

Information and communication technology: a variable tool for mitigating climate change and improving crop production

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ABSTRACT

Climate change is widely recognized as one of the most complex challenges that humankind has to face in the next decades. As agriculture is likely to suffer the biggest impacts, sound adaptation processes are required to sustain agricultural production and food system as a whole. IPCC, the Intergovernmental Panel for Climate Change, stressed the ability of decision-makers to manage information as an important factor determining the chance for a community to adapt to climate change. We all know that information and communications technologies (ICTs) have revolutionized our world. ICTs are also very vital to confronting the problems we face as a planet the threat of climate change. Indeed ICTs are part of the solution. Already these technologies are being used to cut emissions and help countries adapt to the effects of climate change. This is one of the reasons why the Information and Communication Technologies (ICT) can play an important role in this challenge.

Keyword: climate change; ICT; mitigating; Crop Production

1. INTRODUCTION

Application of ICT in crop production though a relatively new phenomenon, evidence of the contribution of ICT to agricultural development and poverty alleviation is becoming increasingly obvious. Some common problems in adoption of ICT in rural segments such as ICT illiteracy, unavailability of relevant and localized contents in their own languages, uneasy and unaffordable accessibility and other issues like awareness and willingness for adoption of new technologies among the rural peoples can definitely be handled with the application of ICT. (Ugwuishiwi, Udanor & Ugwuishiwi 2012). Climate change is one of the most complex challenges that humankind has to face in the next decades. As the change process seems to be irreversible, it became urgent to develop sound adaptation processes to the current and future shifts in the climate system. In particular, it is likely that the biggest impacts of change will be on agricultural and food systems over the next few decades (Brown, and Funk, 2008).

Some scientists (Lobell et al., 2008), due to the application of crop modeling tools, have pointed out that climate change is likely to reduce food availability due to a reduction in agricultural production.

2. CONCEPTUAL DEFINITIONS

2. 1. The Concept of ICT

Agbetuyi and Oluwatayo, (2012) stressed that ICT is the term used to describe the tools and processes to access, retrieve, store, organize, manipulate, produce, present and exchange information by electronic and other automated means. These include hardware, software and telecommunications in the forms of personal computers, scanners, digital cameras, handhelds/PDAs, phones, faxes, modems, CD and DVD players and recorders, digitalized video, radio and TV and programs like database systems and multimedia applications. The term is often used in plural form (ICTs) to mean a range of technologies instead of a single technology. It represents a broad and continually evolving range of elements that include the television (TV), radio, mobile phones and the policies and laws that govern the widespread use of these media and devices. (Magawata, 2013)

2. 2. The Concept of Climate Change

Climate change is the measurable increases in the average temperature of the earth's atmosphere, oceans and landmasses. This affects the weather, ice sheets and glaciers, sea level, agriculture, plants and animals together with human health. (Bello, 2012)

Climate refers to the characteristic conditions of the earth's lower surface atmosphere at a specific location; weather refers to the day-to-day fluctuations in these conditions at the same location. The variables that are commonly used by meteorologists to measure daily weather phenomena are air temperature, precipitation (e.g., rain, sleet, snow and hail), atmospheric pressure and humidity, wind, and sunshine and cloud cover. Schmidhuber, and Tubiello, (2007)

2. 3. Concept of Mitigation and Adaptation

Mitigation refers to actions taken to reduce greenhouse gas emissions, which are primarily driven by energy use.

Adaptation refers to activities that reduce harm or risk of harm, or realize benefits associated with climate variability and climate change. (Wong and Schuchard, 2011)

Climate change mitigation involves reductions in the concentrations of GHGs (Green House Gasses), either by reducing their sources or by increasing their sinks. (Johnson and Neves, 2007)

2. 4. Causes of Climatic Change

Climatic fluctuations of today are caused by both natural and human activities, unlike in the past, when the climatic changes were mostly caused by natural phenomena (Goudie, 1977). Some of the causes of climatic change include:

- 1) Atmospheric composition of the earth: These could be through change in carbon dioxide levels, ozone levels, dust levels and water content. For example, volcanic eruption could lead to a cooling of climate by the production of a dust-veil in the atmosphere.
- 2) Change in terrestrial geography: Climate of an area can change if for example, the area is located closer to sea and there is sea floor spreading, this may affect the entry of ocean current into the region and thereby affecting the climate of the area. Similarly, if there is uplift of an area, the climate of the area may change.

- 3) Increase of ice in the oceans: This leads to redirection in the world temperature, promoting glaciations in certain other parts of the world leading to cooling effect.
- 4) Level of carbon dioxide: Reduction and increase in carbon dioxide in the atmosphere may lower or increase temperature respectively.
- 5) Solar radiation hypothesis: This states that, the change in solar radiation output may lead to significant change in the receipt of radiation on the earth's surface. This change affects the quantity and quality of radiation, hence affecting crop photosynthesis in the manufacture of food.
- 6) Variation in terrestrial magnetism: Changes in the intensity of earth's magnetic field cause climate to get colder.
- 7) Earth's Geometric Theory: The eclipse nature of earth, variations on when the earth is nearest to the sun in the year and variability of tilt of the axis about which the earth rotates, cause climate change into different seasons in a year, in which we have either summer, winter, dry and wet seasons.
- 8) Man's consumption of fossil fuels: The consumption of fuels like coal and oils adds to the heat in the atmosphere as the heat adds more to the carbon dioxide.
- 9) Atmospheric pollutants: Dust, household aerosols and smoke particles released by man into the atmosphere scatter and absorb solar radiation leading to changes in temperature, rainfall and ozone layer.
- 10) Rockets and other aircrafts: The use of these in high altitude tend to intrude into the natural situation by discharging exotic chemicals and discharge of water vapour thus affecting or changing the climate.
- 11) Afforestation and deforestation habit: These may lead to increase or decrease in vegetation. Deforestation influences desertification of the Sudan zone of West Africa through man's activity (Dimbley, 1973). This may lead to aridity, damage to the habitat and loss of biodiversity.

2. 5. Climate Change on Crop Production

The implications of climate change on some aspects of crop production are in the following areas:

2. 5. 1. Crop distribution, extinction, growth and yield

Crops require light, heat, water and humidity to grow. Globally, distribution of crops is determined by climate, thereby giving rise to tropical and temperate crops localized by climatic belts. Thus, in Nigeria, tree and root crops are found in the southern part where moisture supply to the crop and soil system is always ample (Abdullahi & Idris, 2013). Similarly, in the Middle Belt and Northern parts of the country we have different crop species as per each region depending on the amount and distribution of rainfall. Apart from distribution of crops as a result of variations in climatic factors, climate change also leads to extinction or loss of certain crop species. Human activities such as tropical forest clearance, may lead to changes in climate and may cause some losses of potential genetic materials for agriculture and medicinal plants (Abdullahi & Idris, 2013). (IPCC, 2007) indicated that the effects of changing climate on potential extent of forest and other major biome types when concentration of carbon dioxide is assumed to be doubled. Similarly, crop production is extremely susceptible to climate change. It has been estimated that climate changes are likely to reduce yield and/or damage crops in the 21st century.

2. 5. 2. Biotic factors and crop production

Climate change affects the microbial population of the micro-environment (soil, air and water) and the population of pests and other vectors, thus affecting crop production (IPCC, 2007). This is therefore, a contributing factor to the occurrence and gravity of biotic diseases attributable to micro-organisms such as fungi, bacteria, viruses and insects. Pests and diseases attacking crops are controlled by atmospheric weather condition.

Agricultural production in the tropics is being infested by pests and diseases. In Nigeria, losses due to pests infestation and diseases are of the order of 50 %. Crops are affected during their growth period and after harvest.

The periodic nature of the outbreak of any pests and diseases show that weather or climatic variables are important (Ajayi, 2000).

In Nigeria, the most important pests that attack crops as a result of climatic changes are grasshoppers, locust, and weaverbird.

These pests become a menace to crops by eating the leaves, stems and grains.

The locusts require adequate moisture for egg laying and for them to grow on moist ground when matured; they migrate along the north easterly wind and move when temperature is b/w 20-40°C. Similarly, tsetse fly as one of the agricultural pests is also limited to certain ecological zone as a result of the differences or changes in climate.

Most of the fungal diseases affecting crops production are favoured by high relative humidity, one of such diseases is the black pod diseases of cocoa, the disease is aided by high rainfall and high relative humidity, the disease reduces the number of pods produced per cocoa tree. Other diseases favoured by moist and humid conditions are smut diseases, mould diseases and leaf spots of cereals to mention but a few.

2. 5. 3. Abiotic factors and crop production

The non-living factors such as nutrient deficiencies, air pollutants and temperature/moisture extremes affect crop health and productivity. Deficiencies of nutrients, as a result of poor soils which are caused by climatic changes affect the growth and yield of crops. Similarly, air pollutants like dust, aerosols, smoke particles, form a screen that re-directs solar radiation for crop productivity.

Moisture and temperature extremes also affect the health and productivity of crops, too much moisture may lead to water logging, while extremely high temperatures lead to crop and soil desiccations and crop damage, most of these changes in the abiotic factors result from changing climatic factors, hence affecting crop productivity and health. Similarly, changes in sunlight and wind as climatic elements greatly influence crop productivity.

The radiation from the sun and intensity of the light affect crop production especially if the atmosphere is polluted with dust, aerosols and smoke particles, these affect the quantity and quality of light spectra for crop photosynthesis.

Wind velocity is important in crop stand establishment, strong and turbulent wind is disastrous as it makes crops to lodge and displaces spray chemicals away from the target.

2. 6. ICT and Climate Change

Information and Communication Technology (ICT) is a wide term that refers to all computer-based advanced technologies for managing and communicating information. It is broader than Information Technology (IT) which is defined as “the study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware” (Magawata, 2010).

Within the ICT domain, what is typically stressed by the users' communities is the great potential of ICT tools regardless of their ultimate goals. Usually, ICT is employed for three major actions: (1) to record data and information, (2) to transform the data and information into knowledge which can be shared and, eventually (3), communicate the data, information and knowledge.

Geographic Information Systems (GIS) are also used in several ICT applications, such as the Open Risk Data Initiative (Open RDI). Open RDI aims to minimize the effect of disaster in developing countries by encouraging them to open their disaster risk data. GIS technologies such as satellite imagery, thematic maps, and geospatial data play a big part in disaster risk management. The areas which are receiving priority attention include natural resources information assessment, monitoring and management; water shed development, environmental planning, urban services and land use planning. (Meera, 2002)

In order to tackle climate change, Meera, Jhamtani, and Rao (2004) asserted that three main strategies are available: mitigation, adaptation or both. The application of information technologies in this sector follows the approach of applying it to mitigate climate changes as well as to adapt to changes (or both, in some cases). For this reason it is important to understand the differences between adaptation and mitigation in the technological context, before analyzing how technologies can contribute to both strategies.

Adaptation is older than Mitigation. Strategies of adaptation to climate change have been employed by man throughout all of history, while mitigation initiatives have been designed only when the scientific community determined a possible interaction between human actions and climate. Therefore, adaptation processes can also begin from the application of techniques already used and handled in various ways from all human communities. Mitigation is connected mainly to the energetic sector, while adaptation actions are necessary for all the associate-economic fields (health, agriculture, water management, etc.). These fields have their own specific actors and their own series of institutional, economic and normative barriers. This means that the technologies applied should have high levels of variety and granularity. Many positive examples of application of technologies for adaptation in developing countries already exist. The nature of technologies varies in response to the different local requirements, determined by the specific environmental systems and socio-economic situations, going from coastal protections to new techniques of farming. It must also be noted that technologies that may be considered obsolete in some countries could be functional to solve adaptation problems in other areas of the World and this can stimulate the opening of communication channels between different communities on climate change related issues.

2. 7. Roles of ICT in Mitigating Climate Change and Improving Crop Production

In the intersection between climate change and agriculture there are several tools available because of the high number of crops and the complexity of replicating the same conditions across different regions. Every tool allows one to analyze different processes of the agricultural sector, from local crop modeling under climate change conditions to the management of economic impacts of climate change on agriculture (variations in land value, production demand and supply, etc.), just to name a few examples. As many tools exist, it's interesting to focus on their common aspects rather than their specific peculiarities.

Some of the tools allow simulating the growth of specific crops, verifying their variations under different climate change scenarios. Usually these tools are site-specific, but they can be applied at a national and/or regional level through a link to an appropriate Geographic Information System (GIS).

The first step of the application process happens with the definition of boundary conditions (which include data on crop calendar, soil status, etc.) and input climate parameters and data (such as: temperature, precipitations, wind speed, global radiation, soil moisture, air humidity, water flows...). Some of the tools include data related to crop management conditions. The second step is the development of the growth simulation in a specific state of potential crop production (e.g. with a certain fixed amount of water resources and nitrogen production) for different management options and for a chosen climate change scenario, through the link to an appropriate GCM (general circulation model) or an ad-hoc expert system.

The general output of this kind of software is the assessment of crop production under given scenarios, facilitating decision making at a farm level up to a whole crop system. Examples of these tools are:

WOFOST, CFWS, it can be applied on several different crops, such as barley, field bean, maize, potato, rice, soybean, sunflower, wheat, etc.

GOSSYM/COMAX (is a software tool that can be applied to model climate change impact on cotton. It can be applied to all locations all the world. Target users are researchers, cotton farmers and operators of the agricultural sector.) It is the merge of the GOSSYM model, used to simulate cotton growth, with COMAX (Crop Management expert, an expert system), GCMs and weather generators to study the effects of climate change on cotton production.

APSIM (Agricultural Production Systems Simulator): it can be applied on more than twenty crops and plants, such as alfalfa, barley, chickpea, cotton, eucalyptus, lupine, maize, peanuts, sugarcane, sunflower, tomato, wheat, etc.

Another class of information tools is applied at a higher scale, up to the regional level, with the aim of supporting decision-making in the agricultural sector from a broader perspective. These systems can focus on a variety of factors that can influence climate change and related responses, which can either be exogenous (e.g. government policies, economy, etc.) or endogenous (e.g. location, scale, etc.) in relation to a specific farming system. As a result, these systems facilitate the planning of adaptation responses into a set of actions at a farm and regional level, starting from a comprehensive assessment of the impacts of climate change and different farming techniques on crop productivity and agro-ecological systems sustainability, up to support the adoption of appropriate agronomy techniques or setting up an agro-technology transfer system. Among these systems, some examples are:

1. DSSAT (Decision Support System for Agrotechnology Transfer)
2. MAACV (Model of Agricultural Adaptation to Climatic Variation). (Simone, 2010).

Karanasios, (2011) stress that ICTs and climate change can be used for (1) Monitoring: observing, detecting and predicting, and informing science and decision making; (2) Disaster management: supporting emergency response through communications and information sharing, and providing early warning systems; and (3) Adaptation: supporting environmental, health and resource management activities, up-scaling technologies and building resilience.

William (2008) asserted that Farmers who have better access to ICT have better lives because of the following:

1. Access to price information – farmers will be informed of the accurate current prices and the demands of the products. Hence, they will be able to competitively negotiate in the agricultural economy and their incomes will be improved.
2. Access to agriculture information – according to the review of global and national agricultural information systems done by IICD with support from DFID in 2003, there is a need for coordination and streamlining of existing agriculture information sources, both internationally and within the developing countries. The information provided is usually too scientific that farmers cannot comprehend. Therefore, it is vital that the local information to be relayed to the farmers must be simplified.
3. Access to national and international markets – Increasing the level of access of farmers is very vital in order to simplify contact between the sellers and the buyers, to publicize agricultural exports, facilitate online trading, and increase the awareness of producers on potential market opportunities including consumer and price trends.
4. Increasing production efficiency – due to several environmental threats such as climate change, drought, poor soil, erosion and pests, the livelihood of farmers are unstable. Thus, the flow of information regarding new techniques in production would open up new opportunities to farmers by documenting and sharing their experiences.
5. Creating conducive policy environment – through the flow of information from the farmers to policy makers, a favorable policy on development and sustainable growth of the agriculture sector will be achieved.

3. CHALLENGES OF ICT IN MITIGATING CLIMATE CHANGE AND IMPROVING CROPS PRODUCTION

The analysis conducted thus far indicates the existence of positive, valuable linkages between ICTs and the resilience of systems vulnerable to climate change. However, developing countries are characterised by the interplay of a complex set of stressors and inequalities including socio-political contexts where power relations and potential divisions are based on factors such as gender and ethnicity, and where the implementation of innovative ICT approaches must be assessed carefully (Duncombe, 2006). Thus, analysis of ICTs' role must also acknowledge their potential to impact negatively on livelihood systems, possibly reducing their resilience and adaptive capacity to climate related hazards, trends and variability. For example, ICTs may provide unreliable information or information that does not correspond to the local realities or that is made available in a language that is inaccessible for the local actors. This can not only undermine the potential of these tools within adaptive processes, but also contribute more generally to an increase in uncertainty or even encourage mistaken and maladaptive actions. Adaptation as a response to a particular climate related disturbance can undermine systemic resilience by making the community more vulnerable to other shocks, or by constraining generic sub-properties such as flexibility (Nelson et al., 2007).

4. CONCLUSION

Improving Crop production depends highly on climatic factors. These affect the distribution, survival, growth and yield of crops changes in the biotic and abiotic factors of the crop environment. Climatic variation should be strictly monitored for the planning and

execution of crops cultivation, management and harvesting for meaningful transformation of sustainable farmers' socio-economic status. Ultimately, the challenge for developing countries resides not only in their capacity to withstand and recover from climatic events, but mostly in their capacity to adjust, change and transform amidst slow changing trends and unpredictable variability; while facing a future where the only certainty is uncertainty itself, and within which, development outcomes will be determined, to a large extent, by their ability to foster 'development epiphanies' and innovate with the support of tools such as ICTs.

Recommendation

In the light of the changing climatic conditions, the paper recommends the following for better improvement of crops production as well as mitigating climate change:

- 1) That there should be regular and proper research and monitoring of climatic elements so as to forecast any likely change for proper planning of agricultural production.
- 2) Mass enlightenment campaign on the dangers posed by indiscriminate human activities on natural ecosystem, needs to be intensified to reduce the menace of climate change on crop production.
- 3) Appropriate and timely information with the use of ICT devices on future climate change and current level of climatic variation need to be provided to farmers so as to alert them to take appropriate averting actions.
- 4) Vulnerability of national environment needs to be assessed to the most probable projections of climate change and sea level rise in which judgment of how far public and private actions should be modified to avoid undue risk.
- 5) ICT initiatives should focus on providing services such as question-and-answer sessions, cooperative-related accounting methods, market information, input prices/availability and early warning systems for disease and pest problems.
- 6) ICT services should provide early warning of disease and pest problems, question-and-answer services, information on cropping systems and planning, best and latest packages of practices for commercial crops, weather forecasting, soil testing and sampling, post-harvest technology, input prices/availability, farm business information and crop insurance.
- 7) It is also recommended that, before ICT services are set up in a region, efforts are made to develop among the farmers both a satisfactory level of faith in the intentions of the ICT staff and a firm commitment to the goals of the proposed project.
- 8) It is also suggested that participatory and rapid rural appraisals are carried out to ascertain what information the farmers need.
- 9) In the process, the farmers' self-fulfilling faith in the information services provided should be enhanced.
- 10) It is further recommended that the farmers be instructed in how to get the best possible use out of the services provided.

References

- [1] Abdullahi, B. D. and Idris, M. B. (2013). Implications of climate change for sustainable crop production in Nigeria. *Zobe journal of science*, 2(2).
- [2] Agbetuyi, P. A. and Oluwatayo, J. A. (2012). Information and communication Technology (ICT) in Nigerian educational system. *Mediterranean Journal of Social Sciences*, 3(3).
- [3] Ajayi, J.O. (2000). Climate and the Agricultural Management in Democratic Nigeria. Kano. *Journal of Arts and Social sciences*, 1(2).
- [4] Bello, M. (2012). An Analysis of Rainful Characteristics in two Selected Stations in Northern Sokoto Region. An Unpublished Thesis, Department of Geography, Usmanu Danfodiyo University, Sokoto, Nigeria.
- [5] Brown M. E., Funk C. C., (2008). Food Security under Climate Change. *Science*, 319(5863); 580-581.
- [6] Dimbley, G.W. (1973). Ecology and Archeology. Edward Arnold.
- [7] Duncombe, R. (2006). Analysing ICT Applications for Poverty Reduction via Microenterprise Using the Livelihoods Framework. IDPM Development Informatics Working Paper no. 27. University of Manchester.
- [8] Goudie, A.S. (1977). Environmental change. London, Oxford university press, London.
- [9] IPCC (2007). Climate change: contribution of working groups 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, eds S Solomon et al., Cambridge, United Kingdom and New York, Cambridge University Press.
- [10] Johnson, M. and Neves, L. (2007). Using ICTs to tackle climate change. Global e-sustainability Initiatives.
- [11] Karanasios, S. (2011). New and Emergent ICTs and Climate Change in Developing Countries. In R. Heeks & A. Ospina (Eds.). Manchester: Centre for Development Informatics, Institute for Development Policy and Management, SED, International Development Research Centre.
- [12] Lobell, B. et al, (2008). Prioritizing Climate Change Adaptation Needs for Food Security in 2030. *Science*, 319(5863); 607-610.
- [13] Magawata, D. (2010). The contribution of ICT National Development. Farfaru journal of multi-Displinary. Held at Shehu Shagari College of education, Sokoto, Nigeria.
- [14] Magawata, D. (2013). The role of ICT in teaching/learning process for the achievement of national transformation agenda in Nigeria. *Zobe journal of science*, 2(2).
- [15] Meera, S. N., Jhamtani, A. and Rao, D.U.M. (2004). Information and Communication Technology in Agricultural Development: a Comparative Analysis of three projects from India. Agricultural Research & Extension Network. No. 135.
- [16] Meera, S.N. (2002) A Critical analysis of information technology in agricultural development: Impact and implications. Unpublished PhD thesis, IARI, New Delhi-110012.

- [17] Muntaka, Umar and Abubakar, (2013). The Need for Adoption of ICT in Agricultural Extension for Achieving National Development. *Zobe Journal of Science*, 2(2).
- [18] Nelson, D. R., Adger, N. W. & Brown, K. (2007). 'Adaptation to Environmental Change: Contributions of a Resilience Framework', *Annual Review of Environment and Resources*, 32: 395-419.
- [19] Schmidhuber, J. and F.N. Tubiello, (2007). Global food security under climate change. *Proceedings of the National Academy of Science*; Vol. 104.
- [20] Simone, S. (2010). The role of Information and Communication Technologies for community-based adaptation to climate change. A technical paper for FAO/UN Rome.
- [21] Ugwuishiwu C.H, Udanor C., Ugwuishiwu B.O(2012). Application of ICT in Crop Production. *International Journal of Soft Computing and Engineering*, 2(4).
- [22] William C. M, (2008). Modern Agriculture and Its Benefits – Trends, Implications and Outlook;
<http://www.globalharvestinitiative.org/Documents/Motes%20%20Modern%20Agriculture%20and%20Its%20Benefits.pdf>
- [23] Wong, J. & Schuchard R., (2011). Adapting to Climate Change: A Guide for the ICT Industry. Available at www.bsr.org/adaptation.
- [24] Hyginus A. Nwona, *International Letters of Natural Sciences* 4 (2013) 1-9.
- [25] Z. S. Hamidi, N. N. M. Shariff, C. Monstein, *International Letters of Natural Sciences* 8(1) (2014) 9-16.

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