The Relevance of Information Communication Technologies (ICTs) In Agroforestry Practices

Bamgbade B.J., Ugege Peter & Banjo, A.A.
Forestry Research Institute of Nigeria
Ibadan, Oyo State Nigeria

Corresponding author:
e-mail - tundebamgbade@yahoo.com
Phone - 08054643990

ABSTRACT
This paper x-rays the relevance of ICTs in Agroforestry practices. Existing areas of applications such as forest and environmental management, specie identification and research publications are identified. The paper also looked into future possible usage of ICT and concludes that while the application of ICTs to Agroforestry practices in the 21st century is of tremendous importance it is important to know that there are still more areas where ICT would be applicable in Agroforestry which are yet to be discovered

Keywords – ICTs, Agroforestry, Applications, Fuzzy Logic, Environmental management.

1. INTRODUCTION

Heathcote (2000) posited that "Within half a century, computers and information technology have changed the world and affected millions of lives in ways that no one could have foreseen". The great impacts, contributions to knowledge, importance and economic achievements that have emerged from the fields of computer science (information science) and electronic engineering, in the 21st century, are revolutionary and mind boggling (Bamgbade,2011).The extent to which ICT applications have improved agro-forestry practices in recent times cannot be over emphasized. Area of application includes: Forestry and environmental management, species identification, research publication, ICT in agroforestry education, plant pathology studies, wood anatomy, biometrics, Data management, modeling, analysis and mining. The list is infinite; however some of these applications would be discussed in the course of the lecture.

2. FOREST & ENVIRONMENTAL MANAGEMENT

Mathematical and computational programming in Forest Management: Mathematical and computational programming remains a viable approach for strategic planning in forestry and agriculture worldwide. One of such computational based system is the SPECTRUM used by the United State government to carry out strategic planning in agroforestry. The system which evolved from an earlier system (FORPLAN) has the following key attributes:

Multi-resource modeling: The system provides a generic framework for modeling any resource. A basic configuration depends on user-defined analysis units, management actions, activities and outputs, resource coefficients, and economic information.

Spatial and temporal scales: Spectrum applications are not scale-specific. Up to 90 time periods of any length may be used to support analysis at relevant spatial and temporal scales.

Multiple options for mathematical programming: Spectrum supports numerous combinations of optimization techniques and objective functions. Optimization techniques include:

- Linear programming (optimization of a single criterion).
- Mixed-integer programming (optimization with categorical outcomes).
- Multi-objective goal programming (simultaneous optimization of multiple goals).
- Stochastic programming to account for random events such as fires, pest epidemics, and uncertainty about data.

Specifications for objective functions: Options for objective functions in traditional linear programming include maximizing or minimizing a single outcome or measure of performance. Objective Functions for goal programming include minimizing under-achievement of goals, minimizing over-achievement of goals beyond thresholds, or minimizing both. Two additional options for objective functions are MAXIMIN (maximizing the minimum level of occurrence for a critical resource) and MIN/MAX (minimizing the highest level of occurrence of an undesirable outcome).

Simulation of ecological processes and modeling natural disturbance:
Spectrum allows embedding simulation of ecological processes and modeling of natural disturbances by means of state, flow, and accessory variables in dynamic equations.

The Regional Ecosystems and Land Management (RELM) system extends the utility of Spectrum solutions by apportioning forest-wide, strategic planning solutions to tactical sub-units of the forest such as watersheds. Cumulative effects and connected actions can be analyzed both within and between sub-units, allowing planners to evaluate how alternative management scenarios affect neighboring units.

3. RESEARCH PUBLICATION

Information dissemination is a prominent activity in any research institute as it is the means through which it could be adjudged whether it is living up to the mandate and purpose for which it was established. Also, research publications play a pivotal role in any academics environment, be it in a University, Research institute, or polytechnic Paper publication is a useful instrument through which research discoveries and breakthroughs are disseminated to the stakeholders.

However, publishing research papers in a manual format is attached with great difficulties and problems, which includes ineffective and inefficient delivery system of the journal as at when due, prone to natural disasters, lost, theft, mutilation. Sequel to the aforementioned problems, a software (FRIN –e JOURNAL: An Electronic Submission Platform for Research papers) has been developed in FRIN which would allow for easy electronic retrieval, storage and efficient research information delivery system. It will go along way to automate the existing manual journal with easy search tool and navigation properties, providing researchers, administrator and FRIN editors with separate interface with hands on functionality and notification capability also creating a proper record of subscribers and records of subscription. It is cost effective and is not regional bound.

4. SPECIE IDENTIFICATION

Although automated species identification for many reasons is not yet widely employed, efforts towards the development of automated species identification systems within the last decade is extremely encouraging; that such an approach has the potential to make valuable contribution towards reducing the burden of routine identification. A free specie identification software has been developed in Forestry Research Institute of Nigeria (FRIN) called “Design and Development of an expert system for Tree species identification”

There are many factors influencing the taxonomic impediment to the study of biodiversity. A major one being that the demand for routine identification in biodiversity studies extends beyond the available resources. In many spheres the volumes of plant or animal specimens that can usefully be obtained, particularly using modern sampling methods, vastly outstrip any capacity to identify this material. This has limited the progress in some aspect of biodiversity research. These demands are likely to steadily increase as the proportion of previously un-described species in local, national or regional floras and fauna declines and as requirement or desirability of biodiversity inventories and other such survey grows.

This has led to several solutions being proffered to reduce the burden of routine identification. One of the proffered solutions is automating the identification process in some way. This is generically referred to as Computer Assisted Taxonomy (CAT). However, the development and application of an automated approach to taxonomic identification has remained a minority interest till date. Among reasons for this are the notions that it is too difficult, too threatening, too different or too costly. It is most encouraging to know that despite these limitations, efforts towards the development of automated species identification systems have been progressive.

From the evidences witnessed in this area, it buttresses the present minority notion that the automation of species identification process is possible and achievable. A system that uses binary codes generated based on the morphological characters of trees to uniquely identify tree species has been developed. Though this is not the first time an attempt is made to automate species identification using their morphological characters, our approach is far simpler and less expensive to implement. For instance while previous approaches are centered round the need for a computerized pattern recognition system, ours does not require such. We were able to easily prove the effectiveness of the system by restricting our study to the over one thousand Nigerian Trees species. All a user need is a functional computer system, a ruler and personal ability to supply answers to the questions asked by the system and the tree identification process is complete.

5. ICT IN AGROFORESTRY EDUCATION

Information and communication technologies (ICTs) have the potential to enhance access, quality, and effectiveness in education in general and to enable the development of more and better teachers in Africa in particular. As computer hardware becomes available to an increasing number of schools, more attention needs to be given to the capacity building of the key transformers in this process, namely, teachers.

While societies undergo rapid changes as a result of increased access to information, the majority of the school-going youth continue to undergo traditional rote learning. Very little is done to take advantage of the wealth of information available on the Internet. Whereas the processing of information to build knowledge is one of the essential literacy skills vital for the workforce in the 21st century, it is often overlooked in current educational practices. The Computers for Schools Program appears to be doing valuable work and in the process has become an unwitting champion of ICTs in education. Its experiences are real, its challenges huge, and the lessons valuable for the future of a resource poor country such as Nigeria. In order to function in the new world economy, students and their teachers have to learn to navigate large amounts of information, to analyse and make decisions, and to master new knowledge and to accomplish complex tasks collaboratively. Overloaded with information, one key outcome of any learning experience should be for learners to critically challenge the material collected in order to decide whether it can be considered useful input in any educational activity

This is the basis for the construction of knowledge. The use of ICTs as part of the learning process can be subdivided into three different forms: as object, aspect, or medium (Plomp, ten Brummelhuis, & Pelgrum, 1997).

• As object, one refers to learning about ICTs as specific courses such as 'computer education.' Learners familiarize themselves with hardware and software including packages such as Microsoft Word, Microsoft Excel, and others. The aim is computer literacy.

• As aspect, one refers to applications of ICTs in education similar to what obtains in industry. The use of ICTs in education, such as in computer-aided design and computer-aided agroforestry technology, are examples.

• ICTs are considered as a medium whenever they are used to support teaching and learning.

The use of ICT as a medium is rare (Plomp, et al., 1997), in sub-Saharan Africa where the availability of resources is a major obstacle to the widespread integration of ICTs in education. In order to sustain what has already been done and expand into areas still unreached; the objective of this text is to elicit support for training in ICTs in Nigeria as in many other African countries because it is in a state of mild crisis. Sequel to this is the need to explore the use of ICTs in education, such as in computer-aided design and computer-aided agroforestry technology, are examples.

5.1 Why do we need applications of ICTs in Agroforestry Education?

With the advent of ICT, Dutta and Jain (2003) note that ICT forms the "backbone" of several industries and is today a dominant force in enabling companies to exploit new distribution channels, create new products, and deliver differentiated value added services to customers. ICT is also an important catalyst for social transformation and national progress. Disparities in levels of ICT readiness and usage could translate into disparities in levels of productivity and, hence, different rates of economic growth. It is also important to observe that ICTs can lead to economic growth but not development. The social exclusion of large groups of persons, especially women, children, and people living in rural areas, is a common phenomenon when adequate planning has not accompanied ICT exploitation. Education in Nigeria faces a number of problems. These problems include the shortage of qualified teachers, very large student populations, high drop-out rates of students and teachers, and weak curricula.

All of these negative aspects result in poor delivery of education. The education crisis is worsened by the devastating effects of increasing poverty, a brain drain in the teaching community, budgetary constraints, poor communication, and inadequate infrastructure. Technology is not new to education. However, contemporary computer technologies, such as the Internet, allow new types of teaching and learning experiences to flourish. Many new technologies are interactive, making it easier to create environments in which students can learn by doing, receive feedback, and continually refine their understanding and build new knowledge.

Access to the Internet gives unprecedented opportunities in terms of the availability of research material and information in general. This availability of research material and information happens to both inspire and threaten teachers. ICTs are one of the major contemporary factors shaping the global economy and producing rapid changes in society. They have fundamentally changed the way people learn, communicate, and do business. They can transform the nature of education – where and how learning takes place and the roles of students and teachers in the learning process.

6. ICT APPLICATION IN AGROFORESTRY

Diagnosis & Design methodology is a methodology for the diagnosis of land-management problems and the design of agroforestry solutions. It was developed by ICRAF to assist agroforestry researchers and development fieldworkers to plan and implement effective research and development projects. From on-farm research trials, more rigidly controlled on-station investigations, and eventual extension trials in an expanded range of sites. As this iterative D & D process provides a basis for prompt feedback and complementarities between different project components. By adjusting the plan of action as indicated by new information, the D & D process becomes self correcting. In an integrated agroforestry research and extension program, pivotal decisions are made in periodic meetings of the various project personnel who evaluate new results and revise the action plan accordingly. The process continues until the design is optimal and further refinement is deemed unnecessary.

6.1 Expert System in forestry management

Expert system applications in forestry began appearing in the late 1980s (Schmoldt and Martin 1986). Some examples include a diagnostic and risk assessment tool (Schmoldt 1987, Schmoldt and Martin 1989) for insect and disease outbreaks in red pine (Pinus resinosa), an advisory system providing stand prescriptions for deer and gFouse (Buech et al. 1989), a silvicultural system for managing red pine plantations (Rauscher et al. 1990), -and a system for diagnosing the hazard and risk of bark beetle outbreaks in Alaska (Reynolds and Holsten 1997). Numerous other expert systems were developed to assist with forest pest management, silvicultural prescriptions, and timber harvesting, among other things (Durkin 1993). Developed initially as stand-alone software, eventually expert systems were integrated with optimization, simulation, geographic information systems (GIs), and other technologies covered elsewhere in this text.

6.2 Fuzzy Logic network in forestry management

In the early years of knowledge-based system development, prevailing conventional wisdom held that such systems were best suited for very narrow, well defined problems (Waterman 1986). This is clearly reflected in the catalog of systems documented by Durkin (1993). However, the integration of fuzzy logic (Zadeh 1975a, 1975b, 1976) into knowledge-based systems in the early 1990s, as exemplified in systems such as a fuzzy version of CLIPS (Giarratano and Riley 1998) and

NetWeaver (Miller and Saunders 2002) opened up new possibilities for applying knowledge-based methods.
This marriage of technologies permitted application to much more general and abstract kinds of problems related to the management of natural resources, in general, and forest management in particular (Reynolds 2001a, 200 1 b).

6.3 GIS and Remote Sensing in Environmental Management

In the1960s,the Canadian department of forestry and rural development realized that they had one of the largest landmasses and among the largest collections of natural resources anywhere but its knowledge of the extent, quality and longetivity of the national resources was limited .Government planners also recognized that just to map such a large area would require more trained cartographers than were then available and recognizing that such a massive task would require far longer than they could allow if they wanted to develop successful management plans for their resources, they arrived at an essential conclusion, that there was a need for Canadian Geographical Information System (GIS).As it were, GIS functions optimally on the platform of computer science to implement or explore its set objectives. Accordingly, Rhind (1998) defined GIS as "a computer system for collecting, checking, integrating and analyzing information related to the surface of the earth". As it were, there is an ever increasing recognition of the need to perform large scale mapping and map analysis operations for a wide variety of traditionally manual tasks. Furthermore, forests see GIS (a computer based application) as an efficient management tool for their day –to-day operations

A wide variety of software applications are available to support decision making in forest management, including databases, growth and yield models, wildlife models, silvicultural expert systems, financial models, geographical information systems (GIS), and visualization tools (Schuster et al. 1993). Typically, each application has its own interface and data format, so managers must learn each interface and manually convert data from one format to another to use combinations of tools. Considering the scope of topics that may need to be addressed in a typical ecosystem management problem, and consequently the need to run several to many applications, manual orchestration of the entire analysis process can quickly become a significant impediment. LMS relieves this problem by managing the flow of information through predefined pathways that are programmed into its core component. LMS integrates landscape-level spatial information, stand-level inventory data, and distance-independent individual tree-growth models to project changes on forested landscapes over time.

The core component of the application coordinates the execution of, and flow of information between, more than 20 programs, including a variety of utilities for data management such as formatting, classification, summarization, and exporting. Stand projections in LMS are performed with variants of the Forest Vegetation Simulator or FVS (Crookston 1997) or **ORGANON** (Hester et al. 1987). A variety of utilities report stand projection information in tables and graphs, and projection information can be delivered to the ArcView GIS (Environmental Systems Research Institute) for additional spatial analysis, or to the Stand Visualization System (SVS) or to the Envision landscape visualization system (McGaughey 1997). Both forms of output data can be valuable. In some cases, it is useful to analyze projection data further using a spreadsheet or statistical software, while other times it is most instructive to simulate the appearance of a stand to qualitatively assess spatial landscape features (e-g., scenic vistas).

Earth observation from space relies on radiation measured by sensors. The signal depends on the way radiation interacts with the atmosphere and the Earth's terrestrial surface. The complexity of the interaction has promoted the development and use of empirical methods (e.g. vegetation indices). Most of these are based on quantitative, statistical relationships applied to a few images, which limits their robustness and use over large areas. Radiative transfer models, using complex mathematical methods, simulate and provide insight into the radiation interaction processes for varying vegetative parameters. Remote sensing imaging spectrometers have evolved with respect to larger spectral resolution imaging spectrometers (e.g. NASA's AVIRIS, NASA's Hyperion on EO-1, Itres' casi, HYMAP, AISA), increased signal-to-noise ratios, 12-bit (and higher) quantization, and multi-directional sampling capabilities (e.g. ESA's CHRIS PROBA). These improvements have stimulated the development of better models and opened up new prospects for retrieval of more detailed environmental information from these advanced sensors . Physical-based, quantitative canopy models compute vegetation canopy reflectance given leaf and canopy parameters (chlorophyll content, water content, leaf area index, etc.), a selected sun-target-sensor geometry, and information about the background (e.g. soil). Canopy models can be used in direct (forward) mode to build new vegetation indices optimized for a particular sensor. Moreover, such models can be inverted against measured reflectance data to derive surface biophysical and structural parameters such as leaf area index (LAI), fraction of photosynthetically active radiation (fPAR), and vegetation fractional cover, which are used by ecologists to monitor the status and quantify the influence of vegetation.

In contrast to multi-spectral sensors, hyperspectral sensors can produce quantitative estimates of canopy biochemical properties (such as chlorophyll and nitrogen concentrations) . Classification of hyperspectral imagery yields not only higher accuracy in land-cover characterization, but also of species recognition when compared to traditional remote sensing data sources such as Landsat. Forest biomass and carbon have been estimated employing both multi-sensor techniques and AVIRIS data using partial least squares (PLS) regression. Estimates of the chemical concentrations (chlorophyll, nitrogen, lignin, water content) of forest canopies can be made using hyperspectral data.

Canopy models were used to simulate hyperspectral top-ofcanopy reflectance values for analysis of various biophysical and biochemical factors affecting canopy reflectance. Recently, canopy models have been employed to infer quantitative information from hyperspectral data on canopy structure and foliage biochemistry, such as LAI, leaf/needle chlorophyll content, and foliage water content. Hyperspectral imagery and canopy models were also used to analyze biological invasion, biogeochemical change and nutrient availability in tropical ecosystems.

Very high spectral and spatial resolution imaging spectrometer data were used in Malenovsky et al.to separately assess sunlit and shaded crowns of a Norway spruce canopy and quantify the impact of woody elements (e.g. trunks, first order branches and small woody twigs) in turbid media modeled cells using the 3-D radiative transfer model DART to further refine the retrieval of forest relevant ecosystem parameters. These land ecosystem information products can be used in forest disaster detection, invasive species mapping, Kyoto Protocol information products, monitoring forest health, ecosystem protection, and global change.

7. CONCLUSION

The relevance and application of ICT to Agroforestry practices in the 21st century is of tremendous importance. There are still more areas where ICT would be applicable in agroforestry which are yet to be discovered, but in the immediate future. Virtually, all other human endeavours have come to know that the benefits of ICT is far outstripped its disadvantages. It is therefore suggested that ICT should be a tool that all professions should embraced**.**

REFERENCE

Anderson, R.E., & Plomp, T., (2000). ICT knowledge management competencies. http://www.emb.gov.hk

Bamgbade, B.J. and Oyeleye, B.O. (2011). FRIN E-Journal- An Electronic Submission Platform for Research Dissemination, Proceeding of International Conference on ICT for Africa 2011. Vol. III, pp 243-250.

Carlson, S., (2002). The missing link in educational technology: trained teachers. *http://www.TechKnowLogia.org*

Collis, B., & Moonen, J., (2001). Flexible learning in a digital world: Experiences and expectations. London, UK: Kogan Page.

Cornille, B., (2003). Action Research in the living theory of educators of the higher diploma in educational management. Unpublished Action Research.

Dutta, Soumitra Dutta and Amit Jain, (2004). The Networked Readiness Index 2003–2004: Overview and Analysis Framework. www.weforum.org/pdf/Gcr/GITR_2003_2004/Framework_Chapter.pdf. Retrieved on 4/12/2004.

Heathcote, P.M. (2000) 'A' level ICT. 2nd edition payne. Gallway publishers Ltd. pp 1 – 11.

Heide, A., & Henderson, D., (1994). Active learning in the digital age classroom. Portsmouth, NH: Heinemann.

International Food Policy Research Institute (IFPRI, 1995): A 2020 Vision for Food, Agriculture, and the Environment. The Vision, Challenge, and Recommended Action October 1995 International Food Policy Research Institute 1200 Seventeenth Street, N.W. Washington, D.C. 20036-3006

Georgiadi, R., G. K. Koulaouzides, E. Brown and E.A. Vergos. 1999. An Intranet application for Agricultural Education in Greece. In presentation to the 2nd European Conference of theEFITA, Sept. 27-30, 1999, Bonn, Germany

Janssens-Bevernage, A., (2002). Internal assessment of how KTTC members perceive the changes in organisational culture brought about by the integration of an Internet facility into their working environment.(unpublished Action Research)

Kinyanjui, L., (2002). Preparing a workforce for the evolving information economy: a survey on ICT access and use in Kenya secondary schools. Nairobi: SchoolNet Kenya.

Kirkpatrick D., & Jakupec, V. Becoming flexible: what does it mean? In The convergence of distance and conventional education: Patterns of flexibility for the individual learner. USA: Routledge.

Kang, B.T., Wilson, G.F.,and Sipkens, L. 1981. Alley cropping maize *(Zeamays L.)* and leucaena *(Leucaena leucocephala* Lam.) in southern Nigeria. *Plant and Soil* 63: 165-179.

Loveless, A., & Ellis, V. (Eds.), (2001). ICT, pedagogy and the curriculum. London, UK: Routledge Falmer.

Lundgren, B.O. 1982. Cited in Editorial: What is Agroforestry? *Agroforestry Systems* 1: 7-12.

Matthews, J.T. and Tunstall, D.B. 1991.Moving toward eco-development: Generating environmental information for decision makers. *WRI Issues and Ideas,* August 1991. World Resources Institute, Washington, D.C, USA.

Michael, N. Demers. Foundamentals of Geographic information systems (2000) 2nd edition, John Willey & Sons inc. pp 3-10.

Nair, P.K.R. 1979. *Intensive Multiple Cropping with Coconuts in India.* Verlag Paul Parey, Berlin/Hamburg, Germany.

Nwoboshi, L.C. 1981. Soil productivity aspects of agri-silviculture in the west African rain forest zone. *Agro-Ecosystems* 7: 263-270.

Odumbe, J., (2003). Survey of open and distance education learning provisions in Kenya. Nairobi, (unpublished).

Ojeniyi, S.O. and Agbede, O.0.1980. Effects of single-crop agri-silviculture on soil analysis. *Expl. Agri.* 16: 371-375.

Ojeniyi, S.O., Agbede, O.O., and Fagbenro, J.A., 1980. Increasing food production in Nigeria: I. Effects of agrisilviculture on soil chemical properties. *Soil Science* 130: 76-81.

Okafor J.C. & Caldocotte, J.O.(1990) using Biodiversity and Agroforestry systems for Conservation in Nigeria. In Harmony with Nature. Proceedings of the International Conference on Conservation of Tropical Biodiversity. (Yap son Kheong & Lee Su Win-Eds) Malayan Nature Society. 12-16 June 1990.p.608-627.

Okafor J.C. and Lamb, A (1994). Fruit trees: diversity and conservation strategies in Topical trees: the potential for domestication and the rebuilding of forest resources: ITE Symposium No.29 ECTF Symposium No1. (Leakey & Newton-Eds) London, HMSO. P34-41.

Onweluzo, S.K. 1979. Forestry in Nigeria. *J. Forestry* 77: 431-433 and 453.

Peters, O., (2000b). The transformation of the university into an institution of independent learning. In T.

Evands & D. Nation (Edsl), Changing university teaching: Reflections on creating educational technologies. UK: Kogan Page.

Plomp, T., ten Brummelhuis, A., & Pelgrum, W.J., (1997). New approaches for teaching, learning and using information and communication technologies in education. Prospects – Quarterly Review of Education, 27 (3).

Raintree, J.B. 1987a. The state-of-the-art of agroforestry diagnosis and design. *Agroforestry Systems* 5: 219-250.

Ramachandran Nair, P.K. (1992): An introduction to agroforestry
Gainesville, Florida, USA November 1992.

Robinson, B., (2001). Innovation in open and distance learning: some lessons from experience and research. In Innovation in open and distance learning: Successful development of online and web-based learning. London, UK: Kogan Page.

Sharma, N.P. (ed.) 1992. *Managing the World's Forests: Looking for Balance Between Conservation and Development.* Kendall/Hunt Pub. Co., Dubuque, Iowa for the World Bank, Washington, D.C., USA.

Taylor, P., (1996). Flexibility, technology and academics' practices: Tantalising tales and muddy maps. (EIP 96/11). Canberra: Department of Employment, Education and Training and Youth Affairs, Evaluations and Investigations Programme, Higher Education Division.

Thompson, H. M., & Henley, S.A., (2000). Fostering information literacy: Connecting national standards, goals 2000, and the SCANS report. Libraries Unlimited, Inc.

Ugege Peter and Ugbogu Omokafe a. (2010). Automated Binary Based Tree Species Identification. International Journal of computer applications (0975-8887) volume II.
No. 6, December 2010, Pp 30-33.

UNESCO, (2004). The need for a systematic approach. *http://unescobkk.org/education/ict/v2*

UNESCO, (2002). Information and communication technologies in teacher education: A planning guide. *http://www.unesco.org*

Van den Broeck, E., (2003). KTTC-Nairobi 2001-2005 internal periodic review report. Nairobi: KTTC. (unpublished)

World Bank. 1991. *Forestry Policy Paper.* The World Bank, Washington, D.C., USA.

World Resources Institute. 1990. *World Resources 1990-91.* World Resources Institute/Oxford
Univ. Press, New York, USA.