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The Role of ICTs in Biodiversity Management in Nigeria. E12B

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Abstract: *The unwantom destruction of the ecosystem and devastation of biodiversity integrity portend unimaginable consequences for sustainability and livelihoods. The attendant decimation of species, destabilization of habitats, disorganization of food chains and webs have food security implication. The above premise inspired this paper that x-rayed the role Information Communication Technologies (ICTs) and electronic Apps play in biodiversity management and conservation. The paper conceptualizes biodiversity and ecosystem, discusses Information Communication Technologies' (ICTs) and electronic Apps' use and reviews the nexus of ICT and electronic Apps' use and biodiversity management and conservation. The paper recommends scaling up ICT and electronic Apps' use for biodiversity and ecosystem information dissemination, education monitoring and evaluation for improved management.*

Keywords: *ICTs, roles, biodiversity and management.*

INTRODUCTION

One of the main issues we face today in our beautiful environment is the management of biodiversity. Diversity here refers to the diversity within and between organisms, assemblages of organisms, biotic communities and biotic systems, or organisms and it was changed by man. Biodiversity can be measured in terms of genetic diversity, characteristics and numbers of species, species assemblages, biotic communities and biotic processes, and quantities (such as abundance, biomass, cover, and rate) and each arrangement. It can be observed and measured at any scale from microsites and habitat patches to the entire biosphere (DeLong, 1996). While everyone agrees that management of natural resources is a good idea, part of the problem is that managing of living things is expensive. We are still starting to develop the necessary technologies to preserve the biodiversity, but trying to restore the area to its original state is not only expensive, but difficult.
Human needs and activities, along with the increasing population, are stressing the environment and natural resources (Geogios, 2000). Traditional methods of natural resource management have produced negative results, and management methods often focus on short-term yields and economic benefits rather than long-term. This fact, combined with the advent of scientific knowledge about the environment, has led to a new system for the management of natural resources. This new security system is using ICT.

ICT is an umbrella term used to encompass all forms of technology used to process information and facilitate its communication in a digital format - creation, acquisition, processing, storage, retrieval, transmission, exchange, dissemination. ICT includes hardware and software. The software includes computer (desktop, laptop, telephone, PDAs are included in electronic (DSS), planning, commercial doing, continuously with groups), etc. (Okinlaye 2019). The use of ICT covers various areas such as business,

industry, environment, government, communication, healthcare, scientific research, education, etc. and communication technology.

Information technology is defined by the Information Technology Association of America (ITAA)" as the study, design, development, implementation, support or management of computer information systems, especially computer software and hardware". (Veneri, 1998). Communication technology, on the other hand, involves the activity of designing, building and maintaining communication systems used to facilitate virtual communication between individuals or groups.

ICT is increasingly recognized as the most powerful means of change available to humanity and, today, they must be harnessed and directed for the promotion of sustainable economic development. And as ICT becomes more sophisticated and more embedded in our social and organizational systems, we are better placed than ever to work on sustainable development (Alakeson 2003). Also, due to the great impact of ICT on the economy, it is really a strategic advantage to repeat the urgency of creating an ICT strategy with sustainability in mind.

OBJECTIVE

The main objective of this work is to ascertain the roles of ICT in biodiversity management in Nigeria. Specifically, we reviewed the meaning of biodiversity, biodiversity in agriculture, important of biodiversity, prospect of using ICT in biodiversity management.

METHODOLOGY

This paper is based on a desk review of available literature. Data related to the concept of biodiversity, ICT, biodiversity in agriculture and biodiversity theories are very limited in works done in Nigeria, hence information was accessed mainly through web search and it is presented primarily for raising awareness and policy discussions.

THEORETICAL CONCEPT

This study will premise on the theoretical concept of the Ecological Niche theory. A theory is a set of ideas that provides an explanation for something. It is a set of inter-related construct, definitions and propositions that represent a view or phenomena by specifying relations among variables (Haralambos and Holborn, 2008). It explains a set of coordinated occurrence or relationships. A theory refers to the relationship between facts or the ordering of facts in some comprehensible manner (Adedoyin and Adokun 2004; Otite and Ogionwo, 2006). While theory plays an active role unwavering facts, facts themselves equally play significant role in developing theory and science depends really upon stimulation of fact by theory and theory by facts (Eboh 2009).

The theory that is guiding this work is the ecological niche theory. This theory was proposed by Hutchinson (1957). This concept expresses the relationship of an individual or a population to all aspects of its environment. Studies on the relationship between human population and environmental resources have employed niche concept (Adams, 2002; Hanazaki and Begossi, 2004; Cavallini and Nordi, 2005; Silva and Begossi, 2009).

According to Hardesty (1972), ecological niche comprehends all conditions necessary for an organism to exist. Considering the ecological niche, it can analyze each one of all interactions. For example, trophic or food niche (food relationship, such as species preferred and availability), spatial niche (climatic, chemical, and geographical factors, a species needs to survive), and behavior niche (way in which a species interacts with others, such as: foraging, activity period among others) (Raj, 2010).

The ecological niche based theory states that an ecological community is made up of a limited number of niches, each occupied by a single species. Hutchinson (Hutchinson, 1957) defined the fundamental niche as the needs of a species for it to maintain a positive population growth rate, disregarding biotic interactions (Hutchinson, 1957; Pearman et al., 2008). The fundamental niche therefore represents an idealized situation exclusive of interspecific interactions.

In ecology, a niche is a term with a variety of meanings related to the behavior of a species living under specific environmental conditions (Schoener, 2009). The ecological niche explains how an organism or population reacts to the distribution of resources and competitors (for example, by growing when resources are excess, and when predators, parasites, and pathogens are sparsely distributed) and how it in turn changes those particular factors (for example, limiting access to resources by other organisms, acting as a food source for predators, and a consumer of prey).

“The Hutchinsonian niche is a dimensional hyper, where the dimensions are environmental conditions and resources, that define the requirements of an individual or a species to practice its way of life, more specifically, for its population to persist (Schoener, 2009).

The persistence of the individual organism to survive is dependent on proper management of the spices for live sustenance. One key tool of management is ICT which this work seeks to explore.

Literature Review

Biodiversity and Agricultural biodiversity defined

Agricultural biodiversity is the diferent types of people and changes in living things (trees, animals, other things) which are involved in food and agriculture. However, such a definition is general and will be very useful, and it is necessary to explained and analyze if agricultural biodiversity is to be quantified. It can be considered in three levels - those of ecological diversity, organismal diversity and genetic diversity (Heywood, 1999a), each of which forms a hierarchy of element.

(Agreecoseystems as a farmer's field) are not concerned by the mysterious scholars as part of different things. It includes all species (including wild relatives of cultivated plants) and different types of plants, species of animals and species of micro-organisms, which are used directly or in not clear for food and agriculture, except both as food and as food (including grazing).) for domestic and small domestic animals in different types of agricultural environments. This includes not only such foods, but also food, and nutrition. Things like flavors, colors, preservatives, etc. are also covered. used in the preparation, cooking, processing and preservation of food. Agricultural diversity also includes habitat and non-agricultural diversity that benefit agriculture and improve ecosystem services (Heywood, 2003). In addition to the variety of plants that are used directly to provide goods and services that people use, other things are important because of their contribution to ecological services such as pollination (Klein et al., 2007), soil gas management Dynamics (Frison et al., 2011). The production of at least a third of the world's food, including 87 of the 113 staple food crops, depends on pollination by insects, bats and birds (IUCN, 2012). According to Westerkamp and Gottsberger (2001), "Pollinator diversity is the key to plant diversity" and the pollination activity was estimated at 153 billion worldwide in 2005 (Gallai et al., 2009).

What is biodiversity?

Biodiversity is the variety of life on Earth and includes variation at all levels of biological structure, from genetics to species to ecosystems. Genetic, biological and environmental factors are all factors in different species, each with multiple components (Gaston & Spicer 2004). All of these elements of biodiversity

have led to a large number of formal definitions; Delong (1996) reviewed 85 different definitions. An important and widely used definition is that included in the Convention on Biological Diversity (CBD). More than 150 countries signed this agreement at the United Nations Conference on Environment and Development, which was held in Rio de Janeiro, Brazil, in 1992. It defines different ways of life as "the transformation of living things from all things, including inter alia [among others. other things], terrestrial, water and other things in the water and the environment of which they are part; this including intra-species, inter-species and ecological diversity.

Importance of biodiversity

It is significant in the first place because depicts the nearly endless variety of plants, animals, an ecosystems that exist on Earth and support life as we know it. It gives humans the ability to endure challenging situations. The support for evolution and the distinctions between species comes from biodiversity. Because of this, cats, horses, and people are

what they are.

Water, wind, and sunlight produce most of the energy we use, and the various things the Earth has done over ages is to produce and supply things like coal, is used to produce heat and power. Energy from wind, water, sunlight and coal heats our homes and powers all our appliances. Over the centuries, decaying animal feed has provided the fuel we use every day to power vehicles that make transportation easier and more convenient.

Without biological diversity, we would be (if we exist) a single population, each of us with one weakness. This would mean that if there was an epidemic, we would all be killed since there would be no differences in lifestyle that would allow some of us to survive and change. Most of our modern medicine is based on the combination of different substances isolated from different plants. Even before the rise of modern medicine, ayurveda and unani systems of medicine used different plants for different purposes. Without these plants and various types of insects that pollute them and pass through, humans will be more susceptible to disease.

Forest inhabitants receive all of their daily requirements from the ecosystem's biodiversity, including food, building materials, fodder, medicines, and a wide range of other goods. Lumber, granite, and marble are a few examples of the building materials that biodiversity provides us with; without these, much of human settlement would be without shelter.

Even though we are omnivores, there wouldn't be much variation in our diets if biodiversity were absent. Why biodiversity is essential is one reason to question. This is because biodiversity offers a veritable treasure of dietary options, from staples like wheat or corn to unusual ingredients like some of the shellfish used in sushi. Furthermore, because not all the nutrients we require are present in any one dish, our overall health would suffer if we had a wide basis of foods from which to create combinations. The health of our physical and social environments are all impacted by biodiversity.

Prospects of using ICT for biodiversity management include:

- Analysis/evaluation: Evaluation of impacts on organisms, ecosystems and habitats.

- Information gathering includes temperature and humidity monitoring, remote sensing of organisms, species identification by picture analysis of organisms, and mobile terminalbased data collecting of both organism and environmental data.

- Education, dissemination, and enlightenment: Using network communication and picture distribution technologies, knowledge is disseminated and society is explained to all members. Additionally, supporting economic activities, environmental concerns, and productivity enhancement in the main sectors (agriculture, fisheries, forestry, etc.), which directly engage the supply services that make up the ecosystem services, can help preserve biodiversity (various benefits generated by biodiversity).
- Information management: Organism information (species, population, habitats etc.), database for genetic information etc.
- Monitoring; Monitoring and observation of environment changes and organism behaviors.
- Mobile photo system/cloud services: For preservation of biodiversity and its sustainable use, it is critical to run a PDCA (plan-do-check-act) cycle. At first, it is necessary to understand accurately how many wild animals and plants live and grow in which location inside the targeted area (check). Then, it is essential to carry out analysis and evaluation based on this study and monitoring data and to understand the current status and the time related changes (act). Thereafter, based on the analysis/evaluation results, it is requested to develop preservation and utilization plans to specify how the targeted area should be preserved and used, and who takes what action in which timeframe

("plan")(Reddy,2016).

Results and discu

Discussions on ICT Roles In Biodiversity Management

Information Tools for Ecosystem Conservation

Tools used in ecosystem monitoring and earth observations are given a collective name of geoinformatics or geographic information system (GIS). Studies on ICT use in biodiversity management abound in literature. These include technologies of Remote Sensing (RS), digital cartography and Global Positioning System (GPS) (Ikhuoria, Ero and Ikhuoria, 2006). Ground stations and monitors where the information systems are monitored are also included among these. Remote sensing include all of those means of monitoring planetary features that do not involve direct contact. These methods rely on detection, recording, and analysis of wave-transmitted energy (Montgomery, 2000). Data gathered through remote sensing may include aerial photography and radar mapping of surface topography. Remote sensing, especially using satellites, is a quick and efficient way to scan broad areas, to examine regions, rugged topography or hostile climate and to view areas to which access is limited.

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. It is a system of satellites that are mounted to orbit the earth by nations that are wealthy to own them. Since 1960 when the United States Navy successfully tested the first satellite navigation system (Wikipedia, 2013), various countries such as Russia, Britain, Canada, India, and so on, have launched satellite into orbit. Nigeria joined the race recently with the launching of NigeriaSat-1 in September, 2003. NigeriaSat-1 was designed to be part of the world-wide disaster monitoring constellation system. Its primary objectives were: (i) to give early warning signal of environmental disasters; (ii) to help detect and control desertification in the northern part of Nigeria; (iii) to assist in demographic planning and (iv) To give warning signals on future outbreak of diseases such as meningitis with the aid of remote sensing technology.

Such sensors can produce the Environmental Impact Assessment (EIA) of mining areas. It has also been observed that imaging spectroscopy can make valuable contribution to mapping miningrelated contamination and impacts across a large variety of mining environments and in different climatic contexts (Chevrel, 2004). ICT can be used to improve agricultural practices. All stakeholders in agriculture need information and knowledge about crop cultivation, water management, fertilizer application, fumigation, pest management, crop harvesting, post-harvest techniques and so on. In agriculture, the use of GPS provides benefits in mapping survey and geofencing. GPS has been used to monitor the movement of large animals, such as elephant, when approaching farmlands (Wikipedia, 2013). Because of the usefulness of GIS in soil analysis and topography mapping, it helps in decision making such as what to plant and where.

Again, ICT is providing data for vegetation and land cover mapping to describe broad patterns of distribution of plant communities as observed by different authors such as those of Remote sensing data in combination with other data used to predict species abundance (de Sherbinin, 2005). Landsat TM imagery and digital elevation model has been used to predict the total and rare species richness in agricultural landscapes (Luoto, Toivonen and Heikkinen, 2002). As observed by Saveraid, Debinski, Kindscher and Jakubauskas (2001), that multispectral imagery assists in estimating potential habitat for bird species in different montane meadows. The rapid rate of deforestation and forest degradation in developing countries has resulted in the annual loss of about 17-20 million hectare of forest (Flazzel and Magrath, 1992). Lansat TM statellite remote sensing has been used to monitor activities around forest reserves and the result obtained shows that the reserve was gradually reducing (Ikhuoria, Ero and Ikhuoria, 2006). Salami (2006) uses NigeriaSat1 and other satellites to monitor different forest ecosystems in Nigeria and predict what these forest environments will be in the years to come. Venema, Calamai and Feeguth (2005) observe that proper forest monitoring and management can only be achieved by using remote sensing techniques and creating spatial representations such as maps to know the exact locations and extend of deforestation.

Additionally, land managers can utilize remote sensing to assess vegetation productivity and have rapid access to the data, as well as the diversity of bird and butterfly species

(Seto, Fleishman, Fay and Betrus, 2004). As a function of grass greenness, it has also been used to gauge the Presence and population densities of calving ungulates in the Kalahari Desert (Verlinden and Masogo, 1997 as reported in Nagendra, 2001). In order to forecast species richne ss in the scrub savannah region of northern Senegal, Nohr and Jorgensen (1997) use Landsat TM and other imagery tools. In order to determine the distribution of angiosperm species in India's

Western Ghats, Nagendra and Gadgil (1999) used remote sensing. To find areas that need to be Protected or to make sure that wildlife migration routes are preserved, remote sensing can be used. It has also been utilized to identify deforestation zones within protected areas, and to assess areas that are inaccessible due to war or wild animals. Ganzin and Mulama (2002) evaluate forage resources in Nakuru National Park, Kenya with data obtained from Spot Vegetation sensors, available forage forms an important parameter for decision making on wildlife.

Remote sensing therefore can help facilitate management decisions and allocation of scarce resources for establishment of survey stations. Missouni, Tadjerouni, Chikh and Tidjani (2005) showed how RS and GIS can be utilized to prevent and manage forest fires. GIS is a useful tool in water management to take accurate and real time measurement of run-off and transit losses at each stage of the water capture and conveyance process. It enables scientific decision-making about infrastructure and other water-related issues. Soil sensors that detect moisture content may also be used to automatically switch on/off groundwater extraction pumps (or canal sources) and send alerts via mobile technology.

Information and Communication Technologies can help achieve significant improvements in solid waste management in low and middle income countries. ICT-based solid waste management can increase efficient

use of resources through reduction, re-use and recycling (Dorvil, 2007). Illegal dumping could also be monitored with the aid of GPS. Selection of appropriate landfill sites, precise estimation of solid waste generation and optimum allocation of commercially available containers could be realized through GIS-based analysis (Dorvil, 2007). ICTs can also be employed in waste exchange. Waste exchange system is the one which connects firms discharging, recycling and utilizing industrial wastes. Imai (2002) demonstrates that by using exchange systems, one will be able to monitor solid wastes quality and quantity. The economic importance of ICT in natural resources tourism is also potentially large. It is applied mostly in technically dominated areas such as snow-making or discharge release from rafting (de Jong, 2009). Information Communication Technology networks help professionals in mountain regions to counter natural obstacles inherent to mountain territories. The most important role that ICT plays in mountain territories is the development of interment, which facilitates the exchange of information.

CONCLUSION

Issues of biodiversity conservation and management are more urgent now than ever before as the world faces an extraordinary array of challenges ranging from air and water pollution, food insecurity, climate change, natural disasters, an upsurge of slums, inadequate sanitation, unprecedented loss of forests and fragmented leadership at the local, national, and international levels, conflicts and complex emergencies, and glaring disparities in human development across the globe.

Information communication technology helps to assess the ecosystem better than the traditional methods of monitoring the environment and gives opportunity to prepare ahead of emergencies and facilitates quick response to environmental disasters. In conclusion therefore, it was gathered that ICTs are transformative technologies that put intelligence at the edges of networks, thereby maximizing users' capacity to create and adapt. Integrating ICT into environmental management will minimize deterioration of ecosystems and improve their productivity. Hence, to better manage the environmental challenges highlighted, there is the need to enhance the capacity to predict and track such changes, develop appropriate management and adaptation strategies, and plot a course towards better environmental management in Nigeria.

Recommendations

The use of ICT and in biodiversity management of ecosystem should be adopted and adapted to solve problems related to food security and productivity in our country Nigeria today. It is important to note that its use is expensive but the benefit out ways the cost.

REFERENCES

Adams C, 2002.Estratégiasadaptativas de duaspopulaçõescablocas (Pará) aosecossistemas de VárzeaEstuarina e Estacional: umaanálisecomparativa. Tese, São Paulo: Instituto de Biociências, Universidade de São Paulo.

Adedoyin, F.S. and Adeokun, O.A. (2004). Theory building in agricultural extension. In Olowu, T.A. (ed) Research methods in Agricultural Extension. *Agricultural and Rural Management Training Institute Ilorin. Pp. 16-41*

Cavallini M, Nordi N, 2005. Ecological niche of family farmers in southern Minas Gerais State (Brazil).Braz Journal of Biology, 65: 61- 66

Chevrel, S. (2004). Remote Sensing to Monitor Mining Pollution. Information, Society and Media, European Commission, 1-4

DeLong, D. C. (1996). Defining biodiversity. Wildl. Soc. *Bull. 24, 738–749.* DeLong, D.C. (1996) Defining biodiversity. Wildlife Society Bulletin, 24, 736 – 749.

deSherbini, A. M. (2005). Remote Sensing in Support of Ecosystem Management Treaties and Transboundary Conservation. A Report prepared by the Center for International Earth Science Information Network (CIESIN) under the Remote Sensing Technologies for Ecosystem Management Treaties project funded by the U.S. *Department of State Bureau of Oceans, Environment and International Scientific Affairs. Columbia University. Pp 99* Dorvil, P. L. (2007). *Information and communication technologies in solid waste management.* Network Industries Quarterly, 3

Eboh, E.C. (2009). Social and economic research: principle and methods. African institute for applied economics., Enugu Nigeria

Flazell, J. C. and Magrath, U. (1992). A supervised Thematic Mapper Classification with a Purification of Training Samples. International Journal of Remote Sensing, 13(11), 20392049 Frison, E.A., Cherfas, J. and Hodgkin, T. (2011) 'Agricultural biodiversity is essential for a sustainable improvement in food and nutrition security'*, Sustainability 2011, vol 3, pp.238–253, doi: 10.3390/su3010238.*

Gallai, N., Salles, J.M., Settele, J. and Vaissière, B.E. (2009) 'Economic valuation of the vulnerability of world agriculture confronted with pollinator decline', Ecological Economics, vol 68, pp.810–821.

Ganzin, N. and Mulama, M. (2002). Evaluation of forage resources in semi-arid savannah environments with satellite imagery and the contribution to the management of protected areas: A case study on the Nakuru National Park in Kenya. *Paper presented at the Conference on Space Applications for Heritage Conservation, Strasbourg, France, November 5-8, 2002.*

Gaston, K.J & Spicer, J.I (2004) Biodiversity: an introduction. 2nd Edition. Blackwell

Gaston, K.J. and Spicer J.I. (2004) Biodiversity: An Introduction, 2nd Edition, Blackwell. Groombridge, B. and Jenkins, M.D. (2002) World Atlas of Biodiversity, Earth's living Resources in the 21st Century, Berkeley: University of California Press.

Georgios E. Pavlikakis And Vassilios A. Tsihrintzis (2000) Ecosystem Management: A Review of a New Concept and Methodology. *Water Resources Management 14: 257–283, 2000. © 2000 Kluwer Academic Publishers. Printed in the Netherlands. 257*

Hanazaki N, Begossi A, 2004. Dieta de populações de pescadores. In: Ecologia de pescadores da Mata Atlântica e da Amazônia. São Paulo: Hucitec, pp.149-166.

Haralambos, M. and Holborn, M. (2008). Sociology: themes and perspectives. Harper Collins, London.

Heywood , V.H. (1999a) 'Trends in agricultural biodiversity', in J. Janick (ed.) Perspectives on New Crops and New Uses, pp.2–14, ASHS Press, Alexandria, VA.

Heywood, V.H. (2003) 'Conservation strategies, plant breeding, wild species and land races', in K. Ammann, Y. Jacot and R. Braun, (eds) Methods for Risk Assessment of Transgenic Plants IV. Biodiversity and Biotechnology, pp.143–159, Birkhäuser Verlag, Basel/ Switzerland.

Hutchinson, G. E. (1957). Concluding remarks. Cold Spring Harb. Sym. 22, 415– 427.

Ikhuoria, I. A., Ero, I. I. and Ikhuoria, A. (2006). Satellite Detection and GIS Analysis of Lowland Rainforest Reserve Reduction in Edo State, Nigeria. In Salami, A. T. (ed). Imperatives of Space Technology for Sustainable Forest Management in Nigeria. Ile Ife: Space Application and Environmental Lab. pp 72-93.

Imai, K. (2002). ICT facilitated Waste Exchanges. A paper presented at the International Symposium on Information Technology and the Environment, Institute for Global Environmental Strategies. 19-20 September.

IUCN (2012) 'Securing the web of life', 19 June 2012. News story, http://www.iucn. org/?uNewsID=10173 (accessed 19 October 2012).

Klein, A.M., Vaissière, B.E., Cane, J.H., Steffan-Dewenter, I., Cunningham, S.A., Kremen, C. and Tscharntke, T. (2007) 'Importance of pollinators in changing landscapes for world crops', Proc. Roy. Soc. B., vol 274, pp. 303–313

Luoto M., Toivonen T. and Heikkinen R. K. (2002). Prediction of total and rare plant species richness in agricultural landscapes from satellite images and topographic data. Landscape Ecology, 17, 195-217

Missoumi A., Tadjerouni K., Chikh M. and Tidjani L. (2005). Remote Sensing and GIS, Two Major Tools for the Environmental Management and Protection: A Case Of Cartography Of The Natural Disasters. A Paper Presented at FIG Working Week 2005, April 16th - 21st, 2005.

Montgomery, C. W. (2000). Environmental Geology. New York: McGraw Hill

Nagendra, H. and Gadgil, M. (1999). Biodiversity assessment at multiple scales: Linking remotely sensed data with field information. Proceedings of the National Academy of Sciences, 96 (16), 9154-9158.

Nohr, H. and Jorgensen, A. F. (1997). Mapping of biological diversity in Sahel by means of satellite image analyses and ornithological surveys. Biodiversity and Conservation, 6 (4), 545-566.

Otite, O. and Ogionwo, W. (2006). An introduction to Sociological Studies. Heinneman Educational Books, Nigeria.

Oyinloye Olufunke Anuoluwapo and Agbolade Olatutu Opeyemi (2019) The Role of Information and Communications Technology (ICT) In Environmental Sustainability IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSRJESTFT) e-ISSN: 2319-2402,p-ISSN: 2319-2399.Volume 13, Issue 2 Ser. II (February. 2019), PP 13-18 www.iosrjournals.org

Pearman, P. B., Guisan, A., Broennimann, O., and Randin, C. F. (2008). Niche dynamics in space and time. Trends Ecol. Evol. 23, 149–158. doi: 10.1016/j.tree. 2007.11.005

Pocheville, A. (2015). "The ecological niche: history and recent controversies," in Handbook of Evolutionary Thinking in the Sciences, eds T. Heams, P. Huneman, G. Lecointre, and M. Silberstein (Dordrecht: Springer), 547–586. doi: 10.1007/ 978-94-017-9014-7_26 Raj K, 2010.Ecological niche theory. J Hum Ecol, 32(3): 175-182.

Reddy,P.(2016) Role of ICT and Mobile apps in Biodiversity Conservation. Available at *https://www.researchgate.net/publication/293158848_Role_of_ICT_and_Mobile_apps_in_Biodiversity_Conservation?enrichId=rgreq-9a7e21c28f3df77379c67590cc91078c-*

Salami, A. T. (2006). Monitoring Nigerian Forest with Nigeriasat-1 and other Satellites. In Salami, A. T. (ed). Imperatives of Space Technology for Sustainable Forest Management in Nigeria. Ile Ife: Space Application and Environmental Lab. pp 28-61.

Saveraid E.H., Debinski D.M., Kindscher K. and Jakubauskas M. E. (2001). A comparison of satellite data and landscape variables in predicting bird species occurrences in the Greater Yellowstone Ecosystem, USA. Landscape Ecology, 16, 71-83.

Schoener TW, (2009). "Ecological niche". In: Levin SA, Carpenter SR, Godfray HC, et al., eds. The Princeton Guide to Ecology. Princeton University Press.pp. 3 ff. ISBN 9781400833023.

Seto K. C., Fleishman E., Fay J. P. and Betrus C. J. (2004). Linking spatial patterns of bird and butterfly species richness with Landsat TM derived NDVI. *International Journal of Remote Sensing, 25(20), 4309-4324.*

Silva AL, Begossi *A, diversity, food consum2009. Bio ption, and ecological niche dimension: a* study case of the riverine populations from the Rio Negro, Amazonia, Brazil. Environ Dev Sustain, 11: 489-507.

Venema, H. D., Calamai, P. and Feeguth, P. (2005). Forest structure optimization using evolutionary programming and landscape ecology metrics. European Journal of Operational Research, 164 (2), 423-439.

Verlinden A., and R. Masogo (1997). Satellite remote sensing of habitat suitability for ungulates and ostrich in the Kalahari of Botswana. Journal of Arid Environment, 35, 563-574.

Westerkamp, C. and Gottsberger, G. (2001) 'Pollinator diversity is mandatory for crop diversity', in P. Benedek and K.W. Richards (eds) Proceedings 8th Pollination Symposium, Acta Horticulturae, vol 561, pp.309–316.

Wikipedia (2013). The Free Encyclopedia Geographic Information System. http://en.wikipedia.org.

Wilke, D. S. and Finn, J. T. (1996).Remote Sensing Imagery for Natural Resources Monitoring. New York: Columbia University Press.

Xue, X. (2010).The use of remote sensing technology in environmental protection. Proceed of the 6th *International Conference on Wireless Communication Networking and Mobile Computing: pp 1-4*