Review of Geospatial Information Technology for the Implementation of Financial Inclusion to Farmers in Nigeria

Thomas U. Omali

National Biotechnology Development Agency (NABDA), Nigeria

Author's Mail Id: t.omali@yahoo.com, Tel.: +234 0809 980 6705

Abstract—The smallholder agricultural sector in Nigeria occupy a substantial position in the country's economy. However, this agricultural segment is seemingly threatened with inaccessibility to the required finances with which to obtain the necessary materials needed to achieve the desired farm boost and yield. The focus of this study is on the implementation of financial inclusion to farmers in Nigeria, with emphasis on the role of geospatial technology. This study demonstrates that financial inclusion can improve the effectiveness and efficient government–to–person payments, which play an important role in the welfare of many poor people. However, despite the success made so far with regards to financial inclusion in line with global trends, many Nigerians are financially excluded. But the application of geospatial technology can reduce the transactional costs of reaching rural farmers and, ultimately, make finance more affordable for smallholder farmers.

Keywords—Agriculture, banks, microcredit, rural, stakeholders

I. INTRODUCTION

The world human inhabitants surpassed seven billion in 2011 and it will reach ten billion in 2100 [1]. Thus, the international community has become more concerned about how the global resources can offer the needs of the rising population [2]. With this burgeoning global population, the demand for food will apparently remain on the increase [3]. This trend has culminated in a focus on food security, advancement in agricultural activities, and the role of financial institutions in increasing farmers' access to finance. The smallholders' farms provide a substantial quantity of industrial inputs [4], and for a great number of the rural poor. Also, a significant per cent of the global rural dwellers attain their earning from farming. Therefore, intensifying smallholder agriculture will apparently increase the speed at which poverty is alleviated because there will be an increase in the earnings of the rural famers and reduction in food expenses [5]. Yet, smallholders rarely have access to formal credit facility, which restricts their capacity to obtain adequate technologies and inputs required to increase their yields and incomes.

The delivery of microcredit services enhances the latent aptitude of the poor for entrepreneurship, which consequently allows their increased self–reliance, capacity to generate more employment prospects, and eventually increasing household income and wealth creation [6]. Nevertheless, financial exclusion has manifested prominently in Nigeria with the bulk of the money in the economy staying outside the banking system [7]. In this situation, it is difficult for a specific segment of people to access financial products and services at low cost [8]. The issue of financial exclusion has therefore been a major

economic challenge that has received the attention of the various governments over the past four decades. In Nigeria, key services have not been provided in a manner that are commensurate with the needs of the populace, hence a financial services gap measured by the percentage of people excluded have ensued.

The increasing importance of financial inclusion as a catalyst for economic growth and development has been demonstrated by the plethora of literatures (e.g. [9,7,10] etc.). The consciousness that financial inclusion is a strategic and facilitating element, both in combating poverty and in accomplishing the goal of inclusive economic advancement is leading to a growing attention on financial inclusion policies and initiatives. Of course, dependable financial inclusion data, covering the major components of sustainable financial inclusion development is critical to inform these policies and to monitor the consequence of the initiatives, as well as serving as the crux of ambitious financial inclusion targets. Therefore, the purpose of defining a financial inclusion (FI) strategy for Nigeria is to ensure that a clear agenda is set for increasing both access to and use of financial services within a defined timeline.

The poor distribution of financial products and services constrains many people, especially the residents of remote areas from financial services. Consequently, various countries deploy traditional tools for monitoring financial access, such as through country–led, demand–side financial inclusion surveys and supply–side supervisory templates. Also, many authorities apply geospatial technology to enhance the status quo. Of course, geospatial technology has proven to be potent in expositing the

factors restraining financial access and thus aid in planning suitable solution. With geospatial technology, it is easy to map existing financial access points and assess the distribution of financial services in a certain area. This allows authorities to recognize gaps in the existing coverage more clearly and with higher precision. Furthermore, geospatial system allows for prioritization of gaps, considering policy objectives, and consequently designing proper policy interventions at the regional and local levels, in light of their specific context. As a result, policies can be targeted to improve access to financial services in a better manner, particularly in underserved areas.

The reaming part of this paper is organized as follows, Section II contain the related literature, Section III covers the study methodology, Section IV describes results and discussion of the study, Section V concludes the research work with future directions.

II. RELATED LITERATURE

Poverty reduction requires the increase in income, which may involve increasing bank facilities to aid effective agricultural and industrial activities in the rural communities. Thus, rural banking is of great significance to every nation as demonstrated by the existing literatures. For instance, Amadasu [11] used data between 1982 and 2006 to determine the relationship between rural banks credit and the development of rural Nigeria based on regression analysis. Results show that the lending rate, inflation rate, food imports, and the autonomous contribution are anti GDP. Yet, it was revealed that rural banks' credit is positively linked to the development of rural Nigeria. Also, a study by Abiola, Adedoyin, Umoren, and Areghan [12] identified some challenges confronting financial inclusion strategies in Nigeria including macroeconomic and structural issues like double–digit inflation, growing unemployment, poverty, and exchange rate depreciation. Others are poor saving habits that can be linked to the structural issues, lack of adequate infrastructure facilities to encourage rural banking, low level of education, and perception of the rural dwellers. Of course, Nigeria's financial inclusion index has been relatively poor as compared to some other nations. Nigeria is ranked 135 out of 176 countries on financial inclusion index [13]. Specific comparison between Nigeria and South Africa shows that people's access to formal credit is 2% and 32% respectively [14]; and access to formal payment system is about 21.6% and 46% respectively [15]. This corroborate the result of the study by Emeka & Udom [16] that despite the government's effort to facilitate the extension of banks' services and facilities to rural areas, a high proportion of the rural residents are still unbanked.
In order to improve the situation, evidences in literature suggest that the Non-Interest Financial Imstitution (NIFI) strategy is recommendable. For example, Alao [17] conducted a descriptive study based on secondary sources of data and adopted content analysis with regards to Islamic banking in Nigeria. It was found that the principles of Islamic banking that originated from Q30:39, 4:161; 3:130–132 and 2:275–278 is biblical as contained in Exodus 22:25, Leviticus 25: 35–38 and Proverb 19:17 and may reduce or eliminate the unethical activities in commercial banks thereby enhancing access to credit facilities.

Also, several studies towards investigating the relationship between financial inclusion and effectiveness of monetary policy exist. First, Anarfo et al. [18] used panel VAR to investigate the connection between monetary policy and financial inclusion in Sub–Saharan Africa, with result showing the existence of a bi-causal link. Similarly, Evans [19] used a panel Vector Error Correction Model (VECM) to investigate the relationship between monetary policy and financial inclusion using data from fifteen African countries. It was discovered that there is a long–run relationship between inflation and financial inclusion; and a uni–causal relationship from monetary policy effectiveness to financial inclusion. Equally, Mbutor and Uba [20] employed time series data spanning over the period between 1980 and 2012 to evaluate the impact of financial inclusion on the effectiveness of monetary policy in Nigeria. The result revealed that financial inclusion improves the effectiveness of monetary policy in the country.

On the determinants of financial inclusion, Abel, Mutandwa, and Le Roux [21] used logistic regression to establish the probability of an individual being financially included in Zimbabwe. The study indicate that age, education, distance to the nearest access point, financial literacy, income, documentation required to open bank accounts, and internet connectivity affects financial inclusion in the study area. Likewise, Uddin, Chowdhury, and Islam [22] used the generalized method of moments (GMM), and data from 2005–2014 in Bangladesh to assess the determinants of financial inclusion. The results demonstrate that bank size, efficiency, interest rates, literacy rate, and age dependency ratio affects financial inclusion. Also, Adetunji [23] studied the drivers of financial inclusion in Nigeria using panel data sourced from a Nigeria survey conducted between 2008 and 2016. The percentage of the banked population of adults in a state or adults having access to formal financial services was used to reflect financial inclusion. Regressions were performed using pooled ordinary least squares (POLS), fixed effect, and random effect techniques. The results showed that income, education levels, being a woman, being a youth, and living in a rural area were significant determinants of the likelihood of owning a bank account or from any other formal financial service provider.

In summary, it has been established that financial inclusion is a necessity in the current global scheme of things. Of course, it facilitates monetary policy effectiveness. Yet, financial inclusion in Nigeria is confronted with diverse issues. Specifically, the poor spatial spread of financial products and services thwarts many people from financial services, especially those residing in the remote areas.

Though several conventional approaches are deployed for ameliorating the situation, geospatial technology has proven to be more potent in discovering the causes of financial exclusion and therefore aids in planning suitable solution. However, empirical research on the application of geospatial technology in boosting the accessibility to financial products and services in Nigeria is hard to come by. Thus, the current review is focussed on the implementation of financial inclusion to farmers in Nigeria, with emphasis on the role of geospatial technology

III. METHODOLOGY

This review was conducted in 2021. Literature search was carried out through electronic documents. The search was done through specific search terms including 'geospatial information technology' AND 'financial inclusion to farmers in Nigeria'. With this, many literatures were collected encompassing journal articles, conference papers, working papers, and textbooks.

IV. RESULTS AND DISCUSSION

4.1 DEVELOPMENT AND GROWTH OF FINANCIAL INCLUSION IN NIGERIA

Despite the success made so far with regards to financial inclusion in line with global trends, many Nigerians are financially excluded. Nearly 36.8% of Nigeria adults is financially excluded [24]; and 55.1% of the financially excluded persons are women [25]. Thus, various policies have been established in Nigeria to promote financial inclusion (e.g., table 1).

Table 1: Programmes to enhance Financial Inclusion in Nigeria

Programme	Year
Nigerian Bank of Commerce and Industry	1973
Nigerian Agricultural and Cooperative Bank	1973
Nigerian Agricultural Cooperative and Rural Development Bank	1973
Operation Feed the Nation	1976
Rural Banking Scheme	1977
Agricultural credit guarantee scheme	1978
Green Revolution	1980
Nigerian Directorate of Employment	1986
Family Economic Advancement Programme	1997
National Economic Reconstruction Fund	1989
Peoples Bank	1989
Community Bank	1991
Bank of Industry	2002
Microfinance Bank	2005
Non– Interest Financial Institutions	2011

The rural banking scheme was adopted in 1977 with the aim of ensuring that each Nigeria's local government area has one bank branch. Also, the agricultural credit guarantee scheme of 1978 gave farmers access to banks credit to stimulate agricultural expansion. Rules were established which prescribed minimum levels of lending to small scale enterprises, and loans extended in rural areas with corresponding penalties to non–compliance. With this,

many members of the rural community had opportunity of using banks. Another significant impact of the initial policies on financial inclusion in Nigeria result to the decline in the ratio of cash outside bank to the stock of narrow money supply in the economy from 61.% in 1969, to 44.3 % in1979 to 40.9 % in1989 [26].

The emergence of structural adjustment program (SAP) in 1986 made many commercial banks in Nigeria to become distressed and many healthy banks closed their rural branches [27]. It was apparent that the problems and issues which led to the earlier scheme were still prevailing. These include a low level of rural savings mobilization, inadequate use of banking services and the lack of credit for rural people [28]. Thus, the Federal Government established the People's Bank in 1989 and a regulatory environment for Community Banks to be established in 1990.

The People's Bank was established to serve the poor in the society through acceptance of small deposits and provision of microcredit to the low–income members of the economy contrary to the situation associated with conventional banks. The total number of branches grew from 169 in 1990 to 228 in 1992 and reached 275 by the end of 1994 [29]. The number of borrowers increased significantly from 8,007 in 1989 to 79,061 in 1990 but for non–availability of data, the increasing trend as also witnessed in the value of loans and advances could not be highlighted in the later years. The Community Banks (CBs) were meant to serve similar purpose as self–sustaining, community–owned financial institutions. Amongst the various incentives provided by the government to encourage establishment of the CBs was the provision of 100% matching grant for a community raising the minimum capital. The first set of community banks were established at the end of 1990. By 1999, the total of community banks stood at 550 with total assets base of N8.9billion. The total deposit also reached over N5.7 billion with loans and advances of about N2.9 billion [29].

In spite of the many strides achieved by community banks in Nigeria, they were affected by many issues including insider– related credits, poor and ineffective management, poor credit administration and lack of transparency in operations. Generally, one of the unique Nigeria's economic features is financial dualism. On one side is a formal financial sector encompassing ministry of finance, Central Bank of Nigeria, financial institutions, Nigerian Stock Exchange (NSE), etc. On the other side is the informal sector with people lending and borrowing directly from each other through daily contributions and cooperatives, etc. [30]. The major factor influencing the large informal finance sector in Nigeria include population concentration in rural areas most of which are unbanked. Others are low literacy level, loss of confidence in the banking system due to distress, elitist banking practices and absence of other financial institutions in the rural areas [31]. The consequence of this large informal sector is poverty, unemployment, and the difficulty in economic management. Yet, the government makes finance

accessible to the unemployed through different programmes (as shown in table 1) since they are characterized with skills, ideas and willingness to work. Despite decades of public delivery and direction, microcredit, policy orientation, and the entry of new players, the supply of microcredit was insufficient [32]. Some of the challenges that impinged the performance of the microfinance bank include: undercapitalization, inefficient management, regulatory and supervisory loopholes [32], and poor outreach. Others are diversion of funds, inadequate finance, and frequent changes in government policies, heavy transaction costs, huge loan losses, low capacity and low technical skill in the industry as impediments to the growth of the subsector [33]. The aforementioned challenges many of which contributed to the failure of previous microfinance schemes are still confronting the microfinance banking scheme in Nigeria. The establishment of Microfinance banks in 2005 was to correct the underperformance related to inaccessible banking services to the rural people. But the issue of the interest rate chargeable on operation significantly eroded the gains, and the fraudulent and sharp practices by the Directors of some of the banks in addition to weak institutional mechanisms to bring to book such people has remained a significant issue.

The Central Bank of Nigeria in 2011 introduced a new framework for non– Interest Financial Institutions (NIFIs) by granting two preliminary licenses. NIFIs are banks or other financial institutions (OFI) under the purview of Central Bank of Nigeria, that transacts banking business, engage in trading, investment and commercial activities as well as provision of financial services in accordance with any established non– interest banking principles. NIFIs are kinds of Islamic banking which the CBN hoped that it would cajole many Nigerians into the banking sector.

Furthermore, the Central Bank of Nigeria introduced the cashless with the intention to drive the development and modernization of the payment system in Nigeria, reduce the cost of banking services and drive financial inclusion (improve effectiveness of monetary policy) by providing more efficient transactions options and greater reach. In other words, the policy was expected to drive financial inclusion based on the implicit assumption that reduced banking cost and more efficient payment system will encourage more people and business to embrace the formal financial service platforms. Thus, the adoption of the cash– less policy has led to remarkable increase in the level of technology (electronic banking) acceptance by deposit money banks in Nigeria and it is evidenced by the increase in the number of automated teller machines, point– of– sales facilities, internet banking, and mobile banking, among others.

4.2 Potentials of Geospatial Technology in the Operation of Financial Inclusion in Nigeria

There is an exigent need for the financial institutions to benefit from the vast untapped prospect in the smaller communities by providing for them the necessary type and

form of financial products and services. In this regard, the geospatial technology has proven to be an essential tool for improving the accessibility to financial services. Geospatial technology is an integrated multidisciplinary field [34] that includes disciplines such as surveying, photogrammetry, remote sensing, mapping, geographic information systems, geodesy and global navigation satellite system (GNSS) [35]. At the heart of geospatial technology is the geospatial data, which makes it possible to visualize data on a map. Each data point has location information assigned to it in the form of XY coordinates, an address or administrative unit. Many countries have already integrated geospatial mapping into their scheme for financial inclusion programme; others are planning their geospatial mapping deployment; and others are still deciding whether geospatial mapping is essential.

In some nations, the accurate XY coordinates are used to show each financial touch point on the nation's map, which makes it easy to spot the accurate positions of financial institutions. These touch points are then superimposed on appropriate data, including population, poverty levels and infrastructure. This can be used to determine the underserved population, where infrastructural investment is needed.

4.2.1 Geographic Information System

Geographic information system (GIS) is a technological tool for understanding geography and making intelligent decisions. It is one of the most progressing parts of geospatial technology. GIS has grown from a tool of computerized mapping and data management into a capable method for spatial data analysis and further into geographic information science (GISc) [36]. Also, the tool of distributed GIS has transformed from mobile GIS to web GIS and it is currently developing into cloud GIS. GIS provides a rich and flexible medium for visualizing and interacting with geographic data. Thus, it has been a cardinal tool in wider area of application [37]. GIS is a computerized technology for storing, retrieving, manipulating, analyzing and displaying geographically referenced datasets [38]. It can manage two basic types of data including geospatial data that define the location of a feature or object on the ground, and attribute data that describe the characteristics of the features [39]. On the computer screen, map users can scan a GIS map in any direction, zoom in or out, and change the nature of the information contained in the map. They can choose whether to see the roads, how many roads to see, and how roads should be depicted. Then they can select what other items they wish to view alongside these roads such as bank branches, neighborhoods, retail sites, and public facilities, etc.

Banking is a personal business, where people are more than numbers, records in a database, or account codes. GIS can help the banks and other financial institutions to see people for what they are: valuable assets with needs, demands, and preferences that should be met by any successful bank. Thus, the banks can now focus their

resources on designing products and services specifically tailored to fit their customers' needs based on the GIS–enhanced detailed customer information and the new methods of linking clients to preferences and services. Specifically, the GIS–based spatial analysis operation can assist organizations to position the right products and services to customers, locate new branches/ATMs, and others. Spatial analysis is concerned with how we comprehend our world– mapping the locations of things, determining the relation among things, and taking the best decision [40]. Spatial analysis in GIS is often used to create new geographical data from existing geographic data resulting to a more revealing than unorganized dataset. Furthermore, crop–related and environmental information are significant to financial institutions for various decisions. The Farmer's Almanac has been replaced with GIS–based study and predictive modeling, which is now being deployed to visualize farmland, crops, and management practices.

4.2.2   REMOTE SENSING

Remote sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device [41] without any form of physical contact between the sensor and the target of interest [42]. With remote sensing, it is possible to make global maps on diverse topics such as settlement structures, population estimates, climate tracking, poverty and pollution. Also, socioeconomic status can be inferred through remote sensing data rather than mere observation of proximity and segmentation of settlement types. The World Bank has been researching methods of estimating income using satellite imagery and cell tower data. Improving these methods in data–poor areas could enhance financial inclusion by providing remote credit scoring and thereby ease access to loans. Of course, such approach would be substantially dependent on local tenure security enforcement [43]. When compared to the conventional methods of data collection, satellite remote sensing is characterized by cost effectiveness, synoptic view, and quick data collection. Some of the specific potentials of satellite remote sensing in the implementation of financial inclusion are highlighted in the following subsections.

i.   Alternative credit scoring

Farming credit has been a fundamental tool for the development of agriculture in developing countries for many decades. But, creditworthiness is a function of credit history, transaction records, agronomic survey data and lifestyle–related demographics. Such credit scoring models could help increase the scale and scope of lending to small holder farmers and augment existing value chain finance programs and informal lending. This is because, they can be used to evaluate and rank potential borrowers in order of their likelihood to repay a loan. Regrettably, such histories and records are frequently lacking in the case of Nigeria earners, especially in the rural communities, which makes it difficult for them to access loan. Satellite data can afford important inputs to credit assignments. Many maps are delivered every day globally, and a significant size of

agricultural areas is monitored annually using satellite imageries. Certainly, the earth observation satellites captures data that are seldom achieved using the traditional means. This includes, estimating crop yields, mapping crop area, geotagging farmland to particular farmers, farm diversification, planting cycles and trends in production. With these data, it is easy to forecast revenues, potential repayment deficits, and timing of income.

ii.   Estimating local infrastructure, housing, and income levels

Identifying markets, opportunities, and the needs for investment can be enhanced based on reliable estimates of local infrastructure, housing, and income levels. Remote sensing imagery, with the main advantages of higher frequencies, faster acquisition, and lower costs, has been increasingly utilized in that regards. The effectiveness of satellite data in this case is a function of the fact that different built–up areas share different unique sets of spatial and textural features (e.g., geometry, patterns, orientation, and spatial variability) that distinguish them from other areas [44]. Many empirical researches have examined the effectiveness of remotely sensed data for monitoring development in low and middle–income countries (LMICs) through spatial estimation of human well–being [45]. Apart from providing the synoptic data on a range of biophysical parameters and land use/land cover information, satellite remote sensing have the potential for monitoring diverse aspects of socioeconomic development at fine spatial and temporal resolutions. This is especially apparent for rural communities in LMICs [45].

iii.   Calculating crop insurance and risk

The intention of most micro– insurance programs is to act as social security machinery and to offer defence against social and financial exclusion for people whose existing coping strategies are failing [47]. Agricultural insurance can provide portion of the solution by assisting to protect resources, encourage productive investments in smallholder agriculture, unlock access to credit, and increase resilience of rural households and businesses, etc. The idea is that if people's livelihoods are protected, it would encourage investment among lower–income groups and raise overall investment and growth rates. In other words, micro–insurance should reduce the incidence of ''poverty traps'' by providing low–income households, farmers, and businesses with access to post–disaster liquidity and securing or rehabilitating their livelihoods and habitations.

Insurance is thought to enhance the creditworthiness of the insured households and farms, thereby promoting investments in productive assets and/or higher–yield crops [48]. Limited availability, accessibility, quantity and poor quality of data on the ground (e.g., weather and yield data) are some of the main technical constraints preventing scale–up and sustainability of index insurance. Of course, without sufficient quality data, it is impossible to design products for some areas and countries. However, remote sensing satellites collect different types of datasets based

on specific biophysical dynamics, such as cloud temperature to estimate rainfall, evaporation and transpiration of water from the soil/plant system (evapotranspiration), soil moisture content or vegetation greenness. These data are typically calibrated with some ground information to create index data. This index is designed to proxy yield loss based on the remote sensing parameters used.

iv. Forecasting crop yields

Lower crop yields will be felt particularly by rural smallholder farmers in Sub–Saharan Africa, who rely on rain–fed agricultural yield for subsistence and minor economic returns [49]. The lack of early detection of low yields limits the ability of government and organizations to mitigate shortages. This is because data on yield and important variables can significantly support decision–makers and project implementers in defining the best adaptation and risk management strategies in rain–fed agricultural contexts [50]. In this regards, crop–related decisions may include acreage estimation, crop production appraisal, and detection of disaster vulnerability crops, etc. For example, crop/vegetation index map produced regularly is essential for monitoring crop health.

By and large, crop yield information is important in identification of crop areas with low to medium productivity [51]. Unfortunately, accurate and up–to–date reports of regional crop conditions, production estimates, aerial extents are often difficult to obtain in most developing countries as the major part of the agricultural sector is involved in traditional farming techniques, and the methods of production estimation are archaic and rudimentary at best [52]. Also, agricultural monitoring, estimation, and other significant informational results are most times not obtained until the season ends, at which point it becomes relatively obsolete and only relevant for historical purpose. Therefore, satellite methods can be used to collect timely and up–to–date data at regular intervals, for effective measurement of yield–relevant crop parameters.

4.3.4 GLOBAL POSITIONING SYSTEM

The Global Positioning System (GPS) is a space based satellite navigation system that provides location and time information in all weather conditions, anywhere on, or near the Earth where there is an unobstructed line of sight to four or more GPS satellites [54]. Location Based Service (LBS) using GPS is a new way to access bank transaction by android phones. GPS–enhanced LBS as the location provider is utilized to provide the user with his current geographic co–ordinates by displaying it on Google maps on the mobile phone to provide value added services such as identifying the nearest ATM centres. This makes locating ATM centres and fund transactions becomes easier. Also, the GPS can be used to acquire the location of banks and other financial institutions or any other required spatial feature that may be used as input into a GIS database for analysis and mapping. Furthermore, the GPS is an effective tool for reducing the cost of crop area data

acquisition and enhancing crop area data quality needed for the appraisal of farmer's creditworthiness.

V. CONCLUSION

One of the critical success factors in today's world is for a country to be at the cutting edge of technological adaptation. Evidence indicates that using geospatial technology can reduce the transactional costs of reaching rural farmers and, ultimately, make finance more affordable for smallholder farmers. GIS is a useful tool for nearly every field of knowledge from risk management to site selection. The reason for this is that it is characterized with an ability to combine a variety of datasets in an infinite number of ways.

REFERENCES

[1] United Nations. "World population prospects: The 2010 revisions, highlights and advance tables. Working paper number ESA/P/WP.220, " *United Nations*, **New York, 201**1.

[2] F.I. Okeke, S.O. Mohammed, "Early warning for food security for Nigeria using NigeriaSat–1 and other satellite images: applicable tools and techniques," *Nigerian Journal of Space Research*, Vol.**4**, pp.**91–126, 2007.**

[3] FAO, IFAD and WFP. The State of Food Insecurity in the World. The multiple dimensions of food security. *FAO,* **Rome, 2013.**

[4] T. Carroll, S. Andrew, Z. Dan, F. Rocio, R. Angela, L. Yuting "Catalyzing smallholder agricultural finance," dalberg global development advisors; **2012.** *Available from: http://dalberg.com/documents/Catalyzing_Smallholder_Ag_Finance.pdf.*

[5] J.W. Mellor, "The new economics of growth," *Cornell University Press,* **New York, 1976.**

[6] D.–K. Allen, M.–P. Klapperand, "The foundations of financial inclusion: policy research working paper 6290, Development Research," *World Bank,* **Washington DC., 2012.**

[7] U. Kama, M. Adigun, "Financial Inclusion in Nigeria: The Journey so Far," **2013**. *Available from SSRN 2365209.*

[8] R. Mohan, "Economic growth, financial deepening and financial inclusion, *Address at the Annual Bankers' Conference 2006,* **Hyderabad, 2006.**

[9] A. Salami, A.B. Kamara, Z. Brixiova, "Smallholder agriculture in East Africa: Trends, constraints and opportunities," *Working papers series number 105 African Development Bank, Tunis,* **Tunisia, 2010.**

[10] R.J. Cull, E. Tilman, H. Nina, "Financial inclusion and development: Recent impact evidence," *CGAP Focus Note 92,* **2014.**

[11] D.E. Amadasu, "Has Rural Banking Developed Rural Nigeria? An International Multidisciplinary," *Journal, Ethiopia,* Vol.**5,** No.**6,** Serial No. **23**, pp.**121–130, 2011**.

[12] B. Abiola, L. Adedoyin, G. Umoren, I. Areghan, "Financial inclusion in Nigeria: Prospect, issues and challenges," Paper presented at the In Proceedings of the 33rd International Business Information Management Association Conference, IBIMA 2019: Education Excellence and Innovation Management Through Vision 2020, **2019**

[13] P. Cyn–Young, V.M. , Rogelio Jr., "Financial inclusion, poverty, and income inequality in developing Asia," ADB Economics Working Paper Series, No. **426**, Asian Development Bank (ADB), Manila, **2015**.

[14] World Bank. "*Global financial development report 2014: Financial inclusion,*" Washington, DC: World Bank Publications, **2014.**

[15] J. Manyika, S. Lund, M. Singer, O. White, C. Berry. "Digital finance for all: powering inclusive growth in emerging economies," Mckinsey Global Institute. 2016. *Available from: www.mckinsey.com/mgi*

[16] E.E. Emeka, I.A. Udom. "Impact of microfinance in promoting financial inclusion in Nigeria," *Journal of Business Theory and Practice*, Vol.**3**, No.**2**, pp.**139–158, 2015**.

[17] D.O. Alao, E.M. Alao.. "islamic banking: the controversy over non–interest banking system in Nigeria. *Arabian Journal of Business and Management Review* (Nigerian Chapter) Vol.**1**, No.**1**, pp.**65–78, 2012**.

[18] E.B. Anarfo, J.Y. Abor, K.A. Osei, A. Gyeke–Dako, "Monetary policy and financial inclusion in Sub Sahara Africa: A Panel VAR Approach," *Journal of African Business*, Vol.**20**, No.**4**, pp.**549–572, 2019**.

[19] O. Evans, "The effectiveness of monetary policy in Africa: Modeling the impact of financial inclusion," *Iranian Economic Review*, Vol.**20**, No.**3**, pp.**327–337**, **2016**.

[20] Mbutor, M. O., & Uba, I. A. (2013). "The impact of financial inclusion on monetary policy in Nigeria," Journal of Economics and International Finance, 5(8), 318–326.

[21] Abel, S., Mutandwa, L., & Le Roux, P. (2018). "A review of determinants of financial inclusion," International Journal of Economics and Financial Issues, 8(3), 1–8.

[22] Uddin, A., Chowdhury, M., & Islam, N. (2017). "Determinants of financial inclusion in Bangladesh: Dynamic GMM and quantile regression approach," Journal of Developing Areas, 51(2), 221–237.

[23] Adetunji, O. (2017). "The drivers of financial inclusion in Nigeria," The International Journal Of Business & Management, 5(7), 273–279.

[24] Central Bank of Nigeria. "National financial inclusion strategy (Revised)," *In Central Bank of Nigeria, Abuja,* **2018**. Available from: https://www.cbn.gov.ng/out/2019.

[25] T.E. Joseph, N.U. Chinyere, O.C. Pauline, A.A..Gbenga, "Monetary policy effectiveness and financial inclusion in Nigeria: FinTech, 'the disrupter' or 'enabler'," *International Journal of Applied Economics, Finance and Accounting,* Vol.**9**, No.**1**, pp.**19–27, 2021**.

[26] O.N. Martin, "Basic Thoughts on Reversing the Trend of Financial Exclusion in Nigeria," *Economic Reflection Journal,* B(**21**), **2008**.

[27] J.O. Aderibigbe, "The role of the financial sector in poverty reduction," *CBN Economic and Financial Review*, Vol.**39**, No.**4**, pp.**60– 99, 2002**.

[28] A. Okorie, "Rural banking in Nigeria: Lessons from other developing countrie,".*Agric. Adm. Ext.,* Vol.**28**, pp. **147– 159, 1998**.

[29] Central Bank of Nigeria. CBN Statistical Bulletin 2003, **2004**.

[30] G.C. Okpara, "Informal financial system in economic development: The case of Nigeria," In Okonkwo IC et al. (eds). *Issues in National Development*, pp. **260– 268, 1990**.

[31] I.A. Acha, "The Role of other financial institutions in economic development," in Imoh A. (ed), *Readings in Banking and Finance*, pp. **67– 84, 2007**.

[32] K.S. Adeyemi, "Institutional reforms for efficient microfinance operations in Nigeria," *Central Bank of Nigeria. Bullion*, Vol.**32**, No.**1**, pp. **26– 34, 2008**.

[33] O.J. Nwanyanwu, "Microfinance in Nigeria: Problems and Prospects," *African Research Review*, Vol.**5**, No.**2**, pp.**87– 103, 2011**.

[34] G. Konecny, Recent global changes in geomatics education. *Proceedings of ISPRS Commission VI Symposium* (CD– ROM), ISSN 1682– 1750, Sao Jose' dos Compos, Brazil, pp.**16–18, 2002**.

[35] L.S.C. Pun–Cheng, "Knowing our customers: A quantitative analysis of geomatics students," *International Research in Geographical and Environmental Education*, Vol.**10**, No.**3**, pp.**322–341, 2001**.

[36] Q. Weng,, "Remote Sensing and GIS Integration, Theories, Methods, and Applications," *McGraw– Hill Companies, Inc,* **New York, 2010.**

[37] T.U. Omali, K. Umoru, "Survey of Remote Sensing and GIS Integration Method," *International Journal of Latest Technology in Engineering, Management & Applied Science*, Vol.**VIII**, No.**1**, pp.**27–35, 2019**.

[38] B.B Salem, "Application of GIS to biodiversity monitoring," *J. Arid Environ.*, Vol.**54**, pp.**91– 114**, **2003**.

[39] M.A. Larson, F.R. Thompson, J.J. Millspaugh, W.D. Dijak, S.R. Shifley, "Linking population viability, habitat suitability and landscape simulation models for conservation planning," *Ecol. Modelling*, Vol.**180**, pp.**103– 118, 2004**.

[40] ESRI. "The language of spatial analysis," *Esri Press, 380* **New York Street. 2013.**

[41] T.M. Lillesand, R.W. Kiefer, J.W. Chipman, "Remote Sensing and Image Interpretation," fifth ed. *John Wiley & Sons,* **New York, NY, 2004.**

[42] T.U. Omali, "Utilization of Remote Sensing and GIS in geology and mining," *Int. J. Sci. Res. in Multidisciplinary Studies,* Vol.**7**, No.**4**, pp.**17– 24, 2021.**

[43] H. De Soto, "The mystery of capital. Finance and Development, Vol.**38**, No.**1**, pp.**29–33, 2001**.

[44] A. Sandborn, R.N. Engstrom, Determining the relationship between census data and spatial features derived from high–resolution imagery in Accra, Ghana. *IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens.,* Vol.**9**, pp.**1970–1977, 2016.**

[45] Watmough GR, Atkinson PM, Saikia A, Hutton CW. Understanding the evidence base for poverty– environment relationships using remotely sensed satellite data: An example from Assam, India," *World Dev ,* Vol.**78**. pp.**188–203. 2016**

[46] H. Tallis, P. Kareiva, M. Marvier, A. Chang, "An ecosystem services framework to support both practical conservation and economic development," *Proc Natl Acad Sci.,* Vol.**105,** pp.**9457–9464**, **2008**.

[47] P. Mosley, "Assessing the success of microinsurance programmes in meeting the insurance needs of the poor," DESA Working Paper No. 84 (October 2009), **2009**.

[48] U. Hess, H. Syroka, "Weather– based insurancein Southern Africa: the case of Malawi," *Discussion Paper 13. World Bank,* **Washington DC, 2005.**

[49] J.F. Morton, "The impact of climate change on smallholder and subsistence agriculture," *Proc. Natl. Acad. Sci.,* Vol.**104**, pp.**19680–19685**, **2007**.

[50] K. Waha, B. Zipf, P. Kurukulasuriya, R.M. Hassan, "An agricultural survey for more than 9500," *African households. Sci. Data,* Vol.**3, 160020, 2016**.

[51] R. De Jon, J. Verbesselt, M.E. Schaepman, S. De Bruin, "Trend Changes in Global Greening and Browning: contribution of short–term trends to longer–term change," *Global Change Biology,* Vol.**18**, pp.**642–655, 2012**.

[52] F.I. Okeke, R.I. Ndukwu, "Development of web–based GIS application for crop information for Nigeria," *Nigerian Journal of Space Research,* Vol.**4**, pp. **61–72, 2007**.

[53] T.U. Omali, S.B.M. Akpata, K. Umoru, J. Obera, "Imaging spectroscopy for crop monitoring in Nigeria: a review," *Global Scientific Journal,* Vol. **7**, No.**4**, pp.**743–750, 2019**.

[54] K. Puleno, K.M. Munish, K. Lav, "GPS mobile banking: an advance security measures," *International Journal of Development Research,* Vol.**6**, No.**4**, pp.**7672–7674, 2016**.

AUTHORS PROFILE

Thomas U. Omali is currently working at the National Biotechnology Development Agency (NABDA), Federal Ministry of Science and Technology, Nigeria. He is an Associate of Nigeria Institution of Surveyors (ANIS), Member of Geoinformation Society of Nigeria (MGEOSON), and Member of Nigeria Environmental Society (MNES). He has published several journal papers and book chapters. His resent research interest is on agriculture and agroecology, vegetation and forest ecology, global change, resource inventory, health geography, crustal deformation and earthquake analysis, applied remote sensing, GIS/LIS, and spatial analysis.