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CHALLENGES OF DIGITALIZATION IN FOREST OPERATIONS ACTIVITIES IN NIGERIA. A REVIEW

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Abstract

Digitalization is the process of utilizing digital technologies and digitized data to enable or improve forest operations. Digitalization lowers expenses while increasing productivity and efficiency and the existing forestry processes and operations are improved by digitalization. There is little or no knowledge about the use of modern technology in Nigeria which has led to low level or optimum effective and efficient utilization of forest products in a sustainable developmental way. Therefore, there is a need for technology transfer and research development in forestry industry management in Nigeria. Forestry in Nigeria is still majorly managed by the government in view to cater for the welfare of the society rather than the profitability of the forest industry and few private forestry plantations. The adoption and implementation of digitalization in the forestry industry in Nigeria will revolutionize and cause a significant, positive shift, and increase the forest management and productivity of forest operations, which will further improve the forest yields on sustainable basis.

Key Words: *Digitalization, Cyber-physical systems (CPS), Geo-information systems (GIS), Forest operations, Sustainability*

Introduction

Digital forestry is an emerging area that measures, monitors, and manages forests to optimize social, economic, and ecological advantages. It uses digital technologies, such as remote sensing, big data, and artificial intelligence (Abedi Gheshlaghi *et al.,* 2020; Moeller *et al.,* 2011). New opportunities for forest management and regular forest activities have been made possible by digital transformation as stated by Bassole *et al.* (2001). Enterprise resource planning technology and digital quality management solutions have been developed for use in logging and other forest operations (Moeller *et al.,* 2011).

Digitalization is the process of utilizing digital technologies and digitized data to enable or improve forest operations. As a result, simple programme logic controllers (PLCs) logic or proportional integral derivatives (PID) control in a microprocessor-based system, sequenced logic for a batch operation, automated shutdown logic, etc. are examples of this (McKinsey Digital, 2015). It could also be something more complicated, such as a transmitter fault that result in the creation of a work order for a maintenance technician in the enterprise resource planning (ERP) of maintenance system. Digitalization lowers expenses while increasing productivity and efficiency (Roblek *et al.,* 2016; Tufă *et al.,* 2018). Existing forestry processes and operations are improved by digitalization, but they are not altered or transformed. In other words, it converts a process from a human-driven action or sequence of actions to a software-driven action (Weyer *et al.,* 2015; Rao *et al.,* 2018).

Characteristics of Digitalization in Forest

Digitalization in the forest offers real-time data, real-time monitoring, and real-time forest inventory. The following characteristics enable digitalization:

Cyber-Physical Systems (CPS): It describes the blending of the real world and the digital one (Kagermann, 2014). Therefore, the overarching objective is to produce a digital representation of reality that as nearly mimics it as feasible. The foundation for achieving this objective is the use of sensors, which "collect physical data and using actuators influence physical procedures" (Kagermann *et al.,* 2014). These sensors "collect physical data and using actuators influence physical procedures" (Kagermann *et al.,* 2014). These intelligent machinery, storage systems, and manufacturing facilities (smart devices) are interconnected to form the CPS, an embedded system (Moeller *et al.,* 2011; Zuehlke, 2010).

Internet of Things and Services (IoTS): The Internet of Things is the term used to define the network in which cyber-physical systems communicate with one another (Hermann *et al.,* 2016). According to Kagermann *et al.* (2014), this idea refers to the "linkage of objects (things) with a virtual representation on the internet or a structure similar to the internet." According to Lu (2017), objects in this context include not only machines but also all gadgets and people with sensing, identification, processing, and communication and network capabilities. According to Hermann *et al.* (2016), the Internet of Services refers to the possibility of providing services and industrial technologies online.

Small Factory: According to this idea, a factory's CPS serves as the cornerstone for decentralized, real-time communication, and self-regulating production processes (Kagermann *et al.,* 2014). As it comprises autonomous fractal systems connected via the IoTS, the Smart factory is meant to be more intelligent, flexible, and dynamic (Kagermann *et al.,* 2014). Processes will be able to be improved by machines and equipment through self-optimization and autonomous decision-making (Roblek *et al.,* 2016). Bartodziej (2017) assert that the smart factory is a necessary precondition for addressing the difficulties posed by the future and present's escalating complexity.

Sensing Technology: A setting for linking the real and virtual worlds can be created thanks to sensor technologies. In addition to collecting signals, sensors also convert them into digital information and continue processing them. Sensors accurately transform informational messages regarding the present status of the physical environment (Moeller *et al.,* 2011; Roblek *et al.,* 2016).

Machine-to-Machine Communication (M2M Communication): The Smart Factory's communication between items, namely the machines in and between CPS, is a crucial element. According to Bartodziej, (2017) reported that the common data standards are crucial, as are real-time competent cable and radio-based communication networks (WLAN interfaces or mobile phone networks) as linking technology.

Human to Machine Interaction: Integrating humans into CPS is a very essential topic because they will still play a significant role in the Smart Factory (Zuehlke, 2010). Information from the CPS must be displayed on a device and in a format that is suitable for both human users and corporate decision-making (Bartodziej, 2017). In this context, portable devices like tablets or smartphones are an example of this technology, the technological advancement toward forest operation includes touch interfaces and gesture detection, voice control, as well as virtual and augmented reality, developed, for example, via smart glasses (McKinsey Digital, 2015).

***Human to Forest Interaction*:** Integrating a cyber-physical system (CPS) in the forest is a highly important problem since humans are still fundamental to the digitalized forest (Brettel *et al.,* 2014). The ability to see data from the forest's CPS on a portable device that helps people make decisions is important. In this instance, it's crucial to concentrate on developing touch-screen, and robust communication handheld devices (Chesbrough, 2010).

Big Data and Cloud Computing: A significant amount of data is generated during the communication process between the physical system embedded in the forest and must be stored. A platform for digital interaction called cloud computing stores and displays data. Big data analysis is made easier and more economical by cloud computing, frequently in the form of so-called pay-per-use programmers (Bartodziej, 2017; Blattert *et al.,* 2012).

Advanced Analytics: Improved analytics helps to comprehend data that was previously extremely time-consuming or difficult by identifying improved computing tools. For the conversion of huge data into relevant data for enhanced decision-making, advanced analytics technology is very necessary (Brettel *et al.,* 2014).

Artificial Intelligence: Artificial intelligence aims to give technical objects the capacity to learn through experience and observation, as well as the ability to make judgments and take action.

Internet of Trees

The phrase "internet of trees" means that internet-based modules are being incorporated into the trees to sense, communicate, and monitor environmental parameters in the forest via internet access. The Internet of Trees is a system for real-time environmental parameter monitoring, fire accidents, and illegal logging identification using Internet-based modules. We frequently hear references to the Internet of Things (IoT), where objects are tracked, communicated with, and monitored using IP (Bassole *et al.,* 2001; McKinsey Digital, 2015).

Application of Digitalization

Environmental Parameter Monitoring: To sense the environmental conditions in the forest in a real-time scenario, sensor nodes are incorporated into the various trees. The wireless connection module and environmental sensors are often integrated into the sensor node. Wireless communication is the biggest obstacle in a forest environment, so a wireless personal network (WPAN) is incorporated into the architecture to help (Lu, 2017; McKinsey Digital, 2015).

Forest Fire Detection and Prediction: The Sensor Node will be able to detect the emergence of a fire in its immediate area utilizing sudden IR, Lux, Temperature, and Humidity data. It will then activate the fire status prediction system installed at the central analysis node shortly after the fire is discovered. The system will take into account factors such as the local wind speed, and temperature changes at various sensor nodes deployed in different directions (for example, temperature rise at nodes deployed in the south-west referential direction is higher than that at nodes deployed in the north-east referential direction, indicating that the direction of the fire is more directed towards south-west with reference from the origin node), and information from the CV node regarding the type of plantation present in the vicinity). (Rao *et al.,* 2018).

Fire Tracking and Monitoring: The geographical mapping of fire-prone areas has been carried out using geo-information systems (GIS) and remote sensing (Abedi Gheshlaghi *et al.,* 2020). There is a need for cost-effective technology for sensing the real-time parameters of the forest environment as GIS and remote sensing implementation in forest monitoring only offer spatial data (Tuf *et al.,* 2018; Rao *et al.,* 2018; Lu, 2015).

Geographic Information Systems (GIS)

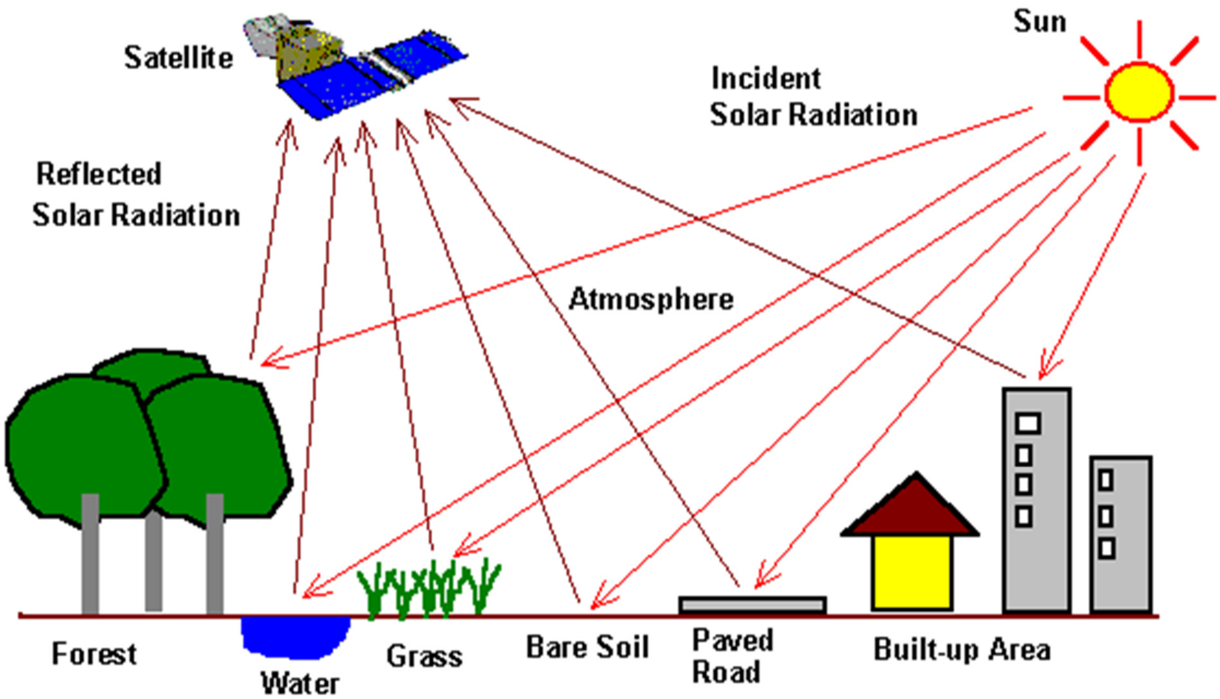
Geographic Information System (GIS) is an information technology that has been used in public policy-making for environmental and forest planning and decision-making over the past two decades (Bassole *et al*, 2001). GIS and related technologies provide foresters with powerful tools for record-keeping, analysis, and decision-making.

Remote Sensing

Remote sensing is the method of identifying and keeping track of an area's physical properties by measuring the radiation that region reflects and emits from a distance (usually from a satellite or an aircraft). Researchers can "sense" information about the earth (forest) with the use of special cameras that gather remotely sensed images. Several instances are:

The Earth's surface is captured in photos by cameras on satellites and aircraft, giving us access to a considerably wider range of views than we would have from the ground (Rao *et al.,* 2018). The ability to map major forest fires from space allows rangers to observe a far wider region than they could from the ground. This is just one example of how remotely sensed photographs of the Earth are used Bassole *et al*. (2001). Observing erupting volcanoes, tracking clouds to aid in weather prediction, and keeping an eye out for dust storms are all examples. Monitoring changes in agriculture and woods over several years or decades, as well as the expansion of cities. Discovery and mapping of the rough ocean floor topography, including the enormous mountain ranges, deep gorges, and "magnetic striping" on the ocean floor (Abedi Gheshlaghi *et al.,* 2020; Bassole *et al.*, 2001).

Principles in Remote Sensing



Instruments Used in Remote Sensing

Airborne drone **Lidar drone**

GPS **Satellite sensor** **Radar**

Challenges of Implementation and Technology Adoption in Forest Operation

The implementation and adoption of new technology in forest operation pose challenges of both technical and socio-economic nature (Chesbrough, 2010).

Technical Challenges

The applications in the delivery of wood come with a variety of technical difficulties. They resemble those in other (industrial) sectors for the most part. One of these problems is the implementation of data standards into production processes and elsewhere. This connection cannot be made without standards acting as a common language (Weyer *et al.,* 2015). A variety of data standards have previously been created to facilitate data interchange in the forest industry, including ELDAT smart (Kopetzky, 2017), Stanford (Moeller *et al.,* 2011), and FHPDAT (Blatter *et al.,* 2012). Although these standards are available, it is difficult to acquire data along the supply chain at the national or international level.

Another problem is ensuring data privacy and IT system security. Because it heavily depends on users' confidence in data security, trust in cloud technology has both a technological and a policy component (Kagermann *et al.,* 2014). Additional difficulties include the need for a reliable broadband internet connection (Kagermann *et al.,* 2014) and, ultimately, the investment risks associated with the integration of applications into the production processes.

Socio-Economic Challenges

Social and economic problems are also a byproduct of digitization. One of them is the capacity for cooperation across organizational boundaries and faith in other organizations in the supply chain (Brettel *et al.,* 2014). The management of the fragmentation of the forestry sector's high-stakeholder group represents a major problem. To support the early phases of innovation processes, forest owners, forest enterprises, harvesting contractors, timber transport contractors, and customers must increase their collaboration with one another as well as with players from other industrial sectors (Kubeczko *et al.,* 2006).

Labor qualification is another issue that is unique to labor. According to White *et al.* (2016), the majority of forest businesses have not yet adequately trained their personnel for new digital applications. All businesses need qualified personnel for digitalization (Kagermann *et al.,* 2014); however traditional industries like forestry may have more qualification requirements than more sophisticated industries like the automotive industry.

Conclusion and Recommendations

In summary, the use of digital tools in forestry such as drones, GPS, lidar, satellite radar, etc. will improve forest productivity and efficiency to achieve forest sustainable yield. Digitalization focuses on the proper management of forest resources in a sustainable manner to encourage social benefit, ecological function, and economic value. Sustainable forest management can be achieved due to the use of modern technology such as remote sensing to evaluate and for adequate documentation of forest resources in the country to make proper decision making to have the supply of forest produce in continuity.

Recommendations

- The government should fund research work in the development of technological work to hasten forest operations and very crucial for government to invest heavily in the importation of latest tools and equipment
- Telecommunication and internet service providers should be mandated to extend service coverage to forest areas
- Extension programmers should be carried out after technological research work has been developed
- Adoption of multiple land use approach and Value addition to forest produce.
- Implementation of national policy to encourage digitalization of forest operations in Nigeria

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