agricultural risks. These tools facilitate the mapping and monitoring of environmental shifts, pinpoint vulnerable regions, and help develop effective mitigation strategies. For example, GIS and remote sensing technologies have been widely acknowledged for their roles in supporting disaster preparedness, risk assessment, and recovery planning (Merrett and Chen, 2013). This study is warranted by the necessity to close the gap between technological innovations and their practical use by farmers. By evaluating the awareness and usage levels of geomatics tools among farmers, the research will reveal barriers to adoption and guide policy initiatives aimed at increasing technology integration. Moreover, the findings will be instrumental for policymakers, agricultural extension agents, researchers, and development organizations engaged in disaster risk management and rural development. The insights gained will aid in crafting tailored training programs, capacity-building efforts, and policy frameworks that encourage the application of geomatics tools in agriculture.

There is a significant shortfall in the integration of geomatics tools within agricultural policies and disaster management strategies at both local and regional levels. This gap impedes the effective distribution and use of geospatial information crucial for risk reduction. Additionally, the lack of localized data and tailored applications of geomatics technologies poses a critical challenge. Most research and tools currently in use are designed at national or global levels, rendering them less relevant to the unique environmental and socio-economic contexts of South-South coastal communities. As a result, the

ongoing disconnect between the advancement of geomatics technology and its practical application among farmers intensifies their vulnerability to agricultural disasters. Bridging this gap is vital for enhancing resilience, boosting productivity, and promoting sustainable agricultural development. This study aims to explore the impact of geomatics tools on agricultural and farm disaster risk management and reduction, specifically targeting farmers in South-South coastal communities of Nigeria. It will evaluate the awareness, accessibility, and utilization of these tools while identifying the challenges that obstruct their adoption. The specific objectives include to- a). Identify the major agricultural hazards and disaster risks affecting farmers in the study area; b). examine available geomatics tools (GIS, remote sensing, GNSS, etc.) in agricultural practices; c). describe effective roles of geomatics tools in disaster risk management and reduction; d). Identify the challenges limiting the adoption of geomatics technologies among farmers; e). propose strategies for improving the adoption and use of geomatics tools in agricultural disaster.

MATERIALS AND METHODS

The research was carried out in the coastal regions of South-South Nigeria, encompassing states like Rivers, Bayelsa, Delta, Akwa Ibom, Cross River, and Edo. These regions are known for their high levels of rainfall and humidity, frequent flooding, erosion, and coastal risks. They largely consist of agrarian populations reliant on agriculture and fishing. Given these environmental challenges, the area was chosen for this study due to its heightened susceptibility to agricultural disasters (Nwilo and Badejo, 2006). Demographically, the area is ethnically diverse, home to groups like the Ijaw, Itsekiri, Urhobo, Efik, Ibibio, and Edo, each with unique cultural identities that add to Nigeria's rich heritage. With a predominantly rural population depending on subsistence farming and fishing, urban centers like Uyo, Calabar, Benin City, and Port Harcourt are rapidly growing due to industrialization and migration. The region's environmental landscape faces significant threats from climate change, including flooding, coastal

erosion, and rising sea levels, which often disrupt agricultural productivity and threaten rural livelihoods. Additionally, the vast mangrove ecosystem, among the largest in Africa, is endangered by natural and anthropogenic pressures. Therefore, the pressing need for sustainable resource management and disaster risk reduction strategies is paramount (Uyigüe and Agho, 2007). While the South-South region is well-suited for cultivating crops like cassava, yam, maize, oil palm, and various vegetables, along with flourishing fishing activities, environmental degradation and climate variability threaten food security. There is an increasing interest in adopting modern technologies such as geomatics tools to improve agricultural planning and disaster management efforts. The study employed a descriptive survey research design to investigate how farmers in these coastal communities utilize geomatics tools for managing agricultural and farm-related risks. Utilizing a survey approach is fitting as it facilitates data collection from a representative sample of farmers, allowing findings to be extrapolated to a broader audience. The study population consisted of all registered and active farmers from selected coastal communities in South-South Nigeria, including those engaged in crop farming, fishing, and mixed agriculture, who are at risk from climate-induced disasters like flooding, erosion, and saltwater intrusion. These farmers are the main users and beneficiaries of geomatics-driven agricultural risk management systems. For this study, a total of 450 respondents were chosen through a multi-stage sampling method. Initially, purposive sampling identified coastal areas vulnerable to agricultural threats. Next, stratified sampling grouped farmers according to their farming practices—be it crops, livestock, or fisheries. Lastly, simple random sampling was utilized to select individual participants within each group, ensuring equal representation and minimizing bias. Data were gathered from both primary and secondary sources. Primary data came from structured questionnaires distributed to the 450 farmers, concentrating on their awareness, accessibility, and utilization of geomatics tools for disaster risk management. Additional insights were

acquired through interviews and field observations to corroborate the questionnaire responses. Secondary data were compiled from agricultural organizations, academic journals, and satellite imagery reports to enhance the field data. Descriptive statistics, including frequencies, percentages, and mean scores, were employed to summarize the responses from farmers.

RESULTS AND DISCUSSION

Major agricultural/farm hazards and disasters in South-South Nigeria

Several risks and hazards are associated with farming. Table 1 showed them to include flooding (100%), drought and prolonged dry spell (88.2%), soil erosion and land degradation (69.3%), pests/diseases outbreaks (68.8%), climate variability and extreme events (91.1%), uncontrolled bush fires (90.6%), post-harvest/storage risks/losses (95.7%), resource conflicts (98.8%), theft/pilfering (99.3%), oil spillage/pollution (99.7%) and drying up of rivers and streams (91.1%).

Agricultural systems and rural livelihoods face a growing array of hazards and disaster risks that can severely impact productivity, food security, and income continuity. Key among these are climate-related threats, notably droughts, floods, and unpredictable rainfall. Drought conditions diminish soil moisture, inhibit crop development, and often result in crop failures, which is particularly concerning for rain-fed farming typical in sub-Saharan Africa. In contrast, heavy rainfall and flooding can devastate crops, erode soil, and wash away essential farming inputs, disrupting the essential cycles of planting and harvesting (FAO, 2021). The variability in climate patterns also leads to alterations in growing seasons and adds uncertainty, complicating farmers' efforts to plan their activities effectively (IPCC, 2022). Biological hazards represent another significant risk, affecting both crops and livestock. Invasive crop pests like the fall armyworm and locusts have inflicted considerable damage on staple crops, while plant diseases compromise both the yield and quality of produce.

Additionally, livestock health is threatened by diseases such as foot-and-mouth disease and avian influenza, which can lead to substantial losses in animal populations and incomes for farmers (World Bank, 2020). Climate change often exacerbates these biological challenges by influencing pest and disease spread. Furthermore, environmental degradation adds yet another dimension of risk. Issues like soil erosion, deforestation, and reduced soil fertility progressively diminish land productivity. Unsustainable farming methods, including excessive grazing and improper agrochemical applications, further exacerbate land degradation and contribute to water pollution, undermining the resilience of rural communities (UNDP, 2019). Water shortages, driven by both climate impacts and the overexploitation of resources, also hinder irrigation efforts and affect crop productivity. On a socio-economic level, various risks intensify the vulnerabilities faced by the agricultural sector. Limited access to credit, markets, and agricultural advisory services can hinder farmers from adopting better technologies and adapting to changing environmental conditions. Inadequate infrastructure, such as poorly maintained rural roads and insufficient storage facilities, leads to post-harvest losses and diminishes profitability. Additionally, conflicts and insecurity in rural zones can displace farming families, disrupt agricultural practices, and restrict access to arable land (IFAD, 2021). In summary, the risks associated with agriculture and disasters are multifaceted, involving climatic, biological, environmental, and socio-economic dimensions. The cumulative impacts of these threats pose a serious risk to farming systems and rural livelihoods, particularly in developing regions. To effectively address these issues, integrated strategies are necessary to bolster climate resilience, enhance pest and disease management, encourage sustainable land practices, and fortify institutional support structures.

Geomatics tools for agricultural and farm disaster risk reduction

Table 2 showed various spatial data tools for disaster risk reduction. These tools are Geographic

Information Systems (GIS) (91.1%), remote sensing (88.8%), hazard mapping (70.6%), digital elevation models (67.5%), light detection and ranging (53.3%), geotechnical soil testing (86.6%), participatory community mapping (89.1%), watershed and drainage analysis (64.4%), seismic risk assessment tools (76.6%), land use planning/zoning (98.4%), oil-spill risk mapping (99.3%), coastal erosion mapping (98.0%), and satellite monitoring of lakes (68.8%).

Geomatics tools, which include Geographic Information Systems (GIS), remote sensing, Global Navigation Satellite Systems (GNSS), and spatial data analytics, have become indispensable in assessing and monitoring agricultural vulnerabilities. These technologies deliver precise and timely spatial information that significantly enhances decision-making processes within the agricultural sector, especially in areas prone to climate fluctuations and environmental threats.

By aggregating spatial datasets from various sources like satellites, drones, and ground observations, geomatics tools facilitate the identification of high-risk zones and the evaluation of how hazards affect agricultural systems (FAO, 2020a). One of the standout features of geomatics tools is their capability to track climate-induced risks such as droughts and floods. Remote sensing technology, particularly satellite imagery, offers ongoing surveillance of vegetation vitality, soil moisture levels, and rainfall distributions across vast regions. Indicators like the Normalized Difference Vegetation Index (NDVI) are commonly utilized to identify crop distress and estimate possible reductions in yield. These findings are vital for establishing early-warning systems that empower farmers and decision-makers to implement preventative or adaptive actions (NASA, 2021). Likewise, GIS-based flood assessments can pinpoint at-risk agricultural land and inform land-use strategies to reduce potential damages. Moreover, these tools play a crucial role in managing agricultural biological threats, such as pest infestations and diseases.

Table 1. Major agricultural hazards/disaster risks

Major hazards/Risks	*Frequency	Percentage
Flooding	450	100
Drought/prolonged dry spell	397	88.2
Soil erosion and Land degradation	312	69.3
Pests/diseases outbreak	310	68.8
Climatic variability/extreme events	410	91.1
Uncontrolled bush fires	408	90.6
Post-harvest/storage risks/losses	431	95.7
Resource conflicts	445	98.8
Theft/pilfering	447	99.3
Oil spillage/pollution	449	99.7
Drying up of river/stream	410	91.1

*Multiple responses

Table 2. Geomatics tools for disaster risk reduction

Geomatics tools	*Frequency	Percentage
Geographic Information Systems	410	91.1
Remote sensing	400	88.8
Hazard mapping	318	70.6
Digital elevation models	304	67.5
Light Detection & Ranging (LiDAR)	240	53.3
Geotechnical soil testing	390	86.6
Participatory community mapping	401	89.1
Watershed & Drainage Analysis	280	64.4
Seismic Risk Assessment tools	345	76.6
Land-use planning/zoning	443	98.4
Oil-spill risk mapping	447	99.3
Coastal erosion mapping	443	98.0
Satellite monitoring of lakes	310	68.8

*Multiple responses

Spatial analytics enable the monitoring of pest movements like those of fall armyworms or locust swarms, facilitating targeted action measures. By combining environmental data with pest occurrence statistics, GIS models can forecast outbreak zones and assist in executing timely control approaches (World Bank, 2019). In livestock management, geomatics technologies aid in tracking grazing behaviors and identifying disease occurrences, thus enhancing health management practices for animals. Geomatics also plays a vital role in promoting sustainable management of land and resources. Through mapping land use and coverage, these tools highlight issues such as soil erosion, deforestation, and water scarcity. This information is essential for advancing climate-smart agricultural initiatives and directing conservation efforts. Furthermore, the integration of GNSS with precision agriculture techniques allows farmers to maximize resource efficiency, cut down on waste, and boost productivity levels (UNDP, 2021).

Despite their numerous benefits, the success of geomatics tools is influenced by factors like data accessibility, technical expertise, and institutional backing. In several developing regions, challenges such as restricted access to high-quality data, insufficient infrastructure, and a shortage of skilled workers can limit their utilization. Nevertheless, continuous improvements in open-source technologies and training programs are making progress towards overcoming these challenges.

Geomatics applications in farm disaster reduction and management

Table 3 showed geomatics applications for disaster risk reduction in agriculture. These are mapping of agricultural lands/forests (M= 3.37), guides in selecting crop/fertilizer (M= 3.87), helps to identify soil types (M= 2.87), monitoring of rainfall (M= 3.06), identifies flood-prone areas in farmland (M= 3.66), detection of vegetation stress (M= 3.27), identify soil

moisture (M= 3.18), pests/diseases surveillance (M= 3.38), use for precision agriculture (M= 3.03), optimization of irrigation schedules (M= 3.52), defines actual boundary (M= 3.12), predictions of crop yields (M= 3.18), deforestation monitoring (M= 2.94), crop health mapping (M= 2.84), early-warning system (M=3.05).

Geomatics, an interdisciplinary area that combines geographic information systems (GIS), remote sensing (RS), global navigation satellite systems (GNSS), and spatial data analysis, has become an essential resource for managing agricultural disasters.

As climate variability and environmental degradation escalate, farming systems face heightened risks from hazards like floods, droughts, pest outbreaks, and soil erosion. Geomatics offers innovative approaches for disaster risk reduction (DRR) and effective farm management by facilitating precise mapping, monitoring, forecasting, and decision-making (FAO, 2018a). A key application of geomatics in reducing farm disaster risks is hazard mapping and risk assessment. GIS technologies enable the amalgamation of spatial and non-spatial data to pinpoint regions susceptible to certain hazards.

Table 3. Perceived roles of geomatics tools in disaster reduction

Roles of Geomatics Tools	Mean	SD
Mapping of agricultural lands/forest	3.37	0.83
Guides in selecting crop/fertilizer	3.87	0.57
Helps to identify soil types	2.87	0.74
Monitoring of rainfall/temperature trends	3.06	1.02
Helps to identify flood-prone farmlands	3.66	0.35
Detection of vegetation stress	3.27	1.05
Helps identify soil moisture	3.18	0.80
Pest/diseases surveillance	3.38	0.91
Use for precision farming	3.03	0.54
Optimization of irrigation schedules	3.52	0.78
Defines actual boundary	3.12	0.62
Prediction of crop yields	3.18	1.08
Deforestation monitoring	2.94	1.07
Crop health mapping	2.84	1.18
Early warning system	3.05	0.97

Accepted mean = 2.50

For example, agricultural lands that are vulnerable to flooding can be identified through elevation models, rainfall data, and hydrological patterns. This information allows farmers and policymakers to create targeted mitigation strategies, such as establishing drainage systems or moving farming activities to safer areas (Wang *et al.*, 2019). Similarly, drought risk maps derived from long-term climatic and vegetation data are valuable for planning irrigation systems and choosing drought-tolerant crop varieties. Additionally, geomatics plays a crucial role in early warning systems and real-time monitoring. Remote sensing technologies, especially satellite imagery, provide continuous monitoring of environmental conditions. Vegetation indices like the Normalized Difference Vegetation Index (NDVI) are utilized to

gauge crop health and spot early signs of drought stress or disease outbreaks. These insights enable farmers to take prompt action, thereby reducing potential losses (Rembold *et al.*, 2013). Furthermore, weather forecasting models integrated with GIS platforms improve preparedness by predicting severe weather events such as storms or extended dry spells. Geomatics also significantly contributes to disaster response and damage assessment. Following a disaster, satellite imagery and drone surveys can evaluate the damage to agricultural lands, crops, and infrastructure. This rapid assessment assists in the effective distribution of relief resources and aids insurance companies in accurately processing claims. For instance, post-flood evaluations using high-resolution imagery can reveal submerged

fields and estimate crop losses, which are vital for recovery planning (Zhang and Kovacs, 2012).

Geomatics plays a crucial role in the responsible management of land and water, which is vital for diminishing disaster risks in agricultural settings. Utilizing GIS for land suitability evaluations enables the identification of optimal land use strategies by taking into account factors such as soil composition, terrain, and climate conditions. This approach helps prevent practices that could worsen vulnerabilities, like cultivating on slopes prone to erosion. In terms of irrigation strategies, geomatics technologies facilitate better water management by charting soil moisture levels and tracking water distribution systems, thereby alleviating the effects of drought and water scarcity (UNESCO, 2020). Moreover, precision agriculture is a significant application of geomatics that boosts farms' capacity to withstand disasters. By leveraging GPS-equipped machinery and spatial data, farmers can administer inputs like fertilizers, pesticides, and water with greater efficiency and accuracy. This minimizes environmental strain and enhances crop yields even when conditions are unfavorable. Precision agriculture supports tailored management practices, which are particularly beneficial for addressing specific risks on individual farms (Gebbers and Adamchuk, 2010). However, the implementation of geomatics in disaster management on farms encounters hurdles, especially in developing nations such as Nigeria.

These obstacles include high technological costs, limited technical knowledge, insufficient data infrastructure, and low awareness among farmers. Nevertheless, with enhanced investment in skill development, supportive policies, and incorporation of local expertise, geomatics has the potential to revolutionize agricultural disaster response. In summary, geomatics provides essential resources for mitigating and managing agricultural disasters through better hazard mapping, monitoring, early warning systems, and sustainable resource stewardship. Its capability to deliver precise, timely, and spatially relevant data improves decision-making for both farmers and policymakers. As climate change

escalates agricultural hazards, integrating geomatics into farming practices becomes not just beneficial, but essential for achieving food security and promoting sustainable agricultural development.

Challenges affecting the adoption of geomatics tools

While geomatics could be good, its use and adoption are not without challenges. These challenges according Table 4 include weak disaster coordination efforts (84.4%), inadequate manpower to handle disasters (68.2%), weak data sharing culture of agencies (86.6%), high cost of technology (77.7%), limited knowledge (68.8%), connectivity of infrastructure (71.5%), financial sustainability (99.3%), lack of awareness (73.3%), and climate variability (84.4%).

The incorporation of geomatics—which encompasses tools such as Geographic Information Systems (GIS), remote sensing (RS), Global Positioning Systems (GPS), and spatial data analytics—holds significant promise for improving agricultural risk management. By enabling superior monitoring, mapping, and decision-making, these technologies can make a meaningful impact. However, the utilization of geomatics, particularly in developing nations, encounters numerous institutional and technical obstacles. On the institutional front, poor governance and restrictive policies greatly hinder the implementation of geomatics. Inefficiencies within agricultural ministries often result in delays when it comes to distributing geospatial data and innovations to farmers, thereby reducing the efficacy of timely risk management strategies (Ijaware, 2023). Moreover, many countries do not effectively integrate geomatics into their agricultural frameworks, leading to fragmented execution and weak collaboration between agencies. There is also a noticeable lack of awareness among policymakers and relevant stakeholders about the advantages of geomatics, which hampers investment and prioritization efforts (Life in GIS, 2023). Additionally, issues like corruption and the misallocation of public funds stifle the development of essential geospatial infrastructure

and services. Institutional gaps-such as limited training opportunities and a deficiency of skilled workforce-further impede the successful application of geomatics in managing agricultural risks. On the technical side, significant challenges remain. A critical issue is the insufficient availability of high-quality spatial data. Effective agricultural risk assessments depend on consistent data covering soil types, weather patterns, and land use; regrettably, such datasets are often incomplete, outdated, or inconsistent in many developing regions (Mathenge *et al.*, 2022). Furthermore, data interoperability issues-where information is stored in incompatible formats or lacks sufficient metadata-complicate the integration and analysis processes. The high costs associated with acquiring, processing, and maintaining geospatial technologies, including hardware, software, and satellite imagery, present substantial barriers, particularly for smallholder farmers and underfunded organizations (Oxford Blue, 2024). Another significant technical challenge is the lack of skilled individuals who can effectively utilize advanced geomatics tools. The successful

implementation of GIS and remote sensing requires proficiency in spatial analysis, modeling, and data interpretation-areas where many agricultural systems fall short (Life in GIS, 2023). Additionally, insufficient infrastructure, including inconsistent electricity supply, unreliable internet access, and limited computing resources, significantly impedes the implementation of geomatics, especially in rural regions where agricultural risks are most acute (Oxford Blue, 2024). To sum up, while geomatics has the capacity to significantly enhance agricultural risk management through accurate monitoring and informed decision-making, its adoption is hindered by institutional challenges (like policy gaps, low awareness, ineffective governance, and inadequate capacity) as well as technical issues (such as data quality problems, high costs, a lack of expertise, and infrastructural deficits). Tackling these obstacles necessitates coordinated policy reforms, investments in capacity development, the creation of standardized and accessible spatial data systems, and improved technological infrastructure to bolster resilience in agricultural systems.

Table 4. Challenges limiting adoption of geomatics for agric. risk reduction

Challenges to adoption	*Frequency	Percentage
Weak disaster coordination efforts	380	84.4
Inadequate manpower to handle disasters	307	68.2
Weak data sharing culture of agencies	390	86.6
High cost of technology/infrastructure	350	77.7
Limited knowledge	310	68.8
Connectivity of infrastructure	322	71.5
Financial sustainability	447	99.3
Lack of awareness/adoption	330	73.3
Climate variability/uncertainty	380	84.4

*Multiple responses

Geomatics-based strategies for improving disaster preparedness, mitigation, and resilience among farmers and agricultural stakeholders

Table 5 provides information on addressing challenges faced when using geomatics tools. These strategies include developing agriculture risk and hazard maps (M= 3.41), establish satellite-based early-warning systems (M= 2.80), integrate geomatics into agricultural extension services (M=2.91), creation of national/state agricultural spatial data platform (M= 3.01), support

spatially targeted preparedness investment (M= 3.25), use geomatics in rapid damage and loss assessment (M= 3.35), promotion of farmer-friendly geospatial information system (M= 2.95), build institutional and local technical capacity (M= 3.02) and use spatial analysis to support climate smart practices (M=3.50). Geomatics, which includes tools like Geographic Information Systems (GIS), remote sensing, Global Navigation Satellite Systems (GNSS), and spatial data analytics, provides effective and adaptable methods to enhance disaster preparedness, mitigation, and

resilience in agriculture. These technologies empower stakeholders to gather, analyze, and apply spatial data, enabling informed decision-making—especially in farming systems prone to hazards. A significant strategy involves risk mapping and hazard zonation through GIS and remote sensing data. By combining satellite images, topographic maps, and climate information, agricultural planners can pinpoint areas at risk of flooding, drought, and erosion. This spatial knowledge supports farmers in making proactive choices, such as selecting appropriate crops, adjusting planting schedules, and steering clear of high-risk

locations (FAO, 2018b). Furthermore, early warning systems can be bolstered by geomatics through the integration of meteorological data and real-time satellite monitoring, allowing for more accurate forecasts of extreme weather events, including droughts, floods, and pest outbreaks (UN-SPIDER, 2020). Moreover, another effective method involves precision agriculture techniques, leveraging GNSS and remote sensing. Farmers can track soil moisture levels, assess crop health, and evaluate vegetation indices such as NDVI to refine irrigation practices, fertilizer applications, and pest management.

Table 5. Geomatics strategies for building resilience

Geomatics Strategies for Building Resilience	Mean	SD
Developing agriculture risks and hazard maps	3.41	0.94
Establish satellite-based early warning systems	2.80	0.98
Integrate geomatics into agricultural extension services	2.91	0.64
Creation of national/state agricultural spatial data platform	3.01	1.05
Support spatially targeted preparedness investment	3.25	1.01
Use geomatics in rapid damage and loss assessment	3.35	0.97
Promotion of farmer-friendly geospatial information products	2.95	0.86
Build institutional & local technical capacity	3.02	0.78
Use spatial analysis to support climate smart practices	3.50	0.95

Accepted mean = 2.50

This approach not only minimizes resource waste but also improves productivity while reducing vulnerability to climate fluctuations (Zhang *et al.*, 2019). Additionally, mobile GIS applications offer farmers access to location-specific advice, weather updates, and disaster alerts, enhancing their ability to respond swiftly.

Geomatics plays a vital role in infrastructure planning and managing resources effectively. For example, spatial data can direct the construction of systems for irrigation, drainage, and secure storage, thereby minimizing the risk of hazards. Utilizing Geographic Information Systems (GIS) for land-use planning helps mitigate practices that lead to deforestation and increased disaster risks, such as landslides and flooding (World Bank, 2021). Building capacity and fostering collaboration among stakeholders are also crucial. Educating farmers and extension workers on basic geomatics tools promotes local engagement and sustainability. Initiatives that engage communities in mapping efforts enable farmers to share

traditional knowledge, which enhances the precision and significance of spatial data. Collaborations among government entities, research organizations, and private companies facilitate the sharing of data and technological resources (UNDP, 2019). Moreover, geomatics significantly contributes to evaluating and recovering from disasters. High-resolution satellite imagery and drone technology can quickly assess damage to crops, soil, and infrastructure, allowing for prompt action and efficient distribution of relief resources. This approach not only speeds up recovery but also fortifies long-term resilience. In summary, employing practical geomatics-based approaches—including risk mapping, early warning systems, precision agriculture, and community mapping initiatives—serves a critical function in enhancing disaster preparedness, mitigation, and resilience in the agricultural sector. When these strategies are effectively woven into agricultural policies and practices, they empower farmers and stakeholders to recognize risks, minimize vulnerabilities, and adapt to evolving environmental challenges.

Implications of the challenges for agricultural risk reduction

The reduction of agricultural risks is crucial for ensuring food security, supporting rural livelihoods, and promoting environmental sustainability, especially in developing countries like Nigeria. Yet, ongoing institutional and technical obstacles significantly diminish the success of strategies aimed at risk reduction. These issues, which include inadequate governance structures and poor technological infrastructure, have profound effects on agricultural systems, particularly in at-risk rural areas. One notable consequence is the diminished efficiency of early warning systems and disaster preparedness initiatives. Geomatics technologies, including remote sensing, Geographic Information Systems (GIS), and Global Navigation Satellite Systems (GNSS), are intended to track weather conditions, soil quality, and crop health. However, in contexts where access to dependable data is limited and technical skills are lacking, as well as where institutional coordination is insufficient, these tools are unable to operate effectively. Consequently, farmers often receive outdated or incorrect information, heightening their vulnerability to risks such as droughts, floods, and pest infestations (FAO, 2020b). This situation hampers proactive decision-making and often results in costly, reactive measures that are less effective. Moreover, the issue of information asymmetry among stakeholders remains prevalent. In many developing nations, agricultural information is unevenly shared, largely due to low literacy rates, inadequate extension services, and limited access to digital resources. Many farmers, particularly women and smallholder producers, frequently lack timely and relevant information concerning risks. This situation increases their vulnerability and hampers the adoption of climate-smart agricultural techniques (World Bank, 2021). As a result, overall productivity stays low, and the ability to cope with shocks becomes compromised. Institutional shortcomings, such as ineffective policy implementation and insufficient funding, also play a critical role. When policies aimed at agricultural risk reduction are in place, their execution is often poor, hindered by bureaucratic delays and a lack of political

commitment. The fragmentation of government agencies further complicates coordination, leading to repeated efforts or voids in service provision. This deficient institutional framework restricts investments in essential infrastructure like irrigation systems, storage facilities, and climate monitoring networks, thereby heightening farmers' susceptibility to risks (UNDP, 2019).

Technical limitations, such as the shortage of skilled workers and restricted access to advanced technologies, have a substantial impact on the scalability and long-term viability of initiatives aimed at reducing risk. Many rural regions are devoid of professionals capable of analyzing geospatial data and converting it into practical guidance for agriculturalists. Moreover, the hefty expenses involved in acquiring and maintaining geomatics equipment hinder its broader use.

This gap in technology results in a divide between regions that can effectively mitigate risks and those that struggle, perpetuating existing disparities in agricultural progress (OECD, 2020). The repercussions extend to the economy as well. Subpar risk reduction measures result in greater crop losses, diminished incomes for farmers, and increased fluctuations in food prices. These issues affect not only farmers but also have wider economic ramifications, such as heightened government expenditure on emergency aid and decreased agricultural contributions to the national GDP. In countries like Nigeria, where a significant segment of the population relies on agriculture for employment, these effects can hinder economic advancement and worsen poverty levels (IFAD, 2021). On a social level, these hurdles heighten the vulnerability of rural populations and drive migration. As farming becomes more unstable and less lucrative, individuals living in rural areas—especially young people—may seek better opportunities in cities. This movement from rural to urban areas can put pressure on city infrastructure while depleting the available workforce in agricultural communities. Additionally, gender inequality often worsens, as women in agriculture face increased

obstacles in obtaining resources, education, and technologies necessary for effective risk management. The environmental consequences are also notable. Inadequate adoption of risk reduction strategies can result in unsustainable land-use practices, such as deforestation, overgrazing, and improper irrigation techniques. These practices jeopardize natural resources and heighten the risk of environmental disasters, creating a damaging feedback loop of vulnerability and risk. Without proper monitoring and management frameworks in place, achieving a balance between agricultural productivity and environmental conservation becomes increasingly challenging (IPCC, 2022).

While these challenges present significant hurdles, they also uncover avenues for advancement. By fortifying institutional frameworks, investing in capacity building, and fostering public-private partnerships, we can facilitate the wider adoption of geomatics tools and various risk reduction strategies. Enhancing rural infrastructure, broadening digital connectivity, and providing educational support to farmers can help close information gaps and empower them to make better-informed decisions. Furthermore, merging indigenous knowledge with contemporary technologies can lead to solutions that are not only more relevant but also sustainable. In summary, the obstacles to agricultural risk reduction carry substantial implications across economic, social, institutional, and environmental spheres. These challenges undermine the effectiveness of early warning systems, deepen existing inequalities, decrease productivity, and heighten vulnerability to climate-related threats. Tackling these issues call for a comprehensive approach that integrates policy reforms, technological advancements, and collaborative stakeholder efforts. By embracing this strategy, nations like Nigeria can develop more resilient agricultural systems that are equipped to endure both current and future challenges.

CONCLUSION

Geomatics has emerged as a vital resource for addressing the complex challenges associated with

agricultural risk management and disaster reduction. By utilizing technologies such as Geographic Information Systems (GIS), Remote Sensing (RS), and Global Navigation Satellite Systems (GNSS), stakeholders are equipped to gather, analyze, and interpret essential spatial data, facilitating informed decision-making. These technologies enable accurate mapping of vulnerable areas, real-time monitoring of environmental changes, and early detection of potential threats, such as floods, droughts, and pest outbreaks. The contribution of geomatics significantly enhances preparedness, mitigation, response, and recovery efforts in agriculture. For instance, satellite imagery and remote sensing techniques allow for the continuous evaluation of crop health, soil moisture levels, and climate patterns, thereby enabling prompt interventions. GIS-based models are instrumental in risk assessment and scenario prediction, empowering policymakers and farmers to develop strategies that reduce losses and boost productivity.

Furthermore, GNSS technologies play a crucial role in precision agriculture, improving resource efficiency and minimizing environmental impact. However, challenges persist in the wider implementation of geomatics in agricultural disaster management, including high costs for technology acquisition and maintenance, limited user expertise, inadequate infrastructure, and weak institutional support. Additionally, a lack of awareness and training among farmers, particularly in rural areas, hinders the effective application of available geospatial tools.

Addressing these challenges will require collaborative efforts from governments, research organizations, and development agencies. It is essential to increase investments in capacity building, infrastructure, and policy frameworks. Tailored training initiatives should be designed to empower farmers and agricultural stakeholders with the necessary skills to utilize geospatial technologies effectively. Ultimately, by integrating geomatics into national agricultural and disaster management strategies, a cohesive and sustainable approach can be established, promoting agricultural resilience and mitigating disaster risks.

REFERENCES

- Alimi SA, Oriola EO, Senbore SS.** 2023. GIS-assisted flood-risk potential mapping of Ilorin and its environs, Nigeria. *Remote Sensing in Earth Systems Sciences*.
- Amatebelle CE, Owolabi ST, Ogundeji AA, Okolie CC.** 2025. A systematic analysis of remote sensing and GIS applications for flood disaster risk management. *Journal of Spatial Science*.
- Bello IE, Ortese AS, Dogara DA.** 2025. Appraisal of GIS and remote sensing applications in land and environmental management in Nigeria. *International Journal of Geomatics and Environmental Management*.
- FAO.** 2018a. Geospatial applications for sustainable agriculture and rural development. Rome: Food and Agriculture Organization of the United Nations.
- FAO.** 2018b. The state of food and agriculture: migration, agriculture and rural development. Rome: Food and Agriculture Organization of the United Nations.
- FAO.** 2020a. Geospatial applications for sustainable agriculture. Rome: Food and Agriculture Organization of the United Nations.
- FAO.** 2020b. The state of food and agriculture: overcoming water challenges in agriculture. Rome: Food and Agriculture Organization of the United Nations.
- FAO.** 2021. The impact of disasters and crises on agriculture and food security. Rome: Food and Agriculture Organization of the United Nations.
- Gebbers R, Adamchuk VI.** 2010. Precision agriculture and food security. *Science* **327**(5967), 828–831.
- IFAD.** 2021. Rural development report. Rome: International Fund for Agricultural Development.
- Ijaware VA.** 2023. Web-GIS and artificial intelligence: A panacea for agriculture advancement in developing countries.
- IPCC.** 2022. Climate change 2022: Impacts, adaptation, and vulnerability. Cambridge: Cambridge University Press.
- Life in GIS.** 2023. Geographic information systems in developing countries.
- Makinde EO, Oyebanji EI.** 2018. Application of remote sensing and GIS technology to erosion risk mapping in Nigeria. *Proceedings of ESDEIC*.
- Mathenge M, Sonneveld BGJS, Broerse JEW.** 2022. Application of GIS in agriculture for sustainability.
- Merrett HC, Chen WW.** 2013. Applications of GIS and remote sensing in natural disaster hazard assessment and mitigation. *Geomatics, Natural Hazards and Risk*.
- NASA.** 2021. Remote sensing for agricultural monitoring. Washington, DC: National Aeronautics and Space Administration.
- Nwilo PC, Badejo OT.** 2006. Impacts and management of oil spill pollution along the Nigerian coastal areas. *Journal of Environmental Management* **33**(1), 123–132.
- OECD.** 2020. Innovation, agricultural productivity and sustainability. Paris: OECD Publishing.
- Rembold F, Meroni M, Urbano F, Royer A, Atzberger C, Gadain H.** 2013. Remote sensing time series analysis for crop monitoring. *International Journal of Applied Earth Observation and Geoinformation* **21**, 211–223.
- The Oxford Blue.** 2024. Leveraging GIS technologies in modern agriculture.

- UNDP.** 2019. Climate risk management for agriculture. New York: United Nations Development Programme.
- UNDP.** 2019. Sustainable development goals report. New York: United Nations Development Programme.
- UNDP.** 2019. Sustainable land management and resilience. New York: United Nations Development Programme.
- UNDP.** 2021. Digital transformation in agriculture. New York: United Nations Development Programme.
- UNESCO.** 2020. Water resources management and sustainability using geospatial technologies. Paris: UNESCO.
- UN-SPIDER.** 2020. Space-based information for disaster risk management. United Nations Platform for Space-based Information for Disaster Management and Emergency Response.
- Uyigüe E, Agho M.** 2007. Coping with climate change and environmental degradation in the Niger Delta of southern Nigeria. Community Research and Development Centre (CREDC), Nigeria.
- Wang Y, Zhang X, Chen H.** 2019. GIS-based flood risk assessment in agricultural areas. *Natural Hazards* **95**(1–2), 1–18.
- World Bank.** 2019. ICT in agriculture: connecting smallholders to knowledge. Washington, DC: World Bank.
- World Bank.** 2020. Agriculture and food global practice: climate-smart agriculture. Washington, DC: World Bank.
- World Bank.** 2021a. Climate-smart agriculture and risk management. Washington, DC: World Bank.
- World Bank.** 2021b. Climate-smart agriculture and disaster risk management. Washington, DC: World Bank.
- Zhang C, Kovacs JM.** 2012. The application of small unmanned aerial systems for precision agriculture. *Precision Agriculture* **13**(6), 693–712.
- Zhang C, Kovacs JM.** 2019. The application of small unmanned aerial systems for precision agriculture: A review. *Precision Agriculture* **20**(2), 223–245.