Digitalization of Forest Resources Management in Nigeria: A Review of Concept, Status, Challenges and Way Forward

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ABSTRACT

Nigeria prioritizes the revitalization of forestry due to the abundance of forest resources in the nation and the various challenges that the forestry sector faces. Despite the significant proportion of forest cover, Nigeria has high rates of deforestation driven by factors such as urbanization, agricultural expansion, and other challenges including land degradation, illegal logging, and inadequate enforcement and monitoring. Nigeria can tackle long-standing issues with forestry management and advance toward sustainable development goals with the help of digitization. Digitalizing the management of forest resources has become essential for promoting sustainable practices and conservation initiatives. With the use of cutting-edge technologies like Geographic Information Systems (GIS), remote sensing, and data analytics, digitalization has the potential to significantly improve the management of Nigeria's forest resources. These technologies allow for accurate mapping, real-time monitoring, and well-informed decision-making, which promote sustainable practices. Through the application of advanced technologies, forestry professionals can maximize resource use, minimize waste, and encourage sustainable practices. Sustaining a long-term ecological balance relies on this efficiency. Therefore, establishing long-term monitoring tools to track the advancement and efficacy of digitization initiatives over time is critical. Thus, long-term monitoring programs to track the progress and effectiveness of digitalization initiatives over time should be established. Adaptive management strategies that enable feedback loops, iterative improvements based on data monitoring and stakeholder feedback, and continual learning are paramount. Scholars, practitioners, and policymakers can contribute to advancing the understanding, implementation, and impact of digitalized forestry resources management in Nigeria, ultimately promoting sustainable development and environmental conservation efforts.

INTRODUCTION

Digitalization refers to the process of integrating digital technologies, such as Geographic Information Systems (GIS), remote sensing, and data analytics, into traditional forestry management practices to enhance efficiency, effectiveness, and sustainability (Laudon and Laudon, 2020). It involves the digitization of data, automation of processes, and utilization of digital tools for decision-making, monitoring, and analysis in forestry resources management. Digitalization allows for precise mapping and monitoring of forest resources,

enabling accurate assessments of tree density, species composition, and ecosystem health (Adeofun *et al.,* 2020). Advanced technologies facilitate real-time monitoring of forestry activities, including logging, land-use changes, and illegal activities. This enables prompt responses and interventions for sustainable management (Olabode *et al.,* 2019).

Digitalization provides comprehensive and up-to-date data, empowering forestry managers to make informed decisions regarding resource allocation, conservation strategies, and land-use planning (Adewale *et al.,* 2021). Through digital tools, forestry practitioners can optimize resource utilization, reducing wastage and promoting sustainable practices. This efficiency is crucial for long-term ecological balance (Akindele *et al.,* 2021). Digital technologies support the development of sophisticated ecosystem models, aiding in predicting and understanding the impact of various factors on forest ecosystems. This is vital for proactive management and conservation efforts (Ogunjemiyo *et al.,* 2018).

In the global context, sustainable practices and conservation efforts are paramount for addressing pressing environmental challenges, including deforestation, biodiversity loss, and climate change. Digitalization plays a crucial role in advancing these objectives by providing innovative tools and techniques for monitoring, managing, and protecting forest resources (FAO, 2020). By providing stakeholders with access to accurate and up-to-date information, digital platforms empower communities, NGOs, and governmental agencies to actively participate in conservation initiatives and advocate for sustainable forestry practices on a global scale.

In Africa, the relevance of sustainable forestry practices and conservation efforts is particularly pronounced due to the continent's rich biodiversity and dependence on forest resources for livelihoods and ecosystem services. Digitalization presents unique opportunities for African countries to address deforestation and promote sustainable land management practices (Asare *et al.,* 2020). Through initiatives like the African Forest Landscape Restoration Initiative (AFR100) and the Central African Forest Initiative (CAFI), African nations are leveraging digital technologies to enhance forest monitoring, restoration, and conservation efforts (World Bank, 2018). By harnessing the power of satellite imagery, drones, and mobile applications, African countries can accurately assess forest cover changes, identify deforestation hotspots, and implement targeted interventions to protect critical ecosystems and biodiversity.

In Nigeria, sustainable forestry practices and conservation efforts are essential for safeguarding the country's diverse ecosystems, supporting rural livelihoods, and mitigating the impacts of climate change. With digitalization, Nigeria has the opportunity to address longstanding challenges in forestry management and accelerate progress towards sustainable development goals (Olabode *et al.,* 2019). Digital technologies offer innovative solutions for monitoring and managing Nigeria's forest resources, from the mangrove forests of the Niger Delta to the savannas of the north. By integrating remote sensing, GIS, and mobile applications, Nigeria can improve forest inventory assessments, land-use planning, and enforcement of forestry regulations (Ajayi *et al.,* 2020). Moreover, digitalization enhances community engagement and participatory decision-making in forestry management, empowering local stakeholders to actively contribute to conservation efforts and benefit from sustainable forest practices (Oyinlola *et al.,* 2018). Through initiatives like the REDD+ program and the National Forest Inventory, Nigeria is leveraging digital platforms to strengthen governance, enhance transparency, and promote inclusive development in the forestry sector (Federal Ministry of Environment, Nigeria).

Current Status of Digitalization in Nigeria

The digital infrastructure in Nigeria's forestry sector has been gradually evolving, with various initiatives aimed at modernizing and enhancing forest management practices. One notable aspect of the existing digital infrastructure is the establishment of the National Forestry Information System (NFIS), which serves as a centralized platform for collecting, storing, and analyzing forestry data (Federal Ministry of Environment, Nigeria). The NFIS facilitates access to information on forest cover, biodiversity, land use, and other relevant parameters, enabling informed decision-making and policy formulation processes. In addition to the NFIS, several ongoing digitalization projects are underway to further strengthen the digital infrastructure in Nigeria's forestry sector. One such project is the integration of remote sensing and Geographic Information Systems (GIS) technologies for forest monitoring and mapping purposes. Through this project, satellite imagery and geospatial data are utilized to assess forest cover change, detect illegal logging activities, and monitor forest health indicators (Oyinlola *et al.,* 2018).

Multiple digitalization projects are ongoing in Nigeria. These ongoing projects include but are not limited to the following;

- Forest Inventory and Monitoring System (FIMS): The Forest Inventory and Monitoring System (FIMS) is a project aimed at developing a comprehensive database of forest resources in Nigeria. Using remote sensing technologies and ground-based surveys, FIMS collects data on forest cover, species composition, biomass, and ecological indicators (Ajayi *et al.*, 2020). The project aims to improve forest management decision-making and facilitate sustainable utilization of forest resources through informed planning and monitoring processes.
- Forest Protection and Monitoring System (FPMS): The Forest Protection and Monitoring System (FPMS) is a project focused on combating illegal logging, encroachment, and other forms of forest degradation through enhanced surveillance and enforcement mechanisms. FPMS utilizes a combination of satellite imagery such as NigeriaSat-1 and Landsat Thematic Mapper, drones, and ground-based sensors to detect and respond to forest-related threats in real time (Federal Ministry of Environment, Nigeria). By strengthening forest protection measures, FPMS aims to safeguard biodiversity, mitigate climate change, and promote sustainable forest management practices.
- Digital Training and Capacity Building Initiatives: Various digital training and capacity building initiatives have been launched to enhance the technical skills and knowledge of forestry professionals, government officials, and local communities. These initiatives utilize online learning platforms, webinars, and workshops to provide training on digital tools, data analysis techniques, and best practices in forest management (Ajayi *et al.*, 2020). By improving human capacity in digital technologies, these initiatives support the effective implementation of digitalization projects and contribute to long-term sustainability.

Another noteworthy initiative is the deployment of mobile-based applications such as locus maps for forest inventory and field data collection, allowing forestry officials and field workers to record and update information on tree species, biomass, and ecosystem services in real-time (Ajayi *et al.,* 2020). Despite these efforts, the level of implementation and effectiveness of digitalization projects in Nigeria's forestry sector varies across different regions and jurisdictions. While some states have made significant progress in adopting digital technologies and integrating them into forestry management practices, others continue to face challenges related to infrastructure limitations, funding constraints, and institutional capacity gaps (Ajani *et al.*, 2021**)**. Moreover, the impact of digitalization projects on improving forest management outcomes, such as conservation effectiveness, sustainable utilization, and community engagement, requires further assessment and evaluation (Olabode *et al.*, 2020). While Nigeria's forestry sector has seen advancements in digital infrastructure and ongoing digitalization projects, there is still room for improvement in terms of implementation and effectiveness.

Challenges

Some notable challenges that are affecting the digitalization of Nigeria's forestry resources management include but are not limited to the following;

1. Challenges in Implementation: Despite the introduction of digitalization projects, challenges such as inadequate technical capacity, limited infrastructure, and funding constraints persist in Nigeria's forestry sector. The successful implementation of digital initiatives is hindered by these challenges; leading to delays, suboptimal outcomes, and limited scalability of projects (Ajani *et al.*, 2021).
2. Infrastructure and Connectivity Challenges: Implementation of digitalization projects in Nigeria's forestry sector is hampered by infrastructure limitations, particularly in remote and rural areas. Limited access to electricity, internet connectivity, and digital devices impedes the deployment and utilization of digital technologies, hindering the effectiveness of projects (Oyinlola *et al.*, 2018).
3. Technological Integration and Interoperability: One of the key challenges in implementing digitalization projects in Nigeria's forestry sector is ensuring the integration and interoperability of diverse digital technologies and platforms. Lack of standardization, compatibility issues, and data silos hinder the seamless exchange of information and coordination among stakeholders, affecting the effectiveness of digital initiatives (Oyinlola *et al.*, 2018).

Some ongoing digitalization projects in Nigeria's forestry sector, such as FIMS and CBFM platforms, demonstrate efforts to modernize forest management practices and enhance stakeholder engagement. However, challenges related to implementation barriers and effectiveness assessments remain. Addressing these challenges requires concerted efforts from government agencies, NGOs, local communities, and other stakeholders to ensure the successful adoption and sustainable use of digital technologies in forestry resource

management. Challenges related to technological integration, policy alignment, and institutional support need to be addressed to maximize the effectiveness of these projects. By overcoming these challenges, fostering multi-stakeholder collaboration, addressing existing challenges, and harnessing the potential of digital technologies, Nigeria can enhance its forestry management practices, promote sustainable resource utilization, contribute to biodiversity conservation efforts, and harness the transformative potential of digital technologies to advance its forestry management objectives**.**

Successful Global Practices

Canada has implemented robust forest inventory and monitoring programs that leverage remote sensing, aerial surveys, and ground-based measurements to assess forest health, biodiversity, and ecosystem services (Goodenough *et al.*, 2018). Canada's initiatives include the importance of multi-scale monitoring approaches, adaptive management strategies, and stakeholder engagement in data collection and interpretation processes. Nigeria can adopt Canada's best practices by establishing a comprehensive forest inventory and monitoring framework that integrates remote sensing technologies with ground-based surveys, thereby enhancing the accuracy and reliability of forest data and supporting evidence-based decision-making.

Germany has also developed advanced digital forest management systems that utilize mobile applications, Geographic Information Systems (GIS), and cloud-based platforms to streamline administrative processes, optimize resource allocation, and improve forest planning and operations (Hanewinkel *et al.*, 2018). Germany's experience includes the benefits of digitalizing administrative workflows, automating data collection and analysis tasks, and promoting interoperability and data sharing among stakeholders. Nigeria can draw lessons from Germany's digital forest management systems by embracing digital technologies to enhance administrative efficiency, optimize resource utilization, and strengthen governance frameworks in the forestry sector.

United States Forest Service (USFS) operates the Forest Inventory and Analysis (FIA) program, which conducts comprehensive forest inventories using a combination of field surveys, remote sensing, and geospatial analysis (Bechtold and Patterson, 2005). Lessons learned from the FIA program include the importance of long-term monitoring, standardized data collection protocols, and adaptive management strategies. Nigeria can benefit from implementing a similar nationwide forest inventory program to assess forest resources, monitor changes over time, and inform policy and management decisions. Incorporating these global practices into Nigeria's forestry sector can help address current challenges, enhance management effectiveness, and promote sustainable development. By adopting approaches such as establishing a national forest information system, implementing robust inventory, standardized monitoring protocols, stakeholder engagement strategies, monitoring programs, and leveraging digital technologies for administrative efficiency, Nigeria can overcome challenges, improve the current status of forestry resource management, advance its digital forestry resource management goals and contribute to global efforts towards forest conservation and climate change mitigation.

CONCLUSION

Through an examination of ongoing digitalization initiatives, challenges, and opportunities, several key themes emerge. Firstly, digitalization offers immense potential to enhance forest management practices by providing timely, accurate, and accessible data for informed decision-making. Projects such as the National Forestry Information System (NFIS), remote sensing applications, and community-based forest management platforms demonstrate the transformative power of digital technologies in improving forest monitoring, planning, and conservation efforts. Secondly, while digitalization presents numerous benefits such as revolutionizing traditional practices, and offering a suite of tools and approaches that enhance efficiency, sustainability, and the overall health of the forest ecosystem, its successful implementation in Nigeria's forestry sector requires overcoming various challenges. These include infrastructure limitations, funding constraints, capacity gaps, and policy barriers. Addressing these challenges necessitates concerted efforts from government agencies, research institutions, NGOs, and local communities to build technical capacity, foster collaboration, and create an enabling policy environment.

Lastly, the importance of digitalization for sustainable forestry practices cannot be overstated. By leveraging digital technologies, Nigeria can enhance its forest management capabilities, promote conservation efforts, and support socio-economic development in forest-dependent communities. Digitalization facilitates adaptive management approaches, stakeholder engagement, and data-driven decision-making, leading to more effective and resilient forestry practices. In essence, digitalization serves as a catalyst for transforming

Nigeria's forestry sector towards sustainability. Embracing digital technologies enables the country to overcome traditional constraints, unlock new opportunities, and achieve its conservation and development goals. Therefore, investing in digitalization is not just an option but a necessity for ensuring the long-term health, resilience, and prosperity of Nigeria's forests and the communities that depend on them.

RECOMMENDATIONS

Intense policy analysis studies and research should be carried out to assess the adequacy and effectiveness of existing governance frameworks in supporting digitalization efforts in Nigeria's forestry sector, as well as identify policy gaps, regulatory barriers, and institutional challenges that hinder the adoption and implementation of digital technologies, and propose policy recommendations for improving the enabling environment. There is also a need to evaluate the impact of capacity building and training programs on enhancing the technical skills and knowledge of forestry professionals, government officials, and local communities in utilizing digital tools and technologies. It is also important to investigate opportunities for cross-sectoral collaboration and synergies between forestry, agriculture, environment, and other related sectors in leveraging digital technologies for sustainable development, and also explore integrated approaches and holistic solutions that harness the synergies between different sectors to address complex socio-ecological challenges and achieve shared objectives.

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