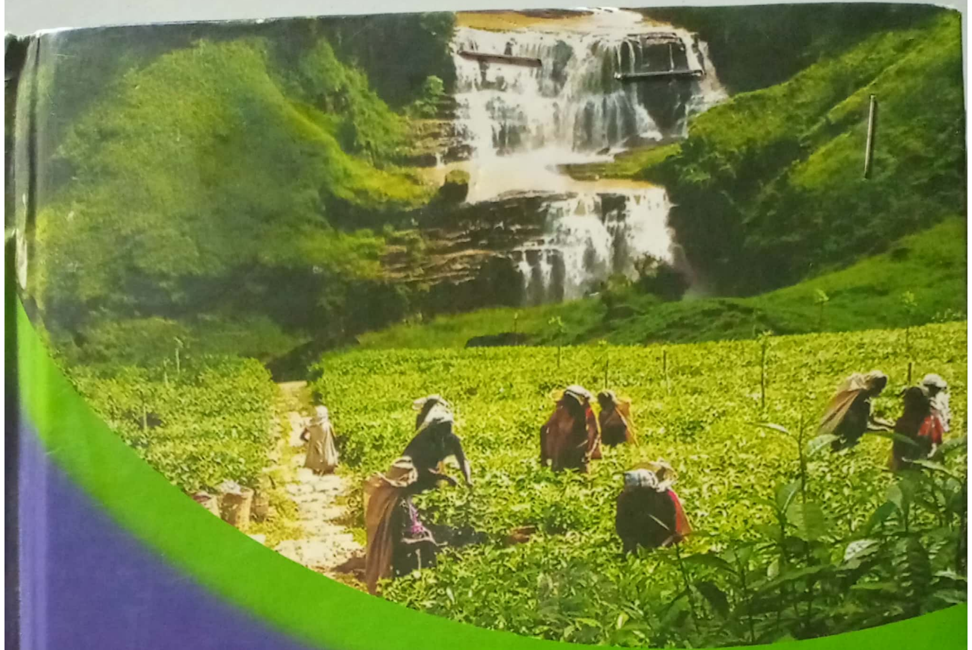

Geography in Development

Issues and Perspectives

S. L. Tilakasiri

Idowu O. Owoeye.

URP Dept. FUT.

Minna.

2017.

Dr. Idowu, O. Owoeye
URP. Dept.
FUT Minna.

1.

Geography in Development

Issues and Perspectives

Editor

S. L. Tilakasiri

STAMFORD LAKE (PVT) LTD
2017

Dedicated

to Geographers around the World

for their Contributions

towards Development of Geography

PREFACE

The book "Geography in Development: Issues and Perspectives" was conceived by Dr. S. L. Tilakasiri based on his background and understanding of how man's DESIRE to satisfy his needs, but oftentimes his "wants" has impacted the environment and consequent shaping and re-shaping of the planet - earth. The earth and its resources, exploitation and level of development vary from region to region.

Indeed, spatial interaction between and within regions is informed by human understanding of available resources and use to which such resources can be put, which in turn determines the level of development. Geography and Geographers therefore, possess the appropriate tools with which to see and understand spatial variation and similarities in regions; why and how these can be explored for human socio-economic development without making OUR WORLD unsafe.

The book is a collection of Chapters written by international scholars' based on their perspectives on the contribution of Geographers and Geography to development with emphasis on the Global South. It is therefore an attempt to synthesize the relationships between Geography and Development.

The book has been divided into four parts of 25 chapters. Part One is on Geography and Development Issues which covers areas such as Geography in development, Geographical thinking and development, looking at the missing basis of development from the spiritual spectacle, presenting the indicators and indices of development, to several applications of remote sensing and Geographical Information System vis-a-vis development, as well as the prospects and challenges of Geographic Information System in the developing countries.

Part Two of the book discusses Geography and the Natural Environment with emphasis on natural resources endowment and development, the need for Geographical knowledge in water resources management, the changing landscape in Geographical hydrology, the role of irrigation in development, variation in agricultural development across ecological zones;

and the challenges of flood risk management arising from climate change. The Third Part explores Geography and Regional Development highlighting urban and rural development, trends and challenges, resource mobilization for rural development and the need for a balanced regional development.

Geography and Socio-cultural Development are extensively discussed in the Last Part with focus on socio-economic development and the challenges of economic development from population perspective, Geographers view on health and development, rural road transport and socio-economy, alternative gender framework, development as cultural engagement, contemporary perception of crime in Geographical space; and municipal waste management from an international perspective.

This book, Geography in Development is a good documentation of the viewpoints of Geographers in the developing world. It is therefore, a must read for scholars that are interested in better and safe management of our environment and its resources. I therefore recommend the book to students of tertiary institutions, post graduate students, policy makers and the general public.

Prof. J. F. Olorunfemi
Professor of Geography,
Department of Geography and
Environmental Management,
University of Ilorin,
Ilorin – Nigeria.

Acknowledgements

Geography as my favorite subject since my school days, made it possible for me to undergo series of trainings through it and other subjoined disciplines. Through Geography which has multifaceted approach, I was able to see, work and research in different issues and contexts.

Publishing a book of this nature on Geography in Development has been a lifetime ambition at least before my exit from the public service. Thanks to the University of Ilorin Nigeria, for giving me the opportunity to fulfill this desire. I am able to realize and fulfill this ambition because of the conducive research environment provided by the University and kind support from the members of the Department of Geography and Environmental Management of the University.

I once again, sincerely appreciate Professor Abdulganiyu Ambali, the Vice-Chancellor – University of Ilorin, Nigeria, and Prof Is-haq O. Oloyede, the immediate past Vice-Chancellor of the University for appointing me as a member of staff and providing a scholarly environment in the Department of Geography and Environmental Management. My thanks go to Professor M. O. Ibrahim, Director – Centre for International Education, Professor Bashir Salawu – Dean, Faculty of Social Sciences and Dr/Mrs. R. M. Olanrewaju – Head, Department of Geography and Environmental Management for their immense support.

It was Associate Professor U.A. Raheem, *University of Ilorin, Nigeria* who encouraged me to bring up the book, and without his intervention this project might be difficult to accomplish.

In the preparation of this book, many people offered active support. I express my profound gratitude to Professors J. F. Olarunfemi, A. F. Adedayo, R. A. Olawepo and L. T. Ajibade, *University of Ilorin, Nigeria* for their advice and moral support. I also appreciate the contributions of Emeritus Professor M. M. Karunanayake, *University of Sri Jayewardenepura, Sri Lanka* and Emeritus Professor C. M. Madduma Bandara, *University of Peradeniya, Sri Lanka* for their support with valuable ideas and continuous encouragements. Thanks are due to Professor Jan Lundqvist, *Stockholm International Water Institute, Sweden* and Professor Ranghild Lund, *University of Trondheim, Norway* for their useful comments.

My gratitude goes to those colleagues who contributed to the success of this book by providing academically inspiring chapters, reviews and comments. I am also indebted to members of the Editorial Consultants from different regions of the world, for their valuable insights and useful comments on the draft manuscripts.

I would like to acknowledge the partial financial assistance provided by the People's Bank and People's Leasing Company, Sri Lanka under their Corporate Social Responsibility programmes to make this publication a success.

My thanks also go to Stamford Lake Publishers and the Staff for their professionalism in publishing this book.

Finally, I thank my family - Sriyani, Sevvandi and Sahan for their understanding and support. Thank you all.

S. L. Tilakasiri (Ph.D.)
Department of Geography
& Environmental Management
University of Ilorin, Nigeria.

Correspondence
Department of Geography,
University of Kelaniya,
Sri Lanka.

July 2017.

Geography in Development

Lundqvist, Jan (Ph.D.)	Professor/Senior Scientific Advisor, Stockholm International Water Institute, Sweden.
Madduma Bandara, C. M. (Ph.D.)	Emeritus Professor, University of Peradeniya, Sri Lanka.
Manawadu, Lasantha (Ph.D.)	Professor, University of Colombo, Sri Lanka.
Olawepo, R. A. (Ph.D.)	Professor, University of Ilorin, Nigeria.
Olorunfemi, J. F. (Ph.D.)	Professor, University of Ilorin, Nigeria.
Sandell, Klas (Ph.D.)	Senior Professor, University of Karlstad, Sweden.
Ulluwishewa, R. (Ph.D.)	Research Fellow – Massey University, New Zealand.
Wanasinghe, Y. A. D. S. (Ph.D.)	Emeritus Professor, University of Sri Jayewardenepura, Sri Lanka.

CONTRIBUTORS

Abdulraheem, M.O. (Ph.D.) – Lecturer, Department of Urban and Regional Planning, University of Ilorin, Ilorin, Nigeria. E-mail: maimunaabdulraheem@yahoo.com

Adeleke, E. A. (Ph.D.) – Lecturer, Department of Geography & Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: adelekeelisha@yahoo.com

Adeniyi, E.E. – Lecturer/Doctoral Candidate, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: eneegboche@yahoo.com

Adenle Ademola, A. – Lecturer/Doctoral Candidate, Department of Geography and Meteorology, Federal University of Technology, Minna- Nigeria. E-mail: ade.adenle@gmail.com

Adetunde, O. T. – Doctoral Candidate, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: adetundesegun@gmail.com

Afolayan, G. P. (Ph.D.) – Lecturer, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: drafolayan@yahoo.com

Ahmed, Y. A. (Ph.D.) – Senior Lecturer, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: royalkayb@yahoo.com

Ajibade, L. T. (Ph.D.) – Professor, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: edabijalt2001@yahoo.com

Akpan, G. P. – Department of Geography, Kebbi State College of Basic and Advanced Studies, Yauri, Kebbi State, Nigeria. E-mail: godisgood885@gmail.com

Ashaolu, E. D. – Doctoral Candidate, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: damash007@yahoo.com

Azeez, A.D. – Postgraduate Candidate, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: adewaledaud@gmail.com

Azmi, F. (Ph.D.) – Research Fellow, Department of Geography, Norwegian University of Science and Technology, Trondheim, Norway. E-mail: fazeehaazmi@gmail.com

Fashagba, I. (Ph.D.) – Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: worldrewol@gmail.com

Hennayake, Nalani. (Ph.D.) – Senior Lecturer, Department of Geography, University of Peradenaiya, Peradeniya, Sri Lanka. E-mail: nalihennayake@gmail.com

Idowu, O. O. (Ph.D.) – Lecturer, Department of Geography, University of Minna. Nigeria. E-mail: olu.idowu@futminna.edu.ng

Ifabiyi, I. P. (Ph.D.) – Associate Professor, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: tokunifabiyi@yahoo.com

Iroye, K. A. (Ph.D.) – Senior Lecturer, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: iroyekayode@yahoo.com

Kazeem, O. Laro – Assistant Lecturer, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: larokazeem@gmail.com

Lund, R. (Ph.D.) – Professor, Department of Geography, Norwegian University of Science and Technology, Trondheim, Norway. E-mail: ragnhild.lund@svt.ntnu.no

Malik, N. A. (Ph.D.) – Lecturer, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: today_2009@yahoo.com

Ogundare I. O. (Ph.D.) – Senior Lecturer, Department of Geography, Emmanuel Alayande College of Education, Oyo, Nigeria. E-mail: oguntoyin@yahoo.com

Olanrewaju, R. M. (Ph.D.) – Senior Lecturer, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: rodamoji@gmail.com

Olawepo, R. A. (Ph.D.) – Professor, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: ralfabbey@yahoo.com

Olorunfemi, Felix (Ph.D.) – Visiting Scholar, MSCP, Department of Urban Studies and Planning, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA. E-mail: felixolorunfemi@gmail.com

Olorunfemi, J. F. (Ph.D.) – Professor, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: funsofem@gmail.com

Oriola, E. O. (Ph.D.) – Associate Professor, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: lolaoriola@gmai.com

Orire, I. O. (Ph.D.) – Lecturer, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: isorire@yahoo.com

Raheem, U. A. (Ph.D.) Associate Professor, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: adebimpeusman@gmail.com

Salami, A. A. – Doctoral Candidate, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: harpheezharlarby@gmail.com

Sanusi, M. A. (Ph.D.) – Lecturer, Department of Geography, Modibbo Adama University of Technology, Yola, Nigeria. E-mail: jibiros99@yahoo.com

Tilakasiri, S. L. (Ph.D.) – Senior Lecturer, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: sltilak@gmail.com

Tunde, A. M. (Ph.D.) – Lecturer, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: afolabi@unilorin.edu.ng or folamoni70@yahoo.com

Ulluwishewa, Rohana (Ph.D.) – Professor/Research Associate, School of People, Environment and Planning, Massey University, New Zealand. E-mail: ulluwishewa@xtra.co.nz

Usman, B. A. (Ph.D.) – Lecturer, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria. E-mail: bolicon2004@yahoo.co.uk

Yahaya, O. Y. (Ph.D.) – Department of Geography and Regional Planning, Federal University Dutsinma, Katsina State, Nigeria. E-mail: yahayauseful@gmail.com

Yusuf, R. O. (Ph.D.) – Lecturer, Department of Geography, Ahmadu Bello University, Zaria, Nigeria. E-mail: royusoba@yahoo.co.uk

CONTENTS

Part One

Geography and Development Issues

The scientific world witnessed the birth of remote sensing before the birth of Geographical Information System or Science (GIS). Arguably remote sensing laid the foundation for the advent of GIS, because of the thematic processing of imagery. In recent years, however, remote sensing and GIS have gone hand in hand, to the extent that remote sensing provides data or input data to GIS.

According to the American Society of Photogrammetry - ASP (1983) remote sensing can be defined as the acquisition of information about an object without physical contact. Remote sensing was further described as the measurement or acquisition of information of some property of an object or phenomenon, by a recording device that is not in contact with the object or phenomenon under study.

In the view of Lillesand & Keifer (1987), remote sensing is the science and art of obtaining information about an object, area or phenomenon under investigation. Sabins (1986) defined remote sensing as collecting and interpreting information about a target without being in physical contact with the object. Remote sensing is commonly restricted to methods that employed electromagnetic energy such as light, heat and radio waves as the means of detecting and measuring target characteristics. What is common to these definitions is the elements of observation, recording, measurement and interpretation of physical objects and the environment using devices that are not in contact with the physical objects and the environment.

GIS on the other hand, is a system of capturing, storing, querying, analyzing and displaying geospatial data (Cheng, 2012). Geo-spatial data illustrate both the locations and attributes of spatial features. The capability of GIS to process and integrate geo-spatial data differentiates it from other information systems. GIS capabilities validates it as a significant geographic tool applied by geoscientists, cartographers, photogrammetrits, environmental engineers, urban and regional planners, among others (Cheng, 2012). The capability of data integration perhaps explains why some softwares such as ArcGIS, QGIS, etc. incorporate GIS and remote sensing together in a single system.

Thus, remote sensing and GIS are powerful tools that are very important in every area of human endeavour over which geographers are very proud, hence the need to showcase some of the very numerous ways in which the technology has been of immense benefit to mankind. This chapter therefore highlights the importance of remote sensing and GIS in their various areas of applications vis-a-vis development.

According to Boroffice & Akinyede (2005), remote sensing and GIS have significantly contributed to over 80 per cent of accurate and real time geo-information data and support for sustainable development efforts. For the purposes of this chapter in the book, efforts are made to highlight many of the areas in which the technology has been used to address specific issues in development. The areas discussed though not exhaustive are: geographical applications; agriculture; geology; disaster management; urban planning, development and management; hydrology; population studies and census organization; human health and epidemiology; archaeology; climatology; as well as ocean and coastal monitoring.

Geographical Applications

These are too numerous, but it will suffice to mention a few spatio-temporal studies of geographical significance here. Rawat & Kumar (2015) evaluated the spatio-temporal dynamics of land use/cover of Hawalbagh block of district Almora, Uttarakhand, India. Landsat satellite imageries of two different time periods of 1990 and 2010 were categorized into five different land use/ cover classes namely vegetation, agriculture, barren, built-up and water body. The results indicated that during the last two decades of the study, vegetation and built-up land increased by 3.51 per cent (9.39 km2) and 3.55 per cent (9.48 km2), respectively. The agriculture, barren land and water body decreased by 1.52 per cent (4.06 km2), 5.46 per cent (14.59 km2) and 0.08 per cent (0.22 km2), respectively. They concluded that remote sensing and GIS are vital tools for temporal analysis and quantification of spatial phenomena which is otherwise may not be possible to attempt through conventional mapping techniques.

Ashaolu & Omotosho (2015) assessed the static water level and overburden pattern for sustainable groundwater development and management in Ilorin, Nigeria using GIS. They computed the static water level and contour map with the data on depth to water to show the pattern of water level in Ilorin. They also plotted the overburden map from the overburden data using IDW interpolating method in GIS. From the result, they classified Ilorin into poor (overburden <10m), marginal (10m-19m overburden) and good or high zone (overburden ≥ 20m) of groundwater potentials. Their analysis of the spatial pattern of overburden depth revealed that the majority of Ilorin city was underlain by marginally thick overburden. They concluded that sustainable groundwater development and management in Ilorin could only be attained by controlling the indiscriminate drilling of boreholes (wells), continuous mapping and regular updating of the available records on groundwater resources.

Olorunfemi (1983a) documented the growth of Ilorin city using aerial photography. He emphasized that monitoring changes in urban growth over time is quite difficult with traditional method of surveying. Thus, satellite remote sensing techniques have proved to be of substantial importance in preparing accurate land use/cover maps and monitoring changes at regular intervals. In fact, inaccessible region can be studied using this technique and perhaps the only available method of obtaining the required data which is cost and time effective.

Agriculture

Agriculture plays a dominant role in economies of both developed and developing countries. The applications of remote sensing and GIS have significantly contributed to providing timely and accurate data to the agricultural sector, in term of its suitability for gathering information over large areas with high revisit capability. Agricultural applications of remote sensing and GIS include: crop type classification; crop condition assessment; crop yield estimation; mapping of soil characteristics; mapping of soil management practices; and compliance monitoring (Atzberger, 2013; Wójtowicz et al., 2016).

In the context of global challenges facing the agricultural sector, Atzberger (2013) identified five areas of application of remote sensing and GIS. These are: (1) biomass and yield estimation; (2) vegetation vigour and drought stress monitoring; (3) assessment of crop phenological development; (4) crop acreage estimation and cropland mapping; and (5) mapping of disturbances and land use/land cover (LULC) changes. Several other studies have applied remote sensing and GIS in assessing nutritional requirements of plants and nutrient content in soil, determining plant water demand and weed control (Burks et al., 2000; Launay & Guerif, 2005; Wójtowicz et al., 2016).

Geology

Geology involves the study of landforms, structures, and the subsurface, so as to understand the physical processes creating and modifying the earth's crust. It is most commonly understood as the exploration and exploitation of mineral and hydrocarbon resources, generally to improve the conditions and standard of living of mankind (Canada Centre for Remote Sensing, Tutorial, 2016). Remote sensing and GIS have been used as a tool to extract information about the land surface, structural composition and features; identification of groundwater potential; structural mapping and terrain analysis (Godebo, 2005; Fadda1 et al., 2007; Theilen-Willige et al., 2014). Remote sensing is not limited to direct geological applications, but has been used to support logistics, such as route planning for access into mining areas, reclamation monitoring, and generating base maps upon which geological data referenced or superimposed (Canada Centre for Remote Sensing Tutorial, 2016; Godebo, 2005). Geological applications of remote sensing include surficial deposit / bedrock mapping; lithological mapping; structural mapping; sand and gravel (aggregate) exploration/ exploitation; mineral exploration; hydrocarbon exploration; environmental geology; geo-botany; baseline infrastructure; sedimentation mapping and monitoring; event mapping and monitoring; geo-hazard mapping and planetary mapping.

Disaster Management

Disasters are extreme events within the earth's system that result in death or injury to humans, and damage or loss of valuable goods, such as buildings, communication systems, agricultural land, forest and natural environment (Van Westen, 2000). Disasters have become an issue of alarming proportions whether natural hazard or through intervention of human activities (Bello & Aina, 2014). Remote sensing and GIS have been applied to address different forms of hazards that are geophysical; hydrological; meteorological; climatological and biological in nature (Hadeel et.al, 2010; Krishnamoorthi, 2016). These hazards range from earthquake; volcanic activity; mass movement; flood; landslide; tropical cyclone; fog; drought; wild fire; urban heat; and epidemic. Applications of remote Sensing and GIS particularly assisted in managing disaster in very effective ways (Van Westen, 2000; Krishnamoorthi, 2016). The tools have predicted disaster vulnerable areas and most probable areas of occurrence. Remote sensing and GIS have played vital roles in evolving suitable and sustainable strategies for preparedness; assessment, mitigating; response (Van Westen, 2000; Krishnamoorthi, 2016), and post disaster management including risk modelling; vulnerability analysis and damage assessment.

Urban Planning, Development and Management

The input of remote sensing and GIS to urban planning, development and management are enormous (Olorunfemi, 1981; 1983b; 1985 & 1987; Madhavan et al., 2001; Fabiyi, 2006; Bhatta, 2010; Basawaraja et al., 2011). Urban planning involves many functions, scales, sectors and stages that can be classified into administration, development control, plan making, and strategic planning. Several other authors have applied the technology to urban growth; urban change detection; land use/ land cover study; urban sprawl mapping and measurement; urban facilities distribution and the generation and development of accurate urban land use map (Olorunfemi, 1985; Madhavan et al., 2001; Fabiyi, 1999; 2006; Braimon & Onishi, 2007; Idowu, 2017). Remote sensing and GIS have been applied in modeling, quantifying, and predicting the future urban phenomena. The combinations of these technologies are capable of calculating the fragmentation, patchiness, porosity, patch density, interspersion and juxtaposing, relative richness, diversity and dominance in term of structure, function and change (Civco et al., 2002; Sudhira et al., 2004). Remotely sensed data provides a robust source of spatial attributes of the urban landscape (Yagoub, 2006).

For example, Ogunbodede and Balogun (2013) determined the spatial growth, rate and direction of growth of Benin City between 1986 and 2017. Future growth projection and the possible effects of the growth on Benin urban environment were determined from their analysis. They discovered that the absolute growth for the 21 years was 115.5785 sq km with an annual rate of growth is 5.5sq km. On the basis of their findings, they recommended regular monitoring of urban expansion and its direction using integrated remote sensing and GIS approaches. This will assist in determining the pattern of land use/cover and will also guide the provision of urban services and infrastructures.

Hydrology

Hydrology is the study of water on the Earth's surface, whether flowing above ground, frozen in ice or snow or retained in soil. Hydrology is inherently related to many other applications of remote sensing, particularly forestry, agriculture and land cover, since water is a vital component in each of these disciplines. Remote sensing and GIS offers a synoptic view of the spatial distribution and dynamics of hydrological phenomena (Canada Centre for Remote Sensing Tutorial, 2016). Several researchers including Godebo (2005) have explored remote sensing and GIS in the identification of groundwater zone. Remote sensing and GIS were used by Soneye (2014) to carry out a detailed study on the hydrology of Sokoto Rima Basin over forty years period and observed tremendous increase in size length and consequently suggested developmental approach toward water security and sustainability in the area. The use of these technologies has reduced the time and money used in exploration and has indeed increased the accuracy of finding groundwater. Examples of hydrological applications include: wetlands mapping and monitoring; soil moisture estimation; snow pack monitoring/delineation of extent; measuring snow thickness; determining snow-water equivalent; river and lake ice monitoring; flood mapping and monitoring; glacier dynamics monitoring (surges, ablation) river /delta change detection; drainage basin mapping and watershed modelling; irrigation canal leakage detection; and irrigation scheduling.

Population Studies and Census Organization

Knowledge of the size and distribution of human population is essential in solving social, political, economical and environmental problems (Liu, 2003). Increasing interests in the applications of remote sensing and GIS to population studies has been driven by ready availability of remotely sensed data and GIS as a tool. It has been used to identify housing structures and estimate populations (Olorunfemi, 1979). Earlier, these technologies have long been used to estimate population, particularly for large areas. Wu et al. (2005) provided a comprehensive review of most of the studies in this direction. The studies conducted by Dong et al. (2010); Lu et al. (2010); Silva´n-Ca´rdenas et al. (2010) focused on recent developments in population estimation using innovative remote-sensing and GIS technologies. Remote sensing and GIS have been used to provide data on settlement identification (NARSDA); settlement size and ordering (Olorunfemi, 1987); demarcation of enumerated areas (Adewara, 2017); and inter-censal population estimation (Olorunfemi, 1987). The effort of the NPC in enumeration demarcation across Nigeria is being anchored by the technical advice of remote sensing and GIS experts.

Human Health and Epidemiology

The use of remote sensing and GIS for the study of diseases has grown rapidly in the past decade. These technologies have help researchers to answer questions concerning the spatial and temporal aspects of diseases outbreaks (Masimalai, 2014; Umaru et al., 2014); diseases mapping (D'Alessandro et al., 1995);

epidemiological study of tropical diseases (Oladejo et al., 2014); the ecology and transmission of malaria in Gambia and Nigeria (Thomson et al., 1996; Ifatimilehin, & Fanan, 2014; Abdulkadir et al., 2015); and prediction of the actual distribution of disease vector (Sherbinin et al., 2002).

Archaeology

The application of remote sensing and GIS technologies are becoming increasingly apparent to researchers whose work has to do with study of the rise and development of human settlements both in the past and present. The archaeologist benefit from satellite data because such data has placed local field studies within a regional context. The integration of remote sensing imagery GIS data layers and fieldwork has enlarged research possibilities and analyses by permitting the synthesis of environmental and ecological data with ethnographic, historic and archaeological research (Sherbinin et al., 2002). The remote sensing imagery utilized by archaeologists for decades became greatly enhanced with the availability of satellite imagery and image analysis software for archaeological inquiry.

Climatology

Satellite remote sensing and GIS have provided major advances in understanding the climate system and its changes, by quantifying processes and spatio-temporal states of the atmosphere, land and oceans (Yang, 2013). The application of remote sensing and GIS allowed the observation of states and processes of the atmosphere, land and ocean at several spatio-temporal scales (Adefolalu, 2001). These tools have proved to be efficient in monitoring land cover and its changes through time over a variety of spatial scale (Adefolalu, 1986). The uses of satellite imagery with climate models have enhanced the simulation of the climatic system and improved climate projection. Utilization of satellite data combined with GIS has also contributed to the improvement of meteorological reanalysis products that are widely used for climate change research and weather forecast by CNN and other television stations across the world. To cope with the impact of climate change, remote sensing data and GIS are widely used for monitoring, developing prevention, mitigation and adaptation measures (Fasona, 2010; Abbas & Fasona, 2012).

Ocean and Coastal Monitoring

The oceans not only provide valuable food and biophysical resources, it is important, sensitive ecological systems and also significant from an economic point of view as they are used for transportation, tourism, fishing, aquaculture, and recreation. Many times, their significance is ignored and they are overexploited or subjected to intense environmental pressures. The ocean has an important link to the earth's hydrological balance (Dassenakis et al., 2013; and Canada Centre for Remote Sensing Tutorial, 2016). Remote sensing and GIS have a wide range of applications in ocean and coastal monitoring (Fasona & Omojola, 2009). Various satellite remote sensing data in combination with GIS provides the real data which can be used to monitor coastal resources and manage such diverse changes as coastal erosion, loss of natural habitat, urbanization, effluents and offshore pollution caused by human activities (Vanderstraete et al., 2005; and Gayathri et al., 2016).

As outlined by Canada Centre for Remote Sensing Tutorial (2016), the applications of remote sensing and GIS in ocean and coastal monitoring include: Ocean pattern identification: currents; regional circulation patterns; shears; frontal zones; internal waves; gravity waves; eddies; upwelling zones; and shallow water bathymetry; Storm forecasting: wind and wave retrieval; Fish stock and marine mammal assessment: water temperature monitoring; water quality; ocean productivity, phytoplankton concentration and drift; aquaculture inventory and monitoring; Oil spill: mapping and predicting oil spill extent and drift; strategic support for oil spill emergency response decisions; and identification of natural oil seepage areas for exploration; Shipping: navigation routing; traffic density studies; operational fisheries surveillance; and near-shore bathymetry mapping; and Intertidal zone; tidal and storm effects; delineation of the land / water interface; mapping shoreline features / beach dynamics; coastal vegetation mapping; and human activity / impact.

Conclusion

The effective means of using space technology and its integration with GIS have assisted in solving problems that are of regional and global significance. As highlighted in this chapter, the application of remote sensing and GIS to different fields has contributed in no small measure to development. Information from satellite remote sensing and GIS has contributed significantly to the acquisition of knowledge and thus, resulted in better management of environmental resources. There is now a recognized need to manage the earth's resources in a sustainable and environmental friendly manner and remote sensing and GIS have provided a variety of information essential in facilitating such management.

References

Abbas, I. I. & Fasona, M. J. (2012). Remote sensing and geographic information techniques: Veritable tools for land degradation assessment. *American Journal of Geographic Information System, 1*(1), 1 – 6.

Abdulkadir, I. F., Yakubu, S. L. & Modibbo, M. A. (2015). Application of remote sensing and GIS techniques in the malaria control program of Katsina State Nigeria. *International Journal of Scientific Engineering and Research (IJSER)*, 76 – 82.

Adefolalu, D. O. (1986). Further aspects of Sahelian drought as evident from rainfall regime of Nigeria. *Arch. Met. Geophy. Biocl, 36*, 277-295.

Adefolalu, D. O. (2001). Towards a meaningful environmental management in Nigeria. A Paper presented on developing linkage programme at Federal University of Technology Minna, Niger State, Nigeria.

Adewara, J. F. (2017). *Spatial modelling for pre-census enumeration area demarcation exercise of Ilorin West LGA of Kwara State, Nigeria.* M.GIS Research Proposal, Geography and Environmental Management, University of Ilorin.

Ashaolu, E.D. & Omotosho, O. (2015). Assessment of static water level and overburden pattern for sustainable groundwater development and management in Ilorin City, Nigeria. *GEOGRAFIA- Malaysian Journal Society and Space, 11* (9), 1-11.

Atzberger, C. (2013). Advances in remote sensing of agriculture: Context description, existing operational monitoring systems and major information needs. *Remote b Sensing*, 5, 949-981.

American Society of Photogrammetry (1983). Manual of Remote Sensing. Vol. 1. Second Edition, ASP Virginia.

Basawaraja, R., Chari, K. B., Mise, S. R. & Chetti, S. B. (2011). Analysis of impact of urban sprawl in altering the land-use, land-cover pattern of Raichur City, India using geospatial technologies. *Journals of Geography and Regional Planning*. Retrieved from http://www.academicjournal.org/JGRP.

Bello, O. M. & Aina, Y. A. (2014). Satellite remote sensing as a tool in disaster management and sustainable development: Towards a synergistic approach, *Procedia – Social and Behavioural Sciences, 120*, 365-373

Bhatta, B. (2010). *Analysis of urban growth and sprawl from remote sensing data: Advances in Geographic Information* Science. Springer-Verlag Berlin Heidelberg. Retrieved from http://www.springer.com/978-3-642-05298-9.

Boroffice, R. A. & Akinyede, J. O. (2005). Space technology and development in Africa and the Nigeria's Experience. National Space Research and Development Agency, Abuja.

Braimoh, A. K. & Onishi, T. (2007). Spatial determinants of urban land use change in Lagos, Nigeria. *Journal of Science Direct and Land Use Policy 24*. Retrieved from www.sciencedirect.com

Burks, T.F., Shearer, S.A. & Payne, F.A. (2000). Classification of weed species using colour texture features and discriminate analysis. *Transactions of the American Society of Agricultural Engineers*, 43, 441–448.

Canada Centre for Remote Sensing Tutorial (2016). Fundamental of remote sensing. Natural Resources Canada. Retrieved from http://www.ccrs.nrcan. gc.ca/resource/tutor/fundam/index_e.php>, modified 2016.

Cheng, K. (2012). Introduction to geographic information system. Sixth Edition. McGraw-Hill, New York

Civco, D. L., Hurd, J. D., Wilson, E. H., Arnold, C. L. & Prisloe, M. (2002). Quantifying and describing urbanizing landscape in the North-east United State. *Photogrammetry Engineering Remote Sensing, 68* (10), 1083 – 1090.

D'Alleandro, U., Olaleye, B., McGuire, W., Bennet, S., Langerock, P., Aitkins, M. K., Thomson, M., Cham, M. K., Cham, B. A., & Greenwood, B. M. (1995). Reduction in mortality and in morbidity from malaria in Gambia children following the introduction of a National Insecticide Impregnated Badnet Programme. *Lancet, 345*, 479 – 483.

Dassenakis, M., Paraskevopoulou, V., Cartalis, C., Adaktilou, N. & Katsiabani, K. (2012). Remote sensing in coastal water monitoring: Applications in the Eastern Mediterranean Sea (IUPAC Technical Report). *Pure Applied Chemistry, 84*(2), 335–375.

Fabiyi, O. (1999). Satellite application to monitoring and surveillance of master plan implementation and monitoring. *Proceed of Nigerian Institute of Town, Planner*, 48- 60.

Fabiyi, O. O. (2006). Urban land use change analysis of a traditional city from remote sensing data: The case of Ibadan Metropolitan Area, Nigeria. *Humanity and Social Sciences Journal, 1*(1), 42–64.

Fadda1, E. H. R., Kakish, M. & Al-Hanbali, N. N. (2007). Utilizing remote sensing and digital image processing to delineate the structural features in the Eastern part of the Dead Sea, Jordan. *Jordan Journal of Civil Engineering, 1*(3), 287–294.

Fasona, M. & Omojola, A. (2009). Land cover change and land degradation in parts of the South- west coast of Nigeria. *African Journal of Ecology, 47*(1), 30-38.

Fasona, M. J. (2010). Patterns of terrestrial ecological imprints and feedbacks and their iImplications on climate change adaptation in the Wooded Savannah of Nigeria. African Climate Change Fellowship Program (ACCFP). Final Technical Report.

Food and Agriculture Organization of the United Nations (FAO) (2011). Global strategy to improve agricultural and rural statistics; Report No. 56719-GB; FAO: Rome, Italy.

Gayathri, K. D., Ganasri, B. P., & Dwarakish, G. S. (2015). Applications of remote sensing in satellite oceanography: A review. International Conference on Water Resources, Coastal and Ocean Engineering (ICWRCOE 2015). Retrieved from www.sciencedirect.com.

Godebo, T. R. (2005). *Application of remote sensing and GIS for geological investigation and groundwater potential zone identification, South-eastern Ethiopian Plateau, Bale mountains and the surrounding areas*. M. A. Thesis, Addis Ababa University, Ethiopia.

Hadeel, A. S, Jabbar, M. T. & Chen, X. (2010). Application of remote sensing and GIS in the study of environmental sensitivity to desertification: A case study in Basrah Province, Southern part of Iraq. *Appli Geomat*, 2,101–112.

Idowu, O. O. (2017). *Spatio-temporal analysis of peri-urban development in Minna, Niger State, Nigeria*. Ph.D. Thesis, Department of Geography, University of Ilorin, Nigeria.

Ifatimilehin, O. O. & Fanan, U. (2014). Application of remotely-sensed data for modeling malaria infection in Lokoja, Nigeria. *International Journal of TROPICAL DISEASE & Health, 4*(6), 634-644.

Krishnamoorthi, N. (2016). Role of remote sensing and GIS in natural-disaster management cycle. *Imperial Journal of Interdisciplinary Research (IJIR)*, 2(3), 144-154,

Launay, M. & Guerif M. (2005). Assimilating remote sensing data into a crop model to improve predictive performance for spatial applications. *Agriculture, Ecosystems and Environment, 111*, 321-339.

Lillesand, T. M. & Kiefer, R. W. (1987). Remote sensing and image interpretation. Second Edition. John Willey and Sons, New York.

LIU, X. (2003). *Estimation of the spatial distribution of urban population using high spatial resolution satellite imagery*. Ph.D. Thesis, University of California, Santa Barbara, CA, USA.

Madhavan, B. B., Kubo, S., Kurisaki, N & Sivakumar, T.V.L.N. (2001). Appraising the anatomy and spatial growth of the Bangkok Metropolitan area using a vegetation impervious soil model through remote sensing. *International Journal of Remote Sensing*, 22 (5): 789 - 806. Retrieved from http://www.tandfonline.com/loi/tres20.

Masimalai, P. (2014). Remote sensing and Geographic Information Systems (GIS) as the applied public health and environmental epidemiology. *International Journal of Medical Science and Public Health, 3*(12), 1430 – 1438.

Ogunbodede, E. F. & Balogun, T. F. (2013). An integrated remote sensing and GIS approach in monitoring urban expansion in Benin-City, Nigeria. *International Journal of Scientific & Engineering Research,4*(5),734-758.

Oladejo, S. O., Nandi, I. & Ajibola, B. (2014). Epidemiological study of tropical diseases using Geographic Information Systems (GIS) and Remote Sensing (RS). *Sci-Afric Journal of Scientific Issues, Research and Essays*, 2(5), 238-247. Retrieved from http://www.sci-africpublishers.org.

Olorunfemi, J. F. (1979). *Inter-censal population estimation and urban land use changes in Nigeria*. Ph.D. Thesis. Department of Geography, University of Bristol, United Kingdom.

Olorunfemi, J. F. (1980). The role of remote sensing in population estimation, *PAN – Journal of the Population Association in Nigeria*, *1*(1).

Olorunfemi, J. F. (1981). *Monitoring urban land use in developing countries: An aerial photographic approach.* Paper Presented at the Annual Conference of the Institute of British Geographers, Leicester.

Olorunfemi J.F. (1983a). Monitoring urban land - use in developed countries: An aerial photographic approach, *Environmental International*, 9,27-32.

Olorunfemi, J. F. (1983b). The spatial expansion of housing land use in Ilorin (1950 -73): A study in aerial photography. Paper Presented at the 24th Annual Conference of the Geographers Association, Bagauda Lake Hotel, Kano.

Olorunfemi, J. F. (1984). Land use and population: A linking model. *Photogrammetric Engineering and Remote Sensing*, *50* (2), 221- 227.

Olorunfemi, J. F. (1985). The growth of Ilorin: A documentation in aerial photography. *Environment International*, *11*, 509 – 514.

Olorunfemi, J. F. (1987). Identification and measurement of the areal extent of settlements from landsat: An exploration into the Nigeria case. *International Journal of Remote Sensing*, *8*(12), 1839-1842.

Olorunfemi, J. F. (2001). *Better by far*, The 51st Inaugural Lecture at the University of Ilorin on 29/11/2001.

Opeyemi, Z. A. (2008). Monitoring the growth of settlements in Ilorin, Nigeria: A GIS and remote s ensing approach. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*. 37 Part B6b. Beijing.

Rawat, J. S. & Kumar, B. (2015). Monitoring land use/cover change using remote sensing and GIS techniques: A case study of Hawalbagh Block, District Almora, Uttarakhand, India. *The Egyptian Journal of Remote Sensing and Space Sciences*, *18*, 77-84.

Sabins, F. F. (1986). Remote sensing: Principles and interpretation. 2nd Edition. Oxford University Press. New York.

Sherbinin, A., Balk, D., Yager, K., Jaiteh, M., Pozzi, F., Giri, C. & Wannebo, A. (2002). A CIESIN thematic guide to social science applications of remote sensing. Center for International Earth Science Information Network (CIESIN) Columbia University Palisades, NY, USA.

Soneye, A. S. O. (2014). Farm size holding in Northern Nigeria for food security: A remote sensing assessment. *African Journal of Food Agriculture, Nutrition and Development*, 14 (2).

Sudhira, H. S., Ramachandra, T. V. & Jagadish, K. S. (2004). Urban sprawl metrics, dynamics and modeling using GIS. *International Journal of Applied Earth Observation and Geoinformatics, 5*, 29-39. Retrieved from www.Elsevier.com/locate/jag.

Theilen-Willige, B., Malek, M. A., Charif, A., El Bchari, F. & Chaïbi, M. (2014). Remote sensing and GIS contribution to the investigation of karst landscapes in NW- Morocco. *Geosciences, 4*, 50-72.

Thomson, M. C., Connor, S. J., Milligan, P. J. M. & Flasse S. P. (1996). The ecology of malaria – as seen from earth observation satellites. *Annals of Tropical Medicine and Parasitology, 90*(3), 243-264.

Umaru, E. T., Ludin, A. M. N. & Sabri, S. (2014). Spatio-temporal analysis of the spread of meningococcal meningitis in Kaduna Metropolis, 2007 – 2011. *IOP Conference Series: Earth and Environmental Science 18*. 8th International Symposium of the Digital Earth (ISDE8).

Vanderstraete, T. Goossens, R. & Ghabour, T. K. (2005). Using remote sensing and GIS for integrated coastal zone Management, A case study: The coral reefs in the Northwestern Red Sea (Hurghada, Egypt). Presented at the 8th International Conference on Remote Sensing for Marine and Coastal Environments, Halifax, Nova Scotia, 17-19 May 2005.

Van Westen, C. J. (2000). Remote sensing for natural disaster management. *International Archives of Photogrammetry and Remote Sensing, 33*, B7; 1609-1617.

Wójtowicz, M. Wójtowicz, A. & Piekarczyk, J. (2016). Application of remote sensing methods in agriculture. *Communications in Biometry and Crop Science, 11*(1), 31–50.

Wu, S. S., Qiu, X. & Wang, L. (2005). Population estimation methods in GIS and remote sensing: A review. *Geosciences and Remote Sensing, 42*, 80–96.

Yagoub, M. M. (2006). Application of remote sensing and Geographic Information Systems (GIS) to population studies in the Gulf: A case of Al Ain City (UAE). *Journal of the Indian Society of Remote Sensing, 34*(1), 7-21.

Yang, J., Gong, P., Fu, R., Zhang, M., Chen, J., Liang, S., Xu, B., Shi, J. & Dickinson, R. (2013). The role of satellite remote sensing in climate change studies. *Nature Climate Change*. Advance Online Publication | www.nature.com/natureclimatechange

CHAPTER 05

REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM IN DEVELOPMENT

J. F. Olorunfemi, O. O. Idowu and E. D. Ashaolu

Introduction

Remote sensing covers camera remote sensing (CRS) which generally means the acquisition of images in the visible and near infrared spectra using photographic camera and digital camera. The camera can be borne by either aircraft or spacecraft and they are both usually manned. Camera Remote Sensing is commonly referred to as Photogrammetry; satellite remote sensing (SRS) in which the sensor is mounted on satellite (a space platform that is un-manned). The sensor system is limited to the visible and infrared regions of the electromagnetic spectrum (EMS); radar remote sensing (RRS) also has its sensor mounted on satellite but the sensor system operates only within the microwave portion of the EMS; and natural remote sensing (NRS). This concerns the human vision system in which the eye is used to view an image object on temporary basis using the eye-optic-nerve-brain combination. Other forms of natural sensing are those of sound with the aid of the ear; smell with the aid of the nose; feel with the aid of body or skin; and taste with the aid of the tongue. Based on the above, it becomes a lot easy for the reader of this book to appreciate or at least have a feel of the closeness the rather universal way in which remote sensing technology can be a tool of investigation in their chosen field of endeavour.