Alexander von Humboldt Stiftung/Foundation
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Biotechnology Development and threat of Climate Change in Africa: The Case of Nigeria

VOLUME 1

Edited by

Odunayo C. Adebooye PhD
Kehinde A. Taiwo PhD
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DEDICATION

This book is dedicated to the Alexander von Humboldt Foundation, Germany for her special support for outstanding African Scholars.

The book also is dedicated to the poor and hungry people in the African Continent who have woken up today to uncertainty, insecurity and poverty.

FOREWORD

Research on biotechnology and climate change issues is of major importance for developing countries. This peer-reviewed publication provides an overview of current Nigerian research projects on these topics. The book, containing peer-reviewed articles, is based on a conference, which took place at Obafemi Awolowo University in Ile-Ife, Nigeria, in September 2009 and which was mainly sponsored by the Alexander von Humboldt Foundation.

The Humboldt Foundation is a German non-profit organisation promoting academic cooperation between excellent scientists and scholars from Germany and abroad. Every year, the foundation sponsors approximately 1,800 research fellowships and awards.

The greatest asset of the Humboldt Foundation is its international alumni network. It embraces 42 Nobel Laureates and approximately 23,800 scientists and scholars from all disciplines in more than 130 countries who are closely associated with Germany. Nigeria has one of the strongest Humboldt networks on the African continent. It comprises about 180 scientists and scholars from all major Nigerian universities.

To support its international network, the Humboldt Foundation provides financial support to organise regional and specialist conferences (so-called "Humboldt Kollegs"). The Humboldt Kollegs have rapidly become one of the most popular instruments for strengthening regional and specialist networks. The majority of participants in these conferences are Humboldtians from a specific region or a major specialist field.

The Humboldt Kolleg at Obafemi Awolowo University has been part of the "Africa Initiative 2008-2009" that the Humboldt Foundation has launched with special support of the German Foreign Office to strengthen the local and regional networks in Africa. The Humboldt Foundation is grateful to the organisers and co-sponsors of the conference for their commitment.

Professor Dr O.C. Adebooye, Conference Convener

FROM THE EDITORS

It is our joy to publish the full texts of the peer-reviewed articles presented at the Humboldt Conference of September 6-10, 2009. We thank the Alexander von Humboldt Foundation, Bonn, Germany for providing the funds for the Conference and for the publication of this book. The Editors also appreciate the painstaking efforts of the reviewers who responded promptly to peer-review requests. Reviewers' comments went a long way to improve the academic qualities of all the articles contained in this book.

We are certain that the articles contained in this book will be of immense values to undergraduate, postgraduate, postdoctoral and full-time researchers on topics that are related to biotechnology and climate change issues in developing countries.

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THE SOCIAL CONSTRUCTION OF BIOTECHNOLOGICAL RESEARCH AND DEVELOPMENT IN NIGERIA

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Abstract

Basically, the contemporary manipulation of identifiable living cells and bacteria in industrial and scientific processes has been functionally essentialized by the desire to improve on the state of the human condition in this modernizing era. Meanwhile, the prevalent globalizing culture has made it feasible for quick exchange of information and, indeed, instant spread of cogent empirical knowledge. Such is the case with biotechnological development, which seeks to enhance agricultural productivity; health care delivery and, of course, the realization of the focal target of the 'Millennium Development Goals' (MDGs), that is 'halving extreme poverty by 2015'. As noble as this innovation seems however, its application in Nigeria as obtainable in most parts of sub-Saharan Africa has been largely uncoordinated, or at best, attenuated; ostensibly due to inactivity on the part of the political leadership. This study focuses on the explication of varying interpretations of the reality of biotechnological incorporation within Nigerian configuration. On the part of the policy planners, have usual proclamations been met with desired actions in the bid to localize such innovation in the country? Are they conscious of its long-run human, social and environmental implications? On the other hand, are the people – the supposed direct beneficiaries of such adaptation aware of its existence and usefulness? How do they perceive and construct its reality? These and related issues are addressed in this study. The methods of In-depth Interviews (IDIs) and Evaluation Research (ER) are engaged as the study's modes of inquiry, while Berger and Luckmann's 'The Social Construction of Reality' is adopted as its theoretical platform.

INTRODUCTION

Although, 'social construction' first appeared in Emile Durkheim's *collective behaviour* as a platform for explicating related social phenomena, Berger and Luckmann (1966) in *The Social Construction of Reality* espoused the concept as a popular medium for understanding social actions. With the *Weberian* essentially imaginative definition of social action in its subjective implication, the idea of an 'everyday sociology' seems to have emerged, and thus, the positioning of sociological analyses has become aptly enriched in symbolic interactionism, phenomenology, ethnomethodology and, even, post-modernism. All of these explicating views have been somewhat integrated into social constructionism over the years. As such, a seemingly vacuous paradigm shifts from the 'exogenous' to the 'endogenous' has become prevalent in the explanation of actions and interactions globally, that is, the relocation of related developmental propensity to the potentiality of immediate environmental positioning.

Imperatively, the effects of any new technology introduced on the scale anticipated for biotechnology, of course, extend beyond the factories and research centres influencing our everyday lives. The last few years have unambiguously revealed a surge in biotechnological research, which has caused a myriad of practical applications in many areas of human endeavour, such as, health care, pharmaceutics, agriculture and the agro-food system, environmental protection, information technologies, criminology and, even economics through the delivery of innovative products and the adaptation of existing products into more competitive outputs. Knowledge of the development opportunities made possible by biotechnologies assumes growing importance, given the 'natural research - innovation transfer - product marketing' cycle. This complex scenario necessarily conditions policy decisions that must be made, as well, emphasizing the need to assure a 'biotechnology culture'.

While the tendency of serious 'biohazards', such as, the risk of a genetic engineering accident, appears to be receding in the developed world, biotechnological incorporation in parts of the developing world, which tends to impact on cogent aspects of social organization, has not been paralleled by commensurate regulatory efforts to convey detail and unbiased information to the general public in the process of its utilization.

This paper, therefore, focally seeks to analyze how 'social constructionism' explains the ensuing phenomenon of biotechnology within Nigerian society. As it is obtainable in most advanced societies, the question of a new technology in the horizontal likeness of biotechnology demands a responsible evaluation of the possible consequences brought about by the modification of the genetic heritage of living organisms or parts of them. As such, adequate forms of communication must be identified so as to guarantee desired ethical lead and unbiased information flow. How has the concerned authorities in Nigeria been projecting such a sensitive development like biotechnological application in the country? How realistic, or probable is the application and management of the technology in Nigeria? Could the usage and positioning of biotechnology be in commensurate consonance with prevalent institutional peculiarities among the people? Has the innovation been, or would it be utilized as mere platform for reproducing political hegemonic propensity, rather than as a tool for attaining self-sufficiency for the Nation, in view of limitless opportunities it offers in food production, health care, crime control, employment generation *et cetera*? It would seem therefore that a safe and productive adaptation of biotechnologies is conspicuously an offshoot of functional policy advancement and projection from the concerned regulatory body.

WHAT IS SOCIAL CONSTRUCTIONISM?

Social constructionism foundationally emanates from an epistemological position, rather than from an outright theoretical leaning; focusing on *meaning* and *influence* often attributed to cogent phenomena (Haslinger, 2003). It focuses on *meaning* and *influence* for its epistemological position usually dictates that *meaning* and *influence* are all that we could actually claim to know about prevalent phenomena. Therefore, a major focus of social constructionism is to account for various ways in which phenomena could be socially constructed. That is, uncovering the platforms by which individuals and groups participate in the creation of their perceived social reality. It involves observing how social phenomena are created, institutionalized, and made into tradition by humans (Prinz, 2007). Socially constructed reality is regarded as a dynamic process through which reality is reproduced by personalities working on their connotations and their experience of it. An instance of this explanation is the focus of this study – how the perceived reality of the applications of biotechnology is constructed among the Nigerian people.

Operationally, there are differing platforms of constructing what a reality is, and what it would *mean*. However, such connotations are often mutually-exclusive and ordinarily advanced from cogent epistemological, cultural and ideological interests. Generally, for constructionists, all phenomena do follow this pattern. Although, both 'social constructionism' and 'social constructivism' usually deal with ways social phenomena develop in social contexts, they are distinct. While 'social constructionism' refers to the development of phenomena relative to social contexts, 'social constructivism' entails an individual's making meaning of knowledge within social context. *Constructivism* basically postulates social origins of mind; 'strong' *constructionism*, however, cannot account for 'mind' *per se* – only for representations of mind in social interaction. Impliedly, the determination of our representations of the world (including our ideas, concepts, beliefs and theories of the world) by factors other than the world or our sensory experience may undermine our belief that any independent phenomenon is represented or tracked, undermining the idea that there is a fact of the matter about which way of representing is correct (Boghossian, 2006).

Equally, the determination of the non-representational facts of the world by our theories seems to reverse the "direction of fit" between representation and reality presupposed by our idea of meaningful epistemic activity. It should be noted that 'social constructionism' differs from an explanatory social theory for it does not affirm that an interactive pattern, such as 'biotechnology adaptation' could be explicated by social variables. It insists that 'biotechnology adaptation' itself is a social construct. Hence, a social construction (social construct) could be regarded as any phenomenon so "established" by individuals existing within a specified cultural or societal configuration; for within the constructionist explication, it is adjudged to be a development that is uniquely the creation of such individuals. Social constructs are ordinarily understood to be the by-products (often, un-intended) of numerous human choices rather than laws resulting from divine will or nature as the *naturalist* would routinely affirm. This is not usually taken to imply a reactionary anti-determinism, nevertheless. Social constructionism is usually anti-essentialism, which categorizes specific phenomena instead in terms of trans-historical features independent of conscious beings that determine the categorical structure of reality. Usually, in the process of interpreting social interactions, constructionists do function putting into cognizance relevant assumptions, that is, the subjective outlook of the social world; histo-cultural specificity; interconnected patterns of interactive disposition and socially-sustained knowledge system.

Put differently, Berger and Luckmann (1966) argue that such knowledge, including the most basic, taken-for-granted common sense knowledge of everyday reality, is derived from, and maintained by social interactions. When people interact, they do so with the understanding of their respective perception of reality, and as they act upon this understanding their common knowledge of reality becomes reinforced. Since this common sense knowledge is negotiated by people, "human *typications*, *significations* and institutions" come to be presented as part of an objective reality. It is in the light of this that reality is socially constructed. Berger and Luckmann thus affirm that "social construction of reality" occurs when actors interacting together form, over time, *typifications* or mental representations of each other's actions, and that these *typifications* eventually become *habitualized* into reciprocal roles played by the actors in relation to each other. When the reciprocal roles become *routinized*, the typified reciprocal interactions are said to be institutionalized. In the process of this institutionalization, meaning is embedded and institutionalized into individuals and society – knowledge and people's conception of (and therefore belief regarding) what reality 'is' becomes embedded into the institutional fabric and structure of society, and existential reality is therefore said to be socially constructed.

Nevertheless, if there is any core idea of social constructionism, it is that human actions and interactions are basically caused or controlled by social or cultural factors rather than by natural determinants as suggested in related naturalistic explications. 'Naturalism' thus affirm that since knowledge emanates only from the empirical world; governed by natural laws, hence attempting to understand it will require the application of related causal models and not a mere *priori* theorizing. Therefore, studying human nature, human culture and social life will require the methods of the natural sciences for they are natural objects within the social world that science explains. On the other hand, social constructionist discourse has a more or less independent, but equally contentious life in the "human nature wars" where it labels the position that human traits (for example, the emotions) or human kinds (which we can think of categories whose members share traits or clusters of traits, especially, dispositions to think and behave) are produced by culture rather than by biology or nature (Kukla, 2000). This view is typically allied with classic empiricism and contrasts with the view that human traits are to be explained in terms of non-cultural mechanisms – especially internal, biological or natural states of the organism. The most pronounced misconceptions are *prima facie* – concerned with whether the clustering of behavioural dispositions in, for example, emotional behaviour is caused by a cultural practice of differentiating individuals or is instead facilitated by natural processes operating in relative independence of culture.

It is worth of noting that any discussion of naturalistic approaches to social construction is often complicated by the fact that "naturalism" itself has no very widespread and uniform understanding. Still, the prospect seems provocative, in part, because social construction has come to be associated with a critical anti-realist attitude towards scientific attitude. The above features characterize substantial threads of contemporary naturalistic thought; threads that arise repeatedly in discussions of constructionism. While a phenomenon may be naturalistic in one sense, it might not in another and that the various threads we have characterized could sometimes be at odds. Meanwhile, naturalists addressing the challenge posed by social construction to the authority of science have attempted to respond to this challenge in a variety of ways that pit various versions of *realism* and *empiricism* against constructionism.

However, in contrast to naturalistic responses to the threat of scientific anti-realism, naturalistic responses to constructionist claims about representations (including beliefs) understood as human traits have been far more sympathetic to constructionist approaches. This is evidenced by the amenability of cultural and social causes of belief to range of naturalistic approaches (Mannheim, 1936).

CONTEXTUALIZING BIOTECHNOLOGY AS A SOCIAL PHENOMENON

For the ameliorating disposition of biotechnologies, their social connotation could be imperatively affirmed. Basically, every scientific invention is often routinely focused on addressing a specific existential exigency or challenge of individuals or the society as a group. From its applications in industrial processes to the tracking down of criminals and early detection of diseases through cogent DNA probes, enhanced agricultural productivity and environmental control, which is making the promise of food sufficiency a reality, the usefulness of biotechnology to human beings are limitless (BIO, 1990).

Although, biotechnological development seems to be ordinarily a scientific concern, at least within the naturalist presupposition, which it is in actual fact, nevertheless, the larger human society is usually the ultimate recipient of its gains and pains. At this juncture, the sociological understanding of this massive innovation; and its positioning within the social context has become expedient.

The use of living organisms to create products or to perform the responsibilities of human beings could always arouse related sociological concern. Products so created are ordinarily for human consumption or societal improvement or the tasks performed on behalf of human beings could save useful manpower or time to be diverted to other productive endeavour, or even, retrogressively send human beings to the labour market. These are potentially tenable social concerns emanating from biotechnological development, which ostensibly call for adequate contextual situationing.

The application of plants, animals and micro-organisms, such as, bacteria as well as related biological processes like ripening of fruits or the bacteria that break down compost in biotechnological endeavour is believed to possess identifiable socio-psychological implications for benefitting individuals. One, there could arise a gerontological alteration in the process of ageing, which could present an eventual distortion in the mode of social relations and interaction. Two, the behavioural patterns of individuals could be altered considerably within the society and equally impacting on the modes of social relation and interaction. In essence, for the conceptual applications of biotechnological development focusing attention on the provision of basic existential (social) needs of human race, such as food, health, clothing *et cetera*, hence, biotechnologies could be considered to aim at social development. Aside, the focal issues, such as, poverty reduction, health care delivery, elimination of hunger, sanitation, employment generation, *et cetera*, which such developmental programmes like the *Millennium Development Goals* (MDGs) of the United Nations (UN) and the *Seven Point Agenda* of the Nigerian Government seek to address are in tandem with most of the issues, which cogent applications of biotechnology seek to address. Therefore, biotechnologies are conceptualized as social phenomena.

THE SOCIETAL IMPLICATIONS OF BIOTECHNOLOGICAL RESEARCH AND DEVELOPMENT

The field of biotechnology has had formidable beneficial contributions in the area of health care, food production and agriculture, industrial production, environmental management and so on. Of course, the arrays of its applicability seem limitless within the evolving civilization. Essentially, such usefulness have had notable practical manifestations mostly in developed countries where there are functional regulations guiding their development and applications, and not in such third world countries like Nigeria. However, this considerable advancement already achieved in this field has equally caused some concerns and controversies from interested individuals and institutions across the globe. Such have included fear for bio-safety, unnaturalness of genetically modified (GM) foods and the increasing tendency for biological warfare. Nevertheless, biotechnologies have come to be seen as an emerging industry, enabling the development of new products or the set-up of new methods for the production of already existing, but scarcely available products, such as human proteins or other complex molecules.

Thus, biotechnologies entail a viable instrument that can offer the productive system the results and outcomes of a more targeted and rational organization of those factors underlying the innovation process, that is, research activity, technology transfer, training, access to funding and capital, in order to stimulate the creation of new industrial sectors. Confirmation of this potentiality is reflective in the global sales of biotechnological products, which in the last few years have experienced an overwhelming growth. However, it is believed that considerable increases would still be attained in the years ahead when many societies, especially in the developing world are expected to have become more stable in the incorporation of biotechnology.

In the area of food production and agriculture, today, less time is being spent on the production and preparation of food than our forefathers did, and we now eat a much greater variety. Over time, we have learnt more about the human body and this has changed the kinds of foods we eat. For example, in 1959, Australians are reported to have consumed about 117 kg of vegetables per person. In 1989, it had risen to 162 kg. Each year, Australians eat an estimated 35 kg of beef per person. Worldwide, it has been estimated that the demand for cereals will increase to 2,466 million tonnes by 2020. Meat demand will increase to 313 million tonnes, and roots and tubers demand will increase to 864 million tonnes (www.dfat.gov.au). As well as changing the food we eat, more land and resources have been used to produce it. Producers want food crops and animal varieties to work harder, and more efficiently. Mostly, this is achieved through new agricultural methods as offered by vagaries of biotechnological innovation.

Aside from its application in attaining food sufficiency, biotechnology is leading the way to a new dispensation in health care delivery for societies, with the development of more-result oriented methods for detecting, preventing and treating diseases. Biotechnology has, for instance, made it possible to detect, and in some cases treat, diseases such as cystic fibrosis, sickle-cell anaemia and diabetes. Biotechnological techniques, such as DNA profiling, are also proving enormously useful in other areas of human life, e.g. forensic science and identification. Improved genetic tests based on biotechnological advances can be used to track down criminals in assault cases based on the uniqueness of their DNA and also in apprehending electoral manipulators. Genetic counselling can provide advice on heritable diseases, and genetic screening of workers in possible risk industries is being considered. DNA probes are providing breakthroughs in early diagnosis of diseases. As detection of genetic predispositions becomes more predictable, a great deal may be known at birth of an individual's prospects in life. The moral question then arises as to who has access to this information and how this will affect the individual's quality of life (Gerald and Robin, 2007). Other seemingly controversial applications of biotechnology, such as, cloning and stem cell research are scientifically considered parts of human use of the innovation.

At another existential realm, biotechnology is being used to address some environmental issues. Biotechnology has the potential for many positive impacts on the environment. For example, it can be used to:

- support work on recovering threatened species;
- control or even eradicate introduced predators and pests;
- remove wastes and pollution from the environment.

It is, however, important to consider the fact that scientific decisions are never devoid of some measure of variation. They can also be coloured by the particular worldview of the researchers trying to solve the problem. For example, a palaeontologist, who studies the history of the earth over millions of years, brings a very different understanding of species extinction to an environmental debate than an environmental biologist. So also, the views of an environmental sociologist studying the implications of scientific inventions on social life and the larger social super-structures would likely be different from those espoused by the palaeontologist and the environmental biologist.

It is equally important to think about actions taken based on conflicting advice and how they are weighed up. These decisions may have the potential to deprive future generations of their right to determine some aspects of their lives. Biotechnology, as it relates to the environment, usually means introducing a new organism into an existing situation. Essentially, understanding the potential environmental impact of releasing these organisms, such as, genetically modified (GM) organisms on the human societies has become imperative so as to prevent environmental damage and to preserve our biodiversity.

Directly linked to the productive and social development potential of biotechnologies are its employment opportunities. Most of the professionals operating in the field, be they technicians, researchers or exporters, will require targeted measures of continuing education and training, biotechnologies being a rapidly developing, science-based discipline. Managers, too, must be contemplated, as professional figures will be needed to link research breakthroughs with technological innovation and industrial development, in order to foster exploitation of research results, also through the detailed knowledge of markets and their demands. As such, biotechnologies do serve as potential employment creators.

ARE BIOTECHNOLOGIES REAL AND SAFE IN NIGERIA?

As obtainable in every sector of Nigerian society, investments in research and development (R & D) has been quite discouraging. In fact, over the years negligible attention has been given to such investments in the country. Hence, the case with biotechnologies has not been an exception. Researches in biotechnological development, aside from the imperative requisite training, entail the prevalence of high level of regulatory and ethical standards, which usually guide their applications as a result of their sensitive nature. Biotechnology, more than other scientific disciplines, demands a detail and painstaking evaluation and management of probable implications resulting from the modification of the generic heritage of living organisms or parts of them. Programmatically, the absence of such attributes has been an integral unit of the qualities that actually made a third world country like Nigeria an undeveloped nation.

Although, cogent researches in developed countries have recently indicated that the chances of constructing a disease-producing organism by accident are very remote because such pathogens require an extremely complex set of distinct characteristics, and are effective only when all are present. Indeed, a special committee of the National Academy of Science (NAS) specifically reviewed the issues generated on the introduction into the environment of organisms genetically engineered using recombinant DNA technology. It concluded that "there is no evidence that unique hazards exist either in the use of Recombinant-DNA (R-DNA) technique or in the transfer of genes between unrelated organisms," and that "the risks associated with the introduction of R-DNA engineered organisms are the same kind as those associated with the introduction of unmodified organisms". The committee affirmed that R-DNA techniques constitute a powerful and safe; new means for the modification of organisms for the benefit of animals and humans. They also stated that there is adequate scientific knowledge to guide the safe and prudent use of such organisms outside research laboratories. Emphasis has just been on containment of experiments being the key to safety.

Meanwhile, an estimate of 92% of the respondents to my question on safety of biotechnologies as observed above were quick to point out that whatever measure of safety that could be tenable in the processes of application of the technology would be limited to the advanced world, and not in such country like Nigeria. Ostensibly, an estimated 89% of them strongly refuted the presence or application of anything biotechnology in Nigeria either at the individual/corporate level or at the level of policy advancement by the government. However, 75% of the respondents were quick to affirm that such technology can neither become realistic nor safe whenever it is transferred into the country in view of the prevalent ineptitude on the part of the political leadership and, of course, the discouraging dispositional attribute towards governmental policies; often perceived and proven rhetorical by the citizenry.

Ironically however, available facts and data from the Nigerian government on biotechnological research, development, application, regulation and control are so scanty as to re-affirm the unreality of the technology in Nigeria as presented by the study’s field findings. Though, the federal government has put in place a regulatory body – the National Biotechnology Development Agency (NABDA) –

saddled with implementing the Nigerian Biotechnology Policy, its impact is yet to be felt in the country. Nevertheless, the functioning of the agency has taken the pattern of usual non-performing 'Nigerian civil service' and as such, cosmetic in orientation.

Ethics, being set of rules or standards that govern the way people behave and their decisions on the 'right' thing to do; demand basic questions about what is right and wrong, how we should act and what we should do in specific situations. It is important to note that ethics relating to biotechnology and its applications are not fundamentally different from other situations. Ethics are practiced and not rhetorized. As is the case with every sector in Nigeria, the ethical question is yet to be answered due to unhealthy corruption, nepotism, sycophancy and bureaucratic impediments in governmental functioning. Therefore, the reality and safety of biotechnologies are still being negated within the Nigerian configuration. One common and global denominator of biotechnology products has often been that they must be safe for humans and the environment.

Many new technologies often raise ethical concerns that might not be part of the world view held by those who develop the technologies in the first place. When it comes to developing products for commercial use, the goal is usually to increase sales and enable profitability. The decision for developing products can be seen as good for industry development, but perhaps not as good for individuals who do not have products developed to suit their needs when there is not enough profit to be made. For example, some products may be of obvious social benefit, such as, a drug that treats cancer. Also, in some areas of biotechnological development, the money needed to fund research projects is most time out of the range of individuals or small groups; it can only be undertaken by multinational/overseas companies. Some perceive this as acceptable, because it helps local researchers form links with wealthy larger companies. But others do not think it is not acceptable, because local research and development leave the community and are then controlled by international corporations. Whatever the view one holds on this, a general consensus is that a re-production of neo-imperialist tendency could be facilitated through this platform, which would eventually lead to further underdevelopment of a country like Nigeria due to the prevalent ineptitude on the part of the policy planners.

SPECIFIC FINDINGS

This study has been able to reveal that biotechnologies are yet a reality within the Nigerian society in terms of incorporation and applications. As such, related extent and measures of their safety in humans and the environment cannot in any way be a subject of discussion, at least for now.

Nevertheless, of all the identifiable impeding factors against the productive utilization of opportunities presented by biotechnological research and development, distorted policy projection and advancement on the part of the political leadership has remained the most potent; and of course, the pivot around which all other factors oscillate.

The following findings are, thus, derived from the study:

i. Biotechnologies, through the genetic modification of living material, have presented to humankind the platforms for tackling cogent existential challenges that were previously considered insurmountable, especially in areas of food production and disease management. As such, biotechnological innovations are taken as formidable social constructs. In turn, however, as these novel possibilities have led to the need for a new ethical framework, they have equally compelled specific legislative provisions;

ii. While the risk of genetic engineering accident and other bio-hazards arising from biotechnologies appear to be receding in the advanced countries, such as, US, Germany, Japan, Canada, Australia and so on, strict regulations of the new technologies are not yet being relaxed in such countries;

iii. The study has sufficiently shown that most Nigerians are ignorant of the opportunities obtainable from the applications of biotechnologies to relevant human endeavours in the country as there are no concrete reasons to be believe such for now;

iv. Though, biotechnological research and development is still, at best, in its infancy in Nigeria, there is however a potent apprehension already in place from concerned individuals vis-à-vis its safe applications and management in such undeveloped society, where rules and regulations are easily flouted at will without any commensurate reprimanding;

v. In all, rather than serving as platforms for advancing the course of humanity as tenable in relatively developed societies, biotechnologies could spell doom for Nigerians and their biodiversities if eventually introduced into their society without any relevant; concrete and positive change in attitudinal disposition, especially, at the level of policy planning.

CONCLUSION AND POLICY RECOMMENDATIONS

This study has been able to present biotechnologies as a potent representation of one of the dynamic technological revolutions of this century, which is set to impact every aspect of our society; introducing radical changes in the way many problems regarding human health, agriculture, security, environment *et cetera* are addressed.

Nevertheless, biotechnological research and development has undoubtedly raised challenging environment-related, ethical and social issues that have caused variations in the level of its social acceptance across the globe. While most societies of the developed world have been able to douse fear of related biohazards by means of cogent empirical affirmations, societies on the other divide, such as, Nigeria are yet to take full advantage of the promises presented by biotechnologies, not to talk of the implications of the technologies for the society.

It is, thus, of a concise summation of this study that since some of Nigerian universities and research outfits have played a major role in the development and promotion of science and technology over the years, they equally have an obligation to help policy planners and the larger society understand and manage the changes that are bound to arise from eventual incorporation of biotechnology and genomics in the country.

More importantly, a significant expansion of sociological research will be needed in elucidating the full range of views from the prevalent interdependent global configuration. The impact of such an integrated approach to social construction of biotechnology's reality in the country will be for enhanced policy and public understanding of the promises, and related undoing, which the technology holds for our society at large.

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CLIMATE VARIABILITY FOR SUSTAINABLE FOOD CROP PRODUCTION: IMPLICATIONS FOR AGRICULTURAL EXTENSION DELIVERY IN NIGERIA.

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Abstract

The relative decline in food crop production in Nigeria has been attributed largely to changing weather conditions. Scientists have indicated that global warming will place millions of people at greater risk of food and water shortages particularly in sub-Saharan Africa. Yet, the impact of changes in agro-climatic conditions on food crop production has received little attention in agricultural research in Nigeria. This study therefore examined the effect of agro-climatic variables on food crop production in Nigeria. Time Series data covering four decades (1965-2004) were obtained for output and prices of Tuber crops (yam, cassava and potato), from Food and Agricultural Organization and Central Bank of Nigeria. Agro-climatic variables (relative humidity, temperature, rainfall, sunshine, solar radiation, wind speed, and evaporation.) were obtained from Meteorological Centre, Nigeria. Data were analysed using descriptive statistics and Error Correction Model (ECM).There was a wide gap in minimal and maximal values of each of the agro-climatic variables, which affected crop output. ECM indicated that rainfall had significant effect on the output of all crops considered ($P<0.05$). Windspeed had significant effect on all the crop outputs ($P<0.05$) but had inverse relationship for yam and cassava outputs in the long run. Sunshine hour had significant effect on yam and cassava outputs. The coefficient of ECM was negative and significant ($P<0.01$) for all the crops, confirming the existence of long- run equilibrium relationship between the crops and the weather variables and also the presence of significant short-run dynamics. Agro-climatic variables significantly influenced the output of all the crops considered. The relationship between food crop output and agro-climatic variables if carefully monitored will increase total output of each of the crops considered. Hence the need for farmers' education and proper monitoring of climatic conditions in the country as this will help stabilize and sustain food crop production.

Keywords: Agro-climatic variables, Food crop outputs, sustainability, Error Correction Model.

INTRODUCTION

Planet earth is increasingly being consumed by unprecedented and dramatic changes in weather conditions. Global warming, El-Nino/ tsunamis and high powered hurricanes are becoming important and critical influences on human lives and soon will be on land economy, land use and eventually on food production. Scientists continue to show evidence that global warming will soon place millions of people at greater risk of food and water shortages particularly in sub-Saharan Africa. Climate change is rapidly emerging as one of the most serious threats that humanity will face. In recent times, there have been changes in the climate across the globe due to the effect of global warming arising from various human activities. Rosenzweig (2001) had predicted that "in a most fundamental way, climate change will bring change to agriculture wherever it is practiced." The highest damage from climate change, has however been predicted to be in the agricultural sector in sub-Saharan Africa

(Kurukulasuriya and Mendelsohn, 2008). Because it is linked so closely to natural resources and climate conditions, agriculture will keenly feel the effect of climate change through changes in both temperature and precipitation. Given Africa's high dependence on agriculture as highest provider of labour, the effect of climate change could put millions of people at risk of poverty and hunger. Africa is particularly vulnerable to climate change because of the high incidence of low-input, rain-fed agriculture, compared with Asia or Latin America.

The climatic changes attributable as they are to global warming and green house effects recorded in many parts of the globe including sub-Saharan Africa (SSA) suggest that a sustainable growth in agricultural production from an increasingly fragile ecosystem requires new and innovative management strategies. Although considerable progress has been made in evaluating the potential effects of climate change on global agriculture, significant uncertainties remain at regional levels and since existing evidence indicates that global effects are manageable, concern is increasingly shifting to regional effects (Reilly, 1999). This flows from the fact that the climate of an area is found to be highly correlated to the vegetation and by extension the type of crop in that area. The quality and character of weather are thus a central determinant of what can be produced, how it is produced, as well as the expectation of achievable results. For example, it has been observed that in spite of qualitative seed selection, subtle management and varietals selection, unusually bad weather can bring about significant output losses (Knerpp and McRae, 1999).

The effect of climate change on agricultural productivity demands greater attention given that agriculture is the single most important occupation and second largest export earner after petroleum in Nigeria. Because of Nigeria's heavy dependence on agriculture, the negative effects of climate change on productive croplands can impact directly on the welfare of the population and the economic development of the country (Mendelsohn and Dinar, 1999). Agriculture in sub-Saharan Africa, vis-à-vis Nigeria has been found to thrive under extreme heat and low precipitation and it relies on relatively basic tools and technologies (McCarthy et. al. 2001).

In spite of the above difficulties, the impact of changes in climatic conditions on agricultural production has received little attention and the development, testing and practical application of methods of agro-climatic analysis have not benefited much from priority areas in agricultural research in Nigeria. For example, relatively limited information is available on the effect of climate on agriculture, Mendelsohn and Dinar (1999) observed that most empirical works, whose results have been extrapolated world wide focused on the industrialized nations, thereby excluding developing nations that are more vulnerable in the face of changing climates. The situation is even more critical for Nigeria, which was excluded from a cooperative research effort among some African countries (Kurukulasuriya and Mendelsohn, 2008). The omission has created a big gap in the knowledge about climate change and its effect on agriculture in Nigeria and the significance for the validity of Africa results thus far.

Nigeria has a land area of 983 000 km^2 which is about 4 percent of the total land area of the sub-Saharan Africa. Nigeria had a CO_2 emission per unit of GDP of 0.9 as opposed to 0.6 for Sub-Saharan

Africa. (Little Green Data Book 2001). Furthermore, Nigeria is the most populous black nation with an estimated population of 140 million (Census, 2006); a fact considered critical to the African continent in the fight against poverty and food insecurity that might arise as a result of the negative impact changing climate may have on agricultural productivity. In the circumstance, there is need for a better understanding of the Nigerian situation.

Food shortages caused by natural and human- caused disasters continue to affect many countries in all regions of the world due to lack of knowledge and understanding of crops, its yield, vis-à-vis agro-climatic variables. Fluctuations in crop outputs over the years have been due mainly to fluctuations in weather and climate. To provide output stability therefore, there is the need for a study that would examine the effect of climate change on staple food crop production in Nigeria. Such a study would also provide a long-term forecast of these climatic factors to be able to predict what the trend in staple food crop production would be and consequently adaptability of agriculture to changing climatic conditions. This study intends to assess the trends in both agro-climatic variables and food crop outputs with a view to examining the effect of climate change on agricultural productivity and implications for agricultural extension delivery in Nigeria.

CONCEPTUAL FRAMEWORK/LITERATURE REVIEW

Conceptual Framework

Sustainable food crop production

There is a growing realization that the optimization of food production goes beyond the question of availability of improved production technologies (Oyekale 2000).It is observed that climate plays a vital role both directly and indirectly in crop growth, development and output and nearly every item of standard meteorological data has some relevance to crop production. It has also been observed that in spite of qualitative seed selection, subtle management and varietals selection, unusually bad weather will amount to significant output losses (Knerpp and Mc Rae, 1999).

Trend analysis in crop production has been known to have relevance for both microeconomic and macroeconomic decision making. At the farm level for example, the pattern of crop output and rainfall distribution can have important consequences on farmers' income and risk management. Considering an aggregate perspective, the growth of crop output and their variability have raminifications for food security programmes of a country, particularly for development of new technologies (Offut *et al.,*1987). For instance, the threat of increasing length of dry season in Nigeria and some other African countries have shifted the attention of agricultural development planners towards expanded irrigation networks while consideration is being given to the establishment of mini-dams for intensive crop production even in the rainfall belt of the country. One major attribute of agricultural production is that output varies from period to period mainly due to changes in policy, biophysical and socioeconomic and agro-climatic environments.

The alarming food deficit projected for sub-Saharan African from recent production figures make it mandatory that no effort be spared in reversing the trend of declining yield. Developing better understanding of such climate related constraints as inadequate or excessive rainfall, high levels of intensity storms, temperatures, evaporation demands and errodability of soils will result in measures that can overcome or mitigate these constraints to crop production and facilitate sustainability. Sustainability has been variously defined; Conway (1985) defines it as the ability of a system to maintain productivity even in the face of a major disturbance. Similarly Lynam and Herdt (1988), stated that a sustainable system must have non-negative trends in total factor productivity .At farm and village levels, the essential concern is that the production system should not collapse under pressure from adverse weather conditions in the foreseeable future .In other words, a sustainable agricultural production system is expected to be both productive and resilient.

A way of achieving sustainable agricultural development is to raise the productivity of the farms by optimizing efficiency within the limits of the existing resource base and available technology. The factor productivity growth of input-output relations and enterprise shows that small-scale farmers operate on the frontiers of the production function (Udoh and Akintola 2001).

Farrell (1957) developed the concept of technical efficiency based on input/output relationship. He suggested a method of measuring technical efficiency by estimating the production function of firms, which are fully efficient. However, according to Udoh and Akintola (2001), a farm is said to be technically inefficient when actual observed output from a given input mix is less than the maximum possible. Efficient use of various inputs, which could be agro-climatic variables, is an important part of sustainability [Harwood, 1987], which implies either fewer input to produce the same level of output or higher output at the same level of inputs.

Methodological Concept

Co integration and Error Correction Modeling (ECM).

In the last decade, co-integration methodology has become a widely used technique for the analysis of economic time series. It has assumed increased importance in analyses that purport to describe long-run or equilibrium relationship Goodwin and Schroeder (1991) and Alexander and Wyeth (1992) employed it to study market integration. Hallam *et al* (1992) used it to establish the determinants of land prices, while Adams (1992) applied the concept of co-integration to estimate the demand for money in Kenya. Other studies that have employed the concept include: estimating agricultural export supply in Cameroon (Tambi, 1999), cocoa export supply in Nigeria (Tijani, 1999) and Chete (1998) in estimating the determinants of direct investment in Nigeria. These studies validated theoretical and antidotal priors, and agreed to the fact that most time series variables are non-stationary at their level but attain stationarity at different levels of differencing, thus, questioning the predictive reliability on empirical results based on Ordinary Least Square (OLS) specification. The above inform our conviction in the application of co-integration and error correction specification as appropriate and plausible in modeling the effect of exogenous variables on sustainable food crops production in

Nigeria. A prerequisite of the ECM estimation is the determination of the characteristics of the time series variables in the model as to whether they are stationary or non-stationary. Co-integration theory Felix and Welch (1998), Goodwin and Schroeder (1991) examined the time series characteristics of data with a view to overcome the problems of spurious correlation often associated with nonstationary time series data and simultaneously generate long-run equilibrium relationship (Engle and Granger,1987). Co-integration means that time series variables [one, two or more] may be regarded as defining a long-run equilibrium relationship if they move closely together in the longrun, even though they may drift apart in the short-run. This long-run relationship is referred to as a co-integrating vector because there is a long-run relationship between the variables. Regression containing all the variables of a co-integration vector will have a stationary error term, even if none of the variables, taken alone is stationary (Campbell and Shiller (1988).

The use of ECM is facilitated when variables are first differenced stationary and co-integrated. An equilibrium relationship exists when variables in the model are co-integrated. A necessary condition for the integration, however, is that the data series for each variable involved exhibit similar statistical properties, that is, be integrated to the same order with evidence of some linear combination of the integrated series. A variable is integrated of order I (0) when it is stationary in level form. A stationary series Xt for example has a mean, variance and autocorrelation that are constant over time (Tambi, 1999). However, most economic series tend to exhibit non-stationary stochastic processes of the form.

$$X1 = \alpha + \beta Xt\text{-}1 + et$$

Where;

α = constant drift

β = regression coefficient and is equal to 1,

et = an error term.

If et has zero mean, constant variance and zero covariance, then Xt is a random walk and said to be integrated of order I(1). Then series Xt is integrated because it is sum of its base value X0 and the differences in X up to time t. Since β is unity, X is said to have unit root. If Xt is non-stationary, the variances may become infinite and any stochastic shock may not return to a proper mean level. As shown by Engle and Granger (1987), such a non-stationary series has no error-correction representation. A non-stationary series requires differencing to become stationary. Xt is integrated of order Dx or Xt ~ I (Dx) if it is differenced Dx times to achieve stationary. Engle and Granger (1987) provide appropriate tests for stationary of the individual series as the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) statistics. These tests are based on t-statistics on δ obtained from estimates of the following OLS regression applied to each of the series.

$\Delta X\mathrm{t} = \alpha + \delta X\,\mathrm{t}\text{-}1 + e\mathrm{t}$ *(for the DF test)*

$\Delta X\mathrm{t} = \alpha + \delta X\,\mathrm{t}\text{-}1 + \Sigma t\text{-}1$

$k\, \beta \Delta X\, t\text{-}1\ 1 + e\mathrm{t}$ (for the ADF test)

Where the lag length k chosen for ADF ensures that et is empirical white noise. The null hypothesis holds that X is I(1) as against the alternative being I(0). The null hypothesis is rejected if the statistics on δ is negative and statistically significant when compared to appropriate critical values established for stationary tests. These critical values have been established for stationary by a number of studies from Monte Carlo simulations (Fuller. 1976; Dickey and Fuller. 1981; Engle and Granger, 1987). Most of the critical values are appropriate or large samples.

Once the stationary properties of the individual series are established, linear combinations of the integrated series are tested for co-integration. If a set of these series (e.g Xt ~ I (Dx), Yt ~ I (Dy) and Zt ~ I(D2) are integrated of the same order I(P), then they form a co-integrating set. Should a linear combination of individual non-stationary series produce a stationary data series, then the variables are co-integrated and unless they co-integrate, they cannot describe equilibrium relationships. If they do not co-integrate, regression of one I(1) variable to another become spurious. As shown by Granger and Newbold (1974) such regressions produce high coefficients of determination and t-ratio that are biased towards rejecting the null hypothesis of no relationship between the variables Estimates obtained from linear combination of individual series that are properly co-integrated are reliable and consistent and are fit for describing the steady-state relationships Studies on co-integration methodology along with tests for evaluating the co-integration properties of a pair of non-stationary series include Engle and Granger (1987), Johansen (1988) and Juselius (1990).

Johansen (1988) and Juselius (1990) presented a co-integration estimation methodology that overcomes most of the problems of the two-step approach. This is based on maximum likelihood estimates of all the co-integrating vectors in a given set of variables and provides two likelihood ratio tests for the number of co-integrating vectors. The risks associated with climate change lie in the interaction of several systems with many variables that must be collectively considered. Agriculture (including crop agriculture, animal husbandry, forestry and fisheries) can be defined as one of the systems, and climate the other (Sombroek and Gommes, 1995). If these systems are treated independently, this would lead to an approach which is too fragmentary. The issue is more global. It is now held as likely that human activities can affect climate, one of the components of the environment. Climate in turn affects agriculture, the source of all food consumed by human beings and domestic animals. It must be further considered that not only climate may be changing, but that human societies and agriculture develop trends and constraints of their own which climate change impact studies must take into consideration.

Literature Review

Climate constitutes a complex of inter-related variables. On average, through a set of regulatory mechanisms, a smooth change in one variable triggers smooth changes in others. With the exception of possible qualitative and abrupt variations, which will be mentioned below, such inter-relations are independent of atmospheric carbon dioxide (CO_2). The latter and other greenhouse gases play a part largely through their effect on the radiation balance of the atmosphere. There is only a weak link between such factors as cloudiness and wind. Temperature, evaporation and rain are strongly correlated. Combined with the projected pressure on land and water use, competition for land and water will certainly become a key social and political issue. Climate variability, therefore, is likely to increase under global warming both in absolute and in relative terms. The rate of change itself is extremely important. Agro-climatic variables have been considered to be of great importance in food crop production, given that all crops and livestock have specific climate or weather required for their survival. Climates are those environmental factors which interact and affect cultivated plant and livestock (Mcmtosh, 1963).The climate of a place is the average weather condition over a long period of time say 35 years. Weather however is described as the real atmospheric conditions experienced in a particular time Ettson (1986). Climate is often associated with the type and geographical extent in which crops can be grown. Weather is however associated with variation in output at particular times. Characterizing climatic conditions are fixed and known ranges of thermal, light and moisture conditions determining animal and plant life. Weather conditions reflect variations in these parameters. Climate and weather can be proclaimed as the most important determinant factors both for plant growth and crop productivity. They both influence most of the processes such as solar radiation which is responsible for energy required for soil warmth, air for metabolic activities, rainfall and its characteristics in terms of amount, distribution and intensity for dilution of soil nutrients which determine quality and quantity of crop production. Also, Oguntoyibo *et al*, 1983) revealed that on an annual basis in Nigeria, there is a general increase in the sunshine hours from the Atlantic to the interior and ranging from a minimum of 1300 hours in the Niger Delta to over 3200 hours in the extreme North-East. The rate of increase is however not constant. Akoroda (1998) has observed that the maximum possible hour of sunshine in a location is very important in determining the amount of photosynthesis that can occur in a growing crop this is referred to as photoperiod. It varies slightly away from the expected 12 hours a day and 12 hours dark period. The variation may be small but it is this small variation that affects crops to the extent that some will flower and others would not except the required amount of photoperiod is available. This confirms the statement made by Wittier (1995) that photoperiod or the length of daylight, while relating to location perhaps more than one climate, has a significant impact on the responses of many, if not all the crops. From the foregoing, there is therefore no gainsaying the fact climate variability directly or indirectly affect food crop production hence the need for the study.

RESEARCH METHODOLOGY

Study Area

The study was carried out in Nigeria. It covered all the ecological regions and agriculturally cultivable land zones in the country. Nigeria is divided into six main ecological zones. This ecological zoning is based on agro-climate variation, which is latitudinal across the country spanning the humid through the sub-humid to the semi-arid zones as one proceeds from the south to the north. The climate is equatorial and semi-equatorial in nature. There are two seasons in Nigeria, the wet (rainy) and the dry (harmattan). The wet season lasts from April to October while the dry season lasts from November to March. The wet and dry seasons are associated with the prevalence of the moist tropical air mass from the Atlantic in the northwest and dry tropical continental air mass from the Sahara in the north. During the year, the boundary between these two air masses, the inter tropical discontinuity (ITD) is gradually pushed to the north and reaches its northernmost position between latitude 19^{o}N- 20^{o}N in early September.

Rainfall varies widely over short distances and from year to year. Niger Delta, where the rainy season is year round, receives more than 4,000mm (160in) of rain each year. Most of the county's middle belt, where the rainy season starts in April or May and runs through September or October receives from 1,000 to 1,500mm (40 to 60in) within this region. The Jos plateau receives somewhat more rain due to its higher elevation. In the dry savanna regions, rainfall is especially variable over distance and time. The regions along Nigeria's northeastern border receives less than 500mm (20in) of rain per year, and the rainy season lasts barely three months. Temperatures are high throughout the year, averaging from 25oc to 28oc. In the higher elevations of the Jos plateau temperatures average 22^{o}C.

Sources and Methods of Data Collection

Secondary data were used. Data were collected from the Department of Meteorological Services, the National Bureau of Statistics, Central Bank of Nigeria statistical bulletins and FAOSTAT.

Data were collected on:

(i) Annual outputs of three tuber crops

(ii) Average temperature, rainfall, wind speed, radiation, sunshine hours, evaporation and relative humidity during the growing periods of each of the crops (1965- 2004)

Analytical Techniques

A number of analytical tools were employed in the study and these include;

Descriptive Statistics: This involves the use of tables, averages and frequencies.

Growth rate: These were used to describe the trend in food crop production and agro-climatic variables over the study period and to predict future values of food crops.

Growth Rate: $$\frac{Y_{it} - Y_{it-1}}{Y_{it-1}}$$

Where:

Y_{it} = crop yield in year t

Y_{it-1} = crop yield in the previous year (i.e year t -1)

Co-integration and Error Correction Model: Error Correction Modeling (ECM): In order to achieve long-run equilibrium relationship the second step of Dickey-Fuller (Augmented Dickey-Fuller – ADF) was applied. Residuals from equilibrium co-integrating regressions were used as an error correcting regressor (Ec+1, lagged one period) in a dynamic model (Chete, 1998) as shown in the equation below:

$\Delta Xt = \alpha 0 + \alpha 1Yt\text{-}1 + \alpha 2ut\text{-}1 + et$

Where;

Yt-1 = one period lagged independent variable

ut-1 = one period lagged value from residual (i.e. ect-1)

Regression analysis based on co-integration and error correction modeling was used to determine the long run equilibrium relationship between agro-climatic variables and food crops outputs in Nigeria. The general form of the model is specified as follows:

$\Delta Yt = Xo + X1\Delta X1t\text{-}1 + X2\Delta X2t\text{-}1 + X3\Delta X3t\text{-}1 + X4\Delta X4t\text{-}1 + X5\Delta X5t\text{-}1 + X6\Delta X6t\text{-}1 + X7\Delta X7t\text{-}1 + ecmt\text{-}1 + \mu$

Where;

Yt = Average output of crop i in year t (million metric tones)

X1t = Total rainfall during the growing period in year t (mm)

X2t = Average temperature during the growing period in year t (oC)

X3t =Average relative humidity during the growing period in year t (%)

X4t = Average solar radiation during the growing period in year t (Mj/m2/day)

X5t =Average windspeed during the growing period in year t (kl/hr)

X6t = Average sunshine during the growing period in year t (hr)

X7t = Evaporation during the growing period in year t (mm)

ecmt-1 = Regressor to capture the short-run dynamics

μ = Error term

In analyzing the data, an Econometric View package (E-View) was used. Augmented Dickey Fuller (ADF) statistics was used to test for stationarity for both individual time series and residuals from Ordinary Least Square regressions.

RESULTS AND DISCUSSION

Figure 1 shows there is a wide gap in minimal and maximal values of all agro climatic variables. The pattern of trend over the observed periods showed fluctuations in the mean values, which indicated instability.This has a lot of implications for crop yields and could be responsible for the high incidence of pest especially in the Southern Nigeria and cloud cover as a result of harmattan dust in the North. These invariable leads to reduction in the rate of photosynthesis and low yields in crops.

Table 1 show that cassava production had the highest production values while potato had the lowest. The low production values of potato could be as a result of the limitation in the area of production. Cassava is grown all over Nigeria and would thrive in any area with limited supply of rainfall and could also be grown all year round. However, potato could only be grown in very few parts of Nigeria where conditions are favourable for its production and it is also seasonal.The growth rates in all the crops considered except potato were positive. However, they all indicate positive trends which show the adaptability of each of the crops to its production zones the negative growth rate indicates that any innovation and/or improvements in the technology of production of potato have not resulted in any dramatically significant increase in outputs.

Table 2 shows the result of co-integration tests for tuber crops. Most of the variables were non stationary [{1}] at their levels but attained stationarity at their first levels of difference and/or second levels of difference, the variables can then be determined directly as to whether or not they are co-integrated. The results using Johansen test are presented for the dependent variables. The table revealed that the different food crops had varying numbers of co-integrating vectors. This is an indication that there was a long-run relationship between the dependent variables and the weather variables.

Table 3 revealed that relative humidity, rainfall, sunshine and windspeed are all significant weather variables for cassava yield, significant at10% except windspeed which is at 1%. Also the coefficient of windspeed is negative indicating an inverse relationship. Windspeed, evaporation, relative humidity, sunshine and rainfall are the significant weather variables for yam yield. They are significant at 10%, 5% and 10% respectively. However windspeed and relative humidity both have negative coefficients which suggest an inverse relationship. Windspeed, relative humidity and rainfall were significant at 1%, 5% and 10% levels respectively for potato yield. Population growth and acreage expansion were highly significant in the yield of all the crops. All other variables are not significant. The error correction (ECM) variable was rightly signed (negative sign) and highly significant for all the crops. This is an indication of the existence of long-run equilibrium relationship between the yield of each crop and the weather variables

CONCLUSION AND RECOMMENDATIONS

The observations registered by this study is that average outputs of all crops covered could be increased if the relationship between yield and ideal weather conditions is better understood and built into agricultural policies.

A number of areas of action recommend themselves and will include among others:

- Establishment of agro-climatic data centres
- Early warning system
- Improvement in farmers' decision making process (resource allocation etc)
- Insurance/protection against flood/drought, Weather-Crop failure
- Storage strategies
- Credit, price support & price stabilization.
- Extension agencies should be informed.

In line with the above, it is therefore recommended that:

(i) A national record of movements and trends in agro-climatic variables and crop outputs should be established for continued collection, analysis and timely dissemination of data (to farmers).

(ii) Control/management measures for these agro climatic variables are necessary for ideal crop outputs since there is a wide gap in minimal and maximal values of all agro climatic variables.

(iii) Appropriate relevant policies (such as flood, drought yield insurance and extension) should be applied for sustaining and improving the growth rates of those crops with positive growth rates such as yam and cassava.

(iv) It is necessary that particular attention be paid to the multi ranged climatic template of Nigerian agriculture for creating and managing sustainable food production and security.

(v) Agricultural extension agencies should include information on climate change in their education to farmers.

(vi) Agricultural extension agencies should develop new calendar of work for arable crop farmers, based on change in climate for sustainable and profitable agricultural production.

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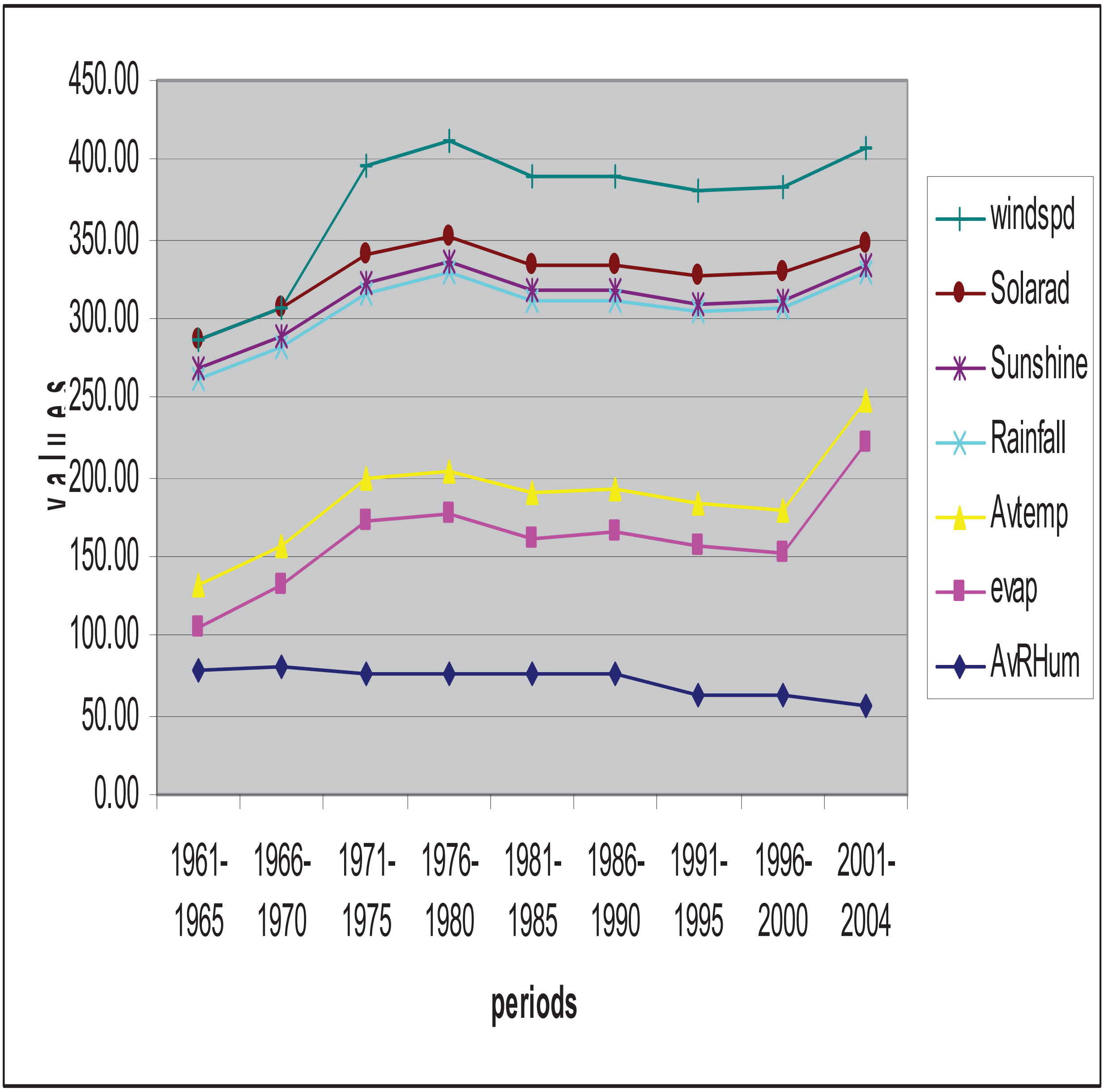

Figure 1: Trend in Agro-Climatic Variables in Nigeria. (1965-2004)

Table 1: Statistical Analysis of Selected Tuber Crops Output in Nigeria.

Crops	**Maximum yield**	**Minimum yield**	**Mean Yield**	**Average growth rate**
Yam	**27.000**	**4.600**	**13.060**	**1.09**
Cassava	**33.380**	**8.180**	**18.400**	**1.17**
Potato	**0.629**	**0.022**	**0.130**	**-0.85**

Table 2: Result of Johansen Co Integration Test for Tubers.

Likelihood Ratios					
Yam	**Cassava**	**Potato**	**Critical Value 5%**	**Critical value 1%**	**Hypo**
276.090	276.644	356.259	156.001	168.361	None
190.422	193.969	242.444	124.242	133.571	At most 1
134.286	139.940	153.541	94.151	103.182	At most 2
88.471**	87.292	101.235	68.521	76.071	At most 3
59.582	**49.426***	63.318	47.211	54.464	At most 4
28.005	20.820	**30.689***	29.681	35.653	At most 5
10.135	5.011	12.758	15.411	20.042	At most 6
0.077	0.559	1.545	3.761	6.651	At most 7

** denotes rejection of the hypothesis at 1% significant level.

* denotes rejection of the hypothesis at 5% significant level.

Table 3: ECM Result on the Effect of Agro-Climatic Variables on Tuber Crop yield

Variables	Coefficients			Standard Error			t-Statistic			Probability.		
	Yam	Potato	Cassava	Yam	Potato	Cassava	Yam	Potato	Cassava	Yam	Potato	Cassava
C	13.171	19.39	13.16	1.423	1.918	1.453	9.258	10.11	9.062	0.000	0.000	0.000
D(WINDSPD(-1))	0.560	-0.220	-0.538	1.092	1.060	1.138	3.261	-1.151	3.108	0.003	0.008	0.005
D(WINDSPD(-1),2)	-1.114		-1.097	0.610		0.650	-1.825		-1.687	0.080		0.005
D(ARELHUM(-1))	-0.776	-0.911	-0.754	0.798	1.101	0.850	-2.226	-1.736	-2.063	0.036	0.097	0.051
D(ARELHUM(-1),2)	0.936			0.502			1.864			0.075		
D(EVAP(-1))	0.217			0.129			-1.686			0.005		
D(RAINFALL(-1))	0.516		-0.504	0.241		0.274	-2.141		-1.838	0.043		0.079
D(RAINFALL(-1),2)	0.246	0.269		0.118	0.213		2.081	1.261		0.048	0.021	
D(SUNSHINE(-1))	0.343	0.306		2.469	6.299		0.139	0.049		0.091	0.062	
D(SUNSHINE(-1),2)		0.226			3.699			0.061			0.052	
D(POPGRWTH(-1))		0.049			0.976			3.065			0.006	

D(POPGRWTH(-1),2)	0.897		0.784	0.176		0,995	4.132		5.057	0.008		0.009
D(ACREXP (-1),2)	0.453	0.576	0.765	0.574	0.987	0.896	6.001	5.789	5.014	0.001	0.002	0.004
RESID01	-0.831	-0.989	-0.857	0.461	0.740	0.475	2.960	2.435	2.855	0.007	1.385	0.009
R-squared	0.783	0.737	0.683									
Adjusted R-squared	0.224	0035	0.190									
Prob(F-statistic)	0.094	0.021	0.042									
Sum squared resid	1394.1	2062.1	1393.5									
F-statistic	1.865	0.087	1.651									
Log likelihood	-119.64	-126.88	-119.61									
Durbin-Watson stat	0.742	0.589	0.740									

SALMONELLA DISEASES: THE POTENTIAL USE OF MEDICINAL PLANTS AS REMEDIES

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Abstract

Salmonella enterica serovars-associated food and water borne-diseases continue to be a major problem to public health in developing countries due to inadequate potable water supply and poor sanitation among other factors. Treatment of salmonellosis have been through the use of antibiotics but reports on the emergence of multiple drug resistant *Salmonella* strains to the first line antibiotics such as chloramphenicol, ampicillin and co-trimoxazole as well as reduced fluoroquinolones susceptibility strains have been documented. The high cost and unavailability of some effective antibiotics for the treatment of salmonella associated diseases with the increasing problem of fake and adulterated orthodox drugs, and emerging virulence strains pave the way for herbal remedies as reasonable alternative.

This article revealed the prevailing *Salmonella* serotypes and the problems associated with the use of modern medicine in relation to the high patronage of herbal medicine. Highlights on some methods use in the preliminary investigations of antibacterial activities of some medicinal plants employed by traditional healers to treat ailments of microbial origins were stressed. The article also revealed results of some preliminary studies on antibacterial properties possessed by some medicinal plants such as *Terminalia avicennoides, Morinda lucida,Combretum paniculatum, Momordica balsamina, Trema guinensis, Ocimum gratissimum, Phyllantus. discoideus,* and *Acalypha. wilkesiana* on *Salmonella* isolates, and their possibilities to serve as valuable resources in the potential discoveries of natural pharmaceutical products for *Salmonella*-associated diseases. The paper also averred the need to purify the antibacterial active components and administration of appropriate dosage to enhance efficacies.

Keywords: *Salmonella enterica* serovars, Diseases, Medicinal plants, Anti-*Salmonella* activity, active components

INTRODUCTION

Salmonella which belongs to the family *Enterobacteriaceae,* was named after an American bacteriologist, D. E. Salmon, who first isolated *Salmonella choleraesuis* from porcine intestine in 1884 (Smith, 1894). According to the CDC system, the genus *Salmonella* contains two species, *Salmonella enterica* and *S. bongori*. A third species "*Salmonella subterranea*" was recognized in 2005 and the CDC is yet to incorporate it in its system (Lin-Hui Su, 2007). In the latest report published in 2004, there were a total of 2,541 serovars in the genus *Salmonella*). Only *Salmonella enterica* serovar Typhi, *S*. Paratyphi, *S.* Typhimurium, *S.* Enteritidis, *S.* Choleraesuis, *S.* Hadar, *S.* Virchow, and *S.* Dublin, among others, play important epidemiological and epizootiological roles (Lin-Hin Su *et al*., 2007). There are two main forms of Salmonella-associated diseases (Salmonellosis); typhoidal salmonellosis (enteric fever) is *caused exclusively by Salmonella* Typhi and S. Paratyphi A, Band C, while non-typhoidal salmonellosis is caused by other *Salmonella enterica* serovars. Although, infections with non-typhoidal *Salmonellae* usually cause self-limited diarrhoeal illness, serious sequelae, including meningitis, sepsis, and death, may occur, especially among infants and elderly persons (Glaser *et al*., 1994; Boop *et al*., 1999). Salmonellosis usually results from improperly handling of food that has been contaminated by animal or human feacal or urine material. It can also be acquired via feacal–oral route either from human or farm animal (Rizzo *et al.,* 2008). Nosocomial outbreaks caused by Salmonellae have been related to the use of contaminated medications, diagnostics, blood products, banked human milk, and the use of raw eggs or yeast. The incubation period is usually 7 to 14days (Meltzer and Schwartz, 2007). Adhesion and invasion of pathogens to the host remain the first step in establishment of infection and it is a highly specific process. In typhoidal salmonellosis, after penetration, the organisms are able to induce extensive micropinocytosis by mononuclear cells of the lymphoid follicles, liver and spleen, but are able to survive and multiply within them, at a critical point that is determined by the number of bacteria, their virulence and the host response. The dendritic cells that are interlaced in the epithelium overlying the Peyer's patches are probably responsible for the internalization of the enteric fever agent and its transport to the underlying lymphoid tissue, The most common sites of secondary infection are the liver, spleen, bone marrow, gall bladder and Peyer's patches of the terminal ileum (Parry *et al*., 2002). Gall bladder invasion either occurs directly from the blood or retrograde spread from the bile. The organisms excreted in the bile either reinvade the intestinal wall or are excreted in the feaces (Figure).

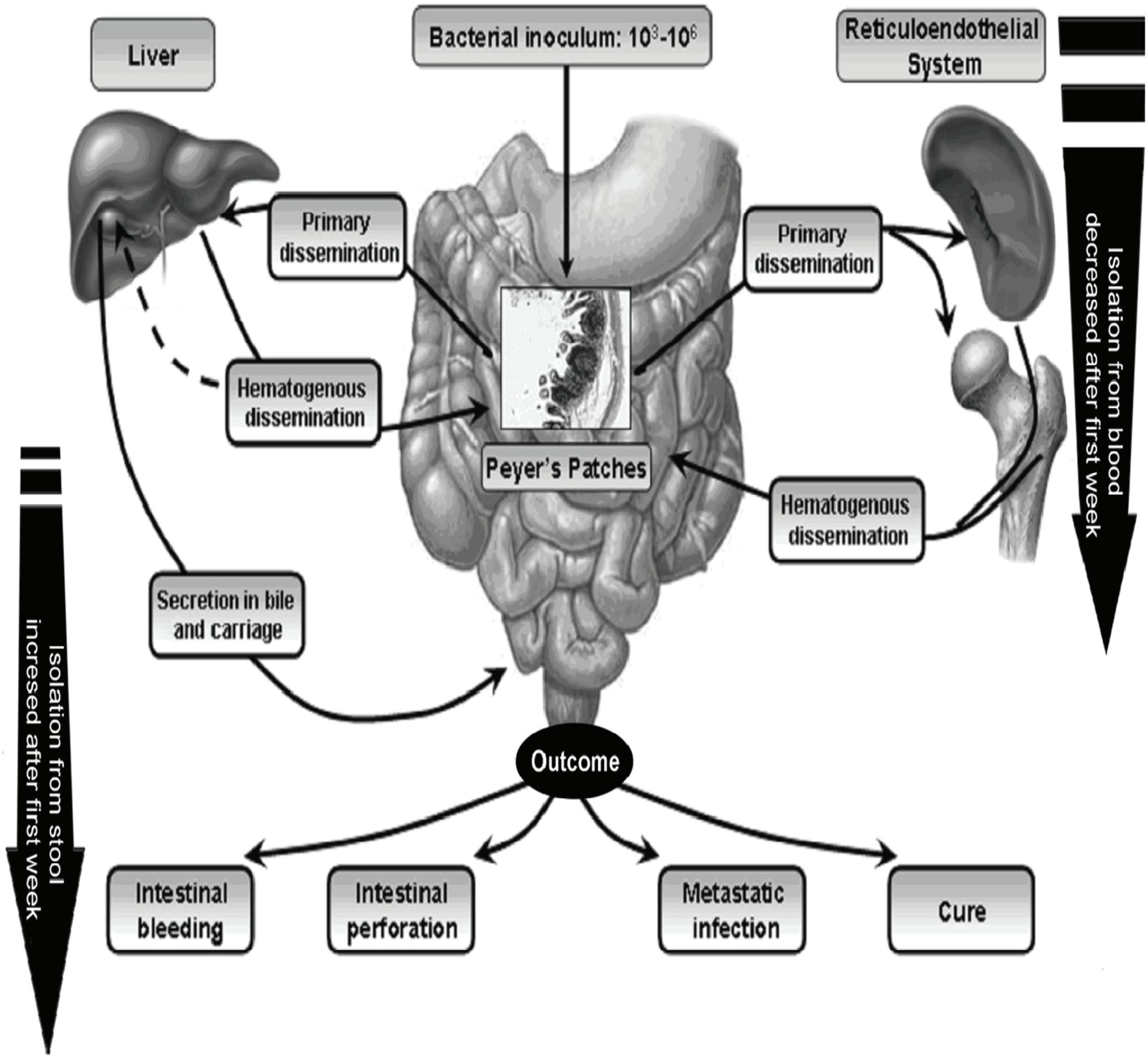

Figure: Pathogenesis of typhoidal Salmonella enterica serovar (Meltzer and Schwartz, 2007)

INFECTIONS AND DISEASES ASSOCIATED WITH *SALMONELLA ENTERICA SEROVARS*

Human infection with *Salmonella enterica* results in two major groups of diseases: gastroenteritis and typhoid fever. Typhoidal *Salmonella enterica* serovars; such as *Typhi*, Paratyphi A, Paratyphi B and Paratyphi C cause systemic illness and WHO has estimated about 27million cases and 200,000 deaths worldwide each year (Cramp *et al*., 2004). Intestinal perforation, bleeding pholecystitis and pancreatitis represent the most serious complications of typhoid fever. Typhoid ileal perforation (TP) is a major problem in developing countries especially in Nigeria with high mortality rates (Rahman *et al*., 2001) and as well the most common cause of bowel perforation (Agbakwuru *et al*., 2003). Infections with non typhoidal strains of *Salmonella* is an important cause of reportable food-borne infections worldwide (Chiu *et al.,* 2004) and are global burden with an estimated 1.4 million cases in the United States alone (Voetsh *et al.,* 2004) and 400 deaths occurring each year (Romani *et al*.,2008).

Non-typhoidal salmonellosis caused by serovar *Typhimurium, Enteritidis, Newport* and *Heildelberg* (Boyles *et al.,* 2006) with *S. Typhimurium* and *Enteriditis* ranked among the major food-borne infection worldwide (Kariuki *et al*., 2006). In Nigeria, *S. Typhimurium* and *Enteriditis* –associated gastroenteritis is the most common manifestation of non-typhoidal *salmonellosis* (Akinyemi *et al*., 2007)

Table 1: Diseases and complications associated with commonn *Salmonella* enterica seovars

***Salmonella* serovars**	**Diseases**	**Complicated cases**	**Source**
Typhi, Paratyphi A, Paratyphi B and Paratyphi C	Typhoid fever (enteric fever)	**Abdominal** Gastrointestinal perforation, Gastrointestinal hemorrhage, Hepatitis, Cholecystitis (usually subclinical) **Cardiovascular** Asymptomaticelectrocardiographic changes Myocarditis, Shock **Neuropsychiatric** Encephalopathy, Delirium Psychotic states, Meningitis Impairment of coordination. **Respiratory** Bronchitis, Pneumonia (*Salmonella enterica* serotype Typhi, *Streptococcus pneumoniae*) **Heamatologic** Anemia, Disseminated intravascular coagulation (usually subclinical) **Other** Focal abscess, Pharyngitis Miscarriage, Relapse, Chronic carriage	Parry *et al.,* (2002) Parry *et al.,* (2002)
Typhimurium, Enteritidis, Newport and Heildelberg	Gastroenteritis (diarrhoea)	Severe dehydration, sepsis, bacteremia **complications of bacteremia include**; endocarditis, mycotic aneurysm,osteomyelitis, meningitis.	Chui *et al.,* (2004) Wong *et al.,* (2007).
Choleraesuis	Gastroenteritis	Bacteremia, focal infection e.g septic arthritis, pneumonia, peritonitis, cuteneous abscess, osteomelytis	Parry *et al.,* (2002)

THERAPY AND PATTERN OF CHANGE IN *SALMONELLA ENTERICA* SEROVARS

Studies have provided evidence that antimicrobial agents used in Agriculture and closely related agents used in human medicine have been exerting selective pressure on their target bacteria particularly *Salmonella, Campylobacter and Escherichia coli* (Wilte, 1998). Adverse climatic conditions or variations such as extremely hot or cold environment, flood etc may make man vulnerable to *Salmonella*-associated food and water-borne diseases**.** Like other countries, treatment of typhoid fever patients has been based on the use of first-line antibiotics, such as chloramphenicol, co-trimoxazole, and the third-generation cephalosporins. But efficacies of some of these drugs have been doubtful, following the emergence of multidrug resistance in *Salmonella* strains (Threlfall *et al*., 2001; Akinyemi *et al*., 2005a). Fluoroquinolones have been found to be efficacious both *in vitro* and *in vivo* in the treatment of severe *Salmonella*-associated illnesses, although strains with reduced susceptibility to ciprofloxacin among travellers have been reported in some parts of the globe (Hakanen *et al*., 2001)

In Nigeria, suggestive evidence of plasmid-mediated MDR *S. typhi* associated with typhoid fever complications and the increasing problem of indiscriminate use of antibiotics had led to treatment failure with empirical therapy such as chloramphenicol, ampicillin and cotrimoxazole (Akinyemi *et al.,* 2005a), this had contributed to the emergence of resistance among the strains of *Salmonella enterica* serovars (Akinyemi *et al.,* 2007).Third-generation cephalosporins (ceftriaxone, cefixime, cefotaxime, and cefoperazone) and fluoroquinolones such as ciprofloxacin and dfloxacin are the most effective drugs for the treatment of typhoidal and severe cases of non-typhoidal salmonellosis, although reduced fluoroquinolones susceptibility *Salmonella enterica* strains had also emerged (Akinyemi *et al*., 2007).

PROBLEMS ASSOCIATED WITH ORTHODOX DRUGS

A wide range of adverse effects are associated with modern or orthodox drugs such as, (1) contribution to cancer development, (2) allergic reaction,(3) destruction of normal flora,(4) multi-drug resistant strains development,(5) immune suppression,(6) high cost and (7) problem of adulteration

Contribute to cancer development: There have been reports that the use of antibiotics is associated with increased risk of incident and fatal breast cancer (Velicer, *et al*., 2004; Kilkkinen *et al.,* 2008)

Allergic reactions Allergic reaction to antibiotics occurs frequently.

Destruction of beneficial bowel flora: Wide-spectrum antibiotics contribute to destruction of beneficial flora. The human intestine has a somewhat delicate ecology in which certain microorganisms help digest food, produce certain vitamins, and maintain a balance of organisms that prevents harmful bacteria and yeasts from multiplying. Wide-spectrum antibiotics derange the normal ecology of the intestine (Ayyagari, *et al*., 2003).

Multidrug resistance strains development: Despite the availability of newer antibiotics, emerging antimicrobial resistance has become an increasing problem in many pathogens throughout the world fluoroquinolones resistance in *Salmonella* strain has also been reported in Nigeria (Akinyemi *et al*., 2007).

Immune suppression: The purpose of antibiotics is presumably to help the immune response. However, evidence indicates that people treated with antibiotics have more repeat infections than those who are not treated (Wilson, 2008) In fact; antibiotics do not aid the immune system. They replace one of its functions. Antibiotics act by inhibiting certain enzymatic processes of bacteria, and by changing mineral balances.

High Cost: While the cost of a single antibiotic prescription may not be extremely high, newer ones are somewhat costly. For example the cost of ciprofloxacin or ofloxacin is over \$5.00 for five-day therapy in adults (Akinyemi *et al*., 2006).

Problem of adulteration: In Nigeria, the National Agency for Food and Drug Administration and Control (NAFDAC) reported 50% of the drug in circulation to be fake or adulterated (Akinyemi *et al*., 2006).

PLANT AND TRADITIONAL MEDICINE

Herbal medicine is the use of herbs for their therapeutic or medicinal value. A herb is a plant or plant part valued for its medicinal, aromatic or savory qualities (Ernest, 1999). It is estimated that there are 250,000 to 500,000 species of plants on Earth (Borris, 1996). Plants have been used in traditional medicine for many years as contraceptives, menstrual regulation, fertility and infections controls. The efficacies of such plants believed to possess medicinal properties led to the 'Doctrine of signatures' which states *that any plant part which resembles the organ of human body is created for the cure of the ailments of the part of the body* (Bennett, 2007). This is still reflected in the common names of some plants whose coincidental shapes and colors reminded the gatherers of such simples of the parts of the body where they could do good: liverwort; snakeroot, an antidote for snake venom; lungwort, bloodroot; toothwort; wormwood, to expel intestinal parasites, Walnuts treat brain disorders (Bennett, 2007).Over three-quarters of the world population relies mainly on plants and plant extracts for health care. More than 30% of the entire plant species, at one time or other was used for medicinal purposes. Traditional medicine is widespread in China, India, Japan, Pakistan, Bulgaria, France, Germany, Spain, Turkey, Belgium, the Netherlands and the United Kingdom. In the United States, plant drugs constitute as much as 25% of the total drugs, while in fast developing countries such as China and India, the contribution is as much as 80% and eventually integrated them in formal health care system (Joy *et al*., 1998; WHO, 2000).

Many plants are used in the African continent for the treatment of skin sores, ulcer, typhoid fever, dysentery, gastroenteritis and others which are typical diseases of tropical country. In Nigeria, traditional medical practitioners use herbal preparations to treat enteric diseases such as typhoid and paratyphoid fevers, and other salmonella-associated diseases. Preliminary investigations of some of these medicinal plants have been documented to possess anti-salmonella properties (Table 1).

Table 2: Some medicinal plants known to have anti-salmonella effects

S/N	Plant name	Family	Active principle	Source
1	*Cassia nigricans*	Leguminaceae	flavonoids, alkaloids, anthraquinones, CHO, saponin glycosides.	Ayo and Amupitan (2004)
2	*Mormodica balsamina* *Linn.*	Cucurbitaceae	tannins, flavonoids, alkaloids, anthraquinones, reducing and non-red. CHO	Akinyemi *et al.,* (2005)
3	Trema gunineensis	Combretaceae	tannins, flavonoids, alkaloids, anthraquinones	Akinyemi *et al.,* (2005)
4	Casuarina equisetifolia	Casuarinaceae	flavonoids, alkaloids, anthraquinones, CHO, saponin, glycoside	Parekh *et al*., (2005)
5	*Acalypha wilkesiana*	*Euphorbiaceae*	tannins, saponins, flavonoids, alkaloidsanthraquinone	Akinyemi *et al.,* (2006)
6	*Embelica officinalis*	Euphorbiaceae	Saponins, alkaloids, flavonoids.	Nair and Chanda, (2007)
7	*Ludwigia suffruticosa*	Onagraceae	flavonoids, CHO, saponin, tannins, steroids.	Aliyu *et al., (*2008)
8	*Ocimum bacilicum Linn.*	Lamiaceae	Saponins, alkaloids, flavonoids, terpenes and steriods, cardiac glycosides, CHO	Sanni *et al .,* (2008)
9	*Anisopus manni*	Ascelpiadaceae	Saponins, alkaloids, flavonoids,terpenes and steroids, glycosides.	Sani *et al.,* (2009)

EXTRACTION METHODS OF MEDICINAL PLANTS

Medicinal active ingredients are present in different parts of the plant parts such as root, stem, bark, heartwood, leaf, flower, fruit or plant exudates. These medicinal principles are separated by different processes; the most common being extraction. Extraction is the separation of the required constituents from plant materials using a solvent (Joy *et al*., 1998).

To facilitate the extraction, the solvent should diffuse inside the cell and the substance must be sufficiently soluble in the solvent. The ideal solvent for complete extraction is one that is most selective, has the best capacity for extraction and is compatible with the properties of the material to be extracted. Water is almost universally the solvent used to extract activity. At home, dried plants can be ingested as teas (plants steeped in hot water) or, rarely, tinctures (plants in alcoholic solutions) or inhaled via steam from boiling suspensions of the parts. Dried plant parts can be added to oils or petroleum jelly and applied externally. Scientific analysis of plant components follows a logical pathway. Plants are collected either randomly or by following leads supplied by local healers in geographical areas where the plants are found (Martin, 1995). Initial screenings of plants for possible antimicrobial activities typically begin by using crude aqueous (hot or cold extract) or alcohol extraction which is most often obtained through ethanol or methanol extraction (Cowan, 1999).

For alcoholic extractions, plant parts are dried, ground to a fine texture, and then soaked in methanol or ethanol for extended periods. The slurry is then filtered and washed, after which it may be dried under reduced pressure and re-dissolved in the alcohol to a determined concentration and antimicrobial activity (Cowan, 1999; Akinyemi *et al.,* 2005).

When water is used for extractions, plants are generally soaked in distilled water, blotted dry, made into slurry through blending, and then strained or filtered. The filtrate can be centrifuged (approximately 20,000 × *g*, for 30 min) multiple times for clarification (Cowan, 1999). Crude products can then be used in disc diffusion and broth dilution assays to test for antibacterial properties

ANTIMICROBIAL SUSCEPTIBILITY TESTING

Antimicrobial Susceptibility Test (AST) is used to determine the efficacy of novel antimicrobials against microorganisms, essentially those of medical importance. In order to validate activity and characterize the compounds responsible for activity from medicinal plants, it is crucial that suitable biological tests for monitoring the required effects are used. Thus, in determining antimicrobial activities the initial step necessitates that many potential plants be evaluated against a biological assay or panel of assays. The goal of *in-vitro* antimicrobial susceptibility testing is to provide a reliable predictor of how a microorganism is likely to respond to antimicrobial therapy in the infected host. This type of information aids in selecting the appropriate antimicrobial agent, provides data for surveillance, and aids in developing antimicrobial use policies (Okigbo *et al.,* 2009).

The following methods have been shown from various studies to consistently provide reproducible and repeatable results when followed correctly.

i) disk diffusion, ii) broth dilution, iii) agar dilution.

Agar disk diffusion assay: Disk diffusion refers to the diffusion of an antimicrobial agent of a specified concentration from disks, tablets or strips, into the solid culture medium that has been seeded with the selected inoculum in a pure culture. These techniques have been widely used to assay plant extracts for antimicrobial activity, although there are limitations with the technique. Disk diffusion is based on the determination of an inhibition zone proportional to the bacterial susceptibility to the antimicrobial present in the disk. Disk diffusion is suitable for identification of leads but not effective for quantification of bioactivity (Hammer *et al*., 1999; Nostro *et al*., 2000; Langfield *et al*., 2004). These diffusion techniques generally do not distinguish bactericidal and bacteriostatic effects. The MIC can not be determined and these are usually used for preliminary screening (Parekh *et al*., 2005) that is, as qualitative tests, since the amount of extract that adheres to the disk is not quantitatively determined. Researchers however have reported MIC values obtained by the agar diffusion method (Lourens *et al*., 2004;Leite *et al*., 2006) although, high activity in the disk diffusion assay does not necessarily correlate to low MIC values in the microtitre plate method (Lourens *et al*., 2004). The agar disk diffusion technique can only be used for AST of pure substances because when it is applied to mixtures containing constituents, which exhibit different diffusion rates, results may be unreliable (Silva *et al.*, 2005). Disk diffusion tests based solely on the presence or absence of a zone of inhibition without regard to the size of the zone of inhibition are not acceptable in antimicrobial susceptibility testing methodology (Okigbo *et al.,* 2009).In this method, 6 mm paper disks, saturated with filter sterilized plant extract at the desired concentration, are placed onto the surface of a suitable solid agar medium. Muller Hinton is usually the medium of choice although Tryptone soy agar (Lourens *et al*., 2004) or Nutrient agar (Doughari, 2006) have sometimes been used by other researchers. The media is pre-inoculated with the test organism and authors have reported inoculum sizes of 1.2 x 10^7cfu/ml (Akinyemi *et al*., 2005), 1.5 x 10^8cfu/ml (Sabahat and Perween, 2005), and 1 x 10^8 cfu/ml of bacteria to seed the plates (Baris *et al*., 2006).

There have been some variations noted on whether the disks are impregnated with antimicrobial substances after or before placing on the inoculated plate. Some impregnate before placing on the agar (Lourens *et al*., 2004; Akinyemi *et al*., 2006), while others place the disk on the plate first before impregnating (Nostro *et al*., 2000; Baris *et al*., 2006). In a report by Mbata *et al.,* (2006), the paper disks were soaked in the leaf extract for about 2 hrs while Basri and Fan (2005) left the disks to dry under a laminar flow cabinet overnight. Other authors refrigerated the plates for an hour or two at 4°C to allow pre-diffusion of the extracts from the disk into the seeded agar layer before incubation (Lourens *et al*., 2004, Tepe *et al*., 2004; Schmourlo *et al*., 2004). The plates are then incubated at 37°C for 24 h for bacteria and 48 h for fungi (Baris *et al*., 2006). Some incubate for 18 h at 37°C for the same bacteria (Nostro *et al.*, 2000; Lourens *et al*., 2004) others 37°C for 24hrs (Akinyemi *et al*., 2005, Akinyemi *et al*., 2006, Aliyu, 2008, Doughari and Okafor, 2008). Zones of inhibition are then measured from the circumference of the disks to the circumference of the inhibition zone or recorded as the difference in diameter between the disks and the growth free zones around the disks (Doughari and Okafor, 2008)

Broth and agar dilution methods: The aim of the broth and agar dilution methods is to determine the lowest concentration of the assayed antimicrobial that inhibits the growth of the bacterium being tested (Minimum Inhibitory Concentration (MIC) usually expressed in mg/ml or mg/litre). However, the MIC does not always represent an absolute value. The 'true' MIC is a point between the lowest test concentration that inhibits the growth of the bacterium and the next lower test concentration. Therefore, MIC determinations performed using a dilution series may be considered to have an inherent variation of one dilution. Antimicrobial susceptibility dilution methods appear to be more reproducible and quantitative than agar disk diffusion (Ncube *et al.,* 2007).

Agar dilution: Agar dilution involves the incorporation of varying concentrations of antimicrobial agent into an agar medium, usually using serial two-fold dilutions, followed by the application of a defined bacterial inoculum to the agar surface of the plate. These results are often considered as the most reliable for the determination of an MIC for the test bacterium/antimicrobial combination (Ncube *et al.,* 2007).

Broth dilution: Broth dilution is a technique in which a suspension of bacterium of a predetermined optimal or appropriate concentration is tested against varying concentrations of an antimicrobial agent (usually serial two-fold dilutions) in a liquid medium of predetermined, documented formulation (Anon, 2008). The broth dilution method can be performed either in tubes containing a minimum volume of 2 ml (macrodilution) or in smaller volumes using microtitration plates (microdilution) (Ncube *et al.,* 2007).

ANTIMICROBIAL ACTIVITIES OF SOME MEDICINAL PLANTS ON *SALMONELLA ENTERICA* ISOLATES

Global Survey: Several plant species have been reported in controlling various human pathogens including *Salmonella* spp, and studies on the antimicrobial activities of these plants have been reported from different countries most especially in Africa and Asia.

Study by Nanasombat and Lohasupthawee (2005), examined crude ethanolic extracts and essential oils of 14 spices including cardamom, cinnamon, clove, coriander, cumin, garlic, ginger, holy basil, kaffir lime leaves and peels, lemongrass, mace, nutmeg, black and white pepper, and turmeric for their antibacterial activity against 20 serotypes of *Salmonella* and 5 species of other enterobacteria using disk diffusion method as preliminary screening, it was concluded that inhibitory activity of spice oils was greater than that of their own ethanolic extracts. Of all serotypes of *Salmonella* tested, *Salmonella Typhimurium* (non-DT104 strain) was the most susceptible strain to both forms of spice extracts. On the other hand, *Salmonella* Derby and *Salmonella Rissen* were the most resistant strains to the extracts, followed by *Salmonella agona* and *Salmonella* Typhimurium DT104. Sabahat and Perween (2007) revealed that the aqueous infusion and decoction of of *Emblica. officinalis* exhibited maximum activity against *S.* Typhi*,* which supported the previous work carried out by Nazia and Perween, (2006).

In India, *Fagonia cretica* leaf extracts were found most effective against *S.* Typhi *in a study conducted* by Gehlot and Bohra (2000). Another twelve medicinal plants indigenous to the Indian were also screened for antibacterial activity by Parekh *et al.,* (2005) using agar disk diffusion method. Both aqueous and methanolic extract of leaf and stem of *Casuarinas equisetifolia*, aerial part of *Caesalpinia pulcherima,* and whole plant of *Euphorbia hirta* showed anti-salmonella properties with extract of *Caesalpinia pulcherima* showing the highest inhibition zone. Girish and Satish (2008), also studied five different plants; *Boerhaavia diffusa, Cassia auriculata, Cassia Lantana, Eclipta alba* and

Tinospora cardiofolia for *a*ntibacterial activity of aqueous and solvent extracts using cup diffusion method. The antibacterial screening of aqueous and methanol extract carried out *in vitro* on the following bacteria; *Bacillus cereus, B. megaterium, B. subtilis, E. coli, K. pneumoniae*, *Pseudomonas aeruginosa, S. typhi, Staphylococcus aureus, Streptococcus faecalis* and *Yersinia enterocolitica.* It was shown that the methanol extracts had wider range of activity on these organisms than the aqueous extracts, which indicates that the methanol extracts of all selected plants may contain the active components. Nair and Chanda (2008) studied the activities of some medicinal plants of the western region of India, and averred that both aqueous and ethanolic extract of *Emblica officinalis* were potent against bacteria pathogen tested inclusive of *S. typhimurium*, with the ethanolic crude extract being more potent inhibitor. Report from Pasha *et al*., (2008) in India indicated both aqueous and methanol extracts of *Nyctanthes arbortristis, Garcinia indica, Rubia cordifolia, Azadiracta indica,* and *Momordica charantia* exhibited strong anti-salmonella activity. The aqueous extracts were found to be more active than methanol extracts in the study.

In Cameroun, study on the antibacterial activity of *Erigeron floribunda* by Metagne *et al*., (2008) indicated that both cold soaked and boiled leaves extracts showed anti-Salmonella activity with boiled extracts exhibited more inhibitory effect than the cold soaked extract on the organism. Activity of Drynaria *quercifolia had been evaluated on Salmonella spp by***.** Kandhasamy *et al*., (2008), results of the study showed that *S.* Typhi*, S.* Paratyphi *A* and *S*. Marcesence were sensitive to ethanolic, benzene and chloroform extracts of the rhizome of *D. quercifolia*

Survey in Nigeria: Numerous plants indigenous to Nigeria have been found with amazing medicinal properties. The activities of these plants on enteric pathogen have been documented in literature. A study by Ayo and Amupitan (2004) reported efficacy of crude etanolic, methanolic, chloroform and petroleum ether extract of the leaves of *Cassia nigricans*, using paper disc diffusion method on *S.* Typhi *strains*. Akinyemi *et al.,* (2005) screened some medicinal plants used in south west Nigerian traditional medicine for anti *S.* Typhi activity, out of the ten medicinal plant screened only six exhibited anti-salmonella activity. Both the aqueous and alcoholic extracts of *Terminalia avicennioides, Momrdica balsamina, Combretum paniculatum*, and *Trema guineensis* were effective on local stains of multi drug resistant *S.* Typhi while the aqueous extracts of *Morinda lucida* and *Ocimum gratissimum* were found to be active against multi drug resistance *Salmonella typhi.* Aqueous extract of the stem of *Morinda lucida exerted* weak activity at a very high concentration on *S.* Typhi *(*Adomi, 2006). There has been report that both water and ethanolic crude extract of *Trema guineensis, Phyllantus discoideus and Acalypha wilkesiana* exhibited good activities on the *S.* Enteriditis strains with ethanolic extract exerting slightly higher activity than water extract (Akinyemi *et al.,* 2006).

Acetone crude extracts of stem and leaf of *Tamarindus indica* linn exert inhibitory activities on the strains of S. Tyhpi and Paratyphi with high inhibition zones (Doughari, 2006). Bioactive compounds of root extracts of *Carica papaya* L was reported to have significant activity on *S.* Typhi (Doughari *et al*., 2007).

Salmonella species were found to be inhibited by the crude aqueous extract of tuber of *Anchomanes difformis* using the agar well diffusion method (Oyetayo, 2007). Eja *et al.,* (2007) carried out a Comparative assessment of the antimicrobial effect of *Allium sativum* (Garlic) and antibiotics; ciprofloxazine and ampicillin on diarrheagenic organisms, using disc diffusion technique, results showed that garlic had antimicrobial effect against *Shigella, Salmonella* and *Escherichia coli.* Garlic and ciprofloxazine had similar levels of antimicrobial activities against diarrhoeagenic organism. Study by Doughari and Okafor (2008) on the antimicrobial activity of leaf extracts of the plant *Senna siamae,* using disk diffusion method, revealed antibacterial activity against *S.* Typhi and all the tested concentrations with the ethanolic extract demonstrating the highest activity of inhibition, followed by acetone extracts while the aqueous extracts of the plant showed the lowest activity. In another study conducted by Adomi, (2008) aqueous extract of the leaf of *Morinda lucida* exerted more activity on. *S.* Typhi

Table 3: Activities of crude extracts of some medicinal plants on Salmonella enterica isolates in Nigeria

S/N	Plant name	Essential product	Plant part used	Average zone of inhibition (mm)		Source
				Aqueous	Alcohol	
1	*Acalypha wilkesiana*	Tannis, saponins, flavonoids, alkaloids, anthraquinone,	Leaf	10.8	11.6	Akinyemi *et al.,* (2006)
2	*Anchomanes difformis*	Tannins, saponins, alkaloids	Leaf	ND	27	Oyetayo (2007)
3	*Ocimum basilicum L*	Tannis, cardiac glycoside, terpenes & steriods flavonoid	Leaf	1.2	ND	Sanni et al., (2008)
4	*Ocimum gratissimum L*	Tannis, saponins,flavonoids, alkaloids, anthraquinone,	;eaf	10.5	ND	Akinyemi *et al.,* (2005)
5	*Combretum paniculatum*	Tannis, saponins, flavonoids, alkaloids, anthraquinone,	Twig	9.5	16	Akinyemi *et al.,* (2005)
6	*Morinda lucida*	Tannis, saponins, flavonoids, alkaloids, anthraquinone	Leaf Leaf	15 12.5	ND	Adomi (2008) Akinyemi *et al.,* (2005)

7	*Cassia occidentalis*	ND	Leaf Bark	22 16	ND	Dabia and Mohammad (2008)
8.	*Cassia nigricans*	Tannis, saponins, flavonoids, alkaloids, anthraquinone,	Leaf	24	ND	Ayo and Amupitan, 2004

PROSPECT OF MEDICINAL PLANTS AS REMEDIES FOR SALMONELLA DISEASES

Different studies had shown that preliminary screenings of some medicinal plants such as *Citrus hystrix, Tamarindus indica, Anisopus mannii, Morinda lucida, Phyllanthus amarus, Caesalpina pulcherima, Phyllanthus discoides,* have promising antimicrobial effect against multi drug resistance *Salmonella* strains, which pose a great threat to public health.

Some bioactive compounds formed during the normal metabolic processes in these medicinal plant parts are precursors for the synthesis of useful drugs; these include alkaloids, flavonoids, glycosides, gums, polysaccharides, phenols, tannins, terpenes and terpenoids. Better therapy for salmonella-associated diseases could be found in the plant parts mentioned that would provide safe and effective remedies for the growing challenges of multiple drug resistant pathogens. Studies in animals to determine the serum attainable level, toxicity status of the active constituents, their side effects, pharmacokinetic properties and diffusion in different body sites are essentials.

CONCLUSION AND RECOMMENDATION

In Nigeria, studies have revealed that medicinal plants could serve as valuable resource in the potential discovery of natural pharmaceutical products against Salmonella-associated diseases. Their antibacterial activities might be enhanced if the active components are purified and adequate dosage determine for proper administration. Above all, a National Health policy that will encourage the search and the use of novel antimicrobial natural products from plants needs to be formulated, implemented and sustained.

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FACTORS DETERMINING CONSUMER'S ADOPTION OF AGRICULTURAL BIOTECHNOLOGY PRODUCTS IN THE GRAIN AXIS OF NIGERIA

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Abstract

There are few studies on consumer response towards GMO products in developing countries at large and Nigeria in particular. This is in spite of the importance of biotechnology in achieving food self sufficiency, poverty alleviation and environmental sustainability. A study of consumer response to biotechnology products is very important in the grain axis given the important role of grains in the diet of the people and in achieving the Millenium Development Goal of halving poverty by 2015. This study modeled the factors influencing adoption of GMO products in the grain axis of Nigeria using the logit regression. A random sample of 440 consumers spanning different strata of the society was undertaken. Data was collected through survey using pre-tested questionnaire schedule. Both descriptive and inferential statistics were used to analyze the data collected. Results revealed that consumer's age, educational level and marital status were critical variables influencing adoption. Consumer's occupation, income and gender do not bear elastic response to biotech products. Efforts should be made to mass educate the youths on biotechnology issues to encourage their adoption.

Keywords: Agricultural Biotechnology, Perception, Awareness, Logit regression, Nigeria

INTRODUCTION

The benefits of agricultural biotechnology towards the improvement of livelihood have been widely acknowledged. For instance, Per Pinstrup- Anderson (1999) noted "that modern biotechnology can enhance agricultural productivity in developing countries in a way that further reduces poverty, improves food security and nutrition, and promotes sustainable use of natural resources".

In a much more pungent way (Bunders and Broerse 1991) observed that since farming is the most important source of income and sustenance for about three quarters of the population of Sub Saharan Africa, there is no doubt that agricultural biotechnology can make very substantial contributions towards increasing food production by rural resource poor farmers while preventing declining resources such as forests, soil, water and arable land. Further, the FAO noted that genetic engineering (biotechnology) has the potential to increase production and productivity in agriculture, forestry and fisheries, and help in the development of new vaccines.

Flavell (1999)observed that biotechnology has produced plants that are more tolerant to drought and salt stresses, toxic heavy metals, and pests and diseases; seeds with greater nutrition by increasing the levels of essential amino acids, vitamins and bio-available irons. Genetic alterations have reduced over-ripening and post-harvest losses of fruits. Rapid advances in biotechnology and immunology have created new opportunities to develop vaccines for parasitic diseases.

Although opinions differ on the role biotechnology can play in African development, all (hopefully) must agree about the urgency to eradicate the perpetual cycle of hunger, malnutrition, and death in a world of plenty. It is an acknowledged fact that Africa is endowed with tremendous natural (including genetic) and human wealth that has yet to be harnessed for the benefit of its people.

Much more disturbing is the case of Nigeria (in-spite of her huge potentials) being unable to perform the vital roles of agricultural and food supply to her citizens talks less of her neighboring countries. For instance, the rate of growth of agricultural output in Nigeria was 4.0 percent in 2002 while the population growth rate was 2.8 percent. In essence, the growth rate of food and agriculture is just enough to meet the growth rate of the population. In-fact, the percentage share of household's income spent on food was 49, which is considered high, leaving very little for meeting other salient needs for good livelihood.

The implication of these is that Nigeria is unable to meet the food needs of her populace (a food deficit) in spite of the fact that she is claimed to be the agricultural giant in Africa Kuta(2004). Nigeria was listed as having to import 3.9 million tones of cereal (commercially) to meet her domestic requirements in the 2003/04 season, and 11,000 tonnes of cereals as food aid requirement. (FAO/GIEWS 2004).

Some of the reasons adduced for the observed inability of Nigeria's agriculture to live up to expectations are: that more than 70 percent of food crop production are in the hands of resource poor smallholder farmers, who cultivate an average of 2 hectares of scattered plots of land, using manual implements.

Few farmers are able to have access to or purchase improved seeds or agro-chemicals and only about a third use organic fertilizer. In addition, agriculture in Nigeria is predominantly rain-fed, which leaves most farmers totally at the mercy of relatively unpredictable climatic conditions. Inappropriate but widespread traditional agricultural practices, which have been largely resistant to change, also result in gradual degradation of agricultural soil thus further compromising productivity.

The above-mentioned production related problems serves as pointer to the great potential that agricultural biotechnology has in helping to transform Nigeria from a food deficit to food surplus country.

In addressing food security in Nigeria, a major sub-sector that has to be addressed is the grains. This is because grains are of vital importance to the livelihood of millions of people, not only in Nigerian but all over the developing world. Grains such as cowpea, rice, millet, sorghum provides food, animal feed and cash income for rural families. For instance, rice has become a staple food in Nigeria with several families eating rice three times a day for several days in month. Nigeria is the leading producer of cowpea in West and Central Africa (with about 4 million hectares) and an impressive yield record.

Rice has grown to become the major cereal for roughly 3.4 billion people in developing countries. World rice is utilization is forecast to reach some 4.15 million tones, in milled equivalent. Most of which will be used for human consumption. On a per caput basis, rice food consumption is forecast at 58.6kg in 2004 (FAO/GIEWS 2004)

However, WARDA as far back as (1981) reported a decline in rice sufficiency in Nigeria from 99.4% in 1965 to 36.7% in 1979, which dropped further to 30% in 1991. This is due to the instability and decline in the domestic production of rice in Nigeria. It has, therefore, been opined by FMAWRD (1989) that to achieve self-sufficiency in rice production in the year 2004 an annual growth rate of 9.43% is required whereas the average growth rate is 2003 was 4.4% (CBN 2003).

The importance of grains in the achievement of food security objective of the Nigerian government cannot be overemphasized. Kuta (2004) noted that the potentials of GM technology in addressing crop production and food quality(especially grains) problems could be exploited to enhance food security in Nigeria. In fact this is already a common knowledge among agriculturist and policy makers. Stakeholders have expressed interest in providing more quality food in the most populous black nation in the world.

Given these objectives, however, and the vital role biotechnology can play in its achievement, there is the need to assess the level of awareness and willingness of major stakeholders in the subsector to adopt biotech. This is because, according to Machuka (2001), "many of the claim and counter-claims concerning what biotechnology can or cannot do to solve Africa's food insecurity problems have mainly been made by non-Africans". Furthermore (Juma 2000) noted that biotechnology remains one of the least developed technological resources in Sub Saharan Africa. If biotechnology is of such vital importance to solving the food insecurity problems especially of grain(s) in Nigeria, the question addressed by this paper is what factors influence the adoption of biotechnology among the respondents?

In spite of the importance of the technology towards solving the food security problem in the country, there is relatively little or no research work on the topic in the literature at least known to the authors. A study of the factors that determine adoption will inform the policy makers and stakeholders of the vital issues to address in encouraging the adoption of the technology. Efforts aimed at solving the food security problems of the nation will then receive a boost given the results of this effort.

The main objective of the study is to examine the factors that determine the adoption of agricultural biotechnology among the Nigerian populace.

Specifically the objectives are to

Assess the socioeconomic characteristics of the respondents

Estimate the willingness to adopt biotechnology, and

Determine the factors responsible for adoption of biotechnology among the respondents

METHODOLOGY

Sources of Data

The study was carried out in "the grain axis" of Nigeria. The grain axis comprises the Savannah zone of the country where "cereals" is a major crop output. Kano State was selected as the representative of the grain axis of Nigeria. This is premised on the level of production of cereal crops as well as the volume of trade in cereals in the state compared to other states in the axis. The state hosts the largest grains market in West Africa – (Dawanau Market along Kano- Katsina highway) major crops traded at the market are cowpea, millet, maize, soybean and sorghum.

Primary data was elicited from the major stakeholders in the state. Multi stage random sampling technique was used to select respondents from each category of stakeholder. The broad categories of stakeholder interviewed are farmers, civil servants, traders, policy makers, Businessmen, Academics (students and teachers) and Religious Organisation. The study area was stratified into broad categories from which random sample of respondents were selected. Concerted efforts were made to ensure adequate representation of each category of stakeholders. Where possible, gender balance was carefully ensured by selecting men and women, while rural and urban as well as public and private sector balancing was ensured.

Table 1 below shows the distribution of the questionnaire among the identified stakeholders by the survey. The main instrument used for data collection is a set of pre-tested structured questionnaire that was administered on the selected respondents. For non-literate respondents, the questions contained in the questionnaire were translated to them in the local language (Hausa), while the responses from them were recorded back in English.

Table 1: Selection of Respondents

Category of Respondent	**Number selected**	**Percentage**
Farmer	100	22.73
Civil Servants	52	11.82
Academics (Students/Teachers)	140	31.82
Businessmen	50	11.36
Traders	60	13.64
Policy makers (Policeman)	25	5.68
Religion Organisation	13	2.95
Total	**440**	**100**

Source: Field Survey (2004)

Descriptive analyses as well as inferential tools such as chi-square measures were used to analyze the data collected after processing.

Modeling adoption of Agricultural Biotechnology

The decision to adopt agricultural biotechnology or not can be explained as a discrete variable. This suggests that the classical linear methods become inappropriate to capture the postulated relationship, because they can lead to heteroskedastic variances. A suggested solution to this problem is the use of maximum likelihood estimation (MLE) method. Although Green(2000) pointed out the possibility of the MLE leading to inconsistent estimators. Wooldridge(2000) suggests that when heteroskedasticity is observed such models require more general estimation.

In making decisions about adoption and use of agricultural biotechnology products, a consumer evaluates the decision in terms of its incremental benefit. If the perceived benefit to be obtained from the consumption of the product is higher than the current benefit, then the utility (U) for that product (assuming monotonic relationship between utility and benefits) will be higher than the current non-biotechnology product.

Greene(2000) suggests that random utility models can be used to address these types of incremental choice situations.

Suppose the qualitative variable Y indexes the adoption decision, then it will take a value of one if the consumer adopts the product and zero otherwise. The probability that a consumer will adopt the biotechnology product can be expressed as a function of Z as follows:

$$
\begin{aligned}
P(Y=1) &= P(\, U_{AGMO} > U_{NGMO}) \\
&= P(\, Z\,(\beta_{AGMO} + \varepsilon_{AGMO} > Z\,\beta_{NGMO} + \varepsilon_{NGMO}) \\
&= \mathbf{P\ Z}(\beta_{AGMO} - \beta_{NGMO}) > (\varepsilon_{NGMO} - \varepsilon_{NGMO}) \\
&= \mathbf{P}\,(\mathbf{Z}\beta > \xi) = \mathbf{F}(\mathbf{Z}\beta)
\end{aligned}
$$

where,

P is a probability function

$\xi = \varepsilon_{AGMO} - \varepsilon_{NGMO}$ is a random disturbance term

$\beta = (\beta_{AGMO} - \beta_{NGMO})$ is a vector of unknown parameters which can be interpreted as the net influence of the vector of independent variables on adoption of GMO product, and;

$F(Z\beta)$ is the cumulative distribution function for ξ evaluated at $Z\beta$.

The exact distribution of F depends on the distribution of the random term ξ. The probit model arises from assuming a normal distribution, and a logit model arises from assuming a logistic distribution. Under the standard assumptions about the error term, there is no a priori reason to prefer probit to logit estimation (Greene 2000). Accordingly, in most applications, it seems not to make much difference. Considering all these aspects, the logit model was developed to study the factors influencing the adoption of GMO products in Kano State of Nigeria.

According to the logit model the probability of a consumer adopting GMO product, given his socio-economic characteristics (Z) is $P_{(AGMO/Z)}$ and can be specified as

$$P_{(AGMO/Z)} = \frac{\exp(Z\beta + \xi)}{1 + \exp(Z\beta + \xi)}$$

where

$$\alpha < Z\beta < \alpha$$

The probability of not adopting GMO product $P_{(NGMO/Z)}$,

is therefore,

$$P_{(NGMO/Z)} = 1 - P_{(AGMO/Z)} = 1 - [\frac{\exp(Z\beta + \xi)}{1 + \exp(Z\beta + \xi)}]$$

$$= \frac{1}{1 + \exp(Z\beta + \xi)}$$

The relative odds of adopting versus not adopting GMO product are given by

$$\frac{P_{(AGMO/Z)}}{p_{(NGMO/Z)}} = \frac{[\exp(Z\beta + \xi)][1 + \exp(Z\beta + \xi)]}{[1 + \exp(Z\beta + \xi)]}$$

$$= \exp(Z\beta + \xi)$$

by taking logarithms of both sides,

$$\ln[\frac{P_{(AGMO/Z)}}{p_{(NGMO/Z)}}] = Z\beta + \xi \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 1$$

The maximum likelihood approach is used to estimate the equation 1

EMPIRICAL MODEL

The consumer specific socio-economic factors included in the model are based on the innovation diffusion theory and other adoption studies. Feder and Umali(1993) gave a review of these factors. Fritz et al(2003), Finke and Kim(2003) amongst others have used some of these factors in their respective works. The selected variables for this study include: consumer's age (age), gender(male=1, female=2), marital status (marstat), level of education (educ), occupation (occup), level of income (income).

A complete description of the variables specified and the types of measures that have been employed is given in Table 1.

Mittal and Kumar(2000) find a positive impact of rural literacy on the adoption of high yield variety of rice and wheat in India. Also, Doss and Morris(2001) indicate that education is a significant determinant of adoption of modern varieties of maize in Ghana. Thus, the impact of the main decision maker's education level on the adoption of biotech product is assumed to be positive.

The impact of age (experience) on adoption is ambiguous *a priori*. As age increases (and therefore experience) risk aversion may increase. However, greater experience could also lead to better knowledge of the product and more accurate assessment of the benefits of adoption. Shiyami et al (2000) find that more experience with growing chickpea, the higher the adoption of new varieties. Past studies of opinions related to recombinant bovine growth hormone (Grobe, Douthitt and Zepeda 1999) have found that younger, less educated consumers tended to perceive more risk from milk from rBGH-treated cows – milk which is scientifically indistinguishable from untreated cow milk. Fitz et al (2003) note that youths are much less aware of the effects of biotechnology on food, health and environment than were adults, hence positive relationship is expected. Considering the above, the impact of age on adoption is expected to be positive.

Younger people and households with young children are the most susceptible to negative media coverage. Frewer, Howard and Sheperd(1998) concluded that television, radio and newspaper followed by discussion with other people were the main information channels by which people base their decision about biotechnology.

Schoell and Guiltinan(1995) conclude that consumer's perception and attitudes are influenced by friends, family, class and their culture. Consequently, prevailing cultural attitudes may influence those consumers who have limited understanding of biotechnology. Thus, peer group formed by reason of occupation is a veritable tool for dissemination of news on GMO products and could influence adoption positively. In addition, we expect a negative relationship between the dependent variable and marital status.

The benefits of genetically modified crops and, hence, genetically modified foods are mainly cost-reducing and/or yield enhancing attributes. Food availability is a large problem in the developing world. Malnutrition is also another major problem of the developing countries. Consumers in developing countries are concerned with their nutritional intake. The third major problem facing developing nations is economic advantage Curtis et al (2004) Therefore, the a priori relationship between adoption and income is positive.

Finke and Kim(2003) report differences in concern about health risks from genetically modified foods by gender, race, urbanization among others variables. Female are more concerned about health risks from GMOs than males. They further suggest that more education, income and gender are factors that shape the perception of young undergraduates on GMO products. We therefore expect a negative relationship with gender.

Table 2: Description of the variables specified in the model

Variable Acronym	Variable Meaning	Type of Measure	Expected Sign
Dependent Variable			
Biouse	Whether a consumer will use biotech product	Dummy – will use = 1 Not Use = 0	
Independent Variable			
Age	Consumer's age	Years	+
Gender	Sex of consumer	Male = 1 Female = 2	–
Marital status	marital status	Discrete Single = 1 Married = 2 Divorced = 3 Widowed = 4	? -
Educ	Consumer's level of education	Discrete None = 0 Primary = 1 Secondary = 2 OND/NCE = 3 HND/BSc = 4 M.Sc/MA = 5 MBBS,DVM = 6 Ph.D =7 Quoranic = 8 Adult Educ = 9	+
Occup	Type of occupation	Discerete Farmer = 1 Trader = 2 Businessman = 3 Civil Servant = 4 Univ Teacher = 5 Sec Sch.Teacher = 6 Scientis in research Inst. = 7 Undergrad = 8 Politician = 9 Civil Soc.Worker = 10 Industry Worker = 11	? +
Income	Consumer's monthly income	Estimated monthly income in Naira	+

Table 3: Descriptive Statistics of Independent Variables

Variable	Mean	Standard Error	Variance
Age	34.51	0.99	11.91
Gender	1.08	0.02	0.27
Marstat	1.58	0.04	0.04
Educ	4.14	0.14	1.70
Occup	5.83	0.23	3.44
Income	21,799.99	2966.18	35594.17

N = 440

Source: Field Survey Analysis(2004)

Table 4: Socio-Economic Characteristics of the Respondents

Variable	**Frequency**	**Percentage**
Age		
Less than 25 years	144	32.05
26 – 35	122	27.72
36 – 45	104	23.64
46 – 55	43	9.77
56 – 65	24	5.45
More than 65	6	1.36
Total	**440**	**100.00** **Mean Age :34.5**
Gender		
Male	362	82.27
Female	78	17.73
Total	**440**	**100.00**
Marital Status		
Single	177	40.23
Married	248	56.36
Divorced	15	3.41
Total	**440**	**100.00**
Education		
No formal education	9	2.05
Primary school	21	4.77
Secondary school	3	0.70
OND/NCE	153	34.77
HND/B.Sc.	61	13.86

M.Sc/MA	119	27.05
MB.BB	46	10.45
Ph.D	9	2.04
Adult Education	9	2.04
Quaranic Education	10	2.28
Total	**440**	**100.00 Mean Years of Formal Education 4.2 years**

Source: Field Survey (2004)

Table 5: Distribution of Respondents by Estimated Income

Estimated Income	**Frequency**	**Percentage**
Less than N7, 500	126	28.64
7501 – 10,000	34	7.73
10001 – 15000	55	12.50
15001 – 20000	39	8.86
20001 – 25000	20	4.55
25001 - 30000	24	5.45
30001 – 35000	28	6.36
35001 – 40000	16	3.64
40001 – 45000	33	7.5
45001 – 50000	24	5.45
750,000	41	9.32
Total	**440**	**100**

Source: Field Survey (2004)

Table 6: Willingness of Respondents to adopt Biotechnology

Willingness	Frequency	Percentage
Willingness to eat GM food	72	16.36
Believe it is safe to eat GM food	107	24.32
Have you eaten GM food?	82	18.64
Is it safe to grow GM crops	67	15.23
Will Biotech put small farmers of business?	86	19.55

Source: Field Survey (2004)

Table 7: Logit Regression results

Dependent Variable: Biouse

Variable	Coefficient	Standard Error	Slope/ Marginal Effects	Elasticity at the means
Age	**0.09141***	**0.0426**	**0.0132**	**2.351**
Gender	**1.1968**	**1.3835**	**0.1734**	**0.9636**
Marstat	**-1.0128**	**1.1087**	**-0.1468**	**-1.1928**
Educ	**0.5127*****	**0.3803**	**0.0743**	**1.5819**
Occup	**0.1546*****	**0.1042**	**0.0224**	**0.6722**
Income	**-0.0011*****	**0.0007**	**0.0000**	**-0.1827**
Constant	**-6.6166***	**2.4555**		

Source: Data Analysis (2004)

N = 440; X^2 = 9.67* ; R^2 = 0.1923; log pseudolikelihood = -24.2939

*** - significant at 1 % level**

***** - significant at 10% level**

EMPIRICAL RESULTS

Hoban (2001) had noted that “anything new takes time to garner awareness and gain acceptance and adoption”. Furthermore, the process of innovation adoption starts with awareness.

Socio-economic Characteristics

The socio-economic status of the adopter goes a long way to determine his ability to adopt. The socio-economic status of the respondents is presented in Table 4. Schoell and Guiltinan (1995) observed that consumer’s perceptions and attitudes are influenced by friends, family, clan and their culture.

Results presented in Table 4 shows that most (32.05 percent) of the respondents are less than 25 years of age. Altogether, more than 80 percent of the respondents are less than 55 years of age, with about 1.36 percent being more than 65 years of age. This is in line with the findings of the Nigerian Population Commission which describes the Nigerian population as being relatively "young" with a median age of 17.4 year and 44.9 percent under the age of 15 in 1991 (NPC 1998).

Most of the respondents are male, (82.27 percent), and married (56.36 percent). The respondents have one form of education or the other as only 2.05 percent do not have any formal education. Equally, 2.05 percent had Ph.D, and attended adult education class respectively. The mean year of formal education was 4.2 years.

The level of income earned determines to a large extent, the social status and th e peers kept by the respondents as well as the kind of information that are transmitted amongst the peers. Most (28.64 percent) of the respondents earn less than N7, 500.00 per month. N7, 500.00 is the approved national minimum wage for public civil servants in the country. This minimum wage has been in existence since the inception of the civilian administration in 1999. That almost one third of the respondents earns below the national minimum wage is indicative of the income poverty level in the study area. Almost half (48.87 percent) of the respondents earn less than N15,000 per month; while only 9.32 percent earns more than N50,000 monthly.

Willingness to adopt

The results in Table 6 showed that more than one-fifth (24%) of the respondents believe it is safe to eat GM food, while almost one-fifth (19%) have eaten GM food and about 16% each believe it is both safe to eat GM food and to grow GM crops. In essence, only about one-fifth of the stakeholders are currently aware and willing to adopt biotech in the study area.

Results of Logit Regression

The empirical logit model(1) was estimated using the STATA software version 9.2 (Statacorp 2005). The estimated coefficients and the corresponding standard errors are given in Table 7. The likelihood-ratio test of the hypothesis that the coefficients of all the explanatory variables are zero, has a chi-squared value of 9.67 with a 6 degree of freedom, suggesting that the estimated model is significant. The goodness of fit measure (Pearson's X^2) indicated a satisfactory fit. The model correctly predicts 81.82 percent of the responses.

In addition to estimated coefficients, the marginal impacts of the changes in the independent variables are also presented. The interpretations of these marginal impacts are dependent on the unit of measurement of the independent variables. For example, the marginal impacts show that a one year increase in age will increase probability of adoption by 1.3 percent. This implies an elastic response of 2.351 when evaluated at the mean value of the independent variables.

Further, every additional year of formal education by the consumers will increase the probability of GMO products adoption by 7.4 percent. Greene(2000) noted that the marginal effect of a binary independent variable can be estimated by simply taking derivative with respect to the binary variable as if it were a continuous variable.

In addition, the computation of the derivatives of the conditional mean function is useful when the variable in question is continuous. However, when the explanatory variable is a dummy, the marginal effects generally produce a reasonable approximation to the change in probability that Y=1, at a point such as the mean of the regressors. Following this, the estimated marginal effects of dummy explanatory variable could be defined. For example, the estimated coefficient of age implies that if the consumers obtained another year of formal education, the probability of adopting GMO product is increased by 7.4 percent which translate to an elastic response of 1.6. Of the independent variables included in the model, income, occupation and gender of the consumers are inelastic, while age, marital status and level of education are elastic. The most elastic response was observed with consumer's age, while income presents the most inelastic response.

Altogether, all the included variables had the expected relationship with the probability of adoption except consumer's income which had negative relationship. This is suggestive of the fact that consumers are less likely to adopt GMO products based on their income level. Also the negative relationship on marital status suggests that unmarried youths are more likely to adopt GMO product than married adults.

DISCUSSION AND RECOMMENDATIONS

The results obtained from the findings of this study shows that the variables of importance to the adoption of GMO products in the grain axis of Nigeria are consumer's age, educational level and marital status. The Nigerian population has been described as relatively young (NPC 1998), therefore the thrust of the message about GMO products should be youth oriented. The message should aim at proper education on the implications of biotechnology for improved livelihood. Fritz et al (2003) had reported that youths are less aware of biotechnology issues than adults in the US. In the same vein, the likelihood of youths to adopt biotech products in Nigeria could be a consequence of lack of awareness and education on the part of the youths too.

The elastic response of education variable is suggestive of the need for massive education of the consumers. The more educated the consumers are the more they are likely to adopt/consume biotech products.

Again, the message on the biotechnology issues should be on unmarried youths, and be gender neutral, and non specific on occupation and income level.

Since the message is targeted at youths the media of communication should be youth friendly. Youths generally patronize the Internet, and read newspapers. These should be the media of choice for the dissemination of the information.

The average level of literacy obtained from the study commends the various educational and research institutes as possible means of mass education for the respondents. Proper and wide publicity need to be given to results of research works on biotech issues from the universities and research institutes. Such results would go a long way to educate and allay the fears of the consumers on the "myths" surrounding consumption of biotech products.

A limitation of this study is the fact that it was conducted in the grain axis of the nation. Similar studies need to be conducted in other agroecological zones before sweeping generalizations can be made. However, the results of the study could be considered as valid for similar zones in other countries.

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EX-SITU BIODIVERSITY CONSERVATION: A MICROSOFT EXCEL IMPLEMENTATION OF THE SEED VIABILITY EQUATION FOR GENE BANK MANAGEMENT

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Abstract

Seeds of crop plants and their wild relatives maintained in gene banks provide valuable genetic resources for crop improvement and serves as a security measure against genetic erosion due to losses of vegetation. Since seed viability is important for maintenance of these genetic resources, the ability to predict seed viability in storage forms a vital decision support tool for the management of gene banks. The Ellis-Roberts' (1980) seed viability equations are accepted as a predictor of viability under experimented conditions of storage temperatures and seed moisture contents. In this study, storage experiments were conducted on tropical vegetable seeds, values of constants of the seed viability equation were estimated and source codes were written with Visual Basic (VB) macros to implement a Microsoft (MS) Excel application that can compute seed viability at specified periods. A unique feature of the application is the possibility of predicting viability of a large number of accessions by a click of a command button, taking advantage of MS Excel spreadsheet capabilities. A user can load viability constant estimates for new species on the spreadsheet, thus extending its use to as many species as possible. Performance of the application is illustrated using estimated parameters for a tropical vegetable species - Amaranth (*Amaranthus hybridus* L.). The potential use of the application in gene bank and seed inventory management will be discussed.

INTRODUCTION

Ex-situ conservation of plant biodiversity in gene banks constitutes a major security against genetic erosion of the world's food, fibre and medicinal plants. The biodiversity serves as genetic resources for food security and as the necessary raw materials for crop improvement and research (Fowler, 2008). Seed preservation is the most common method of maintaining the genetic resources of about 70% of the earth's plant species, accounting for 90% of the 6 million accessions conserved in *ex-situ* gene banks globally (Boerner, 2006).

For crop germplasm stored in seed gene banks, viability is re-tested, usually every ten years for base collections stored at sub-zero temperature conditions, a protocol derived from broad applications of the viability equation and published international standards (FAO/IPGRI, 1994). But considering the wide variability that exist between and within species in rates of seed deterioration and ultimate seed longevity under similar storage conditions (Bird, 2006; Walters *et al*., 2005; Hay *et al*., 2006;

Ellis and Hong, 2007b; Muthoka et al. 2009), more precise seed viability information system during gene bank storage becomes necessary. Moreover, seed gene banks operating at temperature conditions above 0°C temperature conditions, require more precise information on seed deterioration rates for scheduling seed viability testing, rejuvenation or recollection. An example is the gene bank operated at the National Center for Genetic Resources and Biotechnology (NACGRAB) in Nigeria. The NACGRAB gene bank holds over 4,000 accessions of about 20 indigenous tropical species in 5 and 20 °C cold store facilities. In this situation, seed viability prediction tools are invaluable for seed viability management decisions.

Dissertation

The viability equation developed at Reading University in the 1980's has been widely used to predict seed longevity for many plant species with orthodox seed storage biology (Ellis and Roberts*,* 1980; Mutegi *et al*., 2001; Daniel et al , 2003; Chaves and Usberti, 2004; Walters *et al*., 2005; Ellis and Hong, 2007a,b). The equation was derived from empirical data during controlled seed deterioration tests at a wide range of conditions of seed moisture content and storage temperature, thus the equation relates the viability of a seed lot to seed moisture content and storage temperature as follows:

$$V = K_i - p / 10 \exp K_E - C_W \log_{10} m - C_H t - C_Q t^2 \qquad (1)$$

Where V is viability (normal equivalent deviates, NED) after p days of storage at temperature, t (°C) and moisture content, m (% fresh weight basis). K_i, K_E, C_w, C_H, and C_Q are the viability constants (Ellis and Roberts, 1980a, b). K_i, is the theoretical initial viability of the seed lot NED prior to storage. The value of K_i varies between seed-lots due to the effects of genotype and post-harvesting handling but is constant for a single seed-lot under different conditions of storage, because it is not affected by subsequent storage conditions. K_E is a constant reflecting inherent seed longevity, and thus a measure of comparative seed longevity among species. C_w describes the relative effect of change in moisture content on longevity while C_H and C_Q are constants describing the relative effect of temperature and changes in temperature on longevity. These species are species specific. Once the seed moisture content, storage temperature and the initial seed quality can be determined and kept fairly constant, survival curves can be constructed by probit analysis of the seed germination tests data during storage and seed viability constants can be calculated.

To implement this equation for the management of seed viability in gene banks, Roberts, (1960), Ellis and Roberts (1980b) developed the use of seed viability nomographs to estimate seed viability under known conditions of storage temperature and seed moisture. However with the availability of personal computers, it has become relatively easier to estimate seed viability using computer programmes to run the equation. Kraak (1992) developed a programme with Pascal that runs on IBM compatible computers to calculate initial seed viability, resultant seed viability after storage, storage period, moisture content or temperature during storage. The Millennium Seed Bank Project (MSBP) also launched a web-based application that estimates seed viability using published estimates of the seed viability equation for about 66 plant species (Flynn & Turner 2004; Flynn et al. 2006). In these implementations, only estimates of a single seed lot sample can be derived at a time. However, for gene bank management, viability estimation of a large number of accessions is required at a time, thus we investigated a spreadsheet-based implementation of the seed viability equation.

For personal computers, spreadsheets are more common and are good applications for preparation, plotting and analysis of data. One of such spreadsheet software is Microsoft Excel (MS Excel) which is part of the Microsoft office Suite, preloaded with new PCs that run on Windows platform. Hence there is no additional cost to the user. Moreover, the MS Excel spreadsheet has capabilities for application development using macros that runs object oriented Visual Basic (VB) codes. The objective of this study was therefore to implement a MS Excel application for calculating the seed viability equation. A MS Excel calculation template for the seeds of vegetable amaranth (*Amaranthus hybridus*) is presented.

MATERIALS AND METHODS

The NACGRAB gene bank holds 207 accessions of various species of vegetable amaranths, making it the largest indigenous vegetable species in the NACGRAB collection. Seeds of a black-seeded accession of *Amaranthus hybridus* were equilibrated in plastic boxes equilibration chambers over various salt solutions at relative humidities (RH) ranging from 26% to 93% and stored at 10, 20, and 45 °C at the Institute of Plant Genetics and Crop Plant Research, Gatersleben, Germany. Seed samples were drawn for germination tests at predetermined intervals for 17 months. Probit analysis of seed survival data was done using SAS 8.1 version to fit the Ellis and Roberts (1980a) viability equation:

$$V = K_i - p / \sigma \qquad (2)$$

which is similar to fitting seed survival curves constructed on NED equivalent values of percentage seed germination data. Where V is germination in NED after storage for p days, K_i is the seed-lot constant equivalent to the y-intercept of seed survival curves transformed into NED, and σ is the standard deviation of the frequency distribution of seed deaths in time and relates to storage conditions as:

$$\log \sigma = K_E - C_W \log_{10} m - C_H t - C_Q t^2 \qquad (3)$$

PROC NLIN SAS statements were used to model viability as a linear function of initial germination, storage period, and exponential function of seed moisture content and storage temperature as in equation 3. Viability constants K_E, C_w, C_H *and* C_Q were thus estimated.

MS Excel implementation

The MS Excel formulas for computation of equation 1 are shown in Table 1. The public domains of the implementation where attributes of seed lots can be declared by users are in cells A1 to E1. Columns F to K were conditioned as a computation template by writing macros on header cells F1 to K1 that runs formulas which breaks down equation 1 into the model components to estimate viability.

Cell F1 computes the square of storage temperature D1, cell G1 computes the logarithm of equilibrium moisture content, cell I1 computes the seed lot constant K_i using data of % germination of seed lot before storage in cell B1, cell J1 computes σ estimates as in equation 3 using the viability constant values placed in cells N1 to Q1 for the species. Cell K1 estimates viability as in equation 1 (Table 1).

RESULTS AND DISCUSSION

Table 2 shows the estimates of the seed viability constants K, K_E, C_W, C_H and C_Q (equations 1 and 3) of *Amaranthus hybridus* from the SAS NLIN procedure of the seed survival data. As expected, the magnitude of C_W was higher than temperature constants C_H and C_Q, corroborating the insignificant differences in the temperature terms of the equation between seeds of various species reported by Dickie *et al.* (1990) and Ellis and Hong (2007b). Consequently, the MS Excel implementation of the equation was done using the estimates of the constants.

MS Excel implementation

The seed viability equation was implemented on a single spreadsheet template of MS Excel 2003 version. The template contained a total of 15 active columns divided into 3 parts: the data entry columns, the viability calculation columns and the equation parameter columns Figure 1.

The data entry columns A to E are where a user can declare characteristics of seed lots including accession number, percentage germination before storage, the period of time for which seed viability forecast is required, temperature of storage and seed moisture content (Fig. 2). Cells A1 to E1 bear the title headers to identify seed lot characteristics that users can declare and are referenced for calculations. Though a user may change the titles, deleting any of the columns will affect calculations with the application. The viability calculation columns

The next 6 columns (cells F1 to K1) computes seed viability under declared conditions of temperature, seed moisture content and storage period (Fig. 3). Column F contains a formula that squares storage temperature with reference to values in column D, Column G calculates the logarithm of seed moisture content referencing column E, column H transforms the initial percentage germination to fraction, column I calculates NED equivalent of values in column H. Column J runs equation 3 to estimate log σ. Column K runs equation 1 using values in from column B to K to estimate viability. On the header row, formulas for the calculations were programmed by MS Excel macros using the object oriented codes of VB to create command buttons that execute each formula. Clicking on the command buttons on the header rows run the formula on data entered in the data entry columns and presents the results in the appropriate cells of each row containing entry data down the columns for entered accessions (note that MS Excel has more than 10,000 rows).

To implement equation 1, the 4 viability constants expressed in equation 1 are stored in columns N to Q of the spreadsheet. The value of K_E is stored in cell N2, C_w in cell O2, C_H in cell P2 and C_Q in cell Q2. The cells holding the viability constants estimates are referenced by the seed viability calculation columns in the VB program used by the application. In the implementation mode of the spreadsheet, these cells are grayed out. The values in this cell can be changed to estimated viability constants of other species to run viability calculations for different species other than *Amaranthus hybridus* used in this application development mode.

Uses for gene bank management

A spreadsheet program, such as Excel, processes information that is set up in tables. With a spreadsheet program, you can: place numbers and text in easy-to-read rows and columns, perform calculations on data and show the results, automatically recalculate results when data is changed. These features make spreadsheets perfect for tracking information that involves numbers. The implementation of the seed viability equation being examined in the present study takes advantage of some of these MS Excel features.

The application is useful in providing information very rapidly, for example, the effects of seed moisture content and storage temperature on seed longevity can be easily determined from germination tests. Moreover, it can helpful to select storage conditions for individual seed lot. Furthermore, it can be used to choose controlled deterioration tests conditions as a vigour test (Kraak, 1992). Seed viability estimation capabilities will help gene bank managers to be able to assess the viability of accessions in collections of various species. This capability will help gene bank managers to make decisions on accessions and seed lots that need to be rejuvenated at specific times of storage. To make such selections, colour constraints can be place on cells on the viability column to show a certain colour when viability estimates are below specified thresholds according to gene bank standards.

Secondly, the application explores the capacity of MS Excel to compute viability for more than 10,000 accessions at a click on the viability button. Since each seed lot and/or accessions occupy a row in the application, it would be possible to run the seed viability equation on a large number of accessions at a time once the storage conditions and the initial seed viability can be provided in the data entry columns. This capability enhances the use of the application in gene bank management than the previously reported implementation of the seed viability equation (Kraak, 1992, Flynn et al. 2006).

Thirdly, the low cost of the application will enhance the concept of low-input genebanking suggested by FAO/IPGRI (2004). This will benefit gene banks particularly the ones operating at sub optimal condition or with very limited budgets. Since MS excel is part of the Microsoft office Suite, preloaded with new PCs that run on Windows platform, no additional costs are necessary. Moreover, the application does not require technically sophisticated procedures for usage, only that viability constants need to be changed for different species. Since NACGRAB already run all her systems on Microsoft office, the application will be most suitable for seed inventory management at the gene bank. By extension, other gene bank and seed store operators can use the application as a decision support tool.

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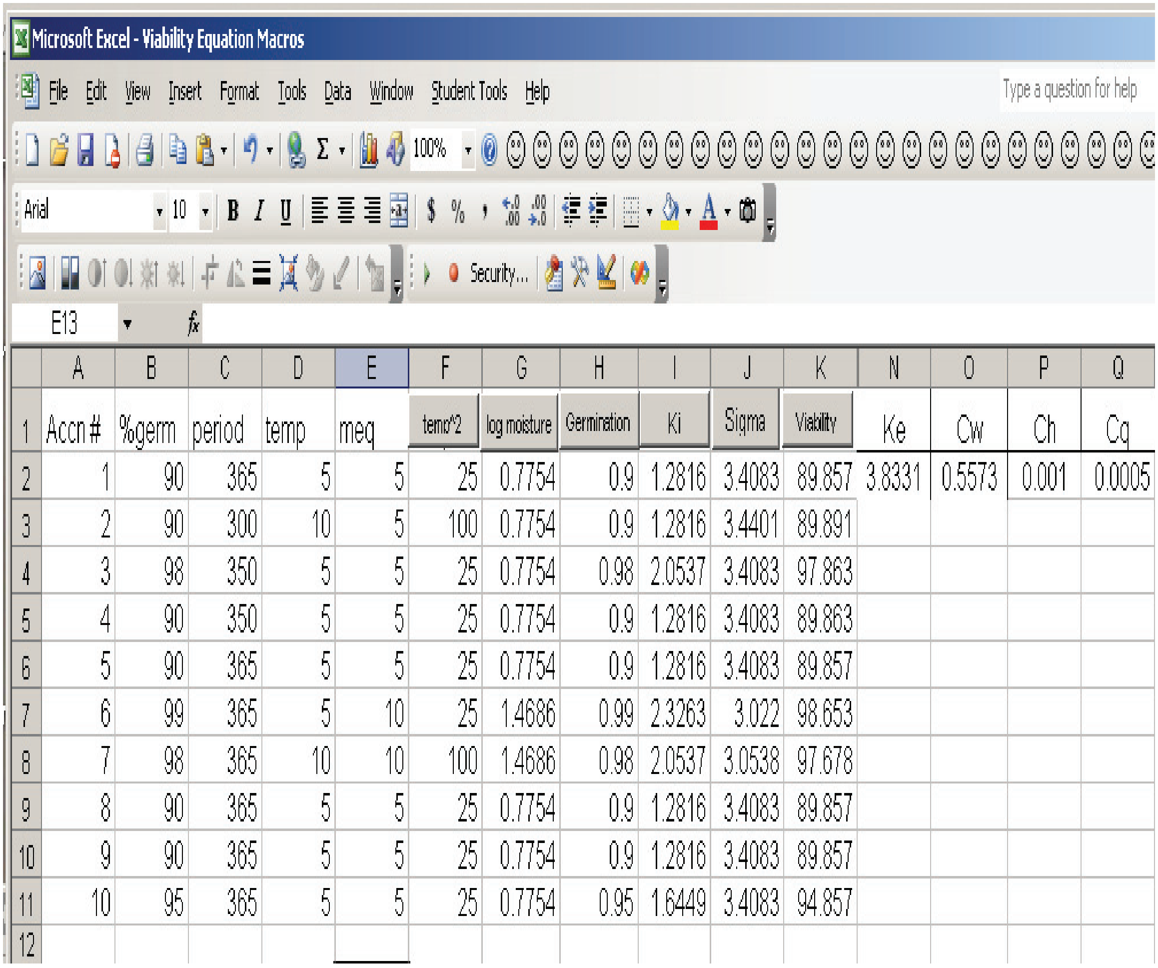
Table 1. Formulas for seed viability model (Equation 1) computation

Model parameter	Cell	Formula
Temperature	F1	Private Sub tempquadrate_Click() Dim i As Integer Let i = 2 For i = 2 To rowcounter() - 1 Cells(i, 6) = Cells(i, 4) ^ 2 Next i End Sub
Seed moisture content	G1	Private Sub logmoisture_Click() Dim i As Integer Let i = 2 For i = 2 To rowcounter() - 1 Cells(i, 7) = LogCells(i, 5) / Log(10)) Next i End Sub
Initial germination (in fraction)	H1	Private Sub germination_Click() Dim i As Integer Let i = 2 For i = 2 To rowcounter() - 1 Cells(i, 8) = (Cells(i, 2) / 100) Next i End Sub
Initial germination (Ki in NED value)	I1	Private Sub Ki_Click() Dim i As Integer Let i = 2 For i = 2 To rowcounter() - 1 Cells(i,9)=NormSInv(Cells(i, 8))

		Next i End Sub
σ (as in equation 3)	J1	Private Sub sigma_Click() Dim i As Integer Let i = 2 For i = 2 To rowcounter() - 1 Cells(i, 10) = Cells(2, 14) - Cells(2, 15) * Cells(i, 7)) - Cells(2, 16)*Cells(i, 4)) - Cells(2, 17) *Cells(i, 6))) Next i End Sub
Viability	K1	Private Sub Viability_Click() Dim i As Integer Let i = 2 For i = 2 To rowcounter() - 1 Cells(i,11)=Cells(i, 2) - Cells(i,3)/(10 ^ Cells(i, 10))) Next i End Sub

Table 2: Estimates of seed viability constants for black vegetable Amaranths

	Viability constants			
	$K_{E},$	C_W	C_H	C_Q
Estimates	3.8331	0.5573	0.0010	0.0005
Standard error	0.2710	0.2050	0.0169	0.0003



	A	B	C	D	E	F	G	H	I	J	K	N	O	P	Q
1	Accn #	%germ	period	temp	meq	temp^2	log moisture	Germination	Ki	Sigma	Viability	Ke	Cw	Ch	Cq
2	1	90	365	5	5	25	0.7754	0.9	1.2816	3.4083	89.857	3.8331	0.5573	0.001	0.0005
3	2	90	300	10	5	100	0.7754	0.9	1.2816	3.4401	89.891				
4	3	98	350	5	5	25	0.7754	0.98	2.0537	3.4083	97.863				
5	4	90	350	5	5	25	0.7754	0.9	1.2816	3.4083	89.863				
6	5	90	365	5	5	25	0.7754	0.9	1.2816	3.4083	89.857				
7	6	99	365	5	10	25	1.4686	0.99	2.3263	3.022	98.653				
8	7	98	365	10	10	100	1.4686	0.98	2.0537	3.0538	97.678				
9	8	90	365	5	5	25	0.7754	0.9	1.2816	3.4083	89.857				
10	9	90	365	5	5	25	0.7754	0.9	1.2816	3.4083	89.857				
11	10	95	365	5	5	25	0.7754	0.95	1.6449	3.4083	94.857				
12															

Figure 1. MS Excel implementation of the seed viability equation for *Amaranthus hybridus* seeds

	A	B	C	D	E
1	Accn #	%germ	period	temp	meq
2	1	90	365	5	5
3	2	90	300	10	5
4	3	98	350	5	5
5	4	90	350	5	5
6	5	90	365	5	5
7	6	99	365	5	10
8	7	98	365	10	10
9	8	90	365	5	5
10	9	90	365	5	5
11	10	95	365	5	5

Figure 2. Data entry columns for users to declare seed germination, treatment conditions and storage period

F	G	H	I	J	K
temp^2	log moisture	Germination	Ki	Sigma	Viability
25	0.7754055	0.9	1.281552	3.355977	89.83919
100	0.7754055	0.9	1.281552	3.549977	89.91544
25	0.7754055	0.98	2.053749	3.355977	97.8458
25	0.7754055	0.9	1.281552	3.355977	89.8458
25	0.7754055	0.9	1.281552	3.355977	89.83919
25	1.4685526	0.99	2.326348	2.969686	98.60861
100	1.4685526	0.98	2.053749	3.163686	97.74962
25	0.7754055	0.9	1.281552	3.355977	89.83919
25	0.7754055	0.9	1.281552	3.355977	89.83919
25	0.7754055	0.95	1.644854	3.355977	94.83919

Figure 3. Programmed columns for computation of viability based on declared values in columns A to E using equation 1.

N	O	P	Q
Ke	Cw	Ch	Cq
3.8331	0.5573	0.001	0.0005

Figure 4. Estimates of seed viability constants calculated by fitting seed survival data under the various storage conditions to equation 3.

ACACIA TREE: A POTENTIAL SOLUTION TO THE NEGATIVE EFFECTS OF CLIMATE CHANGE AND FOOD SHORTAGE IN AFRICA

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Abstract

The industrial revolution and human activities have contributed greatly to climate change, which in turn has negative effect on the precipitation pattern. Agriculture is highly sensitive to climate change, most especially drought, flood and severe storm. Persistent drought in the northern part of Nigeria will no doubt lead to desert encroachment. It is therefore imperative to identify woody species that is resistant to drought and at the same time bear heavy edible seeds to prevent desertification. Australian *Acacia colei* and *Acacia tumida* have been established to be drought resistant shrubs that thrive very well and bear heavy seeds in dry zones of Africa where other food crops have failed. This paper presents information on the potential of these two *Acacia* species as human food, their distribution with reference to climate and soils as well as possibility of using the plants to solve the eminent danger of desert encroachment in Nigeria. This paper also summarises information on the chemical composition and the nutritional value of these all important drought resistant crops.

INTRODUCTION

The advent of industrial revolution and human activities have continued to increase the level of greenhouse gases in the atmosphere. These activities include deforestation, burning of fossil fuels and biomass. The greenhouse gases affect the composition of the atmosphere, which in turn contributes immensely to climate change by influencing the temperature, precipitation pattern, storm and sea level (IPCC, 2007). Change in climate has led to climate warming (increase in temperature), drought, land degradation and desertification of some arid and semi arid regions of the world most especially Africa. Desertification has been reported to ravage one-third of the land mass of Africa, about a quarter of Australia, and occupies a significant portion of America and Asia (Fade Africa, 2009). This shows that climate change is a worldwide problem.

Drought and desertification are known to promote a host of calamites that ranges from loss of biodiversity, depletion of water resources, destruction of arable land, reduction in soil fertility and global warming. All these could cause famine, diseases, reduction in standard of living and death of human and livestock as witnessed in some parts of Africa between 1968 and 1974 when hundreds of thousands of people and millions of animals perished due to drought and desertification (McHarry *et al*., 2002). Ononiwu (2007) reported that the earlier rate (0.6 km per annum) of desert encroachment in Nigeria has now increased to one kilometre per year. It is therefore imperative to find a lasting solution to the desert encroachment and also reclaim the already desertified lands. This can be achieved by planting crops that can withstand the harsh weather of these regions and that also produce heavy edible seeds, which can contribute to the nutritional and economic base of the people living in these drought and desert prone area of Africa.

Acacia is one of the well-known drought resistant shrubs, which has been reported to thrive well in dry zones of Africa where other crops such as millet, corn, and sorghum have failed (Rinaudo *et al*., 2002). There are over 50 *Acacia* species identified to be part of the diets of traditional Australian Aborigine (Devitt, 1992). Some of these *acacia* plants have been introduced into Sahelian region of West Africa where rainfall is less than 600 mm per annum and found to thrive with heavy seeds (Rinaudo *et al*., 2002; FAO, 1995). Of all the *acacia* species tried in Maradi, Niger Republic, *A. colei* and *A. tumida* demonstrated the highest survival and rapid growth on a wide range of soil types (Cossalter, 1987; Rinaudo *et al*., 2002). These attributes make *Acacia* a suitable candidate for combating the problems of drought and desertification. In addition, chemical analysis on the seeds of *Acacia* revealed a rich source of protein and vitamins (Adewusi *et al*., 2003); moderate oil content and a balanced amino acid profile (Falade *et al*., 2005; Falade *et al*., 2008a). Analysis of anti-nutritional factors and toxicological studies also revealed the seeds to be safe for human consumption at 25 % incorporation (Adewusi, *et al*., 2006; Harwood, 1994; Falade, *et al*., 2005).

The purpose of the paper is to provide information on the potential of *Acacia* crops (*A. colei* and *A. tumida*) as famine food and their suitability for use in solving the problems of drought and desertification in the prone areas of Africa.

CLIMATE CHANGE, DESERTIFICATION AND FOOD SECURITY

Climate change

Climate change is generally recognised as the major environmental problem facing the whole world. The threat of climate change on security, peace and sustainable development in the world is so profound that the UN Secretary-General, Ban Ki-moon has made it one of his priorities. As a result of climate change, it has been projected that there will be 5 – 8 % increase in the extent of arid and semi-arid land in Africa (IPCC, 2007) thus making life more difficult. Apart from the change in atmosphere’s ozone layer, which is believed to cause climate change, the change in land use such as rapid deforestation and urbanization also contribute to climate change. This is so because they determine the amount of solar radiation that is reflected or absorbed.

Desertification

Desertification is a process of land degradation in arid and semi-arid; and dry sub-humid areas, due to climate change and human activities (UNECA, 2008). It is a major cause of poverty and resource depletion and also threatens economic growth in Africa. The resource depletion is expected to increase during the twenty first century if nothing is done to curb the process of desertification (Conserve Africa, 2006). It was estimated that 40 % of the surface area of Africa at the edge of Sahara desert is under the threat of drought and desert encroachment (Fade Africa, 2009). It is well known that land degradation and desertification constitute the major cause of human migration, environmental refuges, food insecurity and poverty (Van Crowder *et al*., 1998).

Nigeria is reported to be losing 2168 square km of range and crop land to desertification each year (Brown, 2006) while water level in this desertified region has dropped from 8 to 12 meters below ground level to as much as 150 meters as at 2004 (Fade Africa, 2009). This could be due to overgrazing and over-cultivation, which have been reported to convert 351,000 hectares of land into desert each year (UNECA, 2008). It could also be due to incessant felling of trees for fire wood. It was observed that the livestock population in Nigeria, soared from 6 million in 1950 to 66 million in 2006 (UNECA, 2008) putting a lot of pressure on pasture. In addition, more than 70 % of Nigeria's population was also reported to depend on fuel wood (The Tide on line, 2007). The twin problem of over-grazing and indiscriminate tree felling for fire wood underscores the need for an urgent introduction of edible drought resistant crops into these drought prone regions of Africa and Nigeria in particular.

Food Security

Climate change is a major factor that negatively impacts on agriculture by reducing the period of rainy season while increasing the dry season period (Bationo and Buekert, 2001). The consequence is a mean rainfall of less than 600 mm per annum (FAO, 1995). Thus, people living in the semi-arid regions of the developing countries rely on rain fed agriculture are vulnerable to hunger and periodic famine (Rinaudo *et al*., 2002) and depend on bran, grass, tree bark and leaves for food during the period of drought. The loss of natural resources, environmental degradation and desertification has been reported to affect food security (Van Crowder *et al*., 1998) and if the rate of land degradation continues, it is projected that over half of the present cultivated agricultural area in Africa could be unsuitable by the year 2050 and may be able to feed only 25 % of its population by 2025 (UNECA, 2008). The soil degradation of two northern regions in Ghana was estimated to lead to increase in malnutrition among children from 50 % in 1986 to 70 % in 1990 (UNECA, 2008). The drought of 2002 / 2003 in Southern Africa was estimated to result in a food deficit of 3.3 million tonnes and an estimated 14.4 million people in need of assistance (UNECA, 2008). In 2005, there was severe drought with food shortages in some African countries including Niger Republic (Radford and Vidal, 2005). In Africa as a whole, food consumption exceeded domestic production by 50 % in the 1980s and by more than 30 % in the 1990s (WWI, 1998) while an estimated 15 million people were expected to go hungry in these drought affected areas without food aid (FAO, 2005). Food aid to the drought prone regions of Africa was reported to be approximately 50 percent of the yearly budget of the World Food Aid programme (WB/ISDR, 2007). If part of this fund is used for reforestation to reclaim the arable lands lost to desertification by using drought resistant economic crops like *Acacia*, the money saved can be used for other things and the problem of famine would have been solved. A step in the right direction was the introduction of *Acacia* to Niger Republic because of the country is prone to famine and hunger and also because of the ability of *Acacia* to provide wood for building and fire wood (Rinaudo *et al*., 2002).

ACACIA COLEI AND *ACACIA TUMIDA*

Acacia (Leguminosae, subfamily Mimosoideae) is a large genus. The genus contains between 800 – 900 species; approximately 700 of which are native to Australia with the remainder occurring in tropic and sub-tropical regions of Africa, Asia and America (Evans *et al*., 1977). *Acacia* is one of the well known drought resistant crops, which has been reported to thrive very well in dry zones of Africa where other crops such as millet, corn and sorghum have failed (Thomson, 1989). Over 50 species of the edible *Acacia* have been identified in Australia (Devitt, 1992). In recent years, some of these species have been introduced into Sahelian countries in Africa, most especially in the arid zone of West Africa. This region is noted for its dry conditions and strong winds which cause severe soil erosion, low soil productivity and thus famine (Kimondo, 1991).These *Acacia* species were found to grow well with heavy seed yield (Thomson, 1989).

Acacia seeds have been reported to be essential components of the diets of the traditional Aborigine of Australia (Devitt, 1992). It is believed that the introduction of some of these edible *Acacia* to drought prone regions of Africa will go along way in solving the problem of hunger in the regions (Rinaudo, *et al*., 2002). Of the *Acacia* species sent for trial in Africa, most especially in Niger, *A. colei* and *A. tumida* were observed to be the most promising as human food because of their high rate of survival and very heavy seed production (Cossalter, 1987). These two species were introduced by the Centre Technique Forestier Tropical to West Africa with the principal objective of identifying new animal fodders (Cossalter, 1987). Thomson (1989) drew attention to the human food potential of these *Acacia* species because of their excellent performance on trial plantations.

Acacia colei

A. colei ms is among the identified edible Australian *Acacia* species (Figure 1). It was reported to be an important food source of central Australian Aborigines (Latz, 1984). This *Acacia* grows in hot , semi-arid (270 - 690 mm) tropical zones, where it was observed to form dense, monospecific, stands along dry and stony or sandy drainage lines (Thomson, 1992). *A. colei* was reported to be the best adapted species with excellent survival, and rapid growth on trails and extension plantations in West Africa on sandy soils in 400 - 700 mm rainfall (Harwood *et al*., 1999; Rinaudo *et al*., 1995). Over 100,000 *A. colei* trees were reported planted during the 1994 famine in Niger by MIDP - Maradi Integrated Development Project (Harwood *et al*., 1999).

Silvicultural features

A. colei was observed to show high survival and rapid growth on a wide range of soil types in the tropical, hot semi-arid and sub-humid (500 - 1000 mm) zones of West Africa (Cossalter, 1987). *A.*

colei seeds can be cultivated by treating the seeds with boiling water for 1 min to promote germination. The treated seeds are then planted into black polythene bags 7 x 15 cm in size using a mixture of 90 % sand and 10 % ground cow manure in a nursery (Cunningham, *et al*., unpublished paper). A planting distance of 10 m apart was recommended for Niger (Evans, 2001) although it was reported to do well at closer spacing in Nigeria where rainfall is greater than 450 mm (Evans, 2001). It is however recommended that *A. colei,* being a shallow root crop, should not be planted too close together because it will be stressed. This *Acacia* specie was observed to respond positively to pruning at the on set of the raining season with vigorous new branches within six months, and flowering with heavy seeds on the new branches (Evans, 2001). Cutting time and height were also observed to be critical for the survival of *Acacia*. Plants cut at 5 and 50 cm in April was reported to have 4 and 38 % survival, respectively in Niger (Thomson, 1992), while plants cut in June, at the onset of the rains, at 5 and 50 cm had 51 and 95 % survival, respectively.

Figure 1: Wood collected from *A. colei* var *colei* at Dandja trial site, Niger Republic. Photo by Tony

Acacia tumida

A. tumida is a shrub / tree with a record of being the fastest growing Australia *Acacia* in the Sahelian zone of West Africa (Figure 2) (Kjellstrom and Gamatie, 1989). It was observed to possess nearly all of the attributes to make it a most useful food source for people living in subtropical / tropical dry zones and also reported to have potential as a low windbreak in sandy soils in tropical dry zones (Thomson, 1992).

Figure 2: ***A. tumida*** **tree Photo by Tony Rinaudo**

Silvicultural features

The survival of *A. tumida* was reported to be lower than that of *A. colei* but was satisfactory between 78 and 86 % in Niger (Kjellstrom and Gamatie, 1989). It will survive on an infertile sandy soil (93 – 95 % sand) with low water holding capacity with average rainfall of about 450 mm (Thomson, 1992). The cultivation of the *Acacia* specie is the same as described for *A. colei* above. All *A. tumida* seed lots were reported to display good adaptation (survival) at 41 months after planting with a range of 339 – 514 g weight per tree and a range of 88 – 89 % of tree that produced seed (Cunningham, *et al*., unpublished).

Seed collection, processing and utilization

Good timing is important for efficient seed collection to prevent the matured pods from falling off the plant most especially during hot windy weather. This would prevent the loss of most of the seeds. The seed is collected by beating the dry, matured pod with sticks or by using feet to break up the pods unto a sheet laid under the tree (Thomson, 1992). The mixture of pods and seeds is shaken for the pods and other debris to come to the top. The pods and debris can then be removed by hand picking or by winnowing or sieving.

Edible *Acacia* plants have multi-purpose potential to improve food security and other purposes such as fire wood, timber and for environmental sustainability in the desertified regions. *Acacia* seeds have been established to be traditional foods of Australian Aborigines (Devitt, 1992) and have been reported to be nutritious (Brand and Cherikoff, 1985; Adewusi, *et al*., 2003; Falade, *et al*., 2005). The young green immature pods of *Acacia* are eaten raw in Australia or roasted with the pods and the seeds consumed (Crawford, 1982). Dry seeds of *A. tumida* and *A. colei* are ground into flour, mixed with water and heated and then eaten as a paste (Cane, 1987). Some *Acacia* species have been incorporated into other food products such as bread at 20 % level. Although, the product was reported denser but was palatable (Thorburn *et al*., 1987). *Acacia* has also been incorporated into sweet biscuit at 50 % which was acceptable but the incorporation at 100 % was not acceptable because of its strong flavour, gritty texture and high level of oil (Maggiore, 1985). More recently, *A. colei* seed was incorporated in all the local recipes of Maradi people of Niger during a human feeding trial. The results indicated that the incorporation improved the nutritional value of all the local recipes and volunteers were willing to incorporate the seed into their regular diets (Adewusi *et al*., 2006).

ADVANTAGES OF *ACACIA* SPECIES OVER THE CONVENTIONAL CEREALS

The advantages of these *Acacia* species (Rinaudo, *et al.,* 2002) are given below:

Perennial habit

They have potential of exploiting soil water below the crop root zone. This makes it possible to produce seed during drought when other conventional crops fail.

Adaptability to infertile and non-arable sites

These two *Acacia* species were reported to adapt well to infertile (non arable) soil known to be unsuitable for other agricultural crops (Rinaudo *et al*., 2002). *A. colei* was observed to grow successfully in North-West of Kano, in the northern part of Nigeria most especially on loose, infertile sand believed to be unsuitable for local crops (Rinaudo *et al*., 2002).

They are nutritious

The safety and nutritional studies on these two *Acacia* species indicated that the seeds are safe and nutritious (Adewusi *et al.,* 2003; Falade *et al.,* 2005; Adewusi *et al.,* 2006; Falade *et al.,* 2008a; Falade *et al.,* 2008b). This will be discussed in detail later.

Seed are easily harvestable

The matured seeds of *Acacia* species are easy to harvest without relying on special equipment. It was reported that one person can harvest 3 – 5 kg of clean seed of *A. colei* and *A. tumida* per hour (Rinaudo *et al.,* 2002). The harvesting is done by cutting small seed-bearing branches, which are then beaten on sheets or by beating the bushes or shaking directly onto large sheets.

Long term storage of seed

Matured *Acacia* seed which is made to dry on the tree can be stored at room temperature in a closed container for between 5 and 10 years without spoiling. It was reported that the risk of seed spoilage from moulds and weevils is eliminated be removing the seed aril, which is known to attract weevils to the seed (Rinaudo *et al.,* 2002). This property makes these seeds ideal famine foods because storage of farm produces is one of the major problems confronting farmers.

Ability to produce heavy seeds from early age

A. colei yield of up to 6 kg per tree has been reported on sites at Maradi in Niger (SIM NIGER, 1996). On the average, yields of 1.8 kg per tree have been measured from trees of 2 - 5 years old planted in rows of 8 meters apart, receiving 300 – 400 mm rainfall with regular cultivation and annual pruning (Rinaudo *et al.,* 2002). In India, annual yield of *Acacia colei* was estimated to be 1000 kg per hectare from age 3 – 4 years up to about age 8 – 9 years (Rinaudo *et al.,* 2002).

Ability to provide biomass and other services

Acacia tree can provide people with fire wood. This will reduce pressure on the local vegetation used for this purpose, which will in turn reduce deforestation. *Acacia* will also provide timber for building construction. All these will increase the standard of living of the people. *Acacia* can also be used as windbreak to protect other crops like millet from the damaging effect of wind. Dried foliage of *A. colei* can be used as low grade animal fodder (Rinaudo *et al.,* 2002). Tannin, gums and other compounds with medicinal properties are other useful components of *Acacia* species (ANBG, 2002; Rinaudo *et al.,* 2002).

Ability to fix atmospheric nitrogen and improve soil fertility

Acacia species belong to the family *leguminosae*. Hence they are able to convert atmospheric nitrogen in to soil nitrate (Rinaudo *et al.,* 2002). This will be of tremendous benefit for poor African farmers who are unable to afford the high cost of inorganic fertilizers.

Period of seed maturity

Acacia flowers in October / November of each year and the seed matures by February of the following year. This makes Acacia a unique plant that produces mature seed in the dry season when food reserve is completely used up or depleted. The period of harvest is also not in conflict with other crops and the off season period will make harvesting easy and cheap.

CHEMICAL COMPOSITION AND NUTRITIONAL VALUE OF *ACACIA* SEEDS

Chemical composition

Our research group has carried out significant compositional studies on *A. colei* and *A. tumida* seeds. The results from these studies revealed the potential of these *Acacia* species as human food. The investigations showed the seeds to compare favourably with other legumes and even better in some nutritional parameters (Adewusi *et al.,* 2003; Falade *et al.,* 2005; Falade *et al.,* 2008a; Falade *et al.,* 2008b).

Macronutrients

Protein: Protein is an important component of food that is essential for growth and maintenance. Protein energy malnutrition (PEM) is still an important issue in the developing the countries. The introduction of plant foods rich in protein will go a long way to solving its malnutrition among the poor people living in the developing the countries. Crude protein content of 20.6 to 23.0 % was reported for *A. colei* and three cultivars of *A. tumida* (Table 1). This shows that *Acacia* could replace cowpea and other legumes (Adewusi and Falade, 1995) as a source of protein in the diets of people of the arid zone of Africa. The consumption of as low as 100 g of these *Acacia* seeds could provide about 40 – 50 % of the recommended dietary intake (RDI) for protein (NHMRC, 1987). Crude protein analysis will only provide a rough estimation of protein since some plant foods contain non-protein nitrogenous compounds, which will over-estimate the protein level. Murray and McGee (1986) have observed that *Acacia* seeds contain a substantial level of non-protein nitrogen. The same trend has been equally observed for these two *Acacia* species - 17.5 % true (extractable) protein was reported for *A. colei* and a range of 11.5 – 12.6 % extractable protein was obtained for the three cultivars of *A. tumida* seeds (Table 1). This was about 22 to 45 % reduction of *A. colei* and *A. tumida* seeds' crude protein. The amino acid profile of these *Acacia* species revealed *A. tumida* to be more balanced than in *A. colei* and tryptophan was the first limiting amino acid in both seed samples using the chemical score method (Adewusi *et al.,* 2003). The use of protein digestibility corrected amino acid score (FAO / WHO, 1991) for *A. colei* seed flour revealed histidine (99 %) has the highest, while tryptophan has the lowest (50 %) chemical score (Adewusi *et al.*, 2003). The results also showed sulphur amino acids and threonine jointly as the second limiting amino acids (61 %).

Carbohydrate: Carbohydrates, especially glucose and glycogen serve as the major source of readily available energy for human body. They are also major sources of fuel to the brain (Brand and Maggiore, 1992). The knowledge of levels of carbohydrate in foodstuffs is important to those who are watching their weight and also to the diabetic patients.

The reducing sugar content of these *Acacia* species ranged between 31.1 and 54.5 g / kg on dry weight basis while total sugar content was (139.6 – 154.3 g / kg) (Falade *et al.,* 2005). The total sugar was within the range of 87 – 167 g / kg reported for legumes (Adewusi and Falade, 1996). Since taste is partially dependent on the amount of total sugar present, replacement of the traditional sources of carbohydrate with *Acacia* may not significantly alter the taste of the modified diets of the people of the arid zone. This could also account for the willingness of the Maradi people to incorporate *A. colei* into their local recipes (Adewusi *et al.,* unpublished paper). The starch content was observed to vary between 255.9 and 323.4 g / kg (Falade *et al.,* 2005).

Fibre: Dietary fibre is defined as the portion of plant foods that can not be digested by human digestive secretions in the digestive tract (Deis, 1999). Dietary fibre is made up of cellulose, hemicellulose, hexosans, pectin substances, gum, mucilage and lignin. The major function of fibre in the food is the maintenance of the health of the gastrointestinal tract (CFW 2001; Adegoke *et al.,* 2006). Total dietary fibre content (Table 1) was 29.5 % for *A. colei* and 28.5 – 32.7 % for three cultivars of *A. tumida*. The dietary fibre content of *A. colei* was significantly higher than in cereals (0.5 – 9.8 %) (Falade *et al.,* 2008b). It is therefore expected that the incorporation of *Acacia* seeds into the traditional fare of the people of Maradi will increase their total dietary fibre intake. Our human feeding trial revealed that the incorporation of *A. colei* at 25 % level led to daily intake of 171 g of dietary fibre in male which was 80 % higher than in the traditional fare while it was 170 g in female which was 106 % than in the traditional fare (Adewusi *et al.,* 2006). Falade *et al.,* (2005) observed that the incorporation of *Acacia* seeds in to human diets would increase the level of soluble fibre intake. Soluble fibre is known to decrease postprandial glucose and insulin concentration (Mayer *et al.,* 2000). This means that the incorporation of *Acacia* seeds into the diets of diabetic patients could be of tremendous benefit. Although fibre has beneficial effects, it is not without its advert effects. For example, fibre is known to bind minerals and also reduces protein and carbohydrate digestibility of food (Adewusi and Ilori, 1994; Falade *et al.,* 2005).

Fat and Fatty acid composition: Fat, which is believed to be surplus in western countries, is in short supply in many countries of Africa (Brand and Maggiore, 1992). Fat (Ether extract) content of these *Acacia* seeds was moderate (7.7 – 11.9 %) (Falade *et al.,* 2005). Brand *et al.,* (1985) had earlier reported a range of 7.8 to 10.2 % for some *Acacia* species. This range has been observed to be higher than in most legumes (Brand and Maggiore, 1991) and also reported to be palatable (Brand and Cherikoff, 1985). All these show that *Acacia* could be a good source of vegetable oil. Our earlier investigation on physiochemical properties of *Acacia* seed oils (Table 2) revealed *Acacia* oils to be better than groundnut oil in almost all the nutritional parameters investigated. The properties of these oils also showed that the oils could provide good feedstock for the soap industry, suitable for use as lubricant at low temperature and could be used as biodiesel (Falade *et al.,* 2008a). Linoleic acid is the predominant fatty acid in Acacia constituting 55.9 % of the *A. colei* and 50.1 % of *A. tumida* seed oil (Adewusi *et al.,* 2003). The seeds also have high levels of oleic acid (18 and 23.5 %) for *A. colei* and *A. tumida*, respectively while palmitic acid was low at 11.4 and 14.4 % for *A. colei* and *A. tumida*, respectively (Falade *et al.,* 2003). The high level of the polyunsaturated fatty acids show that *Acacia* seed oils could be suitable for human consumption from the nutritional viewpoint.

Vitamins: The vitamin A precursor (α-carotene and β-carotene) was very low in *A. colei* seed flour which was < 5 µg / 100 g in both precursors (Adewusi *et al.,* 2003). The recommended daily intake (RDI) of this vitamin known to enhance immunity and also for the treatment and prevention of cancer (Adewusi and Bradbury, 1993) is 600 – 800 µg RE for adult (FAO / WHO, 1988). *Acacia* is therefore not a good source of vitamin A.

Thiamine (Vitamin B_1) was relatively high in *A. colei* seed flour (0.34 mg / 100 g), and between 300 – 400 g of the *A. colei* could supply the RDI of 1.1 mg / day for men (NHMRC, 1991; Adewusi *et al.,* 2003). The thiamine content of this *Acacia* was reported to compare well with the levels obtained for some cereals (FAO, 1968).

Riboflavin (vitamin B_2) was 0.36 mg / 100g in *A. colei* seed (Adewusi, *et al.,* 2003). This value was higher than in conventional root crops reported to range between 0.06 – 0.23 mg / 100 g (Bradbury and Holloway, 1988). The niacin content of *A. colei* was 4.2 mg / 100 g while pantothenic acid and α – tocopherol are 1500 μg / 100 g and 0.30 mg / 100 g, respectively (Adewusi *et al.,* 2003).

Minerals: The mineral analysis of these *Acacia* seeds in our laboratory revealed potassium to be the predominant element (Adewusi *et al.,* 2003) which is in agreement with the finding of Brand and Maggiore (1992). The iron content varied between 18 and 54.4 mg / 100 g, higher than a range of 5 – 12 mg / 100 g reported for legume seeds (Adewusi and Falade, 1996). This shows that these *Acacia* seeds will be better sources of this important element. Magnesium, calcium and zinc were also observed to be in high concentration in these *Acacia* species (Adewusi *et al.,* 2003). Heavy metals (lead, cadmium and cobalt) only exist in traces or are not detectable and would not constitute any toxicity problem (Adewusi *et al.,* 2003).

Toxic and antinutritional Factors: Phytochemical screening of *A. colei* and *A. tumida* for alkaloids and saponins revealed that the samples did not contain alkaloids but were positive to the saponin test (Falade *et al.,* 2005). Saponin has been reported to impair iron absorption (Price *et al.,* 1989) and to form complexes with cholesterol, which is then excreted from the body (Jacobberger, 2001).

Tannins are considered to be anti-nutrients due to a range of their adverse effects which include among others reduction in feed conversion, reduction of bioavailability of micronutrients, liver damage and reduced growth (Chung *et al.,* 1998; Adewusi and Falade, 1996). Tannin content of these *Acacia* species (Table 1) ranged between 66.0 and 86.7 mg / g. This range was higher than the 0.9 – 3.9 mg / g reported for some Nigerian legumes (Adewusi and Falade, 1996). The high levels of the compounds in *Acacia* show that tannins will be an important factor in the assessment of the nutritional value of these seeds. Heat treatment has been observed to reduce this anti-nutrient (Adewusi and Falade, 1996), hence it is expected that cooking will reduce its level in *Acacia* based diets.

Phytate, known to impair minerals availability and block the action of a number of digestive enzymes such as pepsin (Adewusi and Falade, 1996; Knuckles, *et al.,* 1989), was very low in these *Acacia* seeds (0.03 – 0.1 mg / g) (Falade *et al.,* 2005). The value was lower compared with a range of 1.7 – 3.8 mg / g reported for sorghum (Doherty *et al.,* 1982). This factor is not likely to play a significant role in the nutritive value of these *Acacia* samples.

Trypsin inhibitors are antinutritional factors associated with pancreatic enlargement, reduced digestibility, reduced absorption of amino acids and reduced bioavailability of essential minerals (Gatel and Grosjean, 1990). The range of the factor (18 – 24.5 TIU / g) (Table 1) was low when compared with a range of 6,700 – 23, 300 TIU / g reported for cowpea (Adewusi and Osuntogun, 1991). This means that this factor is unlikely to pose any problem in the utilization of the *Acacia* seeds for food.

Oxalate is implicated as a source of kidney stones (Chai and Liebman, 2004). The oxalate content of these *Acacia* was fairly high (2.17 – 2.39 g / 100 g) compared with oxalate content of some Nigeria vegetables (Falade *et al.,* 2004) but significantly lower than values of 10.2 and 32.6 g / 100 g reported for cabbage and sweet potato respectively (Santamaria *et al.,* 1999).

Nutritional value of Acacia: Nutritional evaluation of *A. colei* and *A. tumida* seeds, carried out in our laboratory by feeding Wistar strain weanling rats with various diets prepared with these *Acacia* seeds, showed that the seeds are nutritious and safe for human consumption (Adewusi *et al.,* 2006; Falade *et al.,* 2008b).

Complementation study (Falade *et al.,* 2008b) using laboratory rats was carried out to see the possibility of complementing the protein, lipid and dietary fibre component of traditional sources of energy such as millet and sorghum with *A. colei* seed flour. The results showed red sorghum, brown fonio and white acha provided the best complementation with *A. colei* in terms of weight gain, PER and animal health. Millet complemented *A. colei* moderately while cassava - *acacia* diet resulted in morbidity and mortality of the animals.

Rats fed red sorghum incorporation *A. colei* seed flour at 0, 20 and 40 % *Acacia* levels were investigated for growth and reproductive performances (Adewusi *et al.,* 2006). The results showed that weight gain and feed conversion efficiency decreased with increase in *A. colei* incorporation. This was attributed to the quality of *Acacia* protein and not necessarily due to the presence of toxic constituents in the seed. Falade (2004) had earlier reported improvement in the growth of rats fed *A. colei* and *A. tumida* supplemented with methionine, which has been established to be the first limiting amino acid by bioassay (Falade, 2004). Poor growth, resulting from poor feed conversion efficiency, was also believed to be due to this limiting amino acid. The methionine-low *Acacia* protein was also the culprit when the animals were mated and none of the rats on 40 % *A. colei* was pregnant. When the protein level of the diets was raised from 12.5 % to 18 % and the rats fed for additional 9 weeks and mated again, 100 % pregnancy was recorded for 40 % *Acacia* group. This showed that it was not due to toxicity but purely nutritional. The best complementation recorded for *A. colei* – acha diet under the complementation study was attributed to the high level of methionine content of acha (Falade *et al.,* 2008b).

The safety evaluation of *Acacia* seed – based diets by rats and human studies in our laboratory revealed that the seed will be safe if incorporated into human diets at 25 % (Adewusi *et al.,* unpublished paper; Falade *et al.,* 2008b).

CONCLUSION

Climate change and the havoc it is capable wrecking are no longer news. What is expected is for man to find solutions to the menace of this natural phenomenon so as to make this world habitable for us all. *A. colei* and *A.* tumida are drought resistant crops which produced large seeds on non arable land where the conventional cereals would fail. These seeds are nutritious and safe for human consumption at 25 % incorporation. The advantages of the *Acacia* species over the conventional arable crops make them ideal crops suitable for combating the menace of desert encroachment and hunger in Africa.

We wish to recommend these *Acacia* species to the African policy makers and those saddled with the responsibility of preventing desert encroachment and famine in Africa and Nigeria in particular.

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Table 1: Chemical Composition of *Acacia* Seeds (% dry weight) mean and standard deviation of 3-5 replicates.

	A. colei sieved	*A. tumida*(I)	*A. tumida* (II)	*A. tumida*(III)
Moisture	6.4 ± 0.3^{b}	7.2 ± 0.1^{a}	7.8 ± 0.4^{a}	7.4 ± 0.5^{a}
Crude protein	22.3 ± 0.2^{c}	$22.6 \pm 0.4^{a\,c}$	20.6 ± 0.4^{c}	23.0 ± 0.6^{a}
True protein				
Colorimetric method	17.5 ± 0.3^{a}	12.4 ± 1.2^{b}	11.5 ± 0.9^{b}	12.6 ± 0.7^{b}
True protein: ppt at				
pH 8	4.8 ± 0.1^{a}	5.1 ± 0.6^{a}	4.9 ± 0.2^{a}	5.2 ± 0.5^{a}
pH10	13.8 ± 0.2^{a}	7.7 ± 0.5^{c}	7.0 ± 0.1^{c}	8.1 ± 0.9^{b}
Ether extract	11.9 ± 0.5^{a}	7.8 ± 0.1^{c}	10.5 ± 0.5^{b}	7.7 ± 0.06^{c}
IDF*	23.7 ± 1.0^{a}	26.9 ± 2.1^{b}	26.3 ± 0.7^{b}	26.1 ± 0.5^{b}
SDF**	5.4 ± 0.9^{a}	5.8 ± 0.6^{a}	2.2 ± 0.4^{b}	3.2 ± 0.4^{c}
TDF	29.5 ± 1.6^{a}	$32.7 \pm 1.3b^{e}$	28.5 ± 0.8^{a}	29.2 ± 0.3^{a}
Tannins (mg / g)	86.7 ± 1.2^{a}	80.3 ± 6.4^{b}	83.0 ± 7.6^{b}	66.0 ± 5.7^{c}
Phytate (mg / g)	0.09 ± 0.02^{a}	0.03 ± 0.00^{b}	0.03 ± 0.00^{b}	0.04 ± 0.02^{b}
Trypsin Inhibitor				
(TIU / g)	23	24.5	19	18
Oxalate (g / 100 g)	2.4 ± 0.2^{a}	2.3 ± 0.1^{a}	2.2 ± 0.2^{a}	2.6 ± 0.2^{a}

Source: Falade *et al.,* (2005)

Values in the same row with the same superscripts are not significantly different at the 5% probability level.

* IDF = Insoluble Dietary Fibre; **SDF = Soluble Dietary Fibre; TDF = as is (Total Dietary Fibre)

A. tumida (I) = Broome. 18653, *A. tumida* (II) = Pt Hedland. 17964 and *A. tumida* (III) = Tanami. 18646.

Tannin and Phytate = mean ± SD of three determinations

Oxalate = mean ± SD of quadruplicate analysis.

Table 2: Chemical properties of the oils

Characteristics	**Groundnut oil**	***A. colei* seed oil**	***A. tumida* seed oil**
Ether extract*	53.9 ± 1.3 [c]	12.6 ± 0.5 [b]	10.2 ± 0.4 [a]
Iodine value**	109.3 ± 8.3 [a]	154.9 ± 4.1 [b]	178.3 ± 6.7 [c]
Saponification value***	198.0 ± 14.6 [a]	201.7 ± 10.0 [a]	202.2 ± 4.4 [a]
Unsaponifiable matter *	0.6 ± 0.2 [a b]	0.5 ± 0.1 [a]	1.0 ± 0.2 [b]
Acid value**	0.8 ± 0.1 [a]	15.1 ± 1.2 [c]	10.2 ± 0.4 [b]
FFA (as oleic acid) *	0.4 ± 0.0 [a]	7.6 ± 0.6 [c]	5.1 ± 0.2 [b]
Peroxide value****	10.9 ± 1.3 [b]	11.7 ± 1.4 [b]	6.2 ± 1.2 [a]
Total phenols*****	30.3 ± 1.4 [a]	101.2 ± 6.3 [b]	117.3 ± 3.6 [c]
Total tocopherol*****	43.4 ± 0.3 [a]	106.1 ± 5.1 [b]	143.6 ± 6.3 [c]

Source: Falade, *et al.,* (2008a)

Values are means of triplicate determination ± standard deviation of mean.

Values in the same row with the same superscripts are not significantly different at the 5 % probability level.

*Values are expressed in %

** Values are expressed in g iodine / 100 g oil

*** Values are expressed in mg KOH / g oil

**** Values are expressed in meq Peroxide / kg

***** Values are expressed in mg / kg

Use of the SEM-EDX technique for investigating deposit structures and cuticular penetration of active ingredients

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Abstract

In our experiments the SEM-EDX technique was used to study cuticular penetration of active ingredients (a.i.), employing calcium (Ca) and tomato fruit cuticles as model system. For this purpose, tomato fruit cuticles were mounted on penetration chambers with their inner side in close-contact to a receiver solution; on the outer side of the cuticles Ca solution droplets were manually deposited. Structure of the deposits was systematically influenced by a) adding adjuvants to the $CaCl_2$ solutions; b) by holding the penetration chambers under 2 relative humidity conditions (RH = 40% or 78%); and c) by rewetting deposits 1h after droplet application. After 4h of penetration time, cuticles were carefully removed, dry-stored, and analyzed by means of SEM-EDX adopting Net Intensity (NI) as main parameter. Thereafter droplet spread and the surface effectively covered with Ca were determined. Net Intensity, droplet spread, and area covered with Ca were put in relation to the amount of calcium in the receiver solution. In general, samples under 40% RH showed higher area covered by calcium, lower Ca penetration, and higher NI than samples under 78% RH. The effect of adjuvants on NI was stronger at low RH, whereas their influence on Ca-penetration was higher at high RH. Rewetting of deposits induced redistribution of calcium within the original droplet footprint, especially when no adjuvant was added. On summary, there was a very strong (r = 0.99) correlation between NI and remaining deposit area, and a strong and negative (r = -0.70) correlation between NI and penetrated calcium.

Keywords : *agrochemical residues, a.i. penetration, quantification technique, residues.*

INTRODUCTION

The cuticle of leaves and fruits, composed mainly of cutin and cuticular waxes (Holloway, 1969) is the most important physiological barrier against water loss (Popp *et al.*, 2005; Vogg *et al.*, 2004; Riederer and Schreiber, 2001). Besides, it is also the first site of interaction for environmental pollutants and foliar applied agrochemicals and fertilizers. Many pesticides have to penetrate through the hydrophobic cuticle to display biological efficacy, whereas the a.i. movement through cuticle is more difficult for hydrophilic compounds (Schönherr, 2000). Cuticular penetration is a diffusion driven process (Mercer, 2007; Lamb *et al.*, 2001), which is influenced by several factors, such as characteristics of the target surface, physicochemical properties of the applied solution, and the interaction of both (Wang and Liu, 2007; Kirkwood, 1999; Matysiak, 1995). Moreover, environmental factors such as temperature and relative humidity may influence results decisively (Schönherr, 2001; Schönherr and Luber, 2001). Active ingredient (a.i.) diffusion across the cuticle occurs mainly during droplet drying when it is in a liquid or semi-liquid state, or in case of salts, after enhancement of the relative humidity (RH) above its deliquescence point. Under field conditions, dew or rain may also rewet pesticide deposits, modify their distribution at macro- and microscale (Hunsche, 2006) and influence the penetration rate with consequences for biological efficacy of some systemic compounds (Hunsche *et al.*, 2007a; Hunsche *et al.*, 2007b).

Experiments on cuticular penetration of active ingredients are usually done under controlled environmental conditions using well established systems such as the finite-dose chambers (Petracek *et al.*, 2004; Zabkiewicz and Forster, 2001; Bukovac and Petracek, 1993). Here, a solution droplet containing a given amount of a.i. is deposited on the outer surface of isolated cuticles from which a fraction of the xenobiotica diffuses through the membrane and is released to a receiver solution. Thereafter, the penetrated amount of a.i. can be analysed and quantified by using traditional analytical methods.

Analogous, the SEM-EDX is an established technique which is used to study the elemental composition of samples' surfaces (Goldstein et al., 2003; Roinel and Rouffignac, 1993; Morgan and Winters, 1993). Even though it does not give any direct information about the chemical composition of samples, it has the advantage to show a very good spatial resolution of elements at micro scale level, and semi-quantitative information about their concentration. One promising application field for this technique in agricultural sciences is the quantification of fertilizers and selected agrochemicals deposited on plant surfaces using selected parameters such as NI and Peak/Background ratio (Hunsche and Noga, 2008; Hunsche and Noga, 2009). However, there are no reports about the use of the semi-quantitative EDX analysis for studying mechanisms of cuticular penetration of pesticides and fertilizers, yet.

In our study we have hypothesized, Net Intensity of calcium residues on cuticles after penetration experiments correlates inversely with the real penetration of Ca. In order to induce systematic changes in deposit structure and penetration, three $CaCl_2$ solutions ($CaCl_2$, $CaCl_2$+RSO 5, $CaCl_2$+RSO 60) and two relative humidity conditions (RH = 40% and 78%) were chosen. Moreover, the dried deposit of half of the samples of each treatment was rewetted manually by applying one 1µl-droplet exactly on the original deposit.

MATERIAL AND METHODS

Tomato fruit cuticles

Studies were carried out on astomatous tomato (*Solanum lycopersicum* L.) fruit cuticles. Tomato plants (cv. Panovy) were grown pesticide-free in a glasshouse (University of Bonn), and harvested at the optimum maturity stage. Fruit discs were punched out with a cork borer (1.2 cm diameter) and placed for two weeks in a cellulose-pectinase enzyme solution, as described elsewhere (Hunsche and Noga, 2008). After enzymatic separation, cuticles were washed twice in distilled water, dried on Teflon plates at room temperature for one day, and stored in Petri dishes. Before experiments, integrity of cuticles was checked with a light microscope.

Chemicals

Calcium chloride (deliquescence point 33%) solutions at a concentration of 68 mM were prepared using hydrated calcium salt ($CaCl_2$ * $2H_2O$, Merck KGaA, Darmstadt, Germany) and bi-distilled and deionised water. Treatment solutions were established using $CaCl_2$ alone or in combination with one ethoxylated rapeseed oil adjuvant (1 g l^{-1}). The selected adjuvants, a rather hydrophobic (RSO 5; hydrophilic-lipophilic balance = 5.1) containing 5 ethylene-oxide (EO) units, or a rather hydrophilic (RSO 60; hydrophilic-lipophilic balance = 13.8) containing 60 EO units in the hydrophilic chain were supplied by Cognis GmbH (Düsseldorf, Germany).

Cuticular penetration of calcium

Studies on calcium penetration were done using the finite-dose system (Bukovac and Petracek, 1993) with some adaptations for our purposes. Briefly, the stainless steel penetration chambers having an internal volume of 1.3 mm^3 were filled up with deionized water, the isolated cuticles were placed with their abaxial surface in close contact to the water reservoir and fastened with a steel ring. On each cuticle three 1µl-droplets of a treatment solution were applied using a micro syringe (Hamilton, Bonaduz, Switzerland) and maintained in Plexiglas chambers under a constant relative humidity of 40% or 78%. After 1h drying time, residue deposit of half (n = 8) of the penetration chambers was rewetted. The rewetting was accomplished by carefully placing one droplet (1µl) of distilled water on the same position where the calcium chloride droplet was deposited one hour before. Thereafter, rewetted cuticles were returned to the respective environment with controlled relative humidity.

Irrespective of deposit rewetting, the whole penetration period was of 4 hours. After this time, cuticles were arranged individually into glass Petri dishes and dry stored in an exsiccator for the following SEM-EDX studies. The receiver solution was transferred from penetration chambers to Erlenmeyer flasks, which were filled up to 2 ml with deionised water, and the calcium amount was determined by atomic absorption spectrometry (Perkin-Elmer, Analyst 300 spectrometer, Wellesley, USA).

Determination of droplet spread area, calcium residue area, and Net Intensity

Dry stored cuticles were mounted with the abaxial side on SEM aluminium stubs using double-sided adhesive, electric conductive carbon planchets (Plano GmbH, Wetzlar, Germany). Analyses were done using an Environmental Scanning Electron Microscope (ESEM XL 30 FEI-Philips, Eindhoven, Holland) with a coupled energy dispersive x-ray analysis device (EDAX, Ametek GmbH, Meerbusch, Germany, equipped with a SUTW Si-(Li) detector, and the Genesis 4000 Software, version 3.61). Sample analyses were done using previously optimized adjustments (working distance 10 mm; pressure in the sample chamber 0.3 Torr; energy beam 20 kV, Spot Size 5.3, and amplification *x*50). After setting these adjustments, the calcium deposit was visually localized and centred, whereas the elemental composition of the whole displayed area and not just of the deposit residue was analyzed.

Following, the spatial distribution (mapping) and the standardless semi-quantitative analysis (NI) of elements (Figure 1) was accomplished for calcium (least activation energy = 3.72 keV) and chlorine (least activation energy = 2.66 keV). A complete description of the equipment device and elemental analysis can be found in Hunsche and Noga (2008). On each cuticle, measurements on an untreated position were taken and values served as control. SEM and EDX pictures were then appraised with the software Photoshop Elements 2.0 (Adobe Systems, USA); droplet spread area as well as area effectively covered with calcium were determined by considering the pixel counting as basis for calculations.

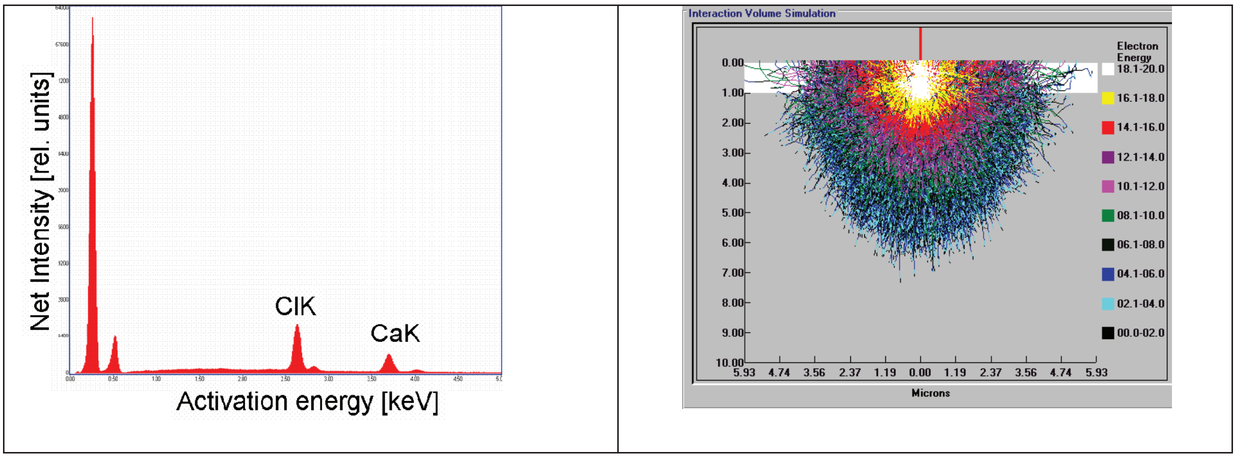

Figure 1. Energy dispersive x-ray microanalysis (EDX) of calcium chloride droplets manually deposited on tomato fruit cuticles. A) Spectrum of an EDX measurement showing peaks of carbon, oxygen, chlorine and calcium, respectively (x-scale indicates the activation energy and y-scale the counting rate). B) Estimation of interaction volume of the electron beam with the sample, and the depth of x-rays generation (scales in µm).

Statistics

Statistical analyses were carried out with the software SPSS 17.0 for Windows (SPSS Inc. Chicago, USA). Means were compared by ANOVA and correlation coefficients determined with the Pearson's bidirectional analysis. Graphs were designed with the software Sigma Plot 7.101 (Systat Software GmbH, Erkrat, Germany).

RESULTS

Calcium penetration

Penetration of calcium through tomato fruit cuticles was significantly influenced by relative humidity, addition of surfactants to the calcium solution, and deposit rewetting. As expected there was a significant interaction between all factors and a detailed examination is required. At 40% RH, there was no difference between the three calcium solutions concerning Ca penetration, which ranged between 25 and 38% of the total applied (Figure 2A). Deposit rewetting had no positive effect on calcium penetration, since even rewetted deposits dried down rapidly under this low relative humidity.

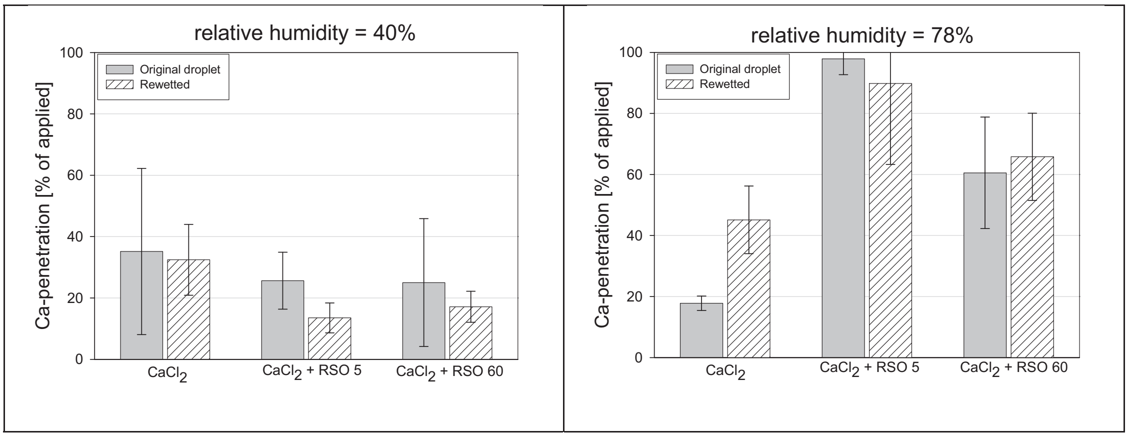

Figure 2. Influence of relative humidity, calcium solutions, and deposit rewetting on penetration of calcium across enzymatically isolated tomato fruit cuticles (Mean ± SE, n = 8).

At 78% RH highest Ca penetration was observed when the surfactant RSO 5 was added to the calcium solution, whereas lowest penetration was observed when unformulated calcium chloride droplets were deposited (Figure 2B). If due to high RH $CaCl_2$ deposits remain for a longer time in liquid form enabling cuticular penetration, on the other hand the employed adjuvants act also as humectants, retaining more water at the interface deposit-cuticle and turning the cuticle more permeable. As a consequence of deposit rewetting, a greater proportional increase of Ca penetration was registered when no adjuvant was in the original solution. However, this higher penetration level was still lower than those observed when adjuvants were added to the calcium solution. Besides, the great variance within treatments, explained in part by the big lateral heterogeneity in structure and permeability of isolated cuticles (Schlegel *et al*., 2005; Schönherr and Riederer, 1988) contributed for the non-significance of statistical tests.

Net Intensity

After penetration studies, cuticles were subjected to EDX analysis for determination of the area effectively covered with calcium and NI (relative units). When samples were exposed to 40% RH, NI increased from 8 (relative units) in case of applying unformulated calcium chloride to 28 due to addition of RSO 5 or RSO 60 (Figure 3). Significant increase of NI was also observed when calcium deposit without adjuvants was rewetted, corresponding to the increase of the area covered by calcium after its physical superficial redistribution (data not shown). When calcium was applied together with adjuvants, the increase of NI due to rewetting was comparatively low since adjuvants *per se* induced a high spreading and calcium distribution within the droplet footprint. The importance of the deposit microstructure, i.e. area covered with active ingredient, for the x-ray generation is discussed elsewhere (Hunsche and Noga, 2008; Hunsche and Noga, 2009)

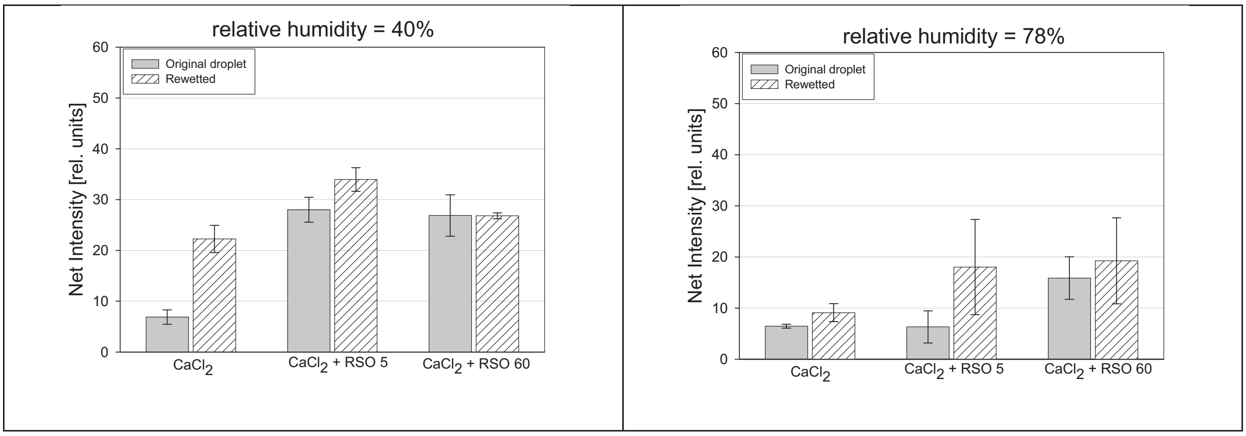

Figure 3. Influence of relative humidity, calcium solutions, and deposit rewetting on Net Intensity of calcium residues after a penetration study using enzymatically isolated tomato fruit cuticles (Mean ± SE, n = 8).

When penetration chambers were kept at 78% RH, NI was low and there was no statistical difference between calcium solutions. Rewetting of the deposit increased NI when adjuvants were present in the original droplet; however, treatments did not differ statistically from each other. In Figure 4 examples of calcium distribution within droplet spread area in dependence of relative humidity, adjuvants, and deposit rewetting are given.

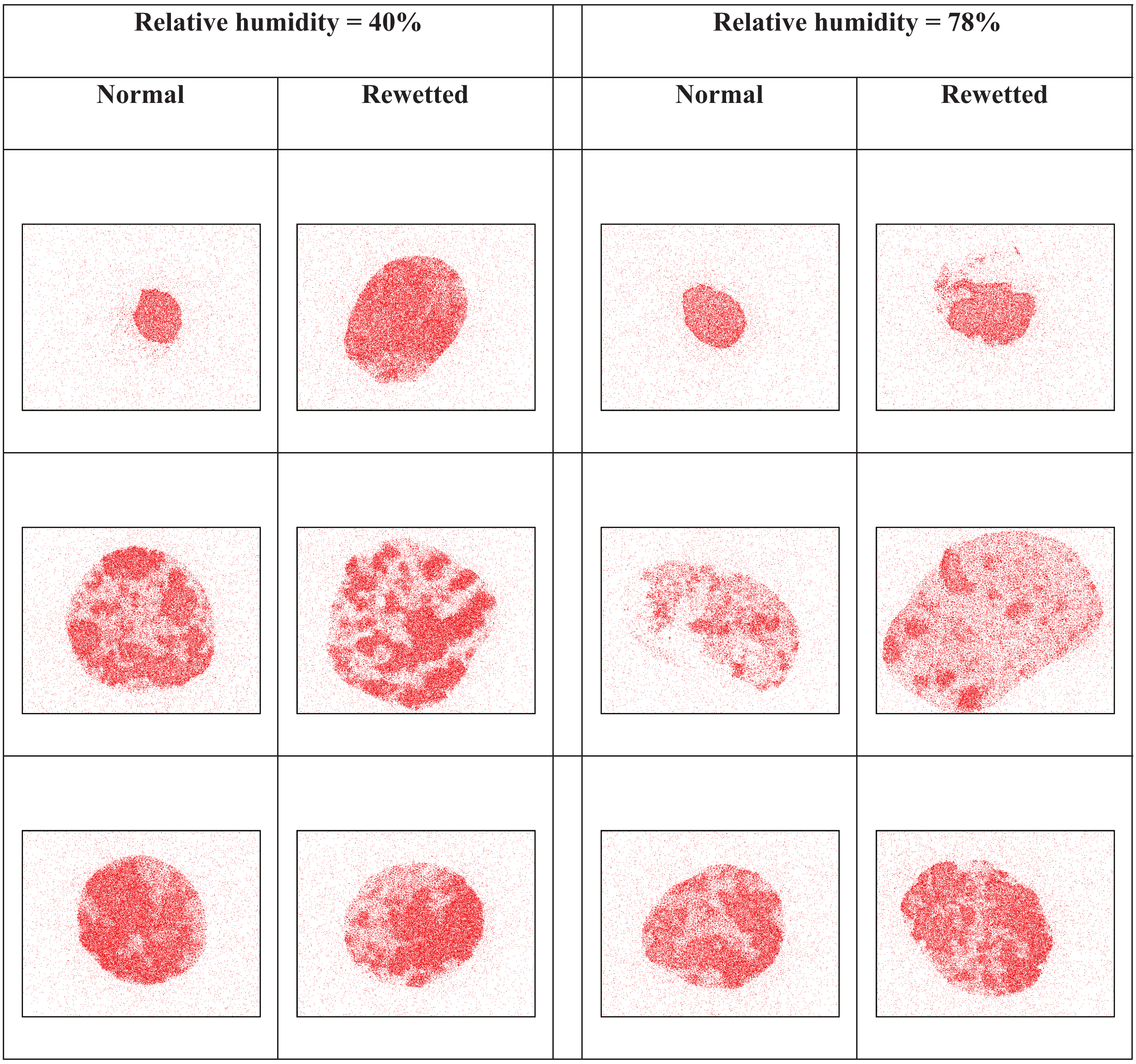

Figure 4. Representative images of the spatial distribution of calcium within the droplet spread area of $CaCl_2$ droplets deposited on tomato fruit cuticles as influenced by relative humidity, deposit rewetting, and adjuvants. The first row shows deposit of unformulated calcium chloride, the second of $CaCl_2$ + RSO 5, and the third of $CaCl_2$ + RSO 60 (magnification x35).

By plotting the penetrated calcium recovered from the receiver solution against NI generated from the calcium residue on the cuticle we observed a strong negative correlation (r^2 = -0.70) between these parameters (Figure 5). In the same figure one can observe that most samples under low RH showed low penetration and consequently high NI.

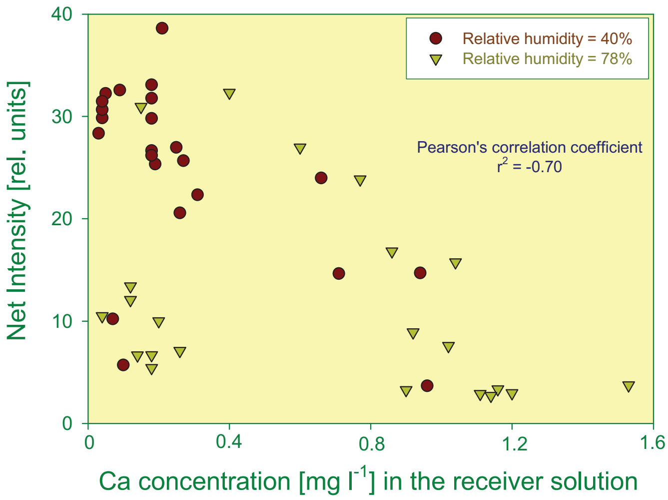

Figure 5. Relation between Net Intensity measured on cuticles and calcium concentration in the receiver solution irrespective of treatment solution.

Similarly, by plotting the area covered with calcium against NI irrespective of calcium solution or deposit rewetting, we observed a very strong correlation between parameters (Figure 6). This indicates that when the SEM-EDX is intended to be used in studies on pesticides or fertilizers quantification, not just the measured NI but also the area effectively covered with the selected element needs to be considered.

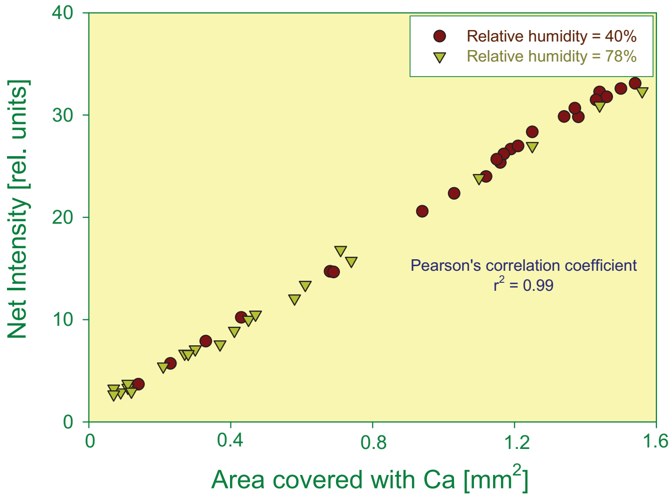

Figure 6. Relation between Net Intensity and area covered with calcium irrespective of treatment solution and deposit rewetting.

DISCUSSION

The aim of this study was to elucidate if there is a correlation between the penetrated calcium amount during a penetration experiment and the EDX Net Intensity of the non-penetrated calcium remaining on the cuticle. As expected, cuticular penetration of calcium was significantly influenced by adjuvants, relative humidity and deposit rewetting, whereas results depended on the interaction between the evaluated factors. Similarly, the other variables, i.e. area covered by calcium and NI were influenced.

Irrespective of relative humidity, addition of adjuvants and deposit rewetting increased the droplet footprint (not shown), area effectively covered by calcium and NI. While under 40% RH penetration and NI were low (Figure 5), under 78% RH both variables had values distributed over a larger range. Correlation between these variables was linear and inverse (r^2 = -0.70).

Net Intensity correlated significantly (r^2 = -0.99) with the area covered with calcium. Good correlation coefficients between NI and deposit area were obtained for calcium as well as for the herbicides glyphosate and glufosinate (Hunsche and Noga, 2009) when concentration ranges were applied on dry fruit cuticles. However, one has to consider that precision of EDX measurements is reduced by sample micromorphology, which depends on characteristics of sample surface and the generated deposit. By using flat surfaces as underground, the three-dimensional structures arise from the remaining deposit. On rough samples, penetration depth of the electron beam may be very heterogeneous, with adverse effects on x-rays generation and count statistics. In the present study the differences in samples micro morphology were negligible, despite of the different calcium distribution patterns within droplet spread area.

CONCLUSION

Results presented here elucidate the use of the SEM-EDX technique as an additional tool for studies on cuticular penetration of pesticides and foliar fertilizers. In our experiments there was a very strong (r = 0.99) correlation between NI and remaining deposit area, and a strong negative (r = -0.70) correlation between NI and penetrated calcium. The SEM-EDX is not as precise as standard analytical methods but it gives valuable information about the spatial distribution of the elements on the analysed surface. The information on the a.i. bi-dimensional distribution enables studies on the interaction between applied solutions and surface micromorphology, having significant impact on a.i. penetration.

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MAN AND HIS ENVIRONMENTAL CHALLENGES IN THE NIGER-DELTA SINCE THE EARLIEST TIMES: A HISTORICAL ANALYSIS

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Abstract

The impact of environment on people's ways of life cannot be over-emphasized. Indeed, man is said to be a product of his environment. The people of Niger-Delta region of Nigeria are no exception to this fact. The ways of life of the people of the Niger-Delta region have greatly reflected their environmental peculiarities. Against this background, this paper gives a historical account of the dependence by the autochthonous peoples of the Niger Delta on their environment as a source of livelihood. It is discovered that, across the Niger-Delta, fishing, farming, gin distillation, lumbering and canoe carving are some of the numerous traditional occupations from which the people earn their living. The aforementioned activities of the indigenous people were, and are still being determined by the environmental factors such as climate, topography, rainfall and so on ever before the advent of the Europeans and subsequent discovery of oil. The discovery and exploration of oil in the region since the 1950s have posed serious environmental challenges and have had a great impact on the peoples of the region. This paper examines some of the environmental changes within the region as a result of both internal and external factors and their attendant effects upon the inhabitants of the region. The paper also analyses how the peoples of the Niger-Delta have responded to their environmental challenges in the pre-oil period as well as to the environmental challenges posed by oil-related activities. These responses vary from occupational change-over, fishermen and farmer's movement/migration and violent reactions against foreign companies in form of pipeline vandalisation, abduction and other vices. This paper concludes that there is a lot to be learned in the history of the Niger-Delta peoples in our efforts to solving the lingering environmental problems of the region.

INTRODUCTION

Environment makes man and man resembles his environment more than his parents. In other words, what a man does for a living is conditioned by his environment and whatever man is able to achieve is made possible by his environmental peculiarities. This is due to the fact that human ingenuity and resourcefulness are not space-bound but the nature of the environment conditions their manifestation and development (Mabogunje, 1976: 1). Since environment makes man, scholars have held rightly that there is a close and enduring relationship between geography and history (Ogen, 2007: 205). This is because while history studies the activities of man in a particular environment over a period of time, geography studies man and his relationship with his environment. This implies that what history studies are determined by geography which determines the nature of the environment. As a matter of fact, the study of history of peoples at different ages has shown that environment played a great role in the ways of life of the inhabitants. This implies that a close interaction exists between the people and their land, between the course of history and the elements of environment (Mabogunje, 1976: 1)

Since environment plays a great role in human life and survival, it is imperative that people protect and manage their environment properly. Based on the series of scientific findings which indicated that poor environmental management endangers human life, the importance of environmental management dawned on many Nigerians, particularly the peoples of the Niger- Delta region where environmental degradation is at its peak due to oil exploration and exploitation (Preboye, 2005: 86-99). Babawale (2006) succinctly describes how environmental degradation peculiarly affects the people of oil-producing areas in these words: “When there is industrial pollution, it endangers the health of the people resulting in diseases while oil pollution in oil producing areas may rob the people of the right to work as farmlands are destroyed and rivers polluted” (Babawale, 2006: 144). This excerpt aptly describes the current situations of the environmental problems faced by the peoples of the Niger Delta which have received reactions and counter-reactions from the inhabitants of the region and the federal government respectively.

Indeed, access to, and control over natural resources is at the centre of the Niger-Delta crisis. This is more complicated by the fact that this access to, and control of natural resources popularly known as environmental entitlements are determined by the political institutions of the state (Oyesola, 1998: xv). In the case of the Nigerian Niger-Delta region and its oil mineral resources, there is little or no political leverage for the region to enjoy its environmental entitlements by the political institutions that reserve the power to grant such leverages This absence of political leverage coupled with the environmental degradation that is associated with the exploitation of the oil minerals and the almost total neglect of the development of the region have influenced the violent reactions of the peoples of the region to the political institutions through such vices as kidnapping, abduction, pipeline vandalisation and so on (Adesina, 2000: 78) This is the root of the crisis in the Niger-Delta region of Nigeria.

Against this background, this paper seeks to examine the nature of the environmental problems and challenges facing the peoples of the Niger-Delta and how they have been responding to these challenges since the earliest times till date. These challenges and problems may either be natural or man-made/human-induced challenges. This paper is provoked basically by the current unfortunate dynamics of the Niger-Delta environmental problems culminating into such vices as kidnapping, pipeline vandalisation, abduction and a host of others on the part of the inhabitants and the military sanctions, direct bombardments/destruction of communities and lately, the amnesty offer to the militants on the part of the federal government (Adesina, 2000: 78; Ebiri and Etim, 2009: 16). It is argued in the paper that while the government amnesty is good and appreciated, finding adequate solution to environmental degradation in the Niger Delta and providing infrastructural facilities in the region are the only ways out of the crises. This will provide opportunity to enhance security and development in the region. It is also posited that finding these solutions will depend greatly on the presence of sincere political will on the part of the government and positive human accommodation on the part of the peoples of the Niger- Delta.

From a historical perspective, this paper takes a critical look at the roots of these environmental problems and shows that restoration of peace and tranquility to the region depends greatly on tackling of the root causes of the problems. The paper is divided into six major parts. The first part introduces the theme of the paper while the second part gives a geographical description of the area referred to as Niger-Delta and some of the peoples who occupy the region. The third part of the paper describes the nature of the environmental challenges faced by the people of the Niger-Delta in the pre-colonial period and how the people responded to them. Part four of the paper examines the challenges of the environment of the Niger Delta region and the responses of the inhabitants to them in the colonial era between 1900 and 1960. The fifth part analyses the environmental challenges facing the people of the Niger Delta since the 1960s particularly those related to oil exploration and exploitation and the nature of the responses of the people. The last part concludes the paper by pointing out some of the historical lessons that are useful for successful restoration of peace and tranquility to the Niger- Delta region of Nigeria.

NIGER DELTA REGION OF NIGERIA: A POLITICO-ECONOMIC USAGE OF A GEOGRAPHICAL TERM

Without mincing words, it could be said that the geographical term 'Niger-Delta Region' has been, and is being greatly abused in its general usage in Nigeria. This is because the term is no longer being used in strict geographical sense but in political and economic terms. In strict geographical sense, the term Niger Delta region should denote only the communities that lie within the Delta of the River Niger (Ogen, 2005: 92). This is the basis of the categorisation of the Niger Delta into three - Western, Central and Eastern Delta. The area and communities between the Forcados and Pennington rivers are referred to as Western Delta, the area between the Pennington and Nun rivers are referred to as the Central Delta while the area between the Nun and Bonny rivers are Eastern Delta (Alagoa, 1972: 11-12). If taken as that, only communities in Bayelsa, Rivers, Delta and perhaps Akwa Ibom and Cross River States would properly and geographically be situated in the Niger-Delta region (Ogen, 2005: 92). As stated earlier, economic and political considerations relating to the exploration of crude oil and national sharing of its revenues have coloured what and who constitutes the Niger-Delta region in the national economic and political discourse in Nigeria.

In the contemporary Nigerian state, the term Niger-Delta is politically and economically used to denote all the crude oil producing states in the country such as the coastal oil producing states - Bayelsa, Delta, Rivers, Akwa Ibom, Cross River and Ondo as well as the inland, non-coastal oil producing states like Edo, Abia and Imo (Ogen, 2005: 92). These nine states belong to the Niger Delta Development Commission (NDDC). The Niger-Delta region as described in this political and economic terms is said to cover a coastline of some 560 kilometres and it is estimated to have more than 20 million inhabitants with about 40 ethnic groups and distributed into 3,000 communities (Nyong and Oladipo, 2003: 194-195). In its description of the geographical coverage of the Niger Delta, the Niger Delta Development Commission (NDDC) once stated that the region that constitutes the Niger-Delta extends from the Mahin Creek to the Bight of Benin and from Apoi to Bakkasi. If this is considered, then the people of the Niger-Delta region would include the Igbo, Ilaje, Ijaw, Urhobo, Isoko, Itshekiri, Ibibio, Annang, Andoni, Efik, Ekpeye, Kalabari, Ogbia, Abua, Odual, Engenni, Edo, Ishan, Etsako, Epie, Ogoni and a host of others (Nyong and Oladipo, 2003; 195). It must be noted that while some of the peoples mentioned here are found on the delta of River Niger, some are not. However, they, and others not mentioned here, are all considered the peoples of the Niger-Delta. The determining factor in this consideration is oil minerals found in the communities which these people inhabit.

With this brief description of the Niger-Delta region, our usage of the term in this paper would mean all the oil mineral producing states and communities in the southern part of Nigeria. This usage is adopted because, though the term 'Delta' is not coterminous with oil-bearing areas, all the oil-bearing areas face the same environmental problems and hazards.

HISTORICIZING ENVIRONMENTAL CHALLENGES IN THE NIGER DELTA: EARLIEST TIMES TO 1900

The settlement of human beings in a particular place is said to be both a geographical and a historical phenomenon (Ogen, 2007: 213). This is why the economic and political development of a particular group of people is closely related to, and is conditioned by the peculiarities of their climatic and physical environments (Udo, 1980: 7). The climate of the Niger-Delta region, like other parts of Nigeria, is divided into two: dry season and rainy season (Preboye, 2005: 55). A major climatic challenge facing the people of the Niger-Delta during the rainy season is the excessiveness of the rain particularly between June and September. During this period, the people witness natural hazards such as acidic rains, thunderstorms, squalls and winds which often led to wiping out of crops, fish ponds or even complete houses by floods (Preboye, 2005: 56). This period was a period of hunger for the people as they could not go out for fishing and other productive activities. Also, in the short dry season between October and March, there was a lot of haze and severe cold in this region and people find it difficult to see clearly in the ocean and on the seas. But since fish was abundant during this time, the people would go out for fishing and in most times, they got missing for days in the vast Atlantic Ocean while some even lost their lives (Preboye, 2005: 56). It must however be said that there is hardly a rain-free month in this region (Akpoghomeh and Badejo, 2002: 189). In both dry and rainy seasons, since the peoples have adequate knowledge of their climatic vicissitudes, they devised ways of coping with the natural challenges of their environment without much ado.

The physical environment of the Niger-Delta region can be divided into three belts of vegetation. These are the sandy beach ridges, the salt water swamp and the fresh water swamp area (Alagoa, 1972: 12-13). In all these areas, the traditional economy has been largely restricted to fishing, salt-making, and transportation has been mostly limited to the use of canoes, and in recent times, powered riverine boats (Udo, 1980: 7-8). However, the environmental differences between the different parts of the Delta as dictated by their geographical peculiarities such as the amount of climate, location, soil, vegetation, e.t.c. have influenced their ways of life - economic, social and political. E.J. Alagoa sums up the impact of environment on the economies of the different peoples of the Niger-Delta in these words:

From ancient times the inhabitants of the lower delta (sandy beach ridge and salt-water swamp) have had to exchange, mainly their fish and salt, for the vegetable produce of the upper delta (freshwater swamp). The lower delta people never produced more than a few plantations and coconuts in backyards garden. The groups of the upper delta, on the other hand, farmed their river banks after the floods receded each year, depositing rich silt. They farmed water yam (discorea alata linn), plantain, bananas, cassava (manioc), cocoyam (taro) and, more recently, swamp rice; as well as peppers, okro, sugar cane, maize and other crops in smaller quantities (Alagoa, 1972: 13-14).

From this excerpt, it is discernible that one of the major ways by which the people of the Niger-Delta have been coping with their environmental challenges was and is still occupational specialization. The people engaged mostly in the production of what their environment favoured and exchanged them for what they needed but could not be produced locally with their neighbours (Alagoa, 1972: 14)

Significantly, migration has been identified as one of the major instruments of environmental survival adopted by different peoples in human history all over the ages and in different parts of the world, particularly West Africa (Mabogunje, 1976: 1-32). The peoples of the Nigerian Niger-Delta are no exceptions to this basic fact. This is because migration is central to the early history of their settlement in the present environment of theirs. Various traditions of the people also point to the fact that the different peoples stopped and settled at different places within the region and at different times before they finally arrived at where they are today (Alagoa, 1972). Several factors may account for the migration of human groups from one geographical area to the other. These may include socio-political factors like the desire of princes to found their own independent settlements, the need for a better defensive position against enemies, the need to flee from the consequences of a fight between lineages and so on (Alagoa, 1972: 189). It is important to stress that all these factors that influence human migrations are not unconnected with the desire to exploit and control environmental resources of different areas.

However, the early history of the settlement of most Niger-Delta communities shows that migrations were largely due to social and political factors such as succession disputes and contest for fertile environments (Jones, 1963: 34). For instance, among the Apoi, some of their early migrations took place during interregnum caused by political problems and misunderstanding. The Nkoro traditions relate that their founders left Okrika and first settled at a place called Iyoba where they killed the Andoni and the Ogoni. These peoples fought back and forced the Nkoro to move to their present site now called Olom Nkoro (Alagoa: 1972, 166). Examples of such migrations abound in the early history of the settlements of other communities in the Niger-Delta. What is however must be noted is that majority of the peoples and communities in the Niger-Delta provided a pattern of migration and expansion within the Niger-Delta (Alagoa, 1972: 188). This shows that the peoples are autochthonous to the Niger-Delta region. Instances of reference to Benin or Ife are suspected to be as a result of socio-political affinities noticed between the Edo and the Yoruba which could be an influence of close economic contacts between these peoples in the past.

As indicated earlier, local and inter-state trade was another way by which the people of the Niger-Delta have adapted to the challenges of their environment. The various peoples of the Niger-Delta region maintained cordial relationship with both their immediate and distance neighbours (Alagoa, 1976: 354-358). The contacts between the various peoples of the Niger-Delta and the neighbours ranged from economic, social and political contacts. Apart from the contacts among the various Niger-Delta peoples, historical evidence show that the people of the Niger Delta such as the Apoi, Egbema and Ijaw maintained economic relations with their Edo and Ijebu Yoruba neighbours to the west and the Itshekiri to the east (Lloyd, 1967: 236). Since no human group can sufficiently provide for all its needs, the internal trade between groups within the Delta and their neighbours was basic to the life of the peoples of the Niger-Delta.

It is significant to state at this juncture that coastal piracy among the peoples of the Niger-Delta much popularized by the European writers is not only baseless but also misleading. This is because its origin could only be historically traced to the emergence of the European trans-Atlantic slave trade (Alagoa, 1972: 26-27). It continued well into the 19th century when the legitimate commerce in palm oil and European manufactures thrived. Piracy among the peoples of the Niger-Delta emerged as a result of the attempt of the peoples to participate in the distribution of goods resulting from the European overseas trade which was organized around state system at the expense of the stateless groups of the Niger-Delta. Thus, the Benin Kingdom through its famous Gwato port and Arbo as well as the Itsekiri and Warri ports benefited immensely from the European trade (Ikime, 1980: 89-108). This made the stateless societies of the Niger-Delta to resort to forcible entry into the trade through the so-called piracy exaggerated by the Euro-centric writers. This is However, not to say that there was no incidence of attacks on trading canoes and other categories of traders on the Niger-Delta before the advent of the Europeans. Since conflict is an unavoidable phenomenon in human co-existence (Abraham, 1982: 105), there were instances of clashes and attacks between and among the peoples of the Niger-Delta region in the pre-colonial era of the people's sojourn in their environment. However, the fact remains that piracy among the peoples of the Niger-Delta has been greatly exaggerated by European writers who claim that the Niger Delta peoples are innately militant.

The argument in this section is that the early history of the settlement of the Niger-Delta communities reveals that the peoples have adapted socially and economically to their environment. Their adaptation strategies range from occupational specialization, migration and internal as well as long distance trade with their neighbours. It is also shown that the peoples related cordially with their close and distance neighbours safe from skirmishes and conflicts which are unavoidable among human groups. The people of the Niger-Delta began to resort to piracy and other violent/militant methods in their attempts for environmental survival in the face of foreign exploitation of their resources first by the Europeans during the palm oil trade in the colonial era and currently by their local acolytes at the helms of the country's political affairs exploiting the oil minerals of the region.

NIGER DELTA AND ENVIRONMENTAL CHALLENGES IN THE COLONIAL PERIOD: 1900-1960

As indicated earlier, issues such as militancy, resource control, derivation formula and environmental degradation usually take the centre stage in the Niger-Delta region discourse. However, it must be emphasized that all these problems take their root from the environmental resources of the region. Geographically, the Niger-Delta region is a coastal environment with a chequered history of environmental problems. Such environmental problems are usually but erroneously traced to the epoch of oil exploration in the region. However, it is absolutely wrong to trace the environmental problems of the region to the emergence of oil exploration in the region. All the same, the period of oil exploration was the height of human-induced environmental problems in the region. On the other hand, the natural environmental problems of the region preceded the era of oil discovery and exploration.

Economically, the importance of the environment cannot be underestimated. Indeed, the environment is the economic bedrock of any society (Iroju, 2007: 90) and human survival is dependent on it. Interestingly, man has a natural culture of adaptation to any environment he finds himself. Thus, to a large extent, the Niger-Delta region as a coastal environment restricted the people within the region to coastal economic activities and modern maritime commerce in the twentieth century. The peoples of the region entered into the twentieth century with the old subsistence economic order that had been their means of livelihood for centuries. They maintained a local economy of fishing and salt making (Udo, 1980: 8). Farming and hunting are also indigenous economic practices of the people. Interestingly, the twentieth century opened with the colonisation of the country and the economy of the country was tied to that of Britain. Therefore, the Niger-Delta peoples, like other peoples of Nigeria, became suppliers of products for both local inhabitants and the European markets. These economic practices depended on the exploitation of the environmental resources such as land, water and forest resources (Uyigue and Agho, 2007: 9).

Obviously, the indigenous man's exploitation of the environment was the origin of environmental problems in the Niger-Delta region. Hence, it could be agreed that there was little knowledge about the effect of man's activity on environment. Perhaps, the low population of the region was yet to exhaustively compete for the abundant environmental resources of the region. Again, it could also be adduced to lack of awareness about man's activities and its attendant environmental damages in the region. The period of commercial petroleum ventures began in the middle of the twentieth century. Environmental damages were not pronounced before this period. Be that as it may, environmental degradation as a result of total dependence of the rural population on unsustainable agriculture, fishing, forestry and wild life exploitation was already a threat to the region (Uyigue and Agho, 2007: 11). These aforementioned human activities contributed to loss of vegetation in the region (Uyigue and Agho, 2007: 11).

In the opening decade of this century, the Niger-Delta environment played a dual economic role in caring for both the livelihood of the indigenous people, as well as the European markets. In furtherance of the economic role of the region to European markets, Sir Percy Girouard, the Royal Engineer in 1907 noted that the waterways were the axis of economic development (Kirk-Green, 1968: 81). Also, Ekundare stated that Nigeria depended largely on the natural waterways for the transportation of people and goods (Ekundare, 1973: 96). This however naturally afforded the Niger-Delta region another opportunity of commercial economic activities alongside the traditional economic activities. The major commercial economic resources were oil palm products and timber which were derived from the natural vegetation. Traditionally, the oil palm tree was a source of revenue for the people of the Niger-Delta during the European legitimate trade which followed the abolition of the Atlantic slave trade (Aghalino, 2000: 22), and thus its harvesting was unchecked. Beginning from 1900, palm produce constituted 89% of Nigeria's total export (Helleiner, 1966: 97). Since the primary aim of colonisation was economic exploitation, the colonial administration was with the intention to extract the region of her palm oil at the detriment of the environment. Hence, the large and unregulated harvesting of the natural palm trees drastically reduced the population of these natural trees, and in turn caused depletion in the vegetation. On the other hand, timber was a principal commodity of export (Geary, 1965: 129). Falola (1984: 169) has rightly asserted that: "the forest wealth i.e. timber was exploited as much as possible". During the period of commercial trade in timber, the Niger-Delta environment was a major supplier of timber to the tune of 50% of the nation's export. The demand for timber however worsened the indiscriminate and uncontrolled logging in the Niger-Delta region. These activities therefore ravaged the environment, and inevitably resulted in deforestation and change of vegetation (Uyigue and Agho, 2007: 8).

In addition, the argument here is that, since 1900, the Niger-Delta region was confronted with environmental menace resulting from man's natural exploitation of the environment for livelihood, as well as the quest to supply European markets with palm products and timber that were largely derived from the Niger-Delta region. The last years of the first half of the twentieth century was also the period ushering in oil exploration in the Niger-Delta region. Already by 1937, Shell D'Arcy arrived in Nigeria and embarked on exploration exercise (NAI O.K.D No 761/76). The constant search for oil concessions areas often led to massive felling of trees with no consideration for the communities where such was done. The felling of trees by this oil company was indeed a huge damage to the Niger-Delta natural environment. Where compensation was offered, it was mere stipends (NAI O.K.D No 761/76).

ENVIRONMENTAL CHALLENGES SINCE 1960: THE ERA OF OIL EXPLORATION AND EXPLOITATION

The development that accompanied the period 1960 upward was a new beginning of environmental challenges that had lasted about five decades in the Niger-Delta region. The environmental challenges that face the region are basically the outcome of the discovery of oil. Notwithstanding, the region was faced with tripartite level of environmental devastation. First, as earlier said, lumbering, oil-palm production, agriculture and fishing were the dominant occupations of the peoples of the region

(Imasogie, Omofenwan and Obareti, 2009: 1). Therefore traditional pre-existing subsistence economic structure of symbiotic relationship between man and his environment and its attendant negative effect on the vegetation was still much felt during this period of oil exploration. Therefore both subsistence and commercial purpose exploitation endangered the region. Osuntokun (1999: 3) rightly observed that: “It was also one of the ironies of Nigerian conditions that we are the sixth largest producer of petroleum in the world and have the world’s largest gas reserve, our people still resolve to wood for fuel”. This however explains the environmental hazards of the Niger-Delta region as a result of gas flaring which equally contributes to global warming (Osuntokun, 1999: 9), as well as the indigenous use of wood for fuel with its attendant effect of vegetation destruction.

In the second instance, this period also witnessed the indiscriminate harvesting of palm oil and timber in the Niger-Delta region for local and international consumptions. However, attention was majorly shifted to oil exploration following the discovery of oil in commercial quantity in Oloibiri in 1958 (Preboye, 2004). Nevertheless, the earlier mentioned economic activities were carried out alongside oil exploration in the region. The disastrous impact of these on the natural environment cannot be over-emphasised. The exploration of oil and its attendant man-induced environmental destruction at Oloibiri had left the once flourishing community to be a shadow of its former self. Despite the environmental hazards inflicted on Oloibiri, the first oil concession community, oil search and drilling activities had been on the increase since then. Out of about two thousand communities in the Niger-Delta about one thousand five hundred Niger-Delta communities are testimonies to the consequences of oil drilling exercise since the 1950s (NDDC, 2004: 22). These communities play host to oil companies such as Shell, Exxon Mobil and Chevron over many decades, which in turn had caused tremendous environmental hazards such as oil spillage, gas flaring, acid rain, pollution of all sorts in the region.

Since the emergence of oil companies and oil exploration in the region, oil spillage has been a major hazard to both the inhabitants and the environment of the region. It must be stressed that oil spillage in the region is a problem that affects both host communities and their neighbouring communities. For instance, in January 1986, there was water pollution as a result of oil spillage of about forty thousand barrels of crude oils from Mobil offshore platform in Idoho which affected nine coastal states including Lagos (Tokun and Adegbola, 1998: 17). For about two decades of oil drilling in the region, that is, between 1976 and 1996, there were a total of 4,647 incidents of oil spillage (Nwilo and Badejo, 2006). This amounted to the spill of approximately 2,369,470 barrels of oil in the environment and thus causing water pollution with untold hardship for the people of the Niger-Delta. In addition, between 1997 and 2001, the Niger-Delta region recorded a total of 2,097 oil spill incidents. The continuous oil spillage has incessantly made the environment hostile to the people. Indeed, oil spillage has given rise to intense water contamination, forest loss, fisheries depletion and serious effects on the entire ecosystem. In the same vein, the constant pollution of the environment has caused 5-10% of the mangrove forest to disappear (Wikipedia, 2009). The penetration of the viscous properties of oil into the water has wiped out large areas of vegetation. The loss of mangrove forest is not only degrading life for plants and animals but also for human beings whose major sources of livelihood depend on the environment and not on the economic benefits from the oil extracted by the multinational oil companies.

Similar to the environmental hazards from oil spillage, the Niger-Delta region is equally under deteriorating environmental conditions resulting from gas flaring (Udia, 2005), acid rain and biodiversity. These hazards further aggravate the obstruction of the peasant economic dependence of man on his environment. Considering the substantive damage done to the environment by the oil industries, the region has experienced tremendous changes in the socio-economic life of the people. Essentially, there has been serious problem of rural-urban migrations, occupational changes, cultural erosion and health hazards for the people. The environmental problems also afford the youths an excuse to vandalize oil pipelines in order to access crude oil and make financial fortunes (Ibibia, 2003: 23). The act of vandalizing oil pipelines by the rural youths is another major cause of oil spillage that is greatly affecting the natural environment of the Niger-Delta.

Among the numerous environmental threats that confront the region in the 21st century, it is important to point at the activities of multinational oil companies and the infliction of flood on the region. A report by the Environmental Study /Action Team (NEST 2004) clearly shows that there is regular occurrence of sea level rise and repeated ocean surges. However, the rise in sea level is associated with flood. This is equally expressed in the views of (Uyigue and Agho, 2007: 9) that the associated inundation will increase problems of flood. The presence of oil companies in the region has prompted constant dredging activities which inevitably led to the intrusion of sea water into fresh water sources, and thus leading to destruction of the ecosystem such as the mangrove, fisheries and general livelihood. By the last three decades of the twentieth century, there emerged a profuse growth in aquatic weeds known as water hyacinth. The invasion by this aquatic weed cuts across a larger part of the region and is impeding economic activities. In other words, the weeds are contributing greatly to the impediment of the economic activities of the people such as fishing, movement of logs to markets and in general terms, transportation in the region.

By and large, it is important at this juncture to state that the overriding effect of the activities of the indigenous peoples and the multi-national oil companies in the Niger-Delta is the environmental degradation of the region. While the people could cope with the natural environmental challenges of their environment through several measures, the environmental hazards resulting from the activities of the oil companies operating in their region have been so enormous and daunting. The over four decades of oil exploration activities have seriously produced a deplorable environmental condition for the inhabitants of the region. To worsen the situation, the political institutions of the country which are the major beneficiaries of the oil minerals of the region have not been responding adequately to the developmental needs of the inhabitants of the region. Consequently, this developmental neglect of the region on the part of the political institutions of the country is a major factor leading to the demand for resource control, transparent fiscal policy, abduction and kidnapping, militancy by the concerned people of the region.

CONCLUSION

This paper has succeeded to provide a historical analysis of the environmental challenges facing the peoples of the Niger-Delta region of Nigeria from the earliest times to the present discussing both the early natural environmental challenges and the contemporary human induced environmental problems. Today, the issue of the Niger-Delta region of Nigeria is no longer a mere environmental issue but an important socio-economic and political issue which poses a great challenge to the generality of Nigerian state and its nationals. While the people of the region which gives the country great economic fortunes in terms of foreign exchange earnings are wallowing in abject poverty, the funds derived from the natural resources of the region are used for the development of other parts of the country to the almost total neglect of the region. As a consequence, the youths of the region, in their attempts to agitate for the provision of basic amenities for their people have continued to resort to violent reactions and vices such as pipeline vandalisation, abduction and kidnapping and other forms of militancy.

Erroneously, many commentators tend to argue that the peoples of the Niger-Delta are innately violent and that this is the reason for the continued violence in the region in spite of what the government has done for the people through the activities of the Oil Mineral Producing Area Development Commission (OMPADEC), the Niger-Delta Development Commission (NDDC), the Federal Ministry of the Niger-Delta Affairs and other governmental and non-governmental agencies. In contrast, this paper maintains that no human being is innately violent but that people tend to be violent when injustice is continued to be meted out to them and every peaceful option has failed to solve the problem. The root of the lingering problems in the Niger Delta is environmental degradation by the activities of the multi-national oil companies and the refusal of the concerned political institutions that benefit from these activities to provide infrastructures for the inhabitants of the region.

Premised on the above, this paper recommends that the concerned governments at all levels in the country should embark on an aggressive and an all-round environmental development of the Niger-Delta region of Nigeria. Also, government should embark on afforestation projects as well as devise workable environmental policy that would regulate oil companies' operations in the region. Therefore this paper is of the opinion that the ongoing "Presidential Amnesty" for militants may end up as a mere utopian agenda. Rather, the genuine implementation of environmental development policies is an assurance to ending crisis in the region. In actual fact, if the problems of oil spillage, water pollution and gas flaring are not objectively addressed in the region, the militant groups would continue to enjoy the sympathy and support of the people and the vices would continue to thrive and peace would not be achieved. In addition, since environmental protection is an issue of international importance, this paper posits that international environmental agencies should intervene in the environmental issues of the Nigerian Niger-Delta to ensure that the international environmental protection standard is maintained by the Nigerian government vis-à-vis the Niger Delta region. On a final note, this paper posits if the Niger-Delta is developed infrastructurally, then the issue of militancy and its attendant socio-economic and political problems would be finally laid to rest. In other words, in infrastructural development lies the solution to the environmental problems of the Niger-Delta and their various dimensions over the years.

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LOGGING AND CARBON REMOVAL IN TROPICAL LOWLAND RAINFOREST ECOSYSTEM: A CASE STUDY OF ONDO STATE, NIGERIA

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Abstract

The implications of logging activities in the tropical rainforest ecosystem of Nigeria, with Ondo State as a case study, on climate change were examined in this study. Logging information from forest reserves and the free areas (unreserved forests) in the State were collected from the State's Forestry Department's official records, annual reports and files. The data collected were the species, volume and number of different economic timbers exploited on monthly basis between 2003 and 2005. Highest number of species, families and stems was exploited in the free areas when compared with what was removed from the reserves for the three-year period. However, more volume of wood was recorded for the reserves because of higher timber sizes. A total of 61 and 56 species were exploited from the free areas and the reserves respectively and the total number of stems from both forest types is 111,377 with an estimated volume of 295,089.67m^3. *Triplochiton scleroxylon* was the most exploited species in the State with an average of 13,801 stems per annum and as a result has the highest amount of carbon (13, 422.1 ton/year) and CO_2 (49,258.8 ton/year) removal from the ecosystem. The least exploited species was *Borassus aethiopical* (1 stem/year) and it has the least amount of carbon (0.57 ton/year) and CO_2 (2.1 ton/year). The quantity of carbon removed for the 3-year period stood at 120, 798.7 tons that translated to 443, 333.6 tons of CO_2. The annual carbon and CO_2 removal therefore was estimated as 40, 267 and 147, 778 tons/year respectively. The results of the student t-test show that there were no significant differences (p>0.05) in all the variables from the free areas and the reserves. Fast economic timbers are disappearing from both the reserves and free areas and the forest ecosystem is seriously disturbed during logging activities. The implications of this on biological conservation and climate change are grave. To make the forest performs his environmental role of carbon sink rather the present carbon source, urgent conservation measures (in-situ and ex-situ) are recommended.

Keywords: Logging, Biomass, Free Area, Forest Reserve, Carbon Sink

INTRODUCTION

Climate change is posing a dreadful threat to the development and poverty reduction processes in the poorest and most vulnerable regions of the world today. It has been considered as one of the most serious threats to sustainable development, with its adverse impacts expected on the environment, human health, food security, economic activity, natural resources and physical infrastructure (IISD, 2009; Dieudonne, 2001). Changes in climatic conditions have significant impacts on the capacity of the forest to provide vital ecosystem services and the well-being of people. African countries where there are low adaptation strategies and mitigation options are the most affected. The low adaptation capacity is due to the extreme poverty, frequent natural disasters such as droughts and floods and an agriculture that heavily dependent on rainfall (Huq et al., 2003). The greatest proportion of Nigerian population are rural dwellers who depend solely on natural resources for survival. The daily activities of this set of people (such as logging) in the forest are culpable of leading to forest degradation and alteration in environmental conditions. Logging has to do with the removal of tree species and the merchantable aboveground wood biomass that acts as carbon sink from the forest for sawn wood production. Houghton (1991) noted that the estimates of carbon fluxes from deforestation, land cover change and other disturbances depend on knowing the forest carbon stocks before the disturbance. Watson et al (2000) reported that the change in carbon storage in terrestrial ecosystems as a consequence of human land use was simplified in the Kyoto protocol to a forest – non-forest dichotomy, and its derivatives.

Above-ground biomass consists of all living biomass above the soil such as stem, stump, branches, bark, seeds, and foliage while below-ground biomass consists of all living roots excluding fine roots (less than 2 mm in diameter) (Drake et al, 2003; Samalca, et al 2007). Therefore, estimates of the total above-ground biomass in forest ecosystems are critical for carbon dynamics studies because plant biomass is an important indicator in carbon sequestration. The amount of carbon sequestered can be inferred from the biomass change since 50% of the forest dry biomass is approximately carbon (Losi et al., 2003; Montagu et al., 2005). For this purpose, one needs to know how much biomass is lost or accumulated over time. These estimates provide initial conditions for ecosystem and biogeochemical models that simulate the exchange of carbon and energy between the atmosphere and biosphere (Potter, 1999). In addition, biomass estimation is very useful in evaluating the amount of carbon sequestrated in the afforestation and reforestation Clean Development Mechanism (AR-CDM) project under the Kyoto Protocol (Hiratsuka, et al., 2003). There are two major methods of biomass estimation (the destructive and non-destructive). The destructive method requires felling of trees but the non-destructive method does not require the trees to be felled (Montes et al., 2000). For non-destructive method, tree growth variables are obtained for computing the total volume (m^3). Tree density, which can be found from literature, is used to convert the measured volume into biomass estimate (Aboal et al., 2005). Such estimate is used to quantify the amount of carbon removal from the ecosystem from the general knowledge that carbon is always 50% of biomass estimate (Samalca, 2007).

Many biomass and carbon estimation studies conducted focused on aboveground forest biomass (Aboal et al., 2005; Brown, 1997; Kraenzel et al., 2003; Laclau, 2003; Losi et al., 2003) because it accounts for the majority of the total accumulated biomass in the forest ecosystem. Aboveground tree dry mass was also estimated using allometric equations (Hiratsuka et al., 2006). However, where allometric equations are not available or feasible, Birdsey (1996) reported that timber cruise estimates of merchantable volume could be converted to biomass and weight by multiplying by a conversion factor for the corresponding region and forest type to determine the carbon mass in living standing trees. Renasingbe and Abasari (2008) also estimated tree biomass, weight and carbon storage from volumes using the same conversion factor. In view of the above, this study focuses on the assessment of above-ground forest biomass from volumes of trees exploited between 2003 and 2005 to estimate the amount of carbon removed during the period.

METHODOLOGY

The Study Area

Ondo State, located in Southwest Nigeria, was created on 1st April, 1996. It is an agrarian state that spread over a landed area of about 14788,728 km^2 and lies within longitudes $4^0 30'$ and 6^0 East of the Greenwich meridian and latitudes 5^0 $45'$ and latitudes 8^0 $15'$ North of the Equator. The climate is the humid sub-tropical indicating that it is basically within the tropical rainforest zone which is dominated by broadleaved hardwood trees that form dense layered stands.

Method of Data Collection

Secondary data for the reserved and unreserved forests (free areas) on the volume and the number of timber species exploited on monthly basis between 2003 and 2005 were collected from the State's Department of Forestry records and reports. The Departmental office is located at Akure, the State capital. The data was collected from the list of returns of felled logs in the 13 productive forest reserves scattered all over the State and the free areas.

Data Analysis

Data collected were analyzed separately for both forest types (forest reserves and the free areas) on monthly basis and generally for the period of study. The student t-test was used to compare and test for significant difference in the all the estimates obtained for the free areas and the reserves. These variables are number of stems, tree species abundance and family richness, volume, biomass and the amount of carbon in the felled logs. To quantify the total, annual and monthly carbon removal with the felled logs for the three-year period, total/monthly volume was converted to biomass in m^3 by using the formula of Renasingbe and Abasari (2008) given as:

Tree biomass (m^3) = 1.67 x volume of wood (m^3).

The biomass was converted to weight measurement with the formula given below:

1m^{3}of wood = 490 kg of dry weight.

The carbon content was estimated as 50% of the dry weight or biomass. Estimate of annual carbon storage in metric tons was done by dividing the total carbon for the three years by three. The relationship between carbon content and carbon dioxide was used to convert carbon in the wood to CO_2. This represents the amount of carbon the wood could sequestrate if they have not been logged or the amount of CO_2 to be released into the atmosphere if they act as carbon source. The relationship is given as follows:

1tC = 3.67 t CO_2 (NIACS, 2008; Renasingbe and Abasari (2008)). Carbon and CO_2 total harvest volume were estimated in metric ton (t). The analyses were performed using SPSS for windows 13.0).

RESULTS

Trees exploited from the Ondo State forest ecosystem by loggers were majorly tropical hardwood species of economic and timber values. Nowadays, virtually all species of trees including the lesser known and those that were not regarded as durable ones in the past are now logged for sawn wood production. In the forest reserves, logging policy has to do with the allocation of compartments to concessionaires by the Forestry Department after the payment of all necessary levies. Such allocations were done in the thirteen productive reserves in the state. The involvement of the government in logging activities in the free areas (unreserved forests) is limited to issuance of log certificate after the production of owner's consent by the loggers. From table 1, a total of 60,817 stems belonging to 61 different species were logged from the free areas while 50,577 stems of 56 species were exploited from the reserves. The species logged from the free areas and the reserves were distributed into 15 and 9 families respectively. Overall, 111,394 stems with diameter at breast height that ranged between 40 cm and 200 cm were removed from the forest ecosystem of Ondo state, Nigeria between 2003 and 2005. The volume of the removed wood from the free areas is 141,034.9m^3 and the corresponding value for the forest reserve is 154,209.8 m^3. The amount of carbon removed from the free areas amounted to 57,775.2 metric tons and 63,094.3 metric tons were removed from the forest reserves. This translated to 443, 333.6 metric tons of CO_2 the removed trees have the ability to sequestrate if they were to remain live standing trees. If these woods are burnt or decay, it is expected that this amount of CO_2 will be released into the atmosphere. There were no significant differences ($p>0.05$) in all the variables when comparison was done with the paired sample student t-test as shown in table 2. A very high standard error of mean estimate was also obtained. This could be attributed to the wide range in discrepancy of variables among the tree species.

Table 1: Summary of variables of the trees exploited and carbon removal in the study area between 2003 and 2005

Variables	*Location*		*Total*
	FA	FR	
No. of species	61	56	61
No. of families	15	9	17
No. of Stems	60,817	50,577	111,394
Volume (m^3)	141,034.9	154,209.8	295,244.7
Carbon storage (metric tons)	57,704.4	63,094.3	120,798.7
CO_2 storage (metric tons)	211,775.2	231,558.4	443333.6

Table 2: Results of Paired Samples t- test Statistics

Variables compared		*Mean	N	Std. Error of Mean	DF	P – values
Pair 1	Number of stem (FA)	830.7500	56	147.86609	55	0.827 NS
	Number of stems (FR)	903.1607	56	285.11072		
Pair 2	Volume (FA)	2003.1946	56	371.61995	55	0.436 NS
	Volume (FR)	2753.7446	56	855.99946		
Pair 3	Biomass (FA)	3345.3429	56	620.60548	55	0.436 NS
	Biomass (FR)	4598.7589	56	1429.52005		
Pair 4	Carbon (FA)	819.6071	56	152.04898	55	0.436 NS
	Carbon (FR)	1126.7000	56	350.23227		
Pair 5	CO_2 (FA)	3007.9571	56	558.01734	55	0.436 NS
	CO_2 (FR)	4134.9714	56	1285.35339		

**Mean of 56 tree species common to both forest types, NS - Not Significant (P> 0.05) degree of freedom = 55*

FA - Free AreasFR – Forest Reserves

The botanical names of all the 61 and 56 species exploited during the 3-year period in the free areas and the forest reserves respectively, their respective volumes, biomass and dry weights are presented in table 3. It is shown in the table that the number of stems logged from the free areas is more than the number from the reserved forest but the volume, biomass and carbon content of trees exploited from the forest reserves are more than what was removed from the free areas. The exploited number of stems is more in the free areas because of the logging policy that is somehow relaxed for loggers in the unreserved forest. Therefore, logging is haphazardly and indiscriminately carried out in the entire free areas without regard to the minimum timber size of about 48 cm DBH specified by logging policy. On the other hand, only the few that could afford the huge cost of possessing a concession could operate in any of the reserves. Trees from the reserved forests have larger diameter (not less than 48 cm DBH) than those from the free areas, and consequently the higher volume, biomass and carbon storage.

The mean monthly and annual rate of wood exploitation and carbon removal in the state is shown in table 4. Generally, more wood and carbon were removed during the dry season. The mean monthly carbon removal in the free area varied between 3,735 and 6,698 metric tons and between 1,998 and 9,397 metric tons in the forest reserves. The month with the highest carbon removal was June. The mean monthly and annual carbon removal in the forest reserves were 1753 and 21, 032 tons respectively while the values for the free areas were 1,603 and 19,235 tons. Therefore, the total annual carbon removal in the state was estimated to be 40, 267 tons and the CO_2 equivalent was 147, 778 tons. It should be noted however that these estimates are for timbers legally removed and recorded in the department's monthly report of timber felled in the State. There is no record for all logs illegally removed and estimating the value is very difficult presently.

DISCUSSION

If forest degradation is disregarded in the implementation of the REDD agreement, forests could lose much of their carbon, not to mention biodiversity and other ecosystem services, when valuable trees are harvested without regard to the ecological consequences (Broadbent *et al*. 2008). This is applicable to Ondo State, Nigeria considering the colossal volume (295,244.7m^3) and number of woods removed (111,394 stems) from the State's forest ecosystem for the three-year period covered by this study (table 1).

The annual and mean monthly carbon estimates in this study is corroborated with the assertion of Sasaki and Putz (2009) that the evergreen forest holds an average above-ground carbon stocks of 121.2 MgC/ha of which 71.4 MgC is in trees ≥45 cm DBH. Similarly, it was reported by Houghton (2003), Achard *et al*. (2004) and Gullison *et al*. (2007) that tropical deforestation and degradation globally will result in the release of an estimated 1.1–2.2 Pg Carbon/year (It should be noted however that 1 Pg C = 10^{15} g C). The total annual carbon obtained in this study (table 3) is less than the values obtained by the earlier mentioned scientists partly because the estimates in this study are for logs removed legally for sawn wood production only. Dahal (2008) reported that a single tree can absorb tons of carbon dioxide over its lifetime, and protecting a young plant and forests is equally important as planting. Conversely, Meyfroidt and Lambin (2008) stated that political instability and governance failures, wildfires as well as the uncontrolled and often illegal logging usually result in forest degradation and deforestation, which has continued unabated in the tropics. Oyebo (2006) hence puts the annual deforestation rate in Nigeria at3%. Similarly, Bond *et al*. (2009) reported that logging and poor management is leading to the loss of approximately 400,000 hectares of tropical forest in the Congo Basin each year. Therefore, the situation is common to most of the developing countries of West African sub-Sahara.

Also, IPCC (2001) noted that the rise in CO_2 concentration and emission could be attributed to human activities such as burning of fossil fuel, land use change and deforestation. The anthropogenic activities such as slash and burn, fire management and timber harvesting (indiscriminate logging) and encroachment have accelerated the release of Green House Gases from the forests (Canadell *et al*., 2007). These activities are very rampant in the State's forest estates and they resultantly have adverse effect on biodiversity conservation, ecosystem services and carbon storage. They are also very inimical to sustainable forest management.

Table 3: Tree species exploited and estimation of Carbon and CO_2 removed in the study area between 2003 and 2005

		Free Areas					*Forest Reserves*				
S/N	*Species*	Volume (m^3)	Biomass (m^3)	weight kg	Carbon (t)	CO^2 (tons)	Volume (m^3)	Biomass (kg)	weight (kg)	Carbon (t)	CO^2 (t)
1	*Afromasia elata*	18.7	31.2	15282.6	7.6	28.0	126.5	211.2	103498.6	51.7	189.9
2	*Afzelia Africana*	2348.5	3922.0	1921797.2	960.9	3526.5	19783.4	33038.3	16188756.2	8094.4	29706.4
3	*Albizia lebbeck*	4218.7	7045.2	3452131.1	1726.1	6334.7	391.7	654.2	320556.8	160.3	588.2
4	*Albizia zygia*	1074.4	1794.2	879181.5	439.6	1613.3	65.7	109.8	53778.7	26.9	98.7
5	*Alstonia boonei*	7756.9	12954.0	6347457.4	3173.7	11647.6	511.5	854.1	418526.9	209.3	768.0
6	*Astonia congensis*	153.4	256.2	125527.2	62.8	230.3	135.3	226.0	110716.0	55.4	203.2
7	*Amphimas pterocarpoides*	1183.1	1975.8	968133.2	484.1	1776.5	60.0	100.3	49124.2	24.6	90.1
8	*Antiaris africana*	10404.7	17375.9	8514187.3	4257.1	15623.5	545.2	910.4	446104.4	223.1	818.6
9	*Berlinia confuse*	408.4	682.0	334171.6	167.1	613.2	133.6	223.1	109304.4	54.7	200.6
10	*Blighia sapida*	555.4	927.5	454498.5	227.2	834.0	30.1	50.3	24653.7	12.3	45.2
11	*Bombax buonopozense*	1475.2	2463.6	1207160.3	603.6	2215.1	955.6	1595.9	781967.5	391.0	1434.9
12	*Borassus aethiopicum*	4.2	7.0	3436.9	1.7	6.3	0.0	0.0	0.0	0.0	0.0
13	*Brachystegia eurycoma*	5474.5	9142.5	4479801.4	2239.9	8220.4	3968.8	6627.8	3247636.3	1623.8	5959.4
14	*Canarium schweinfurthii*	1333.3	2226.6	1091024.7	545.5	2002.0	49.7	83.0	40693.2	20.3	74.7

15	*Carapa procera*	26.9	45.0	22041.7	11.0	40.4	0.0	0.0	0.0	0.0	0.0
16	*Ceiba pentandra*	12288.8	20522.3	10055931.6	5028.0	18452.6	4148.3	6927.6	3394514.6	1697.3	6228.9
17	*Celtis zenkeri*	3473.6	5801.0	2842479.6	1421.2	5216.0	548.7	916.4	449037.2	224.5	824.0
18	*Chrysophyllum spp*	2030.9	3391.6	1661904.3	831.0	3049.6	1267.3	2116.5	1037061.0	518.5	1903.0
19	*Combetrodendron macrocarpum*	39.9	66.7	32665.7	16.3	59.9	16.5	27.6	13518.3	6.8	24.8
20	*Cordia mellinnii*	3073.6	5132.9	2515138.3	1257.6	4615.3	23244.5	38818.4	19020998.9	9510.5	34903.5
21	*Corynanthe pachyceras*	12.3	20.5	10065.1	5.0	18.5	37.2	62.1	30427.7	15.2	55.8
22	*Danielia ogea*	1632.5	2726.3	1335909.1	668.0	2451.4	137.1	229.0	112195.5	56.1	205.9
23	*Dialium spp*	5271.7	8803.7	4313810.8	2156.9	7915.8	14.0	23.4	11488.9	5.7	21.1
24	*Distemonanthus benthamianus*	255.8	427.1	209282.7	104.6	384.0	68.0	113.5	55621.5	27.8	102.1
25	*Entandrophragma cylindricum*	1955.4	3265.5	1600099.7	800.0	2936.2	336.9	562.7	275718.0	137.9	505.9
26	*Entandrophragma utile*	473.1	790.1	387147.5	193.6	710.4	2.0	3.3	1603.9	0.8	2.9
27	*Enthrophilleum sp.*	623.5	1041.3	510228.1	255.1	936.3	1004.7	1677.9	822175.5	411.1	1508.7
28	*Ficus sp.*	4050.3	6764.1	3314389.1	1657.2	6081.9	14.4	24.0	11773.7	5.9	21.6
29	*Funtumia elastica*	28.0	46.8	22912.4	11.5	42.0	7.0	11.7	5728.1	2.9	10.5
30	*Gossweilerodendron balsamiferon*	6.9	11.6	5672.5	2.8	10.4	0.0	0.0	0.0	0.0	0.0
31	*Guarea cedrata*	109.8	183.3	89818.2	44.9	164.8	86.5	144.5	70791.1	35.4	129.9

32	*Hannoa klaineana*	1165.1	1945.7	953414.4	476.7	1749.5	129.2	215.7	105717.0	52.9	194.0
33	*Holloptelia grandis*	1714.6	2863.4	1403049.0	701.5	2574.6	1288.1	2151.2	1054063.7	527.0	1934.2
34	*Irvingia wombulu*	5.9	9.9	4828.0	2.4	8.9	0.0	0.0	0.0	0.0	0.0
35	*Khaya spp*	5994.5	10010.8	4905292.8	2452.6	9001.2	890.0	1486.4	728311.5	364.2	1336.5
36	*Lannea welwitschii*	2350.6	3925.5	1923516.4	961.8	3529.7	539.8	901.5	441729.0	220.9	810.6
37	*Lonchocarpus spp.*	235.0	392.4	192280.9	96.1	352.8	98.6	164.6	80651.6	40.3	148.0
38	*Lophira alata*	483.4	807.3	395569.5	197.8	725.9	76.3	127.3	62400.3	31.2	114.5
39	*Lovoa trichilioides*	86.7	144.9	70982.6	35.5	130.3	122.8	205.0	100464.3	50.2	184.4
40	*Mansonia altissima*	2503.9	4181.5	2048915.2	1024.5	3759.8	16276.5	27181.7	13319051.8	6659.5	24440.5
41	*Melicia excels*	10263.2	17139.5	8398340.6	4199.2	15411.0	922.7	1540.8	755009.4	377.5	1385.4
42	*Milleta thonningii*	5.5	9.1	4467.9	2.2	8.2	0.0	0.0	0.0	0.0	0.0
43	*Mitragna ciliate*	237.2	396.1	194090.9	97.0	356.2	414.7	692.6	339381.7	169.7	622.8
44	*Mitragyna stipulosa*	108.6	181.3	88843.6	44.4	163.0	13.4	22.4	10955.4	5.5	20.1
45	*Nauclea diderichi*	72.0	120.3	58924.1	29.5	108.1	811.0	1354.3	663605.3	331.8	1217.7
46	*Nesogodonia papaverifera*	1935.8	3232.8	1584082.3	792.0	2906.8	3285.5	5486.8	2688528.7	1344.3	4933.5
47	*Other spp.*	2526.3	4219.0	2067307.3	1033.7	3793.5	308.4	515.1	252385.0	126.2	463.1
48	*Pausinystalia johimbe*	35.3	58.9	28845.1	14.4	52.9	16.5	27.6	13518.3	6.8	24.8
49	*Phyllanthus discoideus*	356.1	594.7	291421.2	145.7	534.8	7.2	12.1	5919.6	3.0	10.9
50	*Pipetadeniastrum aficana*	1463.0	2443.2	1197145.1	598.6	2196.8	232.2	387.7	189985.5	95.0	348.6

51	*Pterocarpus santalinoides*	306.4	511.7	250718.1	125.4	460.1	2.8	4.7	2291.2	1.1	4.2
52	*Pterygota macrocapa*	3565.6	5954.6	2917731.3	1458.9	5354.0	2863.8	4782.5	2343427.9	1171.7	4300.2
53	*Pycnanthus angolensis*	2170.9	3625.4	1776452.4	888.2	3259.8	121.8	203.4	99686.9	49.8	182.9
54	*Ricinodedron heudelotii*	401.8	671.0	328770.0	164.4	603.3	418.3	698.6	342311.3	171.2	628.1
55	*Sterculia oblonga*	82.7	138.2	67707.8	33.9	124.2	249.2	416.1	203894.2	101.9	374.1
56	*Sterculia rhinopetala*	2346.4	3918.5	1920059.9	960.0	3523.3	17164.5	28664.8	14045743.1	7022.9	25773.9
57	*Strombosia pustulata*	18.2	30.4	14893.1	7.4	27.3	2.9	4.8	2373.1	1.2	4.4
58	*Terminalia ivorenses*	2113.9	3530.2	1729774.9	864.9	3174.1	2899.9	4842.8	2372973.4	1186.5	4354.4
59	*Terminalia superba*	9169.9	15313.7	7503693.2	3751.8	13769.3	23056.2	38503.9	18866896.6	9433.4	34620.8
60	*Triplochiton sceleroxylon*	16930.1	28273.2	13853891.0	6926.9	25421.9	24262.4	40518.2	19853930.1	9927.0	36432.0
61	*Zanthoxyllum zanthozylioides*	623.9	1041.9	510540.6	255.3	936.8	44.8	74.9	36679.5	18.3	67.3
	Total (3-year period)	141034.9	235528.2	115408836.6	57704.4	211775.2	154209.8	257530.3	126189856.4	63094.9	231558.4
	Annual value	47011.6	78509.4	38469612.2	19234.8	70591.7	51403.3	85843.4	42063285.5	21031.6	77186.1

Table 4: Monthly tree exploitation and carbon removal between 2003 and 2005 in the Study Area

Month	*Forest reserve*						*Free Areas*					
	No of Stems	Volume (m3)	biomass	weight (kg)	Carbon (t)	CO_2 (t)	No of Stems	Volume (m3)	biomass	Weight (kg)	carbon (t)	CO_2 (t)
January	5212	14086	23524	11526574	5763	21151	6036	15302	25554	12521627	6261	22977
February	4226	12149	20289	9941527	4971	18243	3053	10398	17365	8508683	4254	15613
March	4894	14103	23552	11540485	5770	21177	5788	14380	24015	11767154	5884	21593
April	5982	15571	26004	12741749	6371	23381	8456	15489	25867	12674649	6337	23258
May	3320	11908	19886	9744316	4872	17881	2010	10208	17047	8353206	4177	15328
June	6471	16370	27338	13395571	6698	24581	2466	22966	38353	18793078	9397	34485
July	2297	9938	16596	8132265	4066	14923	615	4884	8156	3996577	1998	7334
August	5281	14611	24400	11956181	5978	21940	4661	5117	8545	4187241	2094	7684
September	1824	9129	15245	7470261	3735	13708	5051	7074	11814	5788654	2894	10622
October	3005	11325	18913	9267248	4634	17005	6278	7124	11897	5829569	2915	10697
November	4492	13342	22281	10917759	5459	20034	6768	12509	20890	10236115	5118	18783
December	3573	11677	19501	9555289	4778	17534	9635	15584	26025	12752387	6376	23401
Total	50,577	154,210	257529	126189225	63095	231557	60,817	141035	235528	115408941	57704	211775
Mean/month	1405	4284	7154	3505256	1753	6432	1689	3918	6542	3205804	1603	5883
Annual	16859	51403	85843	42063075	21032	77186	20272	47012	78509	38469647	19235	70592

The roles of forest ecosystem in the global carbon cycle cannot be over estimated. IPCC, (2001) reported that forest stores about 80% of all above-ground and 40% of all below-ground terrestrial organic carbon. During productive season, it was claimed that CO_2 from the atmosphere is taken up by vegetation (Losi et al., 2003; Phat et al., 2004) and stored as plant biomass. In view of this, the UNFCC and its Kyoto Protocol recognized the role of forests in carbon sequestration. Specifically, Article 3.3 and 3.4 of the Kyoto Protocol pointed out forest as potential carbon storage (Brown, 2002). Therefore the present rate of disturbances in the forest ecosystem, due to natural and human influences, will lead to more carbon been released into the atmosphere than the amount utilized by vegetation during photosynthesis (Brown, 2002). Sustainable management strategies are therefore necessary to make the forest a carbon sink rather than source. Accounting for the carbon within forest ecosystems and changes in carbon stocks resulting from human activities is a necessary first step towards the better representation of forests in climate change policy at regional, national and global scales (Canadell *et al*., 2007)..Hence, the need to control logging and forest degradation in developing countries.

CONCLUSION AND RECOMMENDATION

The role of forest ecosystem in carbon sequestration is critical to climate change adaptation and mitigation. The huge volume of wood removed annually from the Nigerian tropical rainforest ecosystem as demonstrated in this study and other human activities are precursory to deforestation and carbon emission. If the present rate of log removal is not controlled, forests could become carbon source rather than carbon sink. Indiscriminate Logging without regeneration negates the Clean Development Mechanism policy. As a result, urgent conservation measure is recommended. Also, appropriate logging policies in the reserves and free areas, afforestation and reforestation and awareness of the effect of the continuous logging activities on the climate should be put in place by all tiers of government and individual.

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INVENTORY ANALYSIS OF URBAN FOREST TREE COVER:CHALLENGES AND OPPORTUNITIES FOR CLIMATE CHANGE ADAPTATION.

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Abstract

An inventory of trees in University of Agriculture, Abeokuta was conducted to provide some basic mensuration information on forest tree cover as an important element in human health sustainability and climate change adaptation. Data collection involved the measurement of all trees 5cm girth at breast height (gbh) and above, in the colleges i.e. inside and within 30 meters radius. Other parameters measured include total heights, and shade widths. A total of 87 trees representing 14 families were recorded. The analysis of tree parameters revealed the following about the status of tress in the campus: total volume; 11.57 m^3; total basal area; 1.21 m^2 and total shadewidth 372.3 meters. The per capita distributions were as follows; shade width, 1.11meters/head; and 0.26 trees/head. Trees in the *Mimosioides* family were more common with *Leucena leucocephala* predominating and of more importance. Diameter at breast height, total height, and basal area contributed significantly to the shade width as revealed by the multiple regression analysis. The conclusion was reached that presently the trees in the campus has fallen short of the minimum of 9 m^2 (WHO) standard green space per city dweller and far below the 2 trees mandatory to supply the oxygen needs of an individual each year. Hence suggestions were made on how to combat the challenges of urban deforestation and enhance the opportunities of forest trees as important elements in human heath sustainability and climate change adaptation.

Keywords: Trees, Urban forests, Climate change adaptation.

INTRODUCTION

The human habitat is rapidly undergoing transformation from rural to urban especially in developing countries like Nigeria. According to Henry David Thoreases, cities are places where “millions of people are feeling lonely together”. Urban cities are praised as centres of innovation and learning, transmitting and accumulation of knowledge on which future achievements can be built (Giravdet, 1993). Whether one like it or not, majority of the worlds population now lives in urban cities and further urbanization cannot be halted. By 2030, 60% of all people are expected to reside in cities and towns (Topfer, 2001). Also urban areas are said to be growing thrice faster than their rural counterparts (Palijon, 2002; WRI, 2004). Urbanisation is no longer an industrialized or developed world phenomenon alone. Urban areas in developing countries will account for nearly 90% of the projected world population increase between 1995 and 2030. According to Konijuendijk, et. al. (2004) very soon more than half of the Asian and African populations will live in urban areas while this will be between 75% and 85% for Central and South America (FAO 2002, WRI, 2004).

The ongoing urbanization has brought about a wide range of challenges across the globe and not only in terms of population growth. It is exacerbating serious socio-economic and environmental problems especially in the developing world like Nigeria. This is because more lands are needed for urban areas to provide inputs and outputs of resources and energy, with detrimental effects on forests and green areas. During the late 1990s and early 2000s, up to the present moment, more forests and urban vegetation have been lost to urbanization in Nigeria as a result of improved earnings and economic growth. More built structures, roads and utility layers has let to the massive destruction of urban trees and vegetations.

Managing and catering for urban populations will be one of the main challenges of our time especially in Nigeria where most emerging mega-cities are located. As the pressure to further develop open spaces continues, existing and future forests will take an ever-existing role as a necessary component of the urban landscape. This is now the case as the climate change is now very much with us, for the poorest of the poor, the implications are particularly daunting. These remote or marginalized communities are so burdened, they will struggle to meet the coming challenges. Adaptation, i.e. to cope with rising temperature and other effects of climate change is one of the responses to climate change. This is a difficult but essential tasks for the vulnerable millions of people

The second type of response is mitigation which involves reducing emissions of green-house gases to slow or stop the process of climate change. Adaptation is more relevant for poorer nations because of their relative vulnerability to the impact of climate change. This is partly due to their geographical location especially in drought-prone areas of sub-Saharan Africa or flood prone Bangladesh. Adaptation activities include using draught resistant crops, introducing new farming systems afforestation and diversifying income sources. As forests play a critical role in climate change adaptation, sustainable forest management is a necessary component of a global strategy to combat climate change. Many developing countries like Nigeria have a good core of professional planners and managers operating in key sectors but they are unaware of the potential impacts of climate change on their respective sector. This could be as a result of inadequate data and information on urban forest cover that will aid relevant planning. The objective of this study therefore is to carry out in inventory assessment and analysis of urban forest tree cover in University of Agriculture, Abeokuta, Nigeria. This will provide further necessary data for planners and decision makers as regards the challenges and opportunities available in incorporating tree elements in urban forest landscape planning.

MATERIALS AND METHODS

The field study was conducted in the University of Agriculture, Abeokuta (UNAAB) campus, established on the 1st January 1988 over an area of 10,000ha stratified into six zones. UNAAB lies within the humid lowland tropical rainforest with two distinct seasons: the wet season (March to October) and the dry season: (November to February). Mean annual rainfall is about 1113mm with peaks in July and September (Aiboni, 2001) while the mean monthly temperatures ranges from 23^{o}C in August to about 36°C in March. The area overlies the Precambrian metamorphic rocks of the basement complex (Jones and Hockey, 1964) with bedrocks predominantly of granite, hornblendes, gneiss, quartzites and quartzeschists.

This study was carried out where the core academic and non-academic activities were concentrated, i.e. College of Animal Production and Health (COLANIM), College of Agricultural Management and Rural Development (COLAMRUCS), College of Environmental Resources Management (COLERM), College of Natural Sciences (COLNAS) and College of Plant Sciences (COLPLANT) besides other academic and administrative structures. The UNAAB community is about 7,854 in population, made up of academic staff, 315; non-academic staff, 852, and students 5,677.

DATA COLLECTION

A complete enumeration of all trees and shrubs (> 5cm dbh) inside and within 20m radius in each of the 5 Colleges, i.e. COLERM, COLNAS, COLAMRUCS, COLANIM and COLPLANT. Some of the tree parameters measured include total height (m), girth at breast height (cm) and shade width (m). The period of data collection was 12.00 noon when the sun was overhead for maximum shade width assessment. The following instruments were used: girthing tapes, linen tapes, Haga altimeter and measuring rulers.

DATA ANALYSIS.

Tree Inventory data analysis.

The following information were obtained from the tree parameters collected:

$$\text{Tree Basal Area (BA m}^2\text{)} = \frac{g^2}{4\pi}$$

$$\text{Volume (Vol. m}^3\text{)} = \text{BA x Ht}$$

$$\text{Relative Shade Width (RSW)} = \frac{\text{Total Individual Sp SW}}{\text{Total SW of all Spp}} \times \frac{100}{1}$$

$$\text{Relative dominance (Rd)} = \frac{\text{Total BA of a spp}}{\text{Total BA of all the spp}} \times \frac{100}{1}$$

No. of individuals & a spp 100

Relative density (RD) = ---------------------------------- x ------
Total number of an spp 1

Importance Value Index = RSW + RD + Rd

(The (iv) provide an indication of a robust indicator of a spp importance than does relative abundance and size).

Descriptive statistical tools such as frequencies, mean, mode and percentages were used to analyse the variables of interest. The multiple regression was also employed to find out the relationship between Tree shade-width (sw) and some tree parameters such as BA, Ht, Vol. and gbh.

Model specifications: The model was specified in general form as:

$$SW = f(x_1 + x_2 + x_3 + x_4 + e)$$

Where = x_1 = Basal Area (BA); x_2 = Height (Ht); x_3 = Volume (Vol); x_4 = Girth (gbh)
e = error term.

Three functional forms were tried in order to choose the one with the best performance, viz:

Linear: $SW = b_o + b_1x_1 + b_2x_2 \ldots\ldots\ldots\ldots\ldots b_nx_n + e$

Semi log: $SW = L_nb_o + b_1L_nx_1 + b_2L_nx_2\ldots\ldots b_nL_n + e$

Double log: $L_nSW = L_nb_o + b_1L_nX_1 + b_2L_nX_2\ldots\ldots\ldots b_nL_nX_n + e$

Where: b_o = constant
$b_1b_2\ldots b_n$ = regression coefficients
e = error term
L_n = natural logarithms

RESULTS AND DISCUSSION

Tree Stock density and per capita distribution.

A total of 87 trees species in 14 families were recorded during enumeration in the study area. The trees had a total basal area (ba) of $1.21m^2$ and a total volume of $11.57m^3$. The highest number of trees occurred in COLERM and subsequently the largest in ba and volume (Tables 1 & 2). Tree shadewidths (SW) summed up to a total of 372.2m. *Leucena leucocephala* spp in Mimosioide family predominated in the entire study area. The results of this study showed that the study area is poorly stocked with trees species. This resulted into a low per capita distribution of some tree parameters as shown in Table 2, i.e. tree per capita; 0.26/capita and shade width; 1.11 meters/capita. The poor stock density could be due to the total clear felling when the campus was being developed. The management implication of these findings are firstly; green space is less than and far below WHO minimum standard of $9m^2$/city dweller, secondly; the tree per capita distribution is below the 2 trees mandatory to supply the oxygen needs of a person each year (Kuchelmeister, 1998).

Trees importance value index (IVI).

More than half of the total species were recorded in front of the Colleges with a larger number of them planted and in good condition. The IVI of *Leucena leucocephala* was 73.8, i.e. the highest (Table 3) indicating that the spp accounted for 73.8% of total importance. The second most important spp was *Eucalyptus camadulensis* (33.1), followed by *Terminalia catapa* (21.5) and *Azardirachta indica* (20.1). It can be observed from the table that importance was not evenly distributed. From a management perspective, a more equitable distribution of importance indicates that the tree population may be more stable and the future stream of benefits more continuous (Mc Pherson and Simpson, 2002).

Regression analysis

The linear model was chosen as the lead equation because it had the highest R^2 value of 0.927 (Table 4). This shows that the selected independent variables accounted for 92.7% of the variabilities in the tree shade widths (i.e. dependent variables). The summary of the full regression model shows that 3 out of the 4 independent variables such as gbh, ht and BA influenced SW of trees at 1% level of probability (Table 4). This shows that all trees, with a large dbh and BA has the tendency to have larger shade widths. These are some of the factors through which tree shadewidths can be determined or predicted in the study area. This finding agreed with Agbeja and Adesoye (2003) who recorded a significant relationship between shade widths and some tree parameters in University of Ibadan Campus, Nigeria.

CONCLUSION

It can be concluded from this study that tree stock density is low in UNAAB campus, i.e. only 87 trees which is less than 1 tree per meter square. Also the per capita distribution of trees and other parameters are very low in the study area. The management implication is that at the present level of tree stockings, the tree service requirements of the population in the study area cannot be met with respect to WHO standards. Hence the following management suggestions are offered. There is the need to step-up an annual tree planting campaign on campuses and other urban areas to meet the shortfalls in per capita distribution of trees services and to enhance the opportunities provided by trees and green spaces in order to cope (adaptation) with the menacing global climate change.

There is the need to carry out an inventory survey of undeveloped sites on campuses in order to ascertain some of the species that can be spared during future development activities to maintain and sustain tree service functions on the campuses and reduce genetic erosion or biodiversity of plants. Fast growing tree species both exotic and indigenous should be introduced into some of the open spaces on campus.

Finally, there is need to initiate programmes to stimulate afforestation, forest and range management and delineation of protected areas in urban step-ups.

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Table 1: Summary of inventory data and per capital distribution of some parameters.

	COLERM	COLPLANT	COLAMRUCS	COLANIM	COLNAS	TOTAL
Population Academic & Non-Academic	65	70	65	45	90	335
Area m^2	5400	8500	9000	8000	6300	37,320
No. of trees	49	25	7	3	3	87
Trees/m^2	0.009	0.0029	0.0007	0.000038	0.0005	0.0345
Trees/capita	0.75	0.36	0.11	0.06	0.03	0.26
Total BA (m^2)	0.3725	0.4919	0.2337	0.09	0.0179	1.206
Total Vol. (m^3)	5.10	4.01	1.37	0.87	0.13	11.57
Shade width (m)	79.13	209.5	45.5	17.5	20.6	372.3
Shade width/capita (m)	1.22	2.99	0.7	0.39	0.23	1.11

Source: Field Survey, 2005.

Table 2: Summary of the entire tree species recorded in study areas showing frequency, shade width, total basal and total volume.

Family Name	Species	Frequency	Total Shade Width SW (m)	Total Basal (BA) (m^2)	Total Vol. m^3
Mimosoideae	*Acacia nilotica*	2	12	0.0033	0.01
	Albizia zygia	1	12	0.0368	0.39
	Leucena leucocephala	12	133.5	0.3372	3.29
	Acacia fistula	2	8	0.045	0.26
Sterculiaceae	*Cola milleni*	1	3.5	0.0575	0.20
	Cola gigantia	1	10.5	0.1385	0.90
Combretaceae	*Terminalia catapa*	5	33	0.0703	0.29
Anacardiaceae	*Magnifera indica*	1	1	0.0032	0.01
	Spondia mombin	1	8	0.0127	0.12
Moraceae	*Ficus thoningii*	2	7	0.0078	0.03
	Ficus bengamina	1	3	0.0020	0.01

Meliaceae	*Azadirachta indica*	3	21.5	0.1202	0.38
Myrtaceae	*Eucalyptus camadulensis*	9	37.5	0.1405	3.86
	Syzygium guineense	1	6	0.0023	0.01
Palmea	*Eleas guinensis*	2	6	0.0287	0.12
Compositae	*Vernonia amygdalina*	2	4	0.0060	0.04
Apocynaceae	*Voacanga Africana*	1	2	0.0046	0.02
Irvingiaceae	*Irvingia gabonensis*	1	14	0.0796	0.84
Pinaceae	*Pinus carribea*	11	6.33	0.0120	0.03
Caesalpiniodieae	*Cassia siamea*	1	6.6	0.0029	0.01
Euphorbeaceae	*Cactus species*	11	5.8	0.0553	0.11
Total		**87**	**341.23**	**1.1665**	**11.2176**

Source: Field Survey, 2005.

Table 3: Clubbing of spp data to determine Relative Shadewidth (RSW), Relative Dominance (RD), Relative Density (RD) and Importance Value Index (IVI).

Family	Spp. Name	Feq.	SW (m)	BA (m^2)	(RSW) Relative Shade Width (a) %	Relative Dominance (RD) (b) %	Relative Density (Rd) (c) %	IVI % a+b+c
Mimosoideae	*Acacia nilotica*	2	12	0.0033	3.52	0.28	2.30	6.10
	Albizia zygia	1	12	0.0368	3.52	3.16	1.15	7.83
	Leucena leucoaphala	12	133.5	0.3372	31.12	`28.91	13.79	73.82
	Acacia fistula	2	8	0.045	2.35	3.86	2.30	8.51
Stereuliaceae	*Cola milleni*	1	3.5	0.0575	1.03	4.93	1.15	7.16
	Cola gigantia	1	10.5	0.1386	3.08	11.89	1.15	16.12
Combreteceae	*Terminalia catapa*	5	33	0.0703	9.68	6.03	5.75	21.46
Anacardiaceae	*Magnifera indica*	1	1	0.0032	0.29	0.28	1.15	1.72
	Spondia mombin	1	8	0.0127	2.35	1.09	1.13	4.59
Moraceae	*Ficus thoningii*	2	7	9,9978	2.96	9,67	2.30	5.03
	Ficus bengamina	1	3	0.0020	0.88	0.18	1.15	2.21
Meliaceae	*Azadirachta indica*	3	21.5	0.1202	6.31	10.30	3.45	20.06
Myrtaceae	*Eucalyptus camadulensis*	9	37.5	0.1405	10.99	12.05	10.35	33.39
	Syzygium guineense	1	6	0.0023	1.76	0.20	1.15	3.11
Palmea	*Elseas guinensis*	2	6	0.0287	1.76	2.47	2.30	6.53
Compositae	*Vernonia amygdalina*	2	4	0.0060	1.18	0.52	2.30	4.00
Apocynaceae	*Voaconga Africana*	1	2	0.0046	0;.59	0.39	1.15	2.13
Irvingiaceae	*Irvingia*	1	14	0.0796	4.10	6.83	1.15	12.08

	gabonensis							
Pinaceae	*Pinus carribea*	112	6.33	0.0120	1.86	1.03	12.65	15.54
Caesalpiniodieae	*Cassia siamea*	1	6.6	0.0029	1.94	0.25	1.15	3.34
Euphorbiaceae	*Cactus species*	11	5.8	0.0553	1.70	4.75	12.65	19.10

Table4: Summary of the Regression Model's Performance and Result of Analysis.

Variable	Regression coefficient	Standard Error	Beta Analysis	t-cal	Sig.
Constant	-1.033	1.942		-532	.600
X_1 Girth (GBH)	-10.599	3.745	-.583	-2.830	.010**
X_2 Height (Ht)	1.0967	.215	1.020	5.105	.000**
X_3 Basal Area (BA)	222.010	49.745	.619	4.463	.000**
X_4 Volume (Vol)	-2.730	3.045	-.103	-.896	.380
Criteria	**Linear**	**Semi-log**	**Double-log**		
R^2	.927	.524	.666		
Adjusted R^2	.914	.433	.603		
Standard Error	7.4170	18.9909	.6268		
F. Calculated	67.028	5.7754	10.478		
Level of Sig.	0.01	0.01	0.01		
Result of hypothesis	Reject Ho	Reject Ho	Reject Ho		

ENERGY VALUES OF CASSAVA TUBER BY-PRODUCTS FERMENTED NATURALLY AND THROUGH A CONSORTIUM OF MICRO-ORGANISMS

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Abstract

Samples of cassava peels (CP) and cassava starch residues (CRS) were obtained from garri and starch processing industries and each was subjected to six different treatments i.e. Fresh samples without any fermentation but was sun dried (T1); Fresh samples were put in polythene bags, tied securely and left in a covered shed to ferment for 5 days (T2; natural fermentation); Sun dried samples were inoculated with *Aspergillus fumigatus, Lactobacillus delbrueckii and Lactobacillus coryneformis* (T3*);* Sun dried samples were inoculated with *Aspergillus niger, Lactobacillus delbrueckii and Lactobacillus coryneformis* (T4)*;* Sun dried samples were inoculated with *Aspergillus flavus, Lactobacillus delbrueckii and Lactobacillus coryneformis* (T5) and Sun dried samples were inoculated with *Saccharomyces cerevisiae, Lactobacillus delbrueckii and Lactobacillus coryneformis* (T6). Thereafter, the nitrogen, crude fibre and gross energy values of the treated samples were determined and the metabolizable energy calculated. Result showed that the gross energy (GE) of the unfermented CSR was 2.70 kcal / g and this increased by 1.8 – 9.4 % (2.85 – 2.98 kcal / g) in the fermented CSR with exception of the one fermented with *A. flavus*. The GE of the unfermented CP (4.16 kcal / g) was significantly ($P<0.05$) higher than those obtained for the fermented CP (3.48 – 3.54 kcal / g); except for the naturally fermented sample (4.11 kcal / g). The same trend was observed for the ME (2.58 vs 2.73 – 2.89 kcal / g) for CSR which is 0.3 – 11.6 % increment and 3.54 vs 3.13 – 3.53 kcal / g for CP. The micro-organisms used influenced the caloric values of the by products with different intensities. It was suggested that these fermented by-products could be used to replace maize in the diets of non-ruminant animals to reduce the cost of finished feeds but it is necessary to also quantify the HCN contents to prevent toxicity.

Keywords: Cassava peels, cassava starch residues, fermentation

INTRODUCTION

The caloric value of any feed stuff is very important as it will help the feed formulator to know the level at which such can be included in the ration of animals, especially non-ruminants. Thus, the determination of the caloric values of feedstuffs is one of the prerequisites needed for channeling their nutrient potentials toward ration formulation or compounding. In fact, the field of ration formulation revolves round two principal nutrients: protein and energy, which must be satisfied in the formulation of any livestock ration especially non-ruminant, before cognizance is given to all other feed nutrients like minerals, vitamins, and dietary fibre (Njike and Ndife, 1980). The crucial role played by energy in the diet is underscored by the fact that animals essentially consume feed to satisfy their energy requirements (MAFF, 1984). Feed intake in livestock is therefore directly related to the energy density in the diet (Obinne and Okorie, 2008). Nutritionists world over have played around the energy content of rations to condition animals to diverse climatic or environmental exigencies and to improve livestock production and productivity (Butcher *et al*, 1983). This was achieved through the determination of energy values of diverse feedstuffs and the use of same towards the formulation of different diets designed to meet the need of specific livestock either in terms of age, breed, species or physiological state (MacDonald *et al*, 1995; Obinne, 2003).

The term “calorie-protein ratio” as used in livestock nutrition is another highpoint in support of the pride of place enjoyed by energy values in ration formulation. The “calorie-protein ratio” defines the amount of energy that should as a matter of importance go along that of protein in any standard diet for maximum utilization of both nutrients, since it is known that energy has a sparing effect on proteins. Literature is replete with the energy values of most cassava products, be it the peels, the leaves, the sieviates, the meal or the chips (Aletor and Fasuyi, 1997; Isaac *et al*, 2002; Olafadehan *et al*, 2008; Omoikhoje *et al*, 2008). The world of biotechnology has however added another dimension to the processing of cassava into value-added-modified products with greater prospects of utilization in both human and animal feeding. These include the various fermentation techniques aimed at producing nutrient enriched products (Oboh and Akindahunsi, 2003; Aro *et al*, 2008). This suggests that more products and by-products from cassava are now available for consumption by both man and animal and thus alleviating hunger among the resource poor populace. However, in most cases analytical information often reported are the proximate composition and mineral component.

Information on the energy values of cassava tuber wastes like the cassava starch residues and the cassava peels subjected to fermentation using selected micro-organisms in this region is rare. Thus, the objective of this study focused on the caloric assessment of two biotechnologically modified cassava tuber wastes – the cassava starch residues (CSR), a waste product of starch making industry and cassava peels (CP), a waste product from garri and flour processing industries, as a prelude towards their use in non-ruminant nutrition, especially in swine and poultry rations.

MATERIALS AND METHODS

Experimental Site

The experiment was approved by the committee on research study of the School of Agriculture and Agricultural Technology of the Federal University of Technology, Akure, Nigeria where both laboratory analysis and animal trial took place.

Collection and inoculation of samples

About 10 kg each of the composite fresh samples of cassava peels and cassava starch residues were collected from Matna Foods Limited – a cassava starch and garri processing industry located on kilometer 19, Akure-Owo Express Road, Nigeria. The fresh samples of the cassava peels were immediately washed with distilled water. Thereafter, the two samples were subdivided into six portions each and subjected to different processing techniques as follows:

T1 = Fresh samples without any fermentation but was sun dried

T2 = Fresh samples were put in polythene bags, tied securely and left in a covered shed to ferment for 5 days (natural fermentation)

T3 = Sun dried samples were inoculated with *Aspergillus fumigatus, Lactobacillus delbrueckii and Lactobacillus coryneformis*

T4 = Sun dried samples were inoculated with *Aspergillus niger, Lactobacillus delbrueckii and Lactobacillus coryneformis*

T5 = Sun dried samples were inoculated with *Aspergillus flavus, Lactobacillus delbrueckii and Lactobacillus coryneformis*

T6 = Sun dried samples were inoculated with *Saccharomyces cerevisiae, Lactobacillus delbrueckii and Lactobacillus coryneformis*

In all 12 processed samples were obtained (6 cassava starch residues; CSR and 6 cassava peels; CP). Prior to inoculation, each dried sample was heat-sterilized for thirty minutes in water-tight cellophane bags. Inoculation was done at 37^{o}C in cellophane-lined wooden trays measuring 60cm x 35cm x 4cm. The inoculated samples were then left for 120 hr to ferment after which they were sun-dried for two days and subsequently kept in airtight plastic containers in readiness for analysis.

Chemical analyses

The processed samples were analyzed for the proximate composition according to the methods of AOAC (1990). The micro-keljdahl method was used for crude protein determination (% N x 6.25) while the crude fibre was determined by alkali and acid hydrolysis.

The gross energy (GE) contents of the feeds and faeces were determined against thermo chemical grade benzoic acid standard using a Gallenkamp Ballistic bomb calorimeter (Cam Metric Ltd., Cambridge, England).

Calculations

The Metabolizable Energy (ME) was computed from the gross energies, nitrogen and crude fibre composition of the feeds according to the equation of Southgate (1975) as follows:

$$ME = 0.98\,(GE) - 6.6N - CF$$

Where: ME = Metabolizable energy

GE = Gross energy of the feed

N = Nitrogen intake of the animals on each feed

CF = the dietary crude fibre intake of the animals

Data obtained on GE and ME were subjected to one-way analysis of variance and the means were separated using SPSS Version 15 Statistical Package.

RESULTS AND DISCUSSION

Table 1 shows the results of gross energy values of both unfermented and fermented samples of CSR and CP. The GE contents of the fermented samples of CSR were consistently (P<0.05) higher than that obtained for unfermented sample with exception of the sample fermented with *A. flavus*. However, the GE values ranged from 2.67 kcal / g in the *A. flavus* fermented sample to 2.98kcal/g in the *A. niger* fermented sample. Thus, fermentation led to increase in gross energy level (1.8 – 9.4%) in all the samples except in the *A. flavus* fermented sample. This anomalous trend shown by the sample fermented with *A. flavus* is not unconnected with the fact that it is the only fungus in the group that is not classified as a generally regarded as safe (GRAS) organisms. *A. flavus* is the species of fungi widely known to be toxigenic and highly implicated in causing aflatoxicosis in livestock. Thus the observed decrease in the energy content of CSR fermented with *A. flavus* could probably have come from its inability to work synergistically with bacteria especially the lactic acid bacteria like the ones used in this trial, thus corroborating the earlier report of Nout, (1994). Also, the relatively low GE obtained in the unfermented CSR supports the observation of the factory workers who complained about the slow burning process of CSR in comparison with other wastes (Personal Communication).

Table 1: Gross energy values (kcal/g) of cassava tuber by products unfermented and fermented with a consortium of micro-organisms

Treatments	Type of Cassava by products	
	Cassava Starch Residues	Cassava Peels
T1	2.70 ± 0.01^{c}	4.16 ± 0.03^{a}
T2	2.85 ± 0.02^{b}	4.11 ± 0.04^{a}
T3	2.89 ± 0.02^{b}	3.48 ± 0.03^{b}
T4	2.98 ± 0.02^{a}	3.54 ± 0.03^{b}
T5	2.67 ± 0.02^{c}	3.50 ± 0.01^{b}
T6	2.88 ± 0.02^{b}	3.35 ± 0.02^{c}

$^{a,\,b,\,c}$ = Means in the same column but with different superscripts are statistically significant (P<0.05).

T1 = Fresh samples without any fermentation but was sun dried; T2 = Fresh samples were put in polythene bags, tied securely and left in a covered shed to ferment for 5 days (natural fermentation); T3 = Sun dried samples were inoculated with *Aspergillus fumigatus, Lactobacillus delbrueckii and Lactobacillus coryneformis;* T4 = Sun dried samples were inoculated with *Aspergillus niger, Lactobacillus delbrueckii and Lactobacillus coryneformis;* T5 = Sun dried samples were inoculated with *Aspergillus flavus, Lactobacillus delbrueckii and Lactobacillus coryneformis;*T6 = Sun dried samples were inoculated with *Saccharomyces cerevisiae, Lactobacillus delbrueckii and Lactobacillus coryneformis*

The gross energy of the CP was highest in the unfermented sample (4.16±0.03 kcal / kg) and lowest in sample fermented with *Saccharomyces cerevisiae*. A generally lower GE ($P<0.05$; except those fermented with *Aspergillus fumigatus*) values was observed in all the fermented CP samples compared with the unfermented sample. The lowest GE value was obtained in *Saccharomyces cerevisiae* fermented sample thus corroborating the findings of Chaven and Kadam (1989) that yeast fermentation mainly degrades the carbohydrate portion of feedstuff without substantial addition of energy. The degradation of the carbohydrate component of the CP by *Saccharomyces cerevisiae* and its bioconversion to other nutritive materials like amino acids, fatty acids and vitamins might have accounted for the lowest gross energy value observed.

Table 2 shows that the highest value (2.89 kcal / g) of the calculated ME for the CSR was observed in the sample fermented with a consortium of *Aspergillus fumigatus* and the two lactic acid bacteria (*Lactobacillus delbrueckii* and *Lactobacillus coryneformis*) but this was not significantly ($P<0.05$) higher than the value (2.86 kcal / g) observed for sample fermented with *Aspergillus niger* and the two lactic acid bacteria (*Lactobacillus delbrueckii* and *Lactobacillus coryneformis*). Also, the lowest value (2.58 kcal / g) was observed in the unfermented CSR sample. However, the present values are higher than the calculated ME values reported by Padmaja and Balagopalan (1990) in their study on *Trichoderma pseudokoningii* enriched cassava wastes/cassava flour mixture as an energy source in broiler rations.

Table 2: Metabolizable energy values (kcal/g) of cassava tuber by products unfermented and fermented with a consortium of micro-organisms

Treatments	Type of Cassava by products	
	Cassava Starch Residues	Cassava Peels
T1	2.58 ± 0.01^{c}	3.54 ± 0.04^{a}
T2	2.73 ± 0.02^{b}	3.53 ± 0.04^{a}
T3	2.89 ± 0.02^{a}	3.35 ± 0.02^{b}
T4	2.76 ± 0.02^{b}	3.35 ± 0.02^{b}
T5	2.86 ± 0.02^{a}	3.33 ± 0.02^{b}
T6	2.74 ± 0.02^{b}	3.13 ± 0.02^{c}

$^{a, b, c}$ = Means in the same column but with different superscripts are statistically significant ($P<0.05$).

T1 = Fresh samples without any fermentation but was sun dried; T2 = Fresh samples were put in polythene bags, tied securely and left in a covered shed to ferment for 5 days (natural fermentation); T3 = Sun dried samples were inoculated with *Aspergillus fumigatus, Lactobacillus delbrueckii and*

Lactobacillus coryneformis; T4 = Sun dried samples were inoculated with *Aspergillus niger, Lactobacillus delbrueckii and Lactobacillus coryneformis;* T5 = Sun dried samples were inoculated with *Aspergillus flavus, Lactobacillus delbrueckii and Lactobacillus coryneformis;*T6 = Sun dried samples were inoculated with *Saccharomyces cerevisiae, Lactobacillus delbrueckii and Lactobacillus coryneformis*

The calculated ME of cassava peels gave values ranging between 3.54 kcal / g for the unfermented CP sample and 3.13 kcal / g for the *Saccharomyces cerevisiae* fermented CP. These calculated ME values revealed that fermentation of cassava peels led to a reduction in its ME content by between 0.3% and 11.58% (Table 2). This observation is at variance with the report of Olafadehan *et al.,* (2008) that obtained a slightly higher ME values (2.35kcal/g or 9.85MJ/kg) for the fermented cassava peel meal than for the sun-dried cassava peel meal (2.34kcal/g or 9.85MJ/kg). The decline in the ME of the peel as a result of fermentation can be attributed to the bioconversion of the high fermentable carbohydrates in the peels to other nutrients like protein, vitamins and fats. The significant rise in the level of crude protein in these by products as a result of fermentation reported by Aro *et al.,* (2008) and Kompiang *et al.*, (1995) gave credence to this bioconversion postulate. In general, the ME values for both the unfermented and fermented CP compared with that of maize (3.234 kcal / g), which is major energy source in non-ruminant nutrition.

CONCLUSION

It could be concluded that fermentation in most cases would enhance the caloric value of CSR while the reverse would hold true for the CP. The different caloric values observed using different micro-organisms for the fermentation suggests that improvement in energy value could vary with the organism used. Improvement in the ME value of CSR could be better realized through fermentation with *Aspergillus fumigatus* and lactic acid bacteria combination.

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RESPONSES AND ADAPTIVE CAPACITIES OF SMALL-SCALE CROP FARMERS TO CLIMATE CHANGE IN SOUTHERN NIGERIA.

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Abstract

Understanding farmers' response to climatic variation is crucial in designing appropriate pro-poor policy variety to mitigate the effect of climate change for the resource poor, small-scale crop farmer. The study was conducted in Ogun state to identify at the micro or farm household level the adaptive strategies used by crop farmers to mitigate climatic perturbations. Multistage sampling technique was used to select total of 256 small scale (≤ 2.0ha) crop farmers in the state. Data on production (input used and output quantities) and cropping practices were collected and analyzed. Also, information on perceived changes in climatic variables (rainfall and environmental temperatures) was collected. The results reveal that majority (86%) of the farmers agreed that there had been remarkable changes in climatic variables (increase in temperature and a reduction in both intensity and duration of rainfall) over the last decade. Effects of modernization, population growth and divine retribution were given as reasons for the change; however, 21% of the farmers could not link the changes to any known reason, though agreeing that the changes were not normal. Also, while 57% of the farmers reported that they know what to do to mitigate the effects, only 28% had adopted strategies to cope with the changes. Most of the young and educated farmers adopt off-farm employment as a measure to mitigate the effects. The reasons proffered for not adopting strategies includes lack of technical knowledge/information, lack of financial capacities, dearth of infrastructures and labour shortage. Some of the adaptive measures are late planting (52%), reduction in the length of the cropping cycle (22%), involvement in off-farm activities (14%), and change of crop mix (12%). It is recommended that formal and informal institutions, that provide information and support to the farm sector, should be strengthened. Also, targeted initiatives should be put in place, that will increase incomes and access to sustainable livelihood of the rural population.

INTRODUCTION

Understanding farmers' responses to climate change is crucial in designing appropriate policy variety aimed at mitigating the negative effects of climate change. This is because any development initiative that can be sustained in a world changed by climate must be enabled by building the adaptive capacity of people and defining appropriate technical adaptive measures (Kaur and Nicol 2008). The resource poor, small-scale crop farmer plays a pivotal role in the food security outcomes in Nigeria and in most sub-saharan African nation (Okuneye 1985; Okigbo 1995). The development roles of the small farmers in the economy of Nigeria cannot be overemphasized. They dominate the food production landscape; over 90% of the food consumed in Nigeria is from small arable crop farms. Next to the non sustainable crude oil, agriculture is the most potent source of revenue to the government (contributes 46% to the GDP); it employs over 70% of the active labour force (NBS 2007). It is also, a potent driver for rural transformation as it promotes the socio-economic wellbeing of the rural poor. Due to its strategic position, development economists are of the view that to achieve sustainable development, in most agrarian societies, agricultural development must precede economic and industrial development. The small farmers are faced with myriads of economic and environmental risks, which have profound impact on their productive capacities and vulnerability to income shocks. Schlenke et al., (2005) reported that consistent crop failures against a background of free-swinging market forces are not very conducive inducement to scratch a living from the soil.

Climate change threatens poverty reduction and the achievement of the development goals. This is because the poor depend directly on endangered ecosystems and their services for their well-being, and because, they lack the resources to adequately defend themselves or to adapt rapidly to changing circumstances (Venema and Cisse2004). Many poor and marginalized people, such as farm laborers and fishers, depend directly on ecosystem services for their livelihoods (Rosenzweig and Parry 1994; Molua 2002; and Kelly et al., 2005). They may be subsistence farmers; they may fish and sell some of the catch or depend on fish for much of their protein; they may hunt and gather in forests or common lands; they may work for wealthier farmers, and thus floods or droughts would affect their incomes. These people are particularly vulnerable to changes in environmental conditions and factors that may limit their access to resources. If the vulnerability of ecosystems to the impacts of climate change is not reduced, poverty is likely to increase and the likelihood of achieving the MDGs will diminish (Mendelsohn, 2006). Kurukulasuriya and Ajwad (2007) submitted that there is enough evidence that shows that the mean temperature has increased. On the otherhand, mean rainfall is expected to decrease, and its variance is expected to increase in Africa. This would impact negatively on crop yield and consequently pose a serious threat to food security among African countries. Kurukulasuriya et al. (2006) observed that sustainable development is at possible risk in most developing nations due to relative laxity on the part of their governments to tackle the problem of climate change. Measures to mitigate the impact of climate change, where it exists, have been slow and sparse. Moser et al., (2008) asserts that the planet's crises–rapid climate change, degraded ecosystems, scarcities of food, water, and energy – will outlast the present economic downturn (Global financial meltdown) that now absorbs the attention of global leaders and affects people worldwide.

PROBLEM STATEMENT

The poor are overwhelmingly the present and future victims of climate change. Its impacts are mixed with, and overlap the impacts of other syndromes such as rising food prices, vanishing demands, the financial crisis, energy shortages, ecosystem degradation due to other human causes, and demographic changes. The poor need adaptive capacity, which consists of assets, health, education, and governance to be able to mitigate the adverse effect of climate change. Thus among the rural poor adaptation is inseparable from development as the capacity to manage risk determines progress. People have been managing climatic hazards for years, however, the way in which individuals and communities adapt to climate change is now at the forefront of climate change policy, and rightly so. Some crises can be reversed, but the damage to climate and ecosystems that contain and support all life may be beyond repair and contribute negatively to economic prosperity. Yet the climate upon which human civilization is based is changing faster than imagined 20 years ago. The change is accelerating and will affect future economic growth and deepen the economic gaps (Mendelsohn and Dinar 2003).

The harsher conditions that climate change brings could lead to major changes to the African farming scene because only those farmers who have access to finance to manage high input farming using mechanization, agrochemicals and irrigation will succeed. In such a scenario, the survival of subsistence farmers, who currently dominate agriculture on the continent, lies in the balance. Scientists may indeed need decades to be sure that climate change is taking place but, on the ground, farmers have no choice but to deal with the daily reality as best they can. Poor farmers are the worst affected by, and least able to cope with, climate change impacts. Therefore the foundation of any initiative to address climate change hinges on individuals and communities being aware of the issues, owning the process of adaptation and having the capacity to undertake and maintain adaptation. To achieve this, there is a need to understand farmers' knowledge, attitude/perception and practices (response mechanisms) to climate change. In the light of these the study was designed to assess small farmers' response and adaptive capacities to climate change that underpins farm production and vulnerability to income shocks.

OBJECTIVES

Specifically, the study seeks to:

- assess farmers' present understanding and knowledge of climate change variables
- describe the knowledge pattern of coping strategies that can be used to mitigate the effects of climate change
- identify strategies adopted and limitations to farmers' capacity to manage climate change

METHODOLOGY

Study Area

The study was carried out in Ogun state, south-west Nigeria. Ogun State commonly known as the Gateway State is in South-Western Nigeria, and lies within the tropics. It is bounded to the West by Benin Republic; to the South by Lagos State and the Atlantic Ocean; to the East by Ondo State; and to the North by Oyo and Osun States. It was carved out from the old western region in 1976 and has an estimated land area of 16,409.26 square kilometers of which over 70 percent are suitable for arable crop production. The estimated human population is 3, 138,570 (NPC, 2006). Agricultural food crop production is the economic backbone of the State through cash crop production. Fisheries and forestry are also common. The vegetation cover ranges from high forest zone of rain forest in the Southern part to the predominantly Savannah region in the North. It has a tropical rainfall pattern, with the rainy season starting about March and ending in November and followed by dry season. The mean annual rainfall ranges between 128cm in the Southern parts to 105cm in the Northern areas. The State has twenty (20) Local government areas. The huge population of small-scale crop farmers makes the state ideal for the study.

Data, Sampling procedure and Analytical method

Data were collected from a 256 small scale (cultivating less than 2ha) farmers in the state. The multistage sampling approach was used to select 64 farmers from each of the 4 agricultural (Abeokuta, Ilaro, Ikenne and Ijebu) zones in the state. The sample frame was the list of farmers registered with the zonal extension offices. The structured questionnaire was used to elicit relevant data from the farmers; this was also combined with four Focus Group Discussion (FGD) sessions held in each of the zones. The exploratory nature of the study relied heavily on descriptive statistics in line with the study objectives. Frequency counts, percentages and charts were used to summarize the response distributions.

RESULTS

Socio-economic characteristics of the farmers interviewed

The socio-economic characteristics (sex, age, educational level, farm size, experience in crop farming, crop mix and ownership of farm land) the farmers are summarized in Table 1. As shown, there are more male (65%) farmers compared to female (35%) farmers. This is expected as women in rural areas of the state get involved in alternative economic activities such as marketing and processing of agricultural products. The mean age of the farmers is 52 years; most (47%) of the farmers are between the age range of 50 and 59 years. The highest education attained by most of the farmers was secondary education; while majority of the farmers (42%) had no formal education. Formal education influences knowledge level, and this, limits adoption and adaptation capacities to mitigate risks associated with climatic variations. Maize and cassava mix is the most dominant crop enterprise in the state. Yams and vegetables (leafy and fruits) are also intercropped to diversify incomes from crops and to meet family food needs. Majority (63%) of the farmers interviewed are land owners. This has implication for land use management as squatters/temporary holders may not be motivated to adopt long term soil management measures.

Farmers' percieved knowledge and adoption of Mitigation measures

Information on farmers' perceptions/knowledge of measures use to mitigate the effect of climate change was described present level of familiarity with associated effects of climate. Majority (57%) reported that they know the appropriate measure(s) to take to mitigate the effects. Some of the adaptive measures suggested/adopted (Fig.3) by the farmers to mitigate farm income risks in crop production are: late planting (62%), reduction in the length of the cropping cycle (57%), involvement in off-farm activities (44%), and change of crop mix (12%). Other measures highlighted include intensification of dry season farming using fadama (low laying flooded plains) resources. However, only about 28% of the farmers reported that they have actually adopted the some of the measures in crop production. Late/delayed planting is the most popular measure used by majority of the farmers. The reason for this is not unrelated to the fact that rain fed agriculture is the dominant production system practiced by farmers. Rainfall duration and intensity have overbearing effects on arable crop farming as they determine the timing of agricultural activities and sometimes, the types of crops to cultivate.

Constraints to Adoption of Measures

It was found that despite the farmers' knowledge of the different strategies to mitigate effects of climate change; only 28% of them have actually adopted some of the measures or combinations of measures. The reason(s) given for not adopting the measures include lack of technical/relevant information (32%), lack of financial capacity to try the measures (46%) , dearth of local facilities/infrastructure and farm labour shortage.

CONCLUSION

The small scale arable crop farmer in Nigeria occupies a critical position in ensuring household and national food security. Their production practices are characterized by minimal or no use of purchased external inputs in small (usually less than 2ha) intercropped farm holdings. This production situation makes them highly vulnerable to economic and environmental perturbations. The harsher conditions that climate change may bring could lead to major changes to the African farming scene because only those farmers who have access to finance to manage high input farming using mechanization, agrochemicals and irrigation will succeed. In such a scenario, the survival of subsistence farmers, who currently dominate agriculture, lies in the balance. The exploratory study analysed farmers' perception/knowledge of climate change and measures adopted to mitigate the adverse effect on crop production and the concumittant income shocks. It was found that the most noticeable evidence of climate change to the farmers are high environment temperatures and decrease in rain intensity and duration.

Table: Socio-Economic Characteristics of farmers

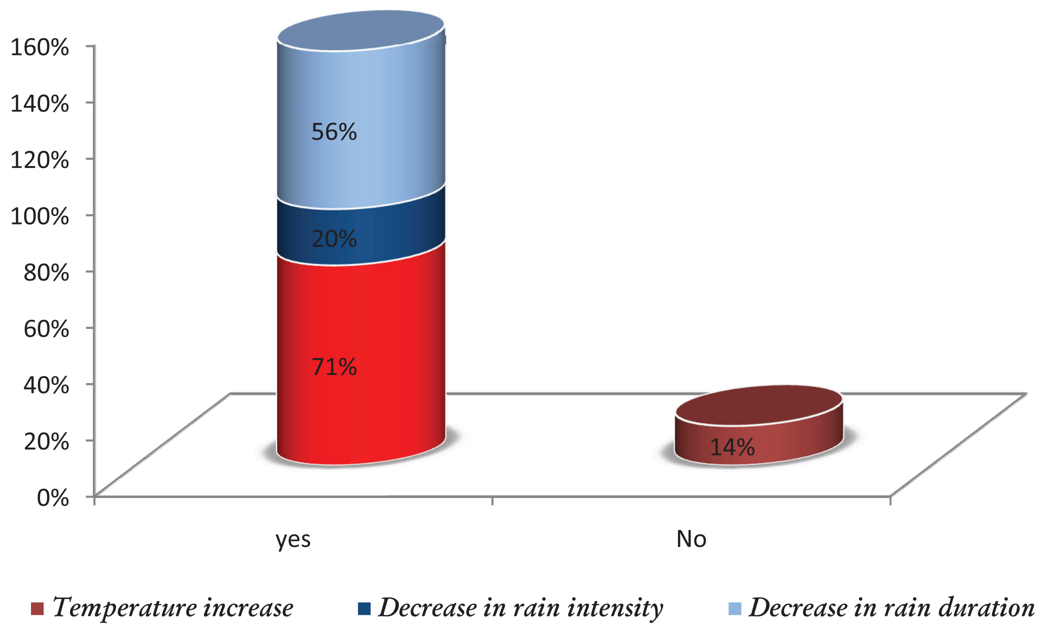
Socio-demographic characteristics	Freq	Percent	Mean	Min.	Max.	Standard Deviation
Sex						
Male	167	65.1	Na	Na	Na	Na
Female	89	34.9				
Age range						
30-39 years	28	11.1				
40-49 years	82	31.7	51.8	32	67	2.51
50-59 years	119	46.8				
>59 years	27	10.4				
Highest educational level						
No formal education	107	42.1				
Primary education only	99	38.8	Na	Na	Na	Na
Secondary education	50	19.1				
Farm size (ha)						
<1.00	125	49.2	0.92	0.13	3.21	5.23
1.01-1.50	90	34.9				
1.51-2.00	41	15.9				
Experience in crop farming						
< 10 years	51	19.9				
10-20 years	73	28.5	24.2	4	36	8.33
>20 years	132	51.6				
Crop enterprises						
Maize/cassava	85	33.3				
Maize/yam/cassava	54	20.9	Na	Na	Na	Na
Maize/vegetables/cassava	57	22.1				
Yam/vegetables	41	16.0				
Yam/maize/vegetables	19	7.7				
Land ownership status						
Land owner	161	62.6				
Non land owner	95	37.4	Na	Na	Na	Na

Source: Field Survey (2008), Na. Not Applicable

Farmers' observed changes in Climatic Variables

The farmers where asked if they had observed any noticeable changes in the climatic variables (rainfall intensity and duration and environmental temperature) in the last 10 years that has affected crop production activities. Majority (86%) of the farmers agreed that there had been remarkable changes in climatic variables (increase in temperature and a reduction in both intensity and duration of rainfall) over the last decade. Increase in environmental temperature (heat stress) was reported (83%) as the most profound climatic change observed. The farmers (65%) also reported that there has been a decrease in the duration (rain days) of rains. These changes they confirmed have affected, directly, crop production practices dramatically and have increase the riskiness of the business. It was also reported that predicting climatic effects has increasingly become difficult and most predictions, even from agricultural agencies, unreliable.

Fig.1:Observed changes in Climatic Variables



Farmers' Knowledge of Causes of climate changes

As highlighted above, majority (86%) of the farmers agreed that there have been profound changes in climatic effects in the last decade which have directly affected crop production practices. Following this assertion, questions were then posed to seek farmers' understanding on the reasons for/or likely causes of climate change. Most (37%) attributed the changes to outcome of modernization and naturally changing times, 31% reported that it was due to high population growth and 11% attributed it to divine retribution (act of God) were given as reasons for the change; however, 21% of the farmers could not link the changes to any known reason, though agreeing that the changes were not normal.

Fig. 2: Farmers' percieved Causes of climate changes

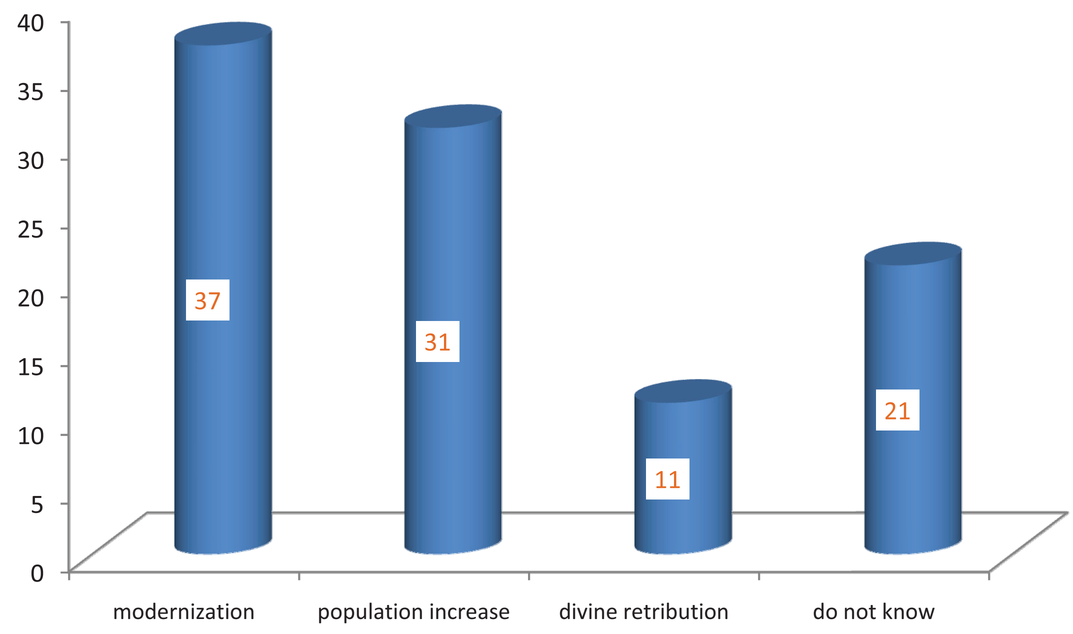
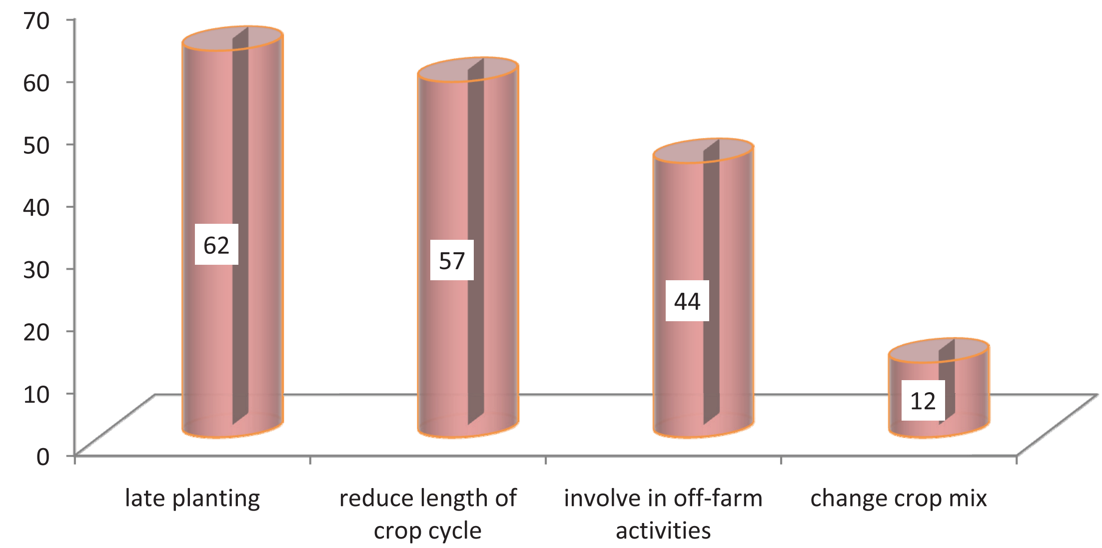


Fig.3: Perception rating of climate change mitigation measures



Educational qualification and climate change adaptation measures

The measures adopted by the small scale farmers to mitigate the adverse effect of climate change on livelihood was analysed in relation to the educational qualification. This was intended to highlight the associations that exist. The reason for this was to provide the basis for policy targeting in climate change adaptation measures based on differences in socio-economic (educational qualification) characteristics. As shown in the spider-web radar diagram (Fig.4), off-farm employment is the most preferred option for about 50% of the educated farmers while about 42% those with little or no education adopt delay planting. This is not unrelated to the enhanced latitude of opportunities available with increased education in the rural off-farm sector. This also has implications for sustainable agricultural development in the country as most young and educated farmers are being forced out of the farms by the adverse effects of climate change.

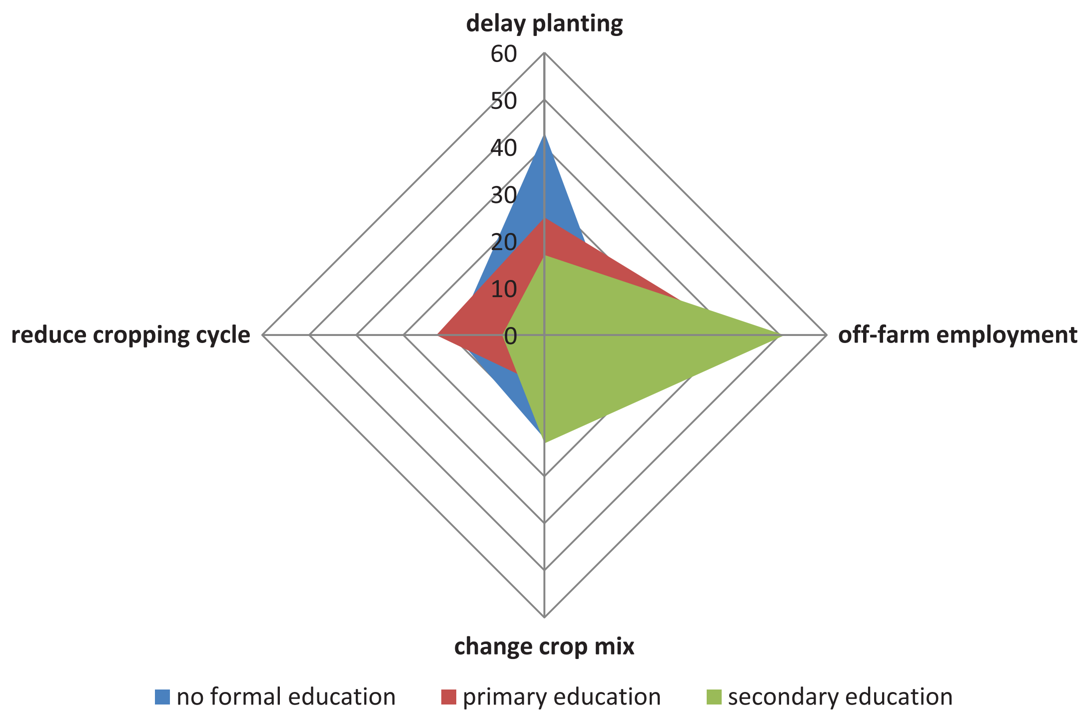
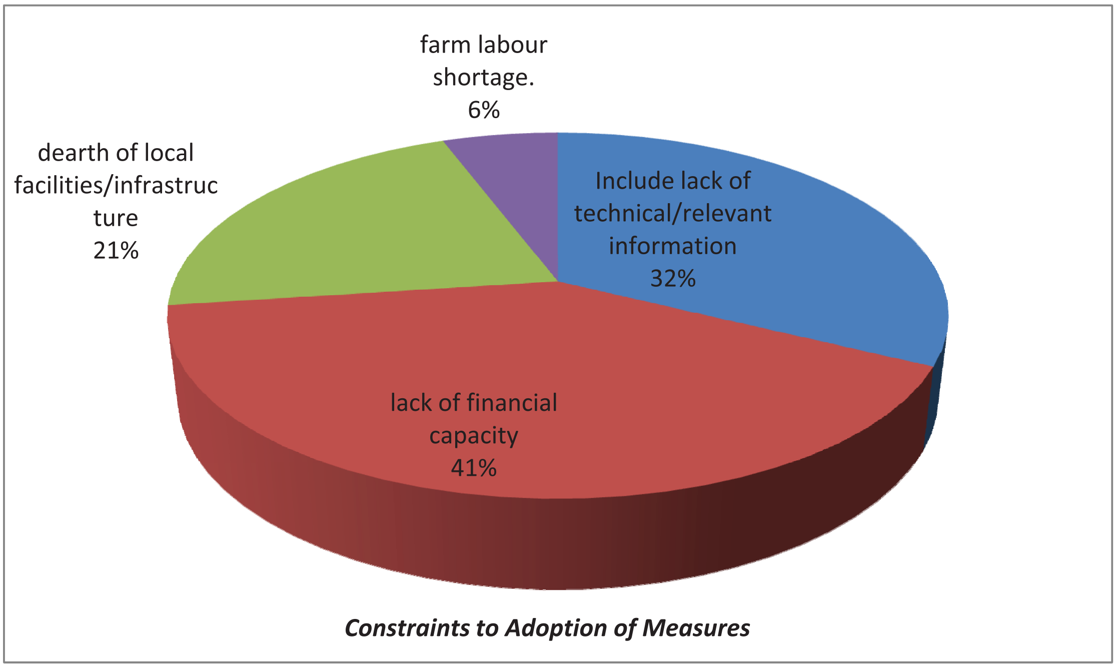


Fig. 4:Educational qualification and adaptation measures adopted



Majority of the farmers attributed the harsher climatic effects on modernization, population increase and divine retribution. However about 21% could not trace the effects to any known cause. To smooth income and consumption in the face of climate change the farmers adopt delay planting, reduction in crop cycle and involvement in off-farm income earning activities. Lack of technical information, low financial capacities and dearth of rural infrastructures were given as limitations to adopting the measures to mitigate the effects of climate change.

RECOMMENDATION

The study recommends formulation of appropriate policy measures that will increase environmental consuiosness of the farmers i.e, environmental education. Also, targeted initiatives should be put in place, that will increase incomes and access to sustainable livelihood of the rural population. Many of the human security impacts of disasters and climate change are linked and should therefore be addressed in a coordinated fashion. This means mutual learning, a common approach to vulnerability reduction with an emphasis on livelihood protection, a common institutional location, and a preparedness for surprises. Measures that reduce vulnerability and disaster risk are obviously also important for adapting to a more violent climate. These types of measures require clear government policy and possibly legislation at the national level, as well as capacity and resources for identifying and implementing appropriate action at the local level.

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AN ASSESSMENT OF THE EFFECT OF FLOODING ON LIVELIHOOD OF COASTAL DWELLERS IN SELECTED SETTLEMENTS IN LAGOS, NIGERIA

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Abstract

Flooding, which is a second order effect of climate change, poses great challenges to socio-economic well-being of many coastal dwellers in Nigeria. The degree of vulnerability varies between the rich and the poor dwellers of these coasts; hence, the study assessed the effect of flooding on the coastal dwellers in the context of their financial status. The objectives of the study were four-fold: one, it examined the existing physical structures such as building and the terrain of the coasts; two, it documented the frequency of flood in the recent times; three, it evaluated the capability of the existing structures to resist flood and four, it investigated various ways by which flooding in the areas is affecting their means of livelihood and their adaptation strategies in meeting the challenges of flood in the study locations and in all Nigerian coastal regions. Three coastal communities in Lagos namely, Eleko, Ilado and Akodo were purposively selected because of the assumed low income of dwellers. A total of 150 questionnaires (50 per coastal settlement) were administered. Systematic sampling was adopted after the house listing had been carried out. The methodology was designed to capture the perceived impact of climate change, and the resultant sea level rise and flood on the livelihoods of the residents as well as the impact on the physical structures in the communities. Analysis showed that the livelihoods of the residents were adversely affected. The residents were very vulnerable because of their poor financial status and high dependence on natural resources to cope. Vulnerabilities were heightened by the poor quality of housing, infrastructure, drainage and sea defences. Positive correlations were found between the degree of flood and vulnerability to challenges on livelihood indices such as farming (**r=0.518**), trading (**r=0.502**), tourism (**r=0.361**), environment (**r=0.411**) and income (**r=0.481**) which were all significant at **p=0.05** confidence level. This implies a considerable vulnerability of the settlements to climate change. Proactive approach was suggested in solving problems in coastal settlements in order to safeguard them from negative externalities of climatic perturbations such as sea level rise.

Keywords: *climate change, vulnerability, livelihoods, urban dwellers.*

INTRODUCTION

The consequences of climate change are numerous and these include, increasing temperature and rainfall variability. Climate change has serious impact on the hydrological balance of the earth system causing, sea level rise, coastal inundation, flooding, erosion and intensive rainfall (Ojo, 2007). Purvis et al (2008) in a recent estimation of future impact of sea level rise on coastal flooding submitted that the entire costal settlements in England face the risk of being affected by the phenomenon. This submission aligns with report of the Intergovernmental Panel on Climate Change (IPCC) 2007, which revealed that nearly 200 million people across the world live in high risk of coastal flooding as more cities actually are located on the sea coasts globally. Since the advent of the global warming phenomenon the water content of the world ecological system has altered and more critically is the increase in the sea and ocean water volume (Hollin and Barry, 1979; Flint 1971; Hansen, 1997a; Harvey 2000). In terms of the spatial dimension of the effects of global climate change, the regions on the higher altitude face more critical challenges from the melting of glaciers and its attendant losses there from. The expected effects on the countries at lower altitudes can be seen in their low technological capacity to cope in the wake of critical alteration of the physical environment. The implication of this is that an estimated 56-96 million people in Africa may be at the risk of losing their livelihoods. This has potential to increase the poverty level of the people in the developing countries.

A number of factors have been ascribed to the trend in global warming and climate change over the year, perhaps the factors can only be attributed to anthropocentric activities which have increased the production of green house gases and the role of natural cataclysmic incidents such as earthquakes and tsunami. Some evidence has also been found in the El Nino phenomenon but this has no universal evidence as many parts of Africa have no El Nino effects at noticeable degree. According to Butler (1990), there is a consensus among scientists that the atmospheric build up of green house gases namely Carbon dioxide, Methane, Nitrous oxide, Chlorofluorocarbons, and Ozone, may lead to global changes and to an associated acceleration in the rate of sea level rise. Global warming, the phenomenon used to describe an increase in the global mean surface air temperature of the earth (Harvey, 2000; Horel and Geisler, 1997; Hansen *et al* 1997a, 1984; Schneider, 1989), which affects the sea in two major ways namely through thermal expansion of water and the glacier and ice cap melting (Mercer, 1968).

The Intergovernmental Panel on Climate Change Third Assessment Report (IPCC 2001) WG II report notes that the current and future climate change would be expected to have a number of impacts, particularly on coastal system. Such impacts may include increased coastal erosion, higher storm-surge flooding, inhibition of primary production processes, more extensive coastal inundation, changes in surface water quality and groundwater characteristics. It also bring about increased loss of property and coastal habitats, increased flood risk and potential loss of life, loss of non-monetary cultural resources and values. Furthermore, it impacts on agriculture and aquaculture through decline in soil and water quality, and loss of tourism, recreation, and transportation functions. All these are directly detrimental to living. The report point out observed differences in coastal environments; regional and local, sea level and climate changes and in the resilience and adaptive measures.

Over the last century, global tides have risen by an average of around 20 cm (IPCC, 2001). This rise in sea levels has been linked to global warming by the IPCC which states that, as a result of large-scale loss of land ice and thermal expansion of sea water, '…it is very likely that the 20th century warming has contributed significantly to the observed sea-level rise…'. Sea-level rise and flooding are already affecting millions of people world-wide. According to the IFRC, 10 million people are at constant risk from coastal floods, and floods in general are making 3 million people homeless every year. Moreover, the number of those affected by sea-level rise and floods is increasing rapidly: 1998 saw the most catastrophic floods of the century, with up to 300 million people affected by torrential rains, storm surges, landslips, mudslides and tidal waves (IPCC, 2007).

Global average precipitation is projected to increase during the 21st century and sea levels are expected to rise by 20-100 cm before 2100. As a result, the IPCC predicted that there would be a ‘widespread increase in the risk of flooding for many human settlements’. Indeed, according to the IPCC, flooding and landslides pose ‘the most widespread direct risk to human settlements from climate change’. With half of the world’s population living in coastal regions, flooding due to storm surges already affects around 46 million people a year and mostly in developing countries. Studies suggest that with a 50 cm sea-level rise, this figure could double to 92 million. Indeed, it is estimated that by 2025 *over half* of all people living in developing countries will be highly vulnerable to floods and storms (IPCC, 2007).

Climate change is thus a very real phenomenon that is already affecting human populations. In line with what has been an expressed earlier, assessment of future climate change have highlighted the potential regional differentiation of impacts. IPCC has made suggestions as to how such changes might impact on human populations through changing patterns of weather and coastal flooding (IPCC, 2001). However, the failure to take account of the differential vulnerabilities of human populations to those environmental risks exposed a limitation of macro approach usually adopted in the cited studies of climate change impact. Understanding how different societies will respond to and adapt to these changes is thus a key element of research and policy relating to global environmental change (Katharine Vincent, 2004). This study is one of the attempts of assessing the impact of climate change from the perspectives of the real victims of the ravaging risks of climate variability at a micro/community level.

Flooding is a second order effect of climate change after sea level rise affecting coastal regions that are critically below sea level. The general problems of erosion and flooding that have suddenly characterised the coastal region of Lagos in the contemporary times have no basis in the past development of the region. Coastal inundation by water was a rarity in Nigeria until late 1980s. This coincided with the time of great earth warming globally. The problem of sea flooding in the coastal regions of Nigeria can no longer be attributed to low relief and rainfall intensity alone but also to the gradual increase in sea level leading to costal erosion and flooding. Ocean surges affect the adjoining settlements some of which, until recently, have been there for centuries without experiencing any critical threats from sea floods. It is therefore suffice to address this issue with three posers: what is the extent of the coastal flooding in the area of study; what are the visible impacts on the residents’ livelihoods and what is the spatial variability of these impacts. The spatial variability of the effects of sea flooding and erosion will definitely provide for the planners and government opportunity to identify the vulnerable areas to target mitigation measures. This study will constitute one of the studies in which multi-disciplinary approach was used in appraising extent of flood and its attendant socio-economic problems and with the aim of achieving the earlier stated objectives. This paper assessed the effects of flooding on livelihoods of residents in three of the numerous littoral communities in Lagos. The socio economic activities under consideration are those that are directly relevant to the survival of the majority of coastal dwellers such as farming, tourism, and fishing. The impacts on the environment and property along the coast also received our attention.

THE STUDY AREA

This study was carried out in three communities of Lagos,namely: Akodo, Ilado and Eleko which are located on the coastal region of Lagos. While Akodo is in Ibeju Lekki Local Government Area, Eleko and Ilado communities are small littoral settlements in Eti Osa Local Government Area of Lagos state. Akodo is the largest of the communities. The three settlements are noted for their fishing and farming activities. The settlements are also characterised by poor housing and dilapidated living residences. As littoral settlements all the communities have recreational tourist resorts that attract people from far and near especially during week ends. The population of the communities is composed of mixed ethnic groups but,Yoruba people form the majority. They share territories with some special and flourishing multi national companies which have their headquarters a few meters away from the coast. Around all these communities thriving agricultural and business activities are going on by those who find the areas as suitable abodes. But due to persistent sea incursion the livelihoods of these residents are under threat and their residences are threatened by sea tides and sea floods which have become more frequently than before.

METHODOLOGY

Primary data were obtained for this study. Three littoral coaster settlements were purposively selected for their frequent experience of sea flooding in recent time. House listing of the front row buildings facing the sea coast that were considered more vulnerable to sea floods was carried out, after which 50 respondents were selected in each settlement using systematic random sampling technique. The target respondents were residents whose means of livelihoods were directly and mainly dependent on coastal resources and coastal services. A total of 150 structured questionnaires were administered in all the three settlements selected for the study. The questionnaire sought information on residents experience about flood problem in their area, there socio economic profile as well as effect of flooding on their livelihoods

Data generated were analyzed using both descriptive and inferential statistics such as frequency, mean, standard deviation, correlations, and chi-square.

RESULTS AND DISCUSSION

Socio Economic Characteristics of Respondents

The characteristics of the communities can be summarily discussed under three main headings: socio economic, lifecycle and their geographic location. This has become crucial because these personal attributes could inform more on the effects that flooding may have upon the individual and the severity of sea flood on livelihoods. Socio-economic wellbeing indicators showed that out of 150 respondents 106 (70.7 %) were males and 44 (29.3%) were females. Variation within the localities showed that 33 (66%) of the respondents were male in Eleko, 38 (76%) also in Akodo and 35 (70%) males in Ilado. while out of the total 44 female respondents 17 were from Eleko, 12 from Akodo and 15 were from Ilado. The male skewed nature of the respondents is understandable since the targets of the survey were head of households whose livelihoods were dependent on coastal resources. This also reflected on the occupational distribution among the respondents, it revealed male dominated activities of farming and fishing. Other notable economic activities among the respondents include tourists guide and petty trading (See Table 1)

The ages of respondents ranged between 25 years and 75 years and the mean was 48.2 years. Going by the mean age of the respondents' one would expect that the effects of flooding on the livelihoods of the people might be severe because this age range could be classified as active population hence having their economic activities seriously hampered.

The income level in these communities was generally low and ranged between N15000 and N65000 per month. The mean income in all the communities was found to be N38,700.00 (see table, 1). This low income level might stem from the recent disruption in their livelihood resulting from sea level rise and associated flooding. But closely related to this is the level of education that the residents had. Study shows that only 128 (85%) of the respondents had at most secondary education and below while, 22 (14.7%) have never attended school in their life. However, these numbers vary among the three littoral communities under study (table 1).

Table 1: Socio- Economic Characteristics by Locations

Variable	All	Eleko	Akodo	Ilado
Male	106 (70.7)	33(66.0)	38 (76.0)	35 (70.0)
female	44 (29.3)	17 (34.0)	12 (24.0)	15 (30.0)
Married	122 (81.3)	39 (78.0)	41 (82.0)	42 (84.0)
single	28 (18.7	11 (22.0)	9 (18.0)	8 (16.0)
Farming/ fishing	112(74.7)	36 (72.0)	38 (76.0)	35 (70.0)
Tourist Guiding	24(16.0)	9 (18.0)	7 (14.0)	8 (16.0)
Petty trading	14(9.3)	5 (10.0)	5 (10.0)	7 (14.0)
uneducated	22(14.7)	7 (14.0)	5 (10.0)	10 (20.0)

Educated at most secondary school	128 (85.3)	43 (86 .0)	45 (90.0)	40 (80.0)
Average Age	48.2	48.58	50	45.98
Average Income	#38,700	#36,960	#38,420	#407,20

Source: Field Survey, 2008 (percentage values in parenthesis)

Incidence of Sea Flooding by Location

The three coastal settlements under study have been noted to be more vulnerable to the threat of critical flooding and coastal erosion among the coastal settlements in Lagos (Aliu and Adebayo, 2009). Findings from this study also revealed that 78 percent of the respondents testified to increased incidence of flooding within the past two year than ever experienced before while only 22 percent claimed no serious change in the pattern of floods (Table 2). It also showed that critical flooding and critical erosion were more pronounced in Ilado and Eleko than experienced in Akodo. This was because they were closer to the sea. This incidence has brought losses to the communities in terms of threat to life and property as well as attack on sources of livelihood. However, the chi-square value shows that there is no significant variation among the localities regarding the increased flood incidence in the three communities.

Table 2: Incidence of Coastal Flooding by Location

More floods In recent time	All	*Ilado*	Akodo	Eleko	Chi-square
Yes	117 (78.0%)	40 (80.0%)	37 (74.0%)	40 (80%)	0.699
No	33 (22 .0%)	10(20%)	13(26.0%)	10 (20%)	0.699

Source: Field Survey, 2008

Effects of Flooding on Livelihoods Activities

An important objective of this study was to assess the level to which flooding has affected livelihoods of the dwellers in the study area. Hence, the three crucial livelihood activities of Farming/fishing, tourism and petty trading in the three localities were appraised. Findings showed that on farming/fishing activity, flooding had severe effects as 118 (78.7%) of the 150 respondents indicated that there was marked effect on farming / fishing and 32 (21.3%) did not experience severe effect on their farming/fishing activities (Table 3). Among the effect on this category include total crop loss, fishing net loss, reduced fish catch and dwindling income. Table 3 further showed that tourism activity was also severely affected by the incessant flooding in recent time as patronage by tourists had drastically reduced thereby reducing incomes of tourist guides and petty traders. There were variations in the flood effects among the communities and the chi-square values for each of the variables namely farming/fishing, petty trading and tourism were found to be highly significant. The implication of this is that flooding might have significantly contributed to the poor wellbeing of the residents in these areas and threats of sea level rise might worsen their poverty level.

Table 3: Effects of Flooding on Livelihood Activities by Location

Variable	All	Eleko	Akodo	Ilado	Chi-square
Farming/fishing					
Severe effect	118(78.7%)	38 (76%)	40 (80%)	40 (80%)	33.113***
No severe effect	32 (21.3%)	12 (24%)	10 (20%)	10 (20%)	
Petty Trading					
Severe effect	110 73.3%)	36 (72%)	38 (76%)	36 (72%)	20.669***
No Severe effect	40 (26.7%)	14(28%)	12 (24%)	14(28%)	
Tourism					
Severe effect	119 79.3%)	38 (76%)	38 (76%)	43 (86%)	15.855***
No severe effect	31 (20.7%)	12 (24%)	12 (24%)	7 (14%)	

Source: Field survey, 2008. $p<0.001$

Effects of Flooding on Housing and Other Infrastructure

As flooding had destabilising effects on the livelihoods of the residents it was also found to have negative effects on housing and other infrastructure. Findings from the survey showed that 79.3 percent of the respondents had experienced severe effect of flooding on their residences, while 21.7 percent experienced less severe effect. Those that experienced severe effect recorded more economic loss of their properties and a few deaths was recorded due to drowning. On many occasions residents had to relocate temporarily till water level subsides apart from the material losses. Table 4 further showed variations of the effect on residences among the three communities, Eleko (84%) was worse off followed by Ilado (80%) and Akodo (74%) with varying degree of severity.

Effect on public infrastructure such as roads, water wells, drainage, bridges, and electric poles were also severe. Roads, bridges and drainage channels were on many occasions seriously damaged cutting off some sections of the community for many days. Electric poles are another public infrastructure constantly threatened by the incidence of coastal flooding in the area. Several times, residents of affected area had to pay for the repairs of such damaged infrastructure. Table 4 showed that Ilado (82%) was the most affected followed by Akodo (80%) and Eleko (78%) in terms of public infrastructure damage. Chi-square values also confirmed significant variations in infrastructural damage among the three communities (Table 4).

Table 4: Effects of Flooding on Housing and Infrastructure

Variable	All	Eleko	Akodo	Ilado	Chi-square
Housing					
Severe effect	119 (79.3%)	42 (84%)	37 (74%)	40 (80%)	9.050**
No severe effect	31 (21.7%)	8 (16%)	13 (26%)	10 (20%)	
Infrastructure					
Severe effect	120 (80%)	39 (78%)	40 (80%)	41 (82%)	24.556***
No severe effect	30 (20%)	11 (22%)	10 (20%)	9 (18%)	

Source: Field survey, 2008 Significant at ***p<0.001; **p=0.05

Correlates of Livelihoods and Flooding Incidence

Analysis of effects of flooding on the livelihood and physical wellbeing of the residents and the communities in the study was further subjected to non parametric correlation using Spearman's correlation techniques. The results showed that there are strong correlations between flood incidence and livelihoods activities and other variables. The correlations are positive and highly signifIcant at both 0.05 and 0.001 levels of significance. From Table 5 floods are strongly correlated with farming/fishing and indeed contributed 26.83 percent to the explanation of the association between floods and farming activities in the three communities. The same holds for petty trading that has strong positive correlation with flooding in the area. Coastal flooding alone accounts for 25.2 per cent of the association with petty trading in all the three communities. Tourism is another means of livelihood that has come under the threat of coastal flooding in the three littoral communities as the two have positive correlation of 0.36 and the degree of association is found to be 13.1 percent. The correlation between environmental degradation and flooding is very significant as the determination of correlation value is 16.9 percent. Likewise the association between flooding and infrastructure and housing gave values of 0.36 and 0.56 respectively which also translates to determination of r^2 value of 13.0 and 28.3 percents respectively. Further analysis showed that consequent upon the association of flooding with virtually all livelihood indices it has been shown to have implicit association with the income of people as given by the correlation of 0.41 and determination of r^2 value of 23.0 percent. Since all livelihood indices are shown to be positively correlated with floods, it thus means that as incidence of flood increases so the threat to livelihood indices increases.

Table 5: Correlations between Flood incidence and Livelihood Variables

Variables	Correlation With flood incidence	Significance	r^2	r^2%
Farming/fishing	0.518	0.000	0.2683	26.83
Trading	0.502	0.000	0.2520	25.20
Tourism	0.361	0.000	0.1303	13.03
Environment	0.411	0.000	0.1689	16.89
Housing	0.532	0.000	0.2830	28.30
Infrastructure	0.361	0.000	0.1303	13.03
Social lives	0.488	0.000	0.2381	23.81
Occupation	0.296	0.000	0.0876	8.76
Income	0.481	0.000	0.2314	23.14

Source: Field survey, 2008 * all correlations are significant at p=0.05 and p=0.001

Vulnerability and Coping Strategies

Vulnerability is relative and relates to the consequences of a perturbation rather than its agent; hence people are vulnerable to loss of lives, livelihood assets, and income rather than to the specific agent of disaster such as flooding or coastal erosion. This means that the level of vulnerability to flooding can only be related to the indices of livelihoods and perhaps to the characteristics of the residents that receive the impacts of coastal flooding. Definitely the vulnerable groups such as women, lowly educated, low income earners, old people are probably going to be more affected by the incidence of floods and coastal erosion. The levels of education, income and age had a lot to do with prediction of vulnerability in these coastal communities. Hence older people were likely to be more affected by flooding and same holds for the uneducated as well as low income people.

In the face of critical risk to life as found in the study area, people were found to seek for survive by all means. The coping strategies employed by the individual to mitigate the effects of flooding on livelihood in the communities vary. Four coping strategies were identified among the people as revealed by the survey result, these are sales of assets, engagement in other jobs, begging and borrowing. As presented in Table 6. The largest proportion of the affected residents has resorted to borrowing and begging. The implication of this result is the fact that the poverty depth of the residents were deepening gradually and something needs to be done quickly to arrest this trend.

Table 6: Coping Strategies against Flood Incidence by location

Coping strategies	All	Eleko	Akodo	Ilado
Sales of assets	30	10	5	15
Change job	15	6	3	6
Begging	45	17	10	18
Borrowing	60	25	10	15

Source: Field survey, 2008

SUMMARY AND CONCLUSION

From the analyses it has become very clear that the incidence of flood had critical impacts on resident's means of livelihoods on the one hand and on the environment and property on the other hand. A spatial analysis of these problems has equally shown that in each of the communities examined in the study there are sufficient bases to believe that their livelihoods were under severe threat occasioned by incessant coastal flooding which has rendered them more impoverished than expected. To the vulnerable groups such as the uneducated or old people and children the findings have shown diverse implications. Definitely, future floods and erosion would have more impact on the low income earners, farmers and fishers, petty traders and tourist workers from lesser to higher degree respectively.

The safety nets currently available to the residents in the areas were grossly inadequate to develop resilience against the impact of sea flooding affecting their means of livelihoods. It thus call for concerted effort by governmental and non-governmental institutions to develop better safety nets and strengthening of the existing safety nets as to make them more responsive to the people in periods of disaster. It is also envisaged that increased level of educational attainments will bring about less dependency on coastal resources as more residents must have been empowered to go into other means of livelihood not too susceptible or vulnerable to flood.

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CLIMATE CHANGE, GLOBAL WARMING AND NIGERIA: LEGAL PERSPECTIVES ON NATIONAL MITIGATION AND ADAPTATION STRATEGIES

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Abstract

A coastal nation with a surging population, high dependence on natural resources, widespread poverty, illiteracy, diseases, infrastructural decay, low-technology, and a disorganized institutional capacity for disaster response, Nigeria, a particularly vulnerable country, is ill-prepared to tackle the ominous and frightening dangers of climate change. Arresting this global menace and its immediate impact on Nigeria, goes beyond mere accessions to the international legal regulatory frame work: that is, the UNFCCC, the Kyoto Protocol, the strident articulation of domestic mitigation policies and the incidental creation of some regulatory institutions. Sustainable human and environmental development will require addressing the roots of the crisis, and then, its ramifications. The Brundtland Report has identified poverty as the cornerstone of environmental problems...and measures to tackle it at the most basic levels are causing massive ecological damage. Reconciling human survival; the most basic tasks to achieve this, with environmental chastity remains one of the peremptory problems of mankind today, especially in developing societies.

Keywords: Nigeria, Climate Change, Mitigation, Adaptation, Strategies, Sustainable Development.

INTRODUCTION

We confront a bleak reality today, as we have found ourselves at the threshold of a global cataclysm. It is no more a novelty to assert that global warming is real, anthropogenic, and presents serious challenges to mankind and the environment, but a repetition of the obvious *ad nauseam* for the current hue and cry generated by the menace is sufficient testimony of its incidence and destructive ecological impact. Our generation stands at the crossroads of history with a burden, if not to improve the environment, then not to compromise its ability to meet the needs of posterity. Nigeria's atypical topographical construction as a nation has flung it at the mercy of the elements: from the ravaging Saharan belt of the North to the exposure of its southern flank to the volatile tides of the Atlantic, and from expansile demographic factors to the incidence of pestilence and uncontrollable disease conditions of endemic and epidemic magnitudes. And climate change or global warming intensifies our pre-existing risks and vulnerabilities. Man is by nature inquisitive and venturesome, and the object of these innate impersonal forces is Mother Nature, the same multi-functional earth ecosystem, a component of which he is, and from which he derives his sustenance. From the invention of primitive tools with capacity to provision only the basic necessities of life, to man's extraterrestrial peregrinations, human technological advancement has waged a full blown war against nature, with fluctuations only in historical intensity. His activities since the dawn of the industrial age have generated increasing concentrations of the major catalysts for climate change: greenhouse gasses and trace constituents, in the atmosphere. Although, it was realized only during the 1840s that the climate had radically changed, yet in many parts of the world, it had altered sufficiently even within the last few thousand years to affect the possibilities of agriculture and human settlement (Barry *et al.,* 1998). The greenhouse gasses have been identified as responsible for the greenhouse effect–the process by which the absorption and re-emission of infrared radiation by atmospheric gasses warms a planet's atmosphere and surface (Article 1, UNFCCC 1992; Callander, 1995; Kiel and Kelvin, 1997). An inclusive terminology, climate change may also refer to global cooling, although in everyday usage, it signifies recent warming with a human interference. But our present abstraction is with the observed increases in the average temperature of the earth's near-surface air and oceans in recent decades and its projected continuation. In this sense, we may correctly describe global warming as the handmaid concept of climate change. Historically, Nigeria might not have been responsible for even a significant ration of global greenhouse gas emissions, but it will be one of the countries most impacted, and yet is among those least prepared to initiate and bear the cost of adaptations. The atmosphere is an integral part of the global commons, and the reverberations of any perturbation in the region cannot be corralled into national boundaries, irrespective of the geographical provenance or temporality of its causation.

COUNTRY IMPACT STATEMENT

Opinions might differ on the exact nature of the problem. And it might even be argued that the phenomenon is still phantasmagoric since its precise magnitude is unknown. But should this preclude preventive actions? Principle 15 of the Rio Declaration canvasses the widespread adoption of the precautionary approach by states according to their capabilities, in order to protect the environment. Furthermore, much understanding of the technical perplexities associated with global warming has been garnered by the Intergovernmental Panel on Climate Change, which was jointly established in 1988 by the United Nations Environment Program, and the World Meteorological Organization. IPCC has estimated the warming over this century to be between a further 1.8 and 4˚C. Impacts are already evident, and changes in water availability, food security and sea level rise are projected to dramatically affect millions of people (GEO4, 2007). With sea level changes, many of the world's richest and densely populated agricultural zones in low-lying lands will be flooded (Rodda, 1991).Nigeria is extremely susceptible to climate change, and is already experiencing a prelibation of its impact. With her coastline of about 850 kilometers extending from Lagos to the low-lying Niger-Delta region, sea level rise will dislodge most coastal businesses, damage residencies as well as aquatic ecosystems. Lagos, the nation's former capital city, is only 3 meters above sea level, and the bar beach, a major tourist resort has lost its fame and attraction due to repeated ocean surges. The coastal zone is the economic hub of the nation as it contains all of its oil fields and major ports (Oyeshola, 1995). Floods are recurring climatic problems in Nigeria today, costing the public huge sums of money in terms of environmental rehabilitation, resettlement and the provision of relief materials to flood victims.

Drought has also been a source of critical concern in the Sudan-Sahel belt. Nigeria recorded heavy livestock losses, above three hundred thousand between 1969 and 1973, on account of the menace. The impact of climate change on public health will further strain Nigeria's dysfunctional health system and the capacity to manage emergent health complications as climate variations will magnify the incidence and distribution of medical disorders. There would be a greater rate of transmission, geographical spread and seasonality of tropically endemic diseases such as malaria, dengue fever, yellow fever, asthma, diarrhea, salmonellosis and poliomyelitis. The agricultural sector will not be spared. It has always been the mainstay of the economy, contributing over 40 percent of the gross domestic product, and at the same time employing more than 60 percent of the country's population (Olatunbosun, 2009). But climate change will jeopardize agricultural productivity through temperature increase and variability, changes in precipitation patterns, increased occurrences of extreme events such as floods and drought, and a rise in the incidence of plant and animal diseases (Ekpu, 2009). Most farmers in Nigeria rely on rain-fed subsistence agriculture, and are dependent on climate patterns. Desertification, an inherent extremity of climate variability, is one of the most serious threats to socio-economic development in the driest part of the country, a region inhabited by an estimated 28 million people and over 58 million livestock. (Madu, 1988). Nigeria losses about 351 000 square km2 of its land mass to the desert whose southward advance is about 0.6 km per annum. Third World countries do not have enough resources to combat desertification and rehabilitate degraded lands (Burns, 1995).

THE LEGAL FRAMEWORK

Although Nigeria was in the vanguard of the nations which are signatory to the UNFCCC, it has no internal legislation with a specific mandate to address global warming. Consequently, the substantive framework has assumed the character of treaty law. This does not mean that there are no meshworks of laws with spheres of operations sprawling over the emission of one greenhouse gas or the other, or policy statements professedly dealing with one or more of the adverse impacts of climate change, but that these parallel actions only have a supplementary benefit on the climate change regime. This complementary regulatory mélange include the Associated Gas Re-Injection (Continued Flaring of Gas) Act of 1990: the Harmful Wastes (Special Criminal Provisions, etc.) Act of 2004, the Criminal Code Act of 2004; the National Drought and Desertification Policy; the National Policy on Environment, and the National Economic Empowerment and Development Strategy of 2004. Nevertheless, the United Nations Framework Convention on Climate Change 1992 and the Kyoto Protocol 1997 are the strongest manifestations of the will of the international community to stabilize atmospheric greenhouse gas concentrations, and are as much legal instruments as they are political contraptions, as can be seen from the negotiations leading to their adoption, the gradualness which preceded their entry into force, and the persisting debates stalling the extension of the regime's reduction targets to the developing states. This is also evident from the connections between the treaties and the vortexes of national, social and economic considerations into which they were sucked.

Each country, irrespective of its economic grouping, sought an egocentric position. In 2001, the United States withdrew from the Protocol claiming that it would lead to more than a 20% rise in energy prices and that it had imposed no binding targets on developing countries (Okorodudu-Fubara, 2005). The Convention has attempted to assign the responsibilities for greenhouse gas reduction upon the contracting parties in proportion to their histories of greenhouse gas emissions and individual capabilities, with the scales inclined in favor of the Group of 77: technically, the concept of common but differentiated responsibility (Article 3, UNFCCC 1992; Sands, 2003). However, this might only prove a respite after all as there are indications of identicalness between the volume of greenhouse gas emissions of the developed countries and some of the large economies in the third world network. Nigeria is the largest gas flaring nation contributing more emissions of greenhouse gasses in sub-Saharan Africa than all other sources combined, and yet has no binding commitments under the regime. The UNDP/World Bank Strategic Gas Plan for Nigeria estimates that the country flares 75 percent of the gas it produces (Okorodudu-Fubara, 2007). Gas flaring and venting contribute to climate change through the emission of carbon dioxide and methane, the main greenhouse gasses. Halting gas flaring by legislation has been unsuccessful in Nigeria largely because of the capital outlay involved in re-injecting associated gas, a substantial portion of which would be borne by the government on account of its joint-venture obligations to the oil multinationals. Nigeria has the same generalized set of obligations within the treaty framework as other developing countries essentially to develop inventories of greenhouse gasses and implement measures to mitigate and adapt to the impact of climate change (Article 4, UNFCCC 1992; Guruswamy and Hendricks, 1997). Although the Kyoto Protocol established binding quantified emissions limitation and reduction targets for the industrialized parties, it did not impose equivalent commitments on developing countries, especially China, India and Brazil: nations whose staggering levels of emission trajectories are projected to outstrip those of the United States and the European Union by 2015. Paradoxically, most developing countries are terribly vulnerable to the adverse impacts of climate change, but are the least able to mitigate or adapt to them. Therefore, should they have the greatest binding emissions reduction targets while others have less, since all countries are vulnerable, but have differential capacities for response? Nevertheless, developing parties may achieve sustainable development and stabilize greenhouse gas concentrations in the atmosphere by participating in the clean development mechanism, with financial and technological assistance from the developed countries. CDM projects in the pipeline in Nigeria include the West African Gas Pipeline Project, and the development of the Obudu Plateau IMW Small Hydro Project (Akeredolu, 2008). The clean development mechanism diminishes the net global emissions of greenhouse gasses at much lower costs by funding emissions reduction projects in developing countries where costs are lower than in their industrialized counterparts. But the Marrakech Accords have stipulated that a country must have ratified the Kyoto Protocol in order to participate in the clean development mechanism (Decision *15/CP. 7*, Para, *5*) and that the host country must have designated a National Authority to superintend and approve the project. Nigeria established its CDM National Authority in 2004.

BIOTECHNOLOGY, FOOD AND ENERGY SECURITY

Food security is trending towards a critical global issue, and sub-Saharan Africa bears a substantial chunk of it (Migiro, 2009). Nigeria, blessed as it is with abundant agro-ecological resources and diversity, has become one of the largest food importers in sub-Saharan Africa (Idachaba, 2009). But, Nigeria's litany of woes is not restricted to acute food shortages alone. The power sector, which plays a strategic role in any economy, and constitutes a necessary infrastructure for industrial development, is in shambles. Production is grossly inadequate, with a capacity of about 2 400 MW per day, for a population of over one hundred and forty million people (Bello *et al*, 2009). However, biotechnology offers formidable opportunities for sustainable development by revolutionizing agriculture, health care and energy supplies. Moreover, Nigeria can also earn carbon credits from the development of renewable energy facilities under the CDM. Some countries have already adopted a large scale use of biofuel. In 2002, about a quarter of Brazil's transportation fuel was ethanol. But one of the drawbacks of this technology is that the usage of food products as staples for biofuel as a mitigation and adaptation response strategy to global warming has precipitated and further exacerbated the world food crisis, constricting the value of, and the demand for petroleum products. Other concerns verge upon bioethics, human safety, the conservation of biodiversity, the trans-boundary movement of LMOs/GMOs, and the uncontrolled development of genetic engineering techniques. Described as any technological application that uses biological systems, organisms or derivatives thereof, to make or modify products or processes for specific uses (Article 2, Convention on Biological Diversity 1992; Agenda 21, Para. 16.1), biotechnology has an ancient heritage, although with breath taking applications in modern times. Chapter 16 of Agenda 21 dealing with Environmentally Sound Managing of Biotechnology enjoined states to "consider the need for and feasibility of internationally agreed guidelines on safety and biotechnology release". Although Nigeria, a signatory to the Convention on Biological Diversity 1992, and the Cartagena Protocol on BioSafety 1997, has no national legislation on biotechnology, it has nonetheless, consigned its regulation to the Biosafety Guidelines issued by the Federal Ministry of Agriculture and Natural Resources in 1994, and subsequently revised. Article 8(g) of the Convention on Biological Diversity encourages the contracting parties to establish or maintain means to regulate, manage or control the risks associated with the use and release of LMOs resulting from biotechnology which are likely to have adverse environmental impacts that could affect the conservation and sustainable use of biological diversity, taking also into account the risks to human health. Furthermore, the Environmental Impact Assessment Act (Chapter E 12, Laws of the Federation of Nigeria 2004), restricts the undertaking of any project which is likely to significantly affect the environment, without the prior identification of its possible hazards.

Nigeria Biosafety Guidelines

The Biosafety Guidelines adopt the precautionary principle in order to preserve, protect and improve the environment irrespective of whether or not such concerns are justified by available scientific data. In operation, the Guidelines extend over the genetic transformation of microorganisms, plants and animals, rDNA technology in vaccine and pharmaceutical products development, to the production and release of LMOs/GMOs or their products, and their exportation or importation. The Guidelines contain elaborate procedures for notification, especially the Advanced Informed Agreement; risk assessment; risk management, the handling and labeling of all LMOs/GMOs or derivatives, and institutional capacity building. The Federal Ministry of Environment is to serve as the National Focal Point, and shall be responsible for liaison with the Secretariat of the Convention on Biological Diversity for the administration of functions required under the Cartagena Protocol on Biosafety. The National Biosafety Committee is constituted to serve as the Competent National Authority for Biosafety in Nigeria. The NBC shall be responsible for the safe management of biotech activities, including research, development, introduction and the use of LMOs/GMOs, risk assessment and risk management. The NBC is required to institute sub-committees for handling sectoral interests like agriculture, health, industry and the environment. Any institution in Nigeria, whether private or public, which plans to undertake biotechnological research or development, must establish its own Institutional Biosafety Committee, which will be responsible to, and also cooperate with the NBC. Several federal agencies such as the Federal Ministries of Agriculture, Environment, Health, Science and Technology, etc., are involved in the implementation of the Guidelines. Although the government has demonstrated the interest to establish an efficient regulatory system for biotechnology, Nigeria lacks the requisite human capacity for risk assessment, and the political will to implement the regulation on biosafety (Omokaye, 2004).

THE UNDERLYING SOCIO-ECONOMIC CONSIDERATIONS

We may be puzzled by the fact that most of the countries which have won for themselves emissions indulgences under the climate change regime are constrained one way or the other to depend upon their advanced emissions-restricted neighbors to acclimatize their economies to the unfolding meteorological scenario. But, the more startling reality is that while this fugacious carnival lasts, these countries have failed to leverage it to eradicate poverty, the greatest source of ecological instability in the Third World. Much of this human collection is distinguishable by a viperish affinity with unrepresentative democracies, endemic corruption and economic underdevelopment, despite huge natural resource endowments (Rivero, 2001). Moreover, they have basic consumption patterns that devastate the environment. Although, it is a complex issue determining whether an economy can develop without greenhouse gas emissions, it involves no complication to assert that a nation might emit greenhouse gasses and still not develop. The National Economic Empowerment and Development Strategy; Nigeria’s economic blueprint, indicates that by 1999, about 70 percent of

Nigerians lived on incomes of less than $1 a day–and the figure has steadily risen since then. Poverty understandably engenders a disjunction between the people, the government and the physical environment. Empirical evidence shows that poverty and environmental degradation are inextricably linked in Nigeria, because 75 percent of rural people depend on natural resources for their livelihood (NEEDS, 2004). Principle 1 of the Rio Declaration affirms that man is at the epicentre of concerns for sustainable development, and is entitled to a healthy and productive life in harmony with nature. But wherever human life is unhealthy and unproductive, the poor and disenchanted will resist any policy, no matter how well intentioned it is, which will further impoverish them. And this will include the vicinal integration of climate change regulation into culture, lifestyle and decision making, unless it convincingly demonstrates how the basic human needs can be met. But the pro-climate change movement is not an exclusively bureaucratic needlework: it can succeed only if is in synchronicity with the will of the populace. Pre-existing lifestyles, even in the absence of basic infrastructure are already eco-hazardous and the government lacks the justification to afflict the citizenry with additional burdens under the guise of a reborn love for nature, unless infrastructural development is prioritized. While most Nigerians obtain electricity from carbon emitting generators imported from Asia, since the national energy system is unreliable, this specific emissions window is supplemented by the ubiquitous fuel guzzling vehicles traversing Nigeria's vast network of unpaved roads. Furthermore, Nigerian is distracted by the immediate challenges facing its survival: and these are more political and socioeconomic than ecological. Ironically, the regions which are the most susceptible to global warming in Nigeria are also the most unstable in the federation. While the northern constituent of the country fringing the Sahara has persistently lost its landmass to the encroaching desert, it is also the cradle of a violent and virulent strain of Islamic fundamentalism whose dogma is the rejection of western education: and has not only canvassed the theocentric rationalization of events like weather and climate change, but has also advocated the superimposition of this belief system on other parts of Nigeria. But the more permissive South, endangered by gully erosions and the surging Atlantic, has long given way to militancy of such intensity that no organized campaign for environmental remediation can be effectively undertaken. This inventory is aggravated by Nigeria's poor literacy syndrome, rated at about 57 percent of the population. There is a huge knowledge gap concerning the linkages between climate change and its causal factors, especially those resulting from man's basic interactions with his environment. Building educational capacity is a peremptory step in promoting mitigation and adaptation to climate change (Kosloff & Trexler, 2004; Balgis *et al*., 2006). A sizable proportion of the population has either no awareness of the climate system, or possesses only a poor knowledge of it. Because of the close nexuses between culture and the environment, any campaign for environmental awareness and conservation must take on a new cultural tone, a paradigm shift calling for new ways of life (NEST, 1991). The message is real, but how can we deliver it? And not risk its rejection? The common man is important. His basic quest for survival devastates the environment. Unless he is mobilized, our existent fixation runs the risk of being labeled the neoteric hobby of the

Nigerian intelligentsia. The masses will rebuff this brand of opium which conjures up only disturbing images of an impending ecocatastrophe and not of heavenly bliss!

CONCLUDING REMARKS

Concluded over 20 years ago, the Brundtland Report effectively identified poverty as the keystone of ecological damage, especially in developing countries. But the situation today is not much different from what it was when the diagnosis was made. The African continent has been differentiated by an intractable tendency towards underdevelopment and instability, and now by ecological vulnerability. The logical consequences of this finding in the age of a global climate change crisis include: (i) the increased likelihood of poverty and human misery on the continent as a direct effect of climate change: (ii) the task of mobilizing the indigenous peoples in the remedial campaign would prove daunting: (iii) the preponderance of inadequate institutional and technological capacities for developing mitigation and adaptation strategies, and (iv), the marginalization of the common man in the scheme for development, thus, severing any affinity he has with nature. The solution goes beyond the mere articulation of law. Developing countries must first tackle poverty, and afterwards, regulatory refinements. But as the continent canvasses new technologies, human and environmental safety must not be sacrificed for scientific sensations. Controlled biotechnological research can lead to sustained revolutionary breakthroughs in the agricultural, energy and pharmaceutical sectors, leading to sustainable development. Furthermore, energy sources are undergoing such a radical transformation that continued reliance on petroleum exports has become risky for Nigeria. Finally, the prospect of ecological disasters should be harnessed by states to harmonize alliances to combat climate change rather than to intensify the classical disparities between the developed countries and the Third World. Climate change remains a regime of conflicts: conflicts not of its realness, but of the responsibility for its resolvability. Sustainable development cannot afford a non-collaborative campaign. This can neither halt the impending doom, nor facilitate the development of mitigation and adaptation strategies.

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IMPLICATION OF THE DEFAULT ABSORPTION FACTOR IN THE DETERMINATION OF THE INTERNAL DOSE FROM THE DIETARY INTAKE OF URANIUM IN NIGERIAN FOODSTUFFS

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Abstract

Daily urinary excretion of uranium for 12 adults occupationally exposed to uranium and 7 adults living in normal areas without radionuclides exposure besides what is assumed as background values in Nigeria has been determined using high resolution sector field inductively coupled plasma mass spectroscopic (HR-SF-ICP-MS) analytical method. The mean daily urinary uranium excretion values for the unexposed and exposed population for infant, child and adult subjects are 3.0 µg d^{-1}, 5.0 µg d^{-1} and 8.0 µg d^{-1}, and 5.3 µg d^{-1}, 11.3 µg d^{-1} and 16.7 µg d^{-1} respectively. The predicted excretion rates using biokinetic model of uranium given by the International Commission for Radiation Protection (ICRP) were also presented and compared with the measured data. Large discrepancy was observed between the measured data and the model predictions using the default ICRP f_1 values for uranium, which suggested the need for the use of an appropriated f_1 values to fit the measured data.

Keywords: urine, excretion, human subjects, uranium, model, absorption factor

INTRODUCTION

Biotechnology development and the threat posed by the global climate change are twin issues that will either impact positively or negatively on the global food security. The quality and quantity of food products will either be enhanced or diminished. In the discussion of the quality of food products, food safety is an important parameter. In view of the various methods involve in biotechnology development, especially the use of ionizing radiations in gene mutation and increasing the chef life of foodstuffs. Radiological impact assessment of foodstuffs will be an important safety criterion. Food gets to the systemic circulation through the small intestine and the fraction of radionuclide like uranium that gets to the blood is the absorption factor for the radionuclide. Uranium is a primeval radionuclide and it is ubiquitously occurring element with several radioactive isotopes. It is the heaviest naturally occurring element and its radiotoxicity and chemical toxicity have been described extensively in the literature (UNSCEAR, 2000), with average activity concentration in the range of 25 – 50 Bq kg^{-1}. However, the activity concentration may vary considerably from one location to the other depending on the local underlying geology.

During decay process, highly penetrating gamma rays are emitted, thereby causing intensive damage to the tissues where they are localized. Improper handling of materials containing uranium can lead to occupational exposure and hence, radiation hazard. Apart from the occupational exposure, population in the vicinity of the numerous applications of uranium element and its compound can also be exposed. Environmental exposure to a population stems from constant daily inhalation and ingestion of the radionuclide from natural, air borne particulates and dietary sources.

Body burden of uranium in any population can be enhanced by human activities resulting in the alteration of the natural constituents of radionuclides in the soil. Mining and milling of ores all over the world have contributed immensely to this observed disequilibrium and the enhanced naturally occurring radioactive materials (Dowdall et al, 2004) and their subsequent processing can lead to the exposure of personnel from external radiation and from intake (UNSCEAR, 2000). This affects the terrestrial ecosystem due to the excavation of large amount of sand and the eventual accumulation of large volume of tailings. Tin mining in Nigeria resulted in the removal of considerable amounts of generated waste as tailings from the mining sites to neighbouring vicinities.

In tin mining industries, the main technologically enhanced naturally occurring radioactive materials (TENORM) are the Uranium and Thorium series and their progenies, together with ^{40}K (Dowdall et al, 2004).

In Nigeria, tin mining and processing lead to the accumulation of tailings with significant amounts of natural radionuclides like ^{238}U. Tin mining activities started in the Jos Plateau some decades ago around 1904 shortly after airborne radiometric mapping revealed high deposit of cassiterite and columbite (niobium) ores. Monazite sands and zircons were later discovered as accessory minerals, which have been known to contain very high amount of thorium (UNSCEAR, 2000). It follows from this that foodstuffs like cereals, tubers, vegetables will contain traces of ^{238}U owing to the radionuclides transport processes in the soil and underground water. Elevated activity of radionuclides in foodstuffs and soil have been reported in the tin mining sites of Jos Plateau (Jibiri et al, 2007) and no efforts have been made to determining the extent of internal health hazards to the inhabitants of the area and even those that are occupationally exposed.

In order monitor and ensure the radiation protection of occupationally exposed person, it is important to have reliable information on the biokinetic behaviour of radionuclide in humans by considering the natural intake scenarios and the body content. Monitoring of occupational incorporation of radionuclide should preferably be carried out by analysis of its urinary excretion since the quantity lost per day via urine is related to the systemic body content. However, for a reliable estimation of the occupational uptake of workers, baseline data of daily urinary excretion in subjects non-exposed occupationally is needed. Furthermore, the knowledge of the ingestion rate of radionuclide with the application of an appropriate absorption (f_1) factor will enhance realistic assessment of the internal dose. In Nigeria, the activity of radionuclides from natural environmental sources in human bodies and its excretion of both exposed and unexposed subjects are yet to be studied. In fact, studies on urinary excretion of these radionuclides from Africa are not available.

The International Commission on Radiological Protection (ICRP) provides guidelines to assess the exposure to thorium using the daily urinary excretion data (ICRP, 1997). In response to this, daily urinary excretion data are now available from studies conducted in many countries (Höllriegl et al, 2005a&b; Roth et al, 2005). However, data on daily urinary excretion of radionuclides are not available in Nigeria, and to the best of are knowledge, little or no data are available from African countries for comparison. This work is a pioneering effort in Nigeria, especially through the ingested pathway in the determination of internal contribution to the overall radiation body burden. In this study, the concentration of uranium in urine samples of unexposed and exposed subjects was quantified and its daily urinary excretion determined. The daily urinary excretion values were compared with the biokinetic model prediction of uranium using the dietary intake values for the same population recently reported (Arogunjo et al, 2009). The excretion values were also compared with values from literature.

MATERIALS AND METHODS

Sample collection

Twenty-four hour urine samples were collected from four different groups of subjects, which include six mine workers in Bisichi mining site, five processing workers from tin processing company in Jos, four members of the public living in the city of Jos and four members of the public in Akure about 900 km away from Jos Plateau as control. The occupational (mining and tin processing workers) groups have age range of 24 – 52y including a subject in Akure who by virtue of his job might have been occupationally exposed to radionuclides. The public group around the mining and processing sites but are not exposed occupationally has age range of 34 – 44y. The public group used as control has age range of 37 – 40y that are not exposed to any artificially higher levels of uranium and its compounds. The 24-h urine samples were collected from both the occupational group and the public group around the mining and processing sites between 14th and 15th September 2006. The public control group 24-h urine samples were collected between 22nd and 23rd September 2006. The 24-h urine was collected starting early in the morning. After wake-up, the subjects emptied their bladder in the toilet noting the time, and all urine thereafter was collected in a graduated 3000 ml pre-cleaned polyethylene container until the following morning, and for the last time at the exact time the bladder was emptied the previous morning. The first void collected at the start of the sampling was acidified with 0.5 ml HCL to prevent decomposition. Thirty (30) ml aliquots of the total urine collected from each subject was put into a plastic vial, which was placed inside a plastic cylinder and stored at 4 ^{0}C until analysis.

Sample Preparation and measurement

All the samples were measured at the Central Analytical Service of GSF, using high resolution sector field ICP-MS Model ELEMENT 1 (Finnigan MAT, Germany). Prior to measurement, all the urine samples were removed from the storage site and allowed to defrost at room temperature. The acidified samples were diluted into ratio 1:2 by the addition of 0.25 ml of concentrated HNO_3, 0.5 ml of concentrated HCL and 4.5 ml of H_2O to 5 ml of the sample. Thorium standards were used to calibrate the instrument for its direct measurement and reagent blanks using deionised water were also measured at intervals during the entire measurement process. In the case of uranium, its natural standard solution was used to prepare the calibrating solution and the samples were measured directly by using 100 µg l^{-1} of internal standard solution of ^{193}Ir to correct for matrix interference.

Biokinetic modelling of Uranium

Radionuclides transport in the human body can be investigated using deterministic model. This process involves model simulation of the linear transfer processes represented by sets of linear differential equations governed by first order kinetics. In order to be able to compare the measured urinary excretion rates with that predicted by the ICRP biokinetic models for thorium and uranium, expected excretion rates through lifetime were simulated using the age dependent biokinetic transfer coefficients for the six age groups given by the ICRP Publication 69 (ICRP 1995). For the purpose of simulating the behaviour of the radionuclides between compartments after ingestion, the systemic model was coupled to the gastrointestinal (GI) tract model. The ICRP age-dependent transfer rates in the GI tract and the transfer rate from the small intestine to blood was calculated according to ICRP (1995). According to the dietary intake values for the same adult population recently reported, the annual ^{238}U intakes of 1.9 mg y^{-1} (23.2 Bq y^{-1} fresh weight) was obtained for the unexposed population (Arogunjo et al, 2009) in Nigeria. This value was added to the intake value for milk and meat given by UNSCEAR (2000), which were not included in the study to represent the adult population. The resultant value (8.0 µg d^{-1}) was age-adjusted according to the respective food consumption rates ratio for the different age groups namely: infant, child and adult given by UNSCEAR (2000) to 3.0 µg d^{-1}, 5.0 µg d^{-1} and 8.0 µg d^{-1}, respectively. The age adjusted intake values for the exposed population are 5.3 µg d^{-1}, 11.3 µg d^{-1} and 16.7 µg d^{-1}, respectively. In modelling the lifetime excretion rates, the biokinetic transfer coefficients governing the distribution and retention of uranium in the various compartments of the systemic and the GI tract models during the integral time course were performed using age-dependent linear interpolation. The distribution and retention of the radionuclide in the various compartments is governed by linear transfer processes represented by sets of linear differential equations. The transfer between the various compartments therefore, follows a system of first-order kinetics. To solve these sets of linear differential equations, different software packages are available for solving multi-compartmental systems and one of such packages is the SAAM II computer program. The SAAM II software package version 1.2.1 was used to perform the biokinetic modelling.

RESULT AND DISCUSSION

Urinary uranium excretion

Baseline data of the daily uranium excretion of human subjects is very crucial to the overall emergency response in case of gross contamination and the assessment of subjects exposed occupationally. In order to determining the extent of radiation health hazards in the population, the results of the daily urinary uranium excretions measured in 52 samples obtained at different times from 19 healthy adult males subjects in Jos, Akure and Bisichi including their ages and weights are presented in Table 1. The range of excretion values along with the mean (±SD), median (95% confidence interval), and geometric mean (±GSD) for the subjects were also shown in Table 1. Large intra-individual variations can be seen in the data provided in the table. These are in agreements with similar studies conducted elsewhere (Paul Roth et al, 2005). It is clear from the frequency distribution of the daily urinary excretion for the radionuclide, the arithmetic mean values of the excretion, and the associated standard deviation that the excretion does not seem to follow a Gaussian distribution pattern. In view of the above, the data could best be represented by the median value provided along with the 95% confidence interval. Furthermore, Figure 1 suggested that the data is log-normally distributed and could best be represented by the geometric mean provided along with its geometric standard deviation calculated using a log-normal distribution function.

Comparison of urinary thorium and uranium excretion with literature values

The present urinary uranium excretion data fall within the normal range obtained in literatures. Figure 2 shows the urinary uranium excretion in an unexposed population from different studies. The figure suggested that the daily urinary uranium excretion range between 3.4 ng and 34 ng although the authors used different statistical parameters and units. The values were converted to the same units by assuming daily urinary volume of 1.4 l d^{-1} proposed by the International Commission on Radiological Protection (ICRP) for adult male and female (ICRP, 2003).

Comparison of urinary uranium excretion with its model data

The expected daily urinary excretion of uranium was determined for adult male using the two intake scenarios and the ICRP biokinetic model discussed earlier. The urinary excretion rates for uranium during lifetime were simulated for the unexposed and exposed groups using the age dependence intake given earlier for the Nigerian population and the result is as shown in Figures 3. The default ICRP f_1 value of 2.0×10^{-2} for uranium was initially used for all the calculations as presented in the Figure. The Figures also included all the individual excretion values plotted to show the large variability in the measured data and the discrepancy with the model prediction. In the model prediction using the f_1 value of 0.02 % and the intake scenario for the unexposed population, overestimation of the excretion using the default f_1 value can be seen and this may lead to gross underestimation of intake when using the model for monitoring purposes. The general observation from the results of the present work and that of the study reported for German subjects, although the subjects are from different geological, ethnic and environmental backgrounds, is that the disagreement between the measured data and the model predictions could be traced to the assumption of a default f_1 values by the ICRP (ICRP, 1995). The need to specified f_1 value for the dietary incorporated radionuclides in the population can be clearly seen in view of the present discrepancies in the application of the default ICRP value. The f_1 value should also take care of situation with high intake scenarios, which is currently lacking as observed in the present study especially in the case of the dietary incorporated uranium. The form in which the foodstuffs are consumed must be taken into account in the assessment of an appropriate f_1 value, the diet constituents of the population are mostly solid unprocessed root tubers, which contribute about 70% of the local foodstuffs. In this form, the radionuclides may be bio-available in the gastrointestinal environment (GIE) but not bio-accessible for absorption from the GIE apparently due to some rebounding processes. Moreover, bio-accessibility may be hampered due to some additives, fat from palm oil, which is majorly used in the cooking process of most foodstuffs can be a contributing factor. Furthermore, the intake values used in this study may not represent the actual intake since the value was obtained from raw foodstuffs (Arogunjo et al, 2009). In Nigeria, foodstuffs usually go through the process of cooking before they are consumed. Uranium is soluble in water by forming uranyl complexes; this can result in the radionuclide going into solution and its eventual removal from foodstuffs during the cooking process.

In view of the above, it then suggest a question as to whether the f_1 value proposed by the ICRP should be applied uniquely in all situation especially when using the bioassay model as a monitoring tool in an emergency response programme. In order to fit the model to the median values of the measured urinary uranium excretion data at the mean ages for the two groups of subjects considered in this work, new f_1 of 0.07 % was proposed for the unexposed (dash-dot-dot line) and the exposed groups (dash-dot line) as shown in Figure 3.

CONCLUSION

The urinary uranium excretion rates have been calculated for the exposed and the unexposed populations in Nigeria using ICP-MS analytical method. The predicted excretion rates using bioassay model of uranium given by the ICRP (1997) were also presented and compared with the measured data. The results show that the median values for the exposed and un-exposed groups are 10.8 (1.0) ng d^{-1} and 4.0 (1.3) ng d^{-1} for thorium daily urinary excretion, respectively. The median for the measured urinary uranium excretion values are 22.2 (0.7) ng d^{-1} and 7.2 (0.9) ng d^{-1} for the exposed and un-exposed, respectively. The urinary excretion rates simulation during lifetime by assuming the default ICRP f_1 values and the age dependence intake for infant, child and adult of 3.0 µg d^{-1}, 5.0 µg d^{-1} and 8.0 µg d^{-1}, respectively predicted an excretion of 142 ng d^{-1} at the mean ages for the unexposed groups. The result shows wide difference between the measured data and the model prediction. These discrepancies suggested the need for the reconsideration of the use of the default ICRP f_1 values for the dietary incorporation of the radionuclide. The model prediction at the mean ages of 31y and 38 y using a new absorption factor for the daily uranium excretion are 22.16 ng and 4.98 ng for the exposed and the unexposed population, respectively.

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Table 1: Daily urinary excretion of ^{238}U in unexposed and exposed adult subjects in Nigeria

Subject	Age	Weight (kg)	U excretion values (ng d^{-1})
		Unexposed Group	
PAC1	39	91	2.96; 3.94; 3.86
PAC2	40	71	8.08; 7.28; 7.19
PAC3	37	67	10.58; 15.29; 7.22
PJS1	34	70	6.06; 7.28; 7.19
PJS2	37	91	0.99; 4.95; 4.90
PJS3	38	84	19.37; 10.44; 7.28
PJS4	44	70	1.35; 6.74; 6.68
Number of samples			21
Range			0.99 – 19.37
Mean (SD)			7.13 (4.23)
Median (95 % confidence interval)			7.19 (0.86)
Geometric mean (GSD)			5.90 (2.00)
		Exposed Group	
TPJ1	27	70	25.35; 32.57; 12.38
TPJ2	26	70	17.63; 30.97; 15.21
TPJ3	36	64	21.71; 31.10; 22.19
TPJ4	26	88	22.23; 28.39; 20.90
TPJ5	24	72	34.91
TMB1	30	58	62.70; 89.25; 59.63
TMB2	34	66	10.01; 35.70; 12.88
TMB3	35	58	3.89; 9.17; 7.64
TMB4	26	64	10.23; 13.17; 10.07

TMB5	28	60	30.75; 32.00; 18.25
TMB6	32	70	26.83; 33.06; 12.98
PAC4	52	84	7.13; 10.98; 10.91
Number of samples			34
Range			3.89 – 89.25
Mean (SD)			24.20 (17.78)
Median (95 % confidence interval)			22.19 (0.67)
Geometric mean (GSD)			19.38 (1.97)

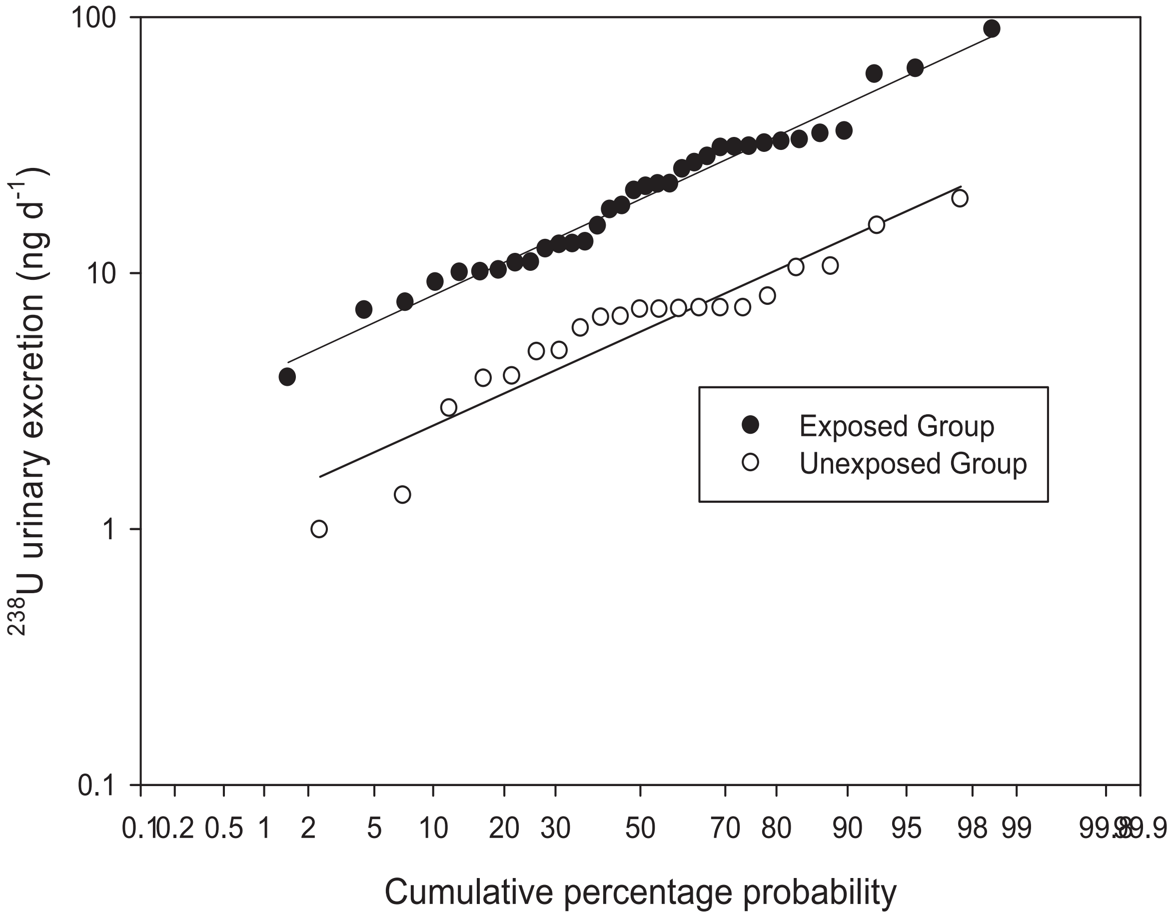

Fig 1: The log-probability plot of urinary ^{238}U excretion rate and the fitted curve.

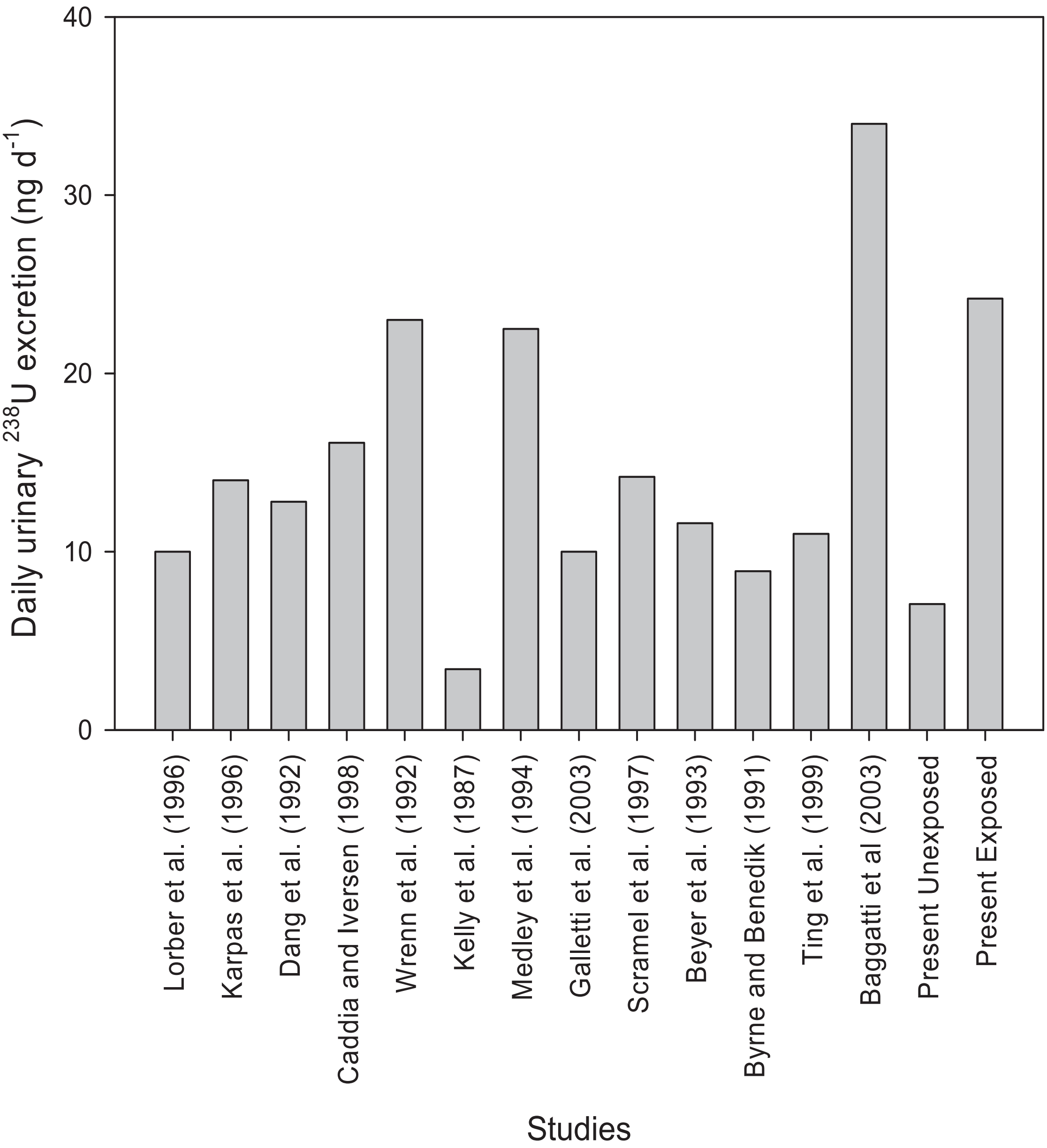

Fig 2: Comparison between the present and other studies on the daily urinary ^{238}U excretion

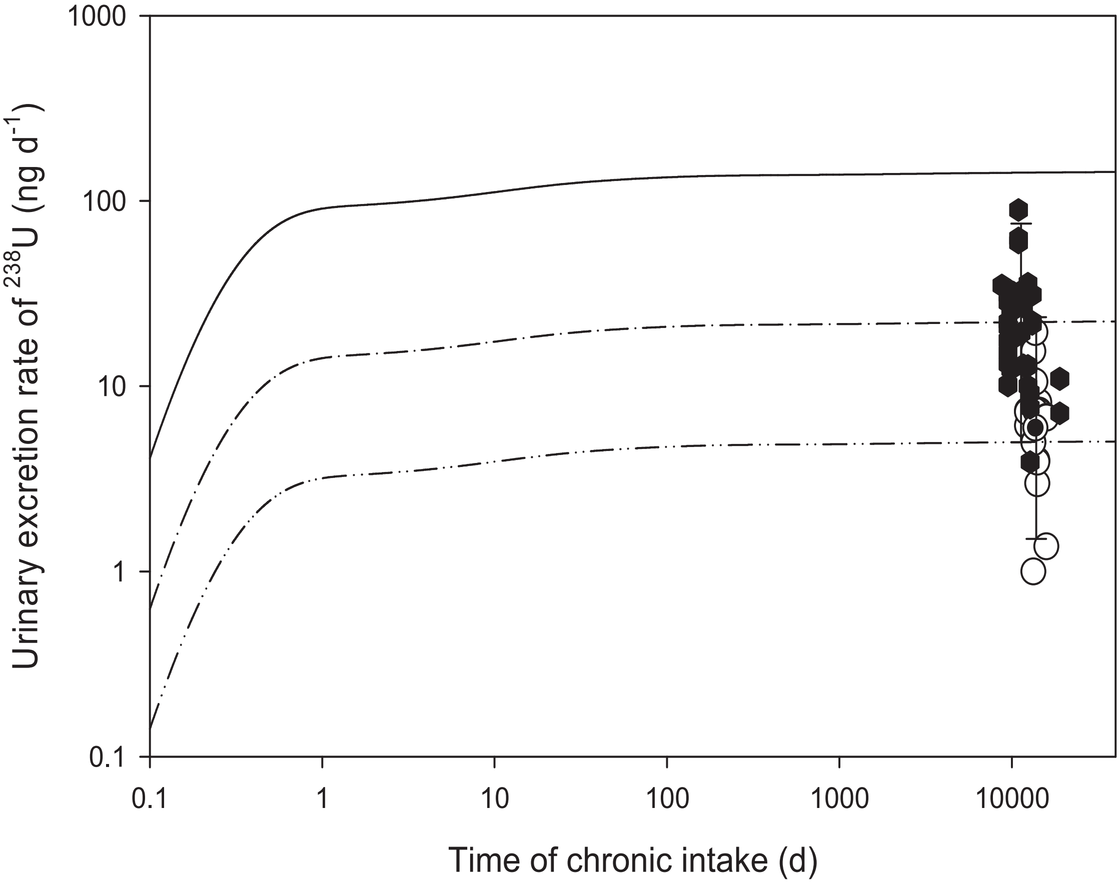

Fig. 3: Predicted urinary uranium excretion during lifetime and the measured excretion values. Solid line: ICRP biokinetic model (ICRP 1995) using the default f_1 value and uranium intake for the exposed; Dash dot line: Model prediction using the modified f_1 value and daily intake for the exposed; Dash dot-dot line: Model prediction using the modified f_1 value and daily intake for the unexposed. Open circle symbol represent individual excretion values for the unexposed group; Closed Hex symbol represent individual excretion values for the exposed group. Error bars are the upper and lower bound at 95 % confidence interval of the GSD for the two groups.

IMPROVING CROP POTENTIALS THROUGH BIOTECHNOLOGY

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Abstract

The discovery of biotechnological techniques of tissue culture and genetic engineering has proved useful in moving genes of interest from suitable alien donors into crop cultivars. Crop improvement received an accelerated boom through biotechnological tools of gene transfer, to engineer new traits into plants that are very difficult to hybridize by traditional breeding. Remarkable accomplishments have been achieved in the successful deployment of transgenic properties to crop cultivars to combat insect pests and diseases of major crops. Edible vaccines are being produced to protect against the deadly viral diseases of humans and livestock. Biofortification of crops has increased the nutritional status of a number of crops. Golden Rice, for instance, is genetically enriched with vitamin A and iron and it has the potential to save millions of lives. However, despite a boon to agricultural growth and development, biotechnology is faced with serious opposition and its constraints especially in the continent of Africa is enormous. Among the opposition to agricultural biotechnology are fears that genetically modified foods can pose health risks to consumers, genetic pollution of related plant, belief that tinkering with naturally occurring plants is unethical among others. Funding seems to be the major constraint to biotechnological development in Africa.

Keywords: Biotechnology, crop improvement, transgene, genetically modified foods.

INTRODUCTION

CTA Annual Reports in 2008 read inter alia, "The year 2008 will be remembered for extreme oil price volatility (plummeting from US $147 in July to $40 in December, food shortages, skyrocketing food prices and the spectre of recession. The economic malaise is globally affecting virtually every sector. More than 70 percent of the population living in developing and under developed countries work in the agricultural sector. As the environmental and social consequences of climate change for the resource poor farmers are on the increase, the jeopardy of losing their means of livelihood is high.

Similarly agricultural production is on the slide due to a general disinterest occasioned by poor yields (low harvests), disease infection and pest infestation. More recently climate change is posing a big threat to sustainable agriculture due to its attendants negative effects which include accelerated evaporation, drought, flooding, genetic erosion, reduction in water volume, drying up of rivers and lakes, sea level rise and desertification. In a time like this, the general outcry in the country is a diversification of the economy from its mono-economic status to other sectors with agriculture taking the lead. For meaningful breakthroughs in agriculture, crop varieties and animal breeds must be high yielding, disease and pest resistant, adaptable to environmental stress and conditions among other factors. This onus rests upon breeders.

Conventional plant breeding has been used as a tool for obtaining far reaching achievements in agriculture but it is time consuming. To save time, to catch up with the ever moving world and to be part and parcel of the global tide of change, a practicable, tractable and useful option is agricultural biotechnology. Biotechnology though is not the only solution to the perennial food crises plaguing the African continent; its contributions which I perceive to be enormous if spiritedly pursued will have great impact in solving the fool palaver.

This paper explores the possibility of using biotechnology to enhance the overall potentials of agricultural crops with a view to revolutionizing agricultural sector of the nation's economy.

Biotechnology at a Glance

Biotechnology can be defined as any technique that uses living organisms, or substances from these organisms, to make or modify a product, to improve plants or animals, or to develop microorganism for specific uses (Brink *et al.*, 1989). The Convention on Biological Diversity (CBD) defines biotechnology as any technological application that uses biological systems, living organisms, or derivates thereof to make or modify products or processes for specific use (FAO, 2000).

In the broad sense, the definition of biotechnology covers many of the tools and techniques that are commonplace in agriculture and food production. In the narrow sense, which considers only the new DNA techniques, molecular biology and reproductive technological applications, the definition covers a range of different technologies such as gene manipulation and gene transfer, DNA typing and cloning of plants and animals.

In plant biotechnology, three applications of broad fields of study such as plant tissue culture, genetic engineering and plant molecular markers can be identified (Brink *et al.*, 1998). These applications range from the simple to the sophisticated and in many cases are appropriate for uses in Africa. Other methods of biotechnology include molecular plant disease diagnosis and cryopreservation.

Tissue culture of plants is based on the totipotence of plant cells or tissues. Totipotence refers to the potential ability of a single plant cell to develop into a whole plant. The applications of tissues culture to crop improvement include rapid multiplication of plants, production of pathogen free plants, germplasm conservation and exchange as well as small scale cloning. Genetic engineering is defined as any non-conventional tool aimed at mobilizing specific genetic information from one member of the plant kingdom (or, for that matter, any organism) into another (Jauhar, 2006). These asexual techniques of biotechnology help engineer into plants new characters that are otherwise very difficult to introduce by conventional breeding.

The molecular techniques, including the recombinant DNA methods, involve the introduction of well-characterized alien DNA into the recipient plant cells of regenerable embryonic calli to permanently transform the plant's genetic makeup. Genetic engineering has the potential to accelerate crop improvement and has already yielded encouraging results (Repellin *et al,* 2001; Wesseler, 2003;

Sharma *et al.*, 2004). Value-added traits engineered into crop plants include resistance to fungal and viral diseases, and biofortification of their nutritional status (Jauhar and Khush, 2002; Bajaj and Mahanty, 2005). Uno *et al*. (2001) reported that in the US, sales of nonfood products from genetically transformed plants grow from about $21 million per year in 1997 to $320 million or more in 2005. The first nonfood commercial product of plant genetic engineering was lauric acid, a 12-carbon fatty acid that is used in making soaps and detergents

Cryopreservation is the storage of organic materials at ultra-low temperature, usually that of liquid nitrogen which is -196ºC. It is used to ensure long time, safe and cost effective storage of biological species that have recalcitrant seeds or are vegetatively propagated. Embryos, pollens, shoot apices, meristems and even whole seeds of fruits, ornamental, horticultural and agronomic crops as well as wild relatives of cultivated crops and other endangered species can be preserved with this technique.

Biotechnology provides powerful tools for the sustainable development of agriculture, fisheries and forestry, as well as the food industry. Its appropriate integration with other technologies for the production of food, agricultural products and services, can be of significant assistance in meeting the needs of an expanding and increasingly urbanized population in this millennium (FAO, 2000).

Modern Biotechnology: A Means of Genetic Enrichment of Crop Plants

It has been widely reported that conventional plant breeding (Jauhar, 1988; Khush, 2001), sometimes assisted by marker-assisted selection (Dubcovsky, 2004), and wide hybridization coupled with manipulation of chromosome pairing (Jauhar, 2003a) has clearly been instrumental in producing superior crop cultivars. Wide hybridization is undoubtedly an effective means of incorporating desirable alien genes into crop cultivars, but it has several limitations. Unwanted alien chromosomes can be transmitted. Sterility can result if the genetic interactions are adverse. This leads to the exploration of other efficient means of biotechnology.

Some of the useful applications of biotechnology are explained below.

Rapid Improvement of Crops

Traditional breeding is generally referred to as being notoriously slow in transferring a desired trait into an otherwise superior crop cultivar. If the gene source is a primary gene pool, the gene transfer may take up to 5 years. Secondary and tertiary gene pool may take more than 5 years for such a transfer, if they are at all possible. Jauhar (2006) reports that pre-and post-fertilization barriers may impede sexual hybridization between the donor and the crop species and then compound the problem of alien gene transfers. In some cases, incorporation of a certain desired trait by conventional means may not be possible as a suitable donor may not be possible to hybridize the donor species with the crop plant.

Genetic engineering offers an excellent tool for introducing gene(s) of unrelated organisms into plants cells, which on regeneration produce full plant with the inserted gene(s) integrated into their genome. This process may take less than a year to about 18 months in some cases, thus accelerating the process of genetic improvement of crop plants. In addition, this technology allows access to an unlimited gene pool without the constraints of sexual incompatibility (Jauhar and Khush, 2002; Altpeter *et al.*, 2005).

Resistance to Insect Pests

Resistance breeding by conventional means is cumbersome and fraught with uncertainty. A gene from a soil-borne bacterium, *Bacillus thuringiensis* (Bt) when bioengineered into the corn genome for instance confers almost complete resistance to European corn borer (ECB). While it took Syngenta, a Swiss agrochemical company 5 years to accomplish this, it took the company 12 years of breeding to produce a corn cultivar with only 10 per cent resistance to ECB. Moreover, Bt corn is beneficial to the environment and Bt – induced insect resistance in corn is much safer to farmers and other field workers, compared with the use of a chemical insecticide. Similarly Ramesk *et al.*, (2004) reports that transgenic rice varieties resistant to yellow stem borer *(Scirpophaga incertulas* (Walker) have been produced in India. Bt cotton has been commercialized in Asian countries like China (Huang *et al.*, (2002a) and India (Whitfied, 2003). It had been reported that convention breeding could not breed resistance to the major pests of cowpea (Vigna unguiculata (L) Walp) in Nigeria which are the flower thrips *(Megalurothrips sjostedti*), pod borer (*Maruca vitrata*) as well as pod sucking bugs and storage weevils (*Callosobruchus maculatus*)(IITA, 2009).

Resistance to Diseases

Conventional plant breeding is credited with offering a useful means of breeding disease resistant cultivars, provided a reliable donor of resistance is available. The painful aspect of it is its slow procedures. With biotechnological techniques, fungal, bacterial, and even viral diseases have been controlled. For instance, genetic engineering has been employed to contain Fusarium head blight (FHB), a ravaging disease of wheat (Datta *et al*., 2001). Xa21, a gene with broad-spectrum resistance to bacterial blight, cloned through map-based cloning has been used to combat bacterial blight of rice caused by *Xanthomonas oryzae pv. oryzae* (Ishiyama)(Song *et al.*, 1995).

Biofortification of Crops to Combat Nutritional Deficiency

One of the greatest contributions of biotechnology to crop improvement is the biofortification of crops. This improvement is necessary to alleviate deficiencies of proteins, minerals and vitamins, in addition to increasing crop yields. Iron deficiency, as well as vitamin A deficiency ravages several millions of people in the world. The production of Golden Rice that is rich in vitamin A as well as iron was achieved through genetic engineering (Ye *et al.,* 2000). Transgenic potato has a more significant increase in most essential amino acids as well as in protein content in tubers compared with nontransgenic potato plants. Similarly, through a technique involving organ-specific gene silencing on tomato, Davuluri *et al*., (2005) have significantly increased the content of both carotenoids and flavonoids in the crop which are highly beneficial to human health.

Production of Edible Vaccines

Vaccines protect millions of people and animals against contagious and deadly viral diseases. However, their production is costly and a lot of problems is associated with their distribution and safe storage. Edible vaccines produced through genetically modified (GM) technologies could be used instead of traditional inoculants. With appropriate genetic engineering, certain food crops could provide immunization against deadly diseases like hepatitis B or tuberculosis. Kumar *et al*. (2005) report that edible vaccines against measles, cholera and hepatitis B are being developed in India. These edible vaccines apart from ready availability and low cost, will not have storability problem compared to synthetic ones.

Genetic Decaffeination of Coffee

Tea (*Camelia sinensis* (L) Kuntze) and coffee (*Coffea arabica* L.) are two most widely used beverages in the world. However, because they contain caffeine, a stimulant that can cause occasional side effects like elevated blood pressure and heart palpitations, people tend to avoid them. These plants have been genetically decaffeinated with remarkable success. *Ogita et al*. (2003) state that decaffeinated coffee is growing on genetically modified bushes that could yield low-caffeine beans in 3 or 4 years.

Increasing Productivity of Crops

Productivity of cultivated crops can be increased via biotechnology. This is achieved by increasing the photosynthetic efficiency of the crops or by channeling photosynthate into the sink of interest or choice such as tubers or seeds. It can also be achieved by reducing to the barest minimum pests and diseases. In this case, genes resistant to biotic components such as insects, bacteria, fungi, nematodes, viruses, parasitic weeds and abiotic components like herbicides can be engineered into crops.

Other useful contributions of transgenetic technology include phytoremediation, reduction of allergenecity of crop plants, breeding for drought resistance and improvement in fruit storage.

Resistance or Opposition to Acceptance of Modern Biotechnology

While there is little controversy about many aspects of biotechnology and its application, genetically modified organisms (GMOs) have become the target of a very intense debate. Some of the perceived dangers of transgenic technology are discussed below.

There is a perception that GM foods could pose health risks to their consumers. Although the safety record of transgenic crops and their products testifies to their wholesomeness, people are not yet convinced that these GM foods have come to stay. Vasil (2003) reports that in the USA, more than 60 percent of all processed foods contain transgenic ingredient and that not a single transgenic food product has been shown to have any harmful effects.

Genetic Pollution of Related Plants

The argument here is that a transgene for herbicide resistance could get incorporated into a wild relative of a genetically engineered crop plant thereby creating a super weed that might be hard to control.

Tinkering with Nature

Transgenic technology as a means of introducing new genes into plants is considered by some as "tinkering with nature". This technology is considered unethical. Aken'Ova (2003) has this to say, "In considering the new technology, I sometimes wonder whether DNA the magical biochemical compound of life, which scientists are transforming hither and thither, is not also an acronym for "Do Not Alter" or "Do Not Amend", DNA could also stand for "Deus Non Approbat" which would be the Latin for "God does not approve."

However, the truth is that any breeding activity is accompanied by genetic modifications which involve changes at the DNA level. The new biotechnological tools of gene transfer into crop cultivars are in fact a refinement of earlier ones and genetic enhancement by those techniques poses no greater risk to the consumer. Many of the current crop cultivars we consume do, after all, contain genes of alien origin (Jauhar and Khush, 2002)

Allergenicity

The concern about the creation of new allergens in GM foods is of major consideration. Although natural foods like peanut are known to produce allergic reaction in some people, it has been shown that genetic engineering can actually be used to make food less allergenic. Soybean is another crop which is known to cause allergies in humans. Herman *et al*. (2003) used the transgene – induced gene silencing to shut down the gene that codes for the protein believed to cause most soybean allergies.

Effects on Non-target Organisms

There is a strong argument against this novel tool of crop improvement that non-target organisms may be affected thereby posing a threat to biodiversity. This is taking to cause a disruption in the balance of the ecosystem.

CONSTRAINTS TO BIOTECHNOLOGICAL DEVELOPMENT

Some of the constraints to the application of biotechnology in African counties are explained below.

Funding

The successful production of transgenic plants requires an adequate infrastructure, expertise in tissue culture and molecular biology and dedicated researchers. To cover these activities and the high cost of research, sustainable funding is required. Due to poor funding only a few laboratories in African countries have the capacity to produce transgenic plants but still could not produce on a commercial scale not to talk of reaching the end user, i.e. the African farmers. For biotechnology to be fully established, it requires huge financial commitment.

Lack of Resources for biotechnology

Production of improved crop varieties through biotechnology involves the building up of skilled human resources and development of human resource capacity. This is however hampered in Africa due to inadequate funds to pay salaries and absorb running costs of project. Basic facilities even for the simplest tissue culture techniques such as micro-propagation are non-existent. Most communication systems are poorly developed while electricity supply in some countries is erratic.

Selection of Crops for Research

Most of the crops utilized in Africa are often not important enough to attract foreign investment in research. There is a telling lack of basic research on neglected or underutilized crops which includes aspect of crop growth and plant protection.

Political and Legislative Constraint

A lack of national priority setting in agricultural research is evident in many African countries. Consequent upon this, specific policy or strategy cannot be formulated by the various national Agricultural Research Centres in each country on the application of biotechnology. In some instances, the programme could not receive the support of law makers due to their insincerity, parochial interest and technicality of the subject matter. In Nigeria for instance the house of representatives passed the Biosafety Bill in February 2009 since the early 1990s.

Climate and Weather Constraint.

Climate and weather conditions in Africa are a serious challenge to biotechnological development, for instance, tissue culture research. The total absence of a viable public or private seed industry contributes to the absence of an appropriate channel for the transfer of products developed through biotechnology.

Problems of Adaptation of GM Crops.

Most of the GM crops may not be well adapted to Africa. This makes the imported lines or cultivars to be inappropriate for local conditions. Apart from the expensive cost involved in their cultivation as premium will be paid, high energy input is also required. These crops may again be susceptible to local diseases and insects. A better alternative is the application of biotechnology to develop indigenous plants.

CONCLUDING REMARK

Although biotechnology should not be seen as the only panacea to the problems of food insecurity in Africa, it is an additional but potent tool in the toolkit of plant breeding. Despite being a supplement to conventional plant breeding its proper implementation will accelerate crop improvement in Africa. Numerous health benefits occasioned by nutrient biofortification, incorporation of high quality agricultural products as well as development of edible vaccines to arrest most deadly viral diseases are appreciable. The successful deployment of transgenic approaches to combat insect pests and diseases of important crops like rice, wheat, maize, barley and cotton, is a remarkable accomplishment. The contribution of GM crops to increased yields and agricultural growth in many developing countries and the benefits to small-scale farmers are noteworthy.

What African countries need do is to take the issues of biosafety, risk assessment and management very seriously. If spiritedly pursued, plant biotechnology will be a blessing or a round peg in a round hole to the overall agricultural development of the continent.

RECOMMENDATIONS

1. Proper funding of biotechnological research
2. The issues of biosafety is to be seriously pursued
3. Since networking is an effective means for enhancing scientific co-operation and maximizing information exchange at the national and international level, it must be fully utilized in biotechnology in Africa.
4. Apart from national biotechnological centres if any, certain universities need be selected as biotechnological centres to train manpower.
5. Graduate students need to be encouraged to venture into plant technology as their research priorities.
6. A partnership should be created between the government and the private sector for adequate funding.
7. There is a need for a science – based evaluation system that would objectively determine the benefits and risks of GM foods from time to time.
8. Aggressive awareness and enlightenment campaigns to alley people's fears concerning GM foods and products.

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THE NUTRITIONAL AND ENVIRONMENTAL IMPLICATIONS OF PHYTASE SUPPLEMENTATION OF ANIMAL FEED AND ALTERNATIVE SOURCES OF PHYTASE FOR THE ANIMAL FEED INDUSTRY

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Abstract

Phosphorus excretion in poultry manure can lead to water pollution when the manure is used as fertilizer. The need to maintain sufficient dietary phosphorus levels while reducing phosphorus excretion in poultry manure has led to an increase in the application of phytase to poultry feed in recent years. The use of phytase reduces phosphorus excretion in poultry manure by allowing the birds to utilize more of the phytate phosphorus. Phytate phosphorus has the ability to complex with cations such as calcium, magnesium, zinc, copper, and nitrogen and certain gastrointestinal proteases, thus reducing the availability of these cations and of amino acids. The use of phytase may free these cations and proteases bound in phytate phosphorus complexes and improve many production parameters and body structure characteristics in broilers and laying hens, such as body weight, bone ash content, feed consumption, egg weight, and egg shell quality. The phytases used for this purpose are usually of microbial origin and the phytase-supplemented poultry feeds are expensive. This is because of the technology involved in the extraction, purification and thermo-stabilization of the enzymes. The technology is unaffordable and thus unavailable in many developing countries especially in Africa. Selected cereals and legumes were screened for phytase activity and the effect of sprouting on enzyme activity was also assessed. It was found that the phytase activity was generally lower in seeds than as reported for microorganisms. Germination for up to 10 days resulted in up to 1000-fold increase in activity. This shows that indigenous cereals and legumes are potential sources of phytase for the poultry feed industry.

Keywords: Phytase, Phytate, Phosphorus, Poultry feed, pollution

BACKGROUND INFORMATION

Phytate (*myo*-inositol(1,2,3,4,5,6)hexakisphosphate, abbreviated as IP6) is ubiquitous among plant seeds and/or grains, comprising 0·5–5% (w/w) (Sathe and Reddy, 2002). It is primarily present as a salt of the mono- and divalent cations K^+, Mg^{2+}, and Ca^{2+}. Phytate rapidly accumulates in seeds during the ripening period (Asada *et al.*, 1969) and in dormant seeds it represents 60–90% of the total phosphate. The function of these high phytate concentrations is unclear. It has been suggested that phytate may serve as a store of phosphate (Hall and Hodge 1966), cations (Williams, 1970), of the cell wall glucuronate precursor (Maiti and Loewus, 1978), of high energy phosphoryl groups (Biswas *et al.*, 1978), and, by chelating free iron, as a potent natural antioxidant (Graf *et al.*, 1987). Monogastric animals, such as pigs and poultry, are not able to utilize phytate phosphorus, since they have only low levels of phytase activity in their digestive tracts and since phytate cannot be resorbed. Additional phosphorus must therefore be added to the feed to provide sufficient phosphorus in the diet, which often leads to excess phosphorus excretion in the manure and consequently environmental pollution. Phytate can also react with protein to form a phytate-protein complex. This complex incorporates about 16 % of protein in beans. Formation of a phytate-cation-protein complex is believed to account for the decreased mineral and protein bioavailability observed in animals consuming diets high in phytate (Aletor, 1993). Microbial phytases are sometimes added to poultry feed to improve the availability of plant protein, phosphorus and chelated minerals.

PHYTATE: STRUCTURE AND DESCRIPTION

Phytic acid or phytate (Figure 1) is the major storage form of phosphorus in matured grains and legumes. It stores more than 60% of the total phosphorus in cereals and legumes (Aletor, 1993). Phytate in cereals is not uniformly distributed within the kernel, but it is associated with specific morphological components in the grain (Ravindran *et al*., 1999).

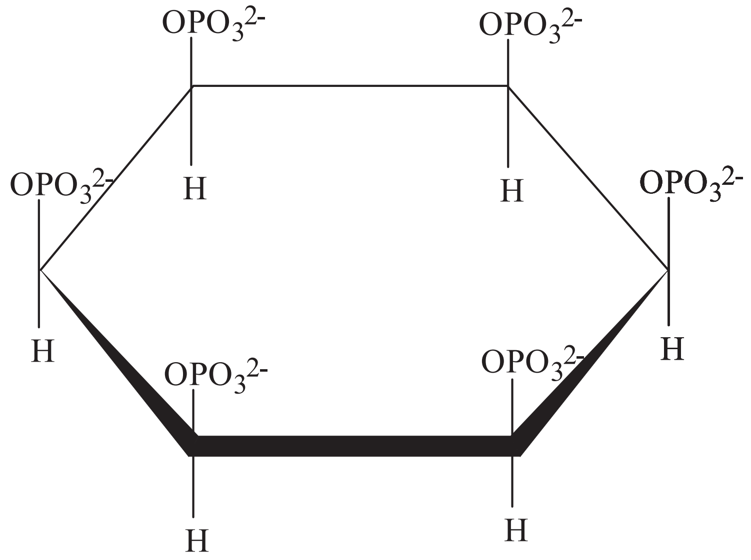

Figure 1: Inositol (1,2,3,4,5,6) hexakisphosphate (Phytate)

Maize grain for example, has 88% of its phytate distributed in the germ layer, 3.2% in the endosperm and the reminder in the hull. In contrast, wheat has 87.1% of the phytate distributed in the aleurone layer, 12.9% in the germ and 2.2% in the endosperm and is in the form of Ca^{2+}, Mg^{2+} salt (Harland and Oberleas, 1999). However phytate in legumes is deposited in protein bodies as complexes of chelated minerals (Ravindran, 1999). Phytate is referred to as an "antinultrient" due to the fact that it readily chelates divalent metal ions, such as Ca^{2+}, Fe^{2+}, Zn^{2+}, Mg^{2+} and Mn^{2+} by binding to these ions to form insoluble complexes (Aletor, 1993). The consequence of this is that, these chelated ions are unavailable for absorption from the intestinal tract of animals and humans (Nelson *et al.,* 1971). Phytate also reduce the digestibility of starch, protein and lipids.

CHEMISTRY OF PHYTATE

Phytate is highly reactive having 12 dissociable proteins with pka values that range from 1.5 to 10 (Costello, *et al.,* 1976). Phytate is negatively charged and is capable of binding divalent cations such as Zn^{2+}, Cn^{2+}, Fe^{2+}, and Ca^{2+}, forming insoluble complexes in the process (Zhou and Erdman, 1995). The consequence of this is that these minerals are unavailable for absorption. However, the reactivity of inositol phosophate is highly dependent on the conformation and configuration of the molecule and the pH of its environment (Costello, *et al.,* 1976). Despite the fact that the IP6 – Ca^{2+} complex has a lower stability than other IP6 metal ion complexes, it may be dietary calcium that plays a more critical role in minimizing the effectiveness of both exogenous and endogenous phytates. The level of calcium added to poultry feed is eight to 40 fold higher than that of Zn and the impact of the much higher concentration of calcium may be more powerful than its lower affinity due to simple mass action (Costello, *et al.,* 1976). When two cations are present simultaneously they increase the proportion of the IP6 metal complex that precipitates it (Zhou and Erdman, 1995).

BIOLOGICAL AND NUTRITIONAL ROLES OF PHYTATES

Biological roles have been suggested for phytate in seeds: a phosphorus store (Hall and Hodges, 1966), an energy store and an activator of dormancy (Sobolev and Rodionova, 1966). These roles of phytate are associated with germination and dormancy of seeds. Phytate has been shown to inhibit several proteolytic enzymes including α-amylase (Desphande and Cheyan, 1984), indicating a strong interaction with minerals. Phytate is considered to be an antioxidant agent, because it is a potent inhibitor of iron – catalyzed hydroxyl radical formation, chelating free iron and then blocking the co-ordination site (Empson *et al*., 1991). Phytate is most commonly thought of as an anti-nutrient because of its ability to complex or bind mineral cations in the seed or diets, rendering these bound cations as well as the phosphorus partially or completely unavailable to the animal. The effect of phytate on mineral availability is influenced by the presence of other mineral in the diet as well as its association with dietary protein to form phytate-protein complex. Other factors could include the degree of heat treatment, pH and processing history of the diet.

Phytate has been found in cereal grains up to a level approximately 5% by weight (Sathe and Reddy, 2002). If ingested it seriously interferes with the absorption of dietary calcium, iron and zinc. Insoluble calcium, iron and zinc phytates are formed and the calcium, iron and zinc are thus lost to the body. For example, phytate addition to diet reduces calcium absorption and subsequently induces rickets. Thus, the nutritional significance of phytate in the diet of man has been considered in recent years because of its implication in mineral deficiency.

POSITIVE EFFECTS OF PHYTATES ON HUMAN HEALTH

Little attention has been paid until now to the positive effects of phytate consumption. Phytate is considered to be antioxidant agent because it is a potent inhibitor of iron-catalysed hydroxyl radical formation by chelating free ion and then blocking the co-ordination site (Empson, *et al.,* 1991). There are some studies dealing with its ability to prevent certain types of cancer, such as colon cancer. First hint of an anti-carcinogenic action of phytate came from epidemiological studies, which showed lower incidence of colon cancer in population consuming vegetarian type diets (Englyst *et al.,* 1982). The mechanism of action is not understood, however phytate may bring about a favourable reduction in the formation of hydroxyl radicals in the colon by complexing ions (Nelson, 1971). Furthermore, lower inositol phosphates such as IP_4, and IP_3 may play roles in mediating cellular responses and have been noted to have a function in second messenger transduction systems (Zhou and Erdman, 1995).

In the last few years epidemiological evidences have strongly supported the hypothesis that phytate and degradation products of phytate, found in bioprocessed foods of plant origin, also have various physiological effects of importance for health. Certain myo-inositol phosphates have been proposed to have positive effects on heart disease by controlling hypercholesterolemia and atherosclerosis (Potter, 1995), and also to prevent renal stone formation (Ohkawa *et al*., 1984), diabetes complications (Carrington *et al.,* 1993) and inflammation (Siren *et al.,* 1991). The most extensively studied positive aspect of myo-inositol phosphates is their potential for reducing the risk of colon cancer (Shamsuddin *et al.,* 1997). Much attention has been focused on lower myo-inositol phosphates, in particular the intracellular second messengers D-myo-inositol(l,4,5)trisphosphate and D-myo-inositol(1,3,4,5)tetrakisphosphate, stimulating intracellular release of calcium affecting cellular metabolism and secretion (Potter 1990). The physiological role of different myo-inositol phosphates is presently undergoing extensive research.

METHODS USED TO REDUCE PHYTATE IN PLANTS FOOD

Soaking, autolysis and other processes: The effect of time, temperature, pH, soaking and heating on the autolysis of phytate in California small white beans was evaluated by Chang (1967). At 50^0C, the hydrolysis of phytate from the beans was 31.0% and it reaches a maximum of 49% at 60^0C. These results suggested an initiation of enzyme activity at about 60^0C and inactivation of the enzyme at 70^0C. They also reported that after 10 hours of incubation of beans at 60^0C, only a negligible amount of phytate was found in the beans, approximately 75% of the total phytate being hydrolyzed and 25% being diffused into the water in which the beans were incubated. Tabekhia and Luhl (1992) demonstrated a phytate decrease of 7.7%, 8.1%, 3.21% and 19.1% respectively for black-eyed beans, red kidney beans, mung beans and pink beans on soaking these beans for 12 hours at 25^0C in tap water. Iyer (1995) found that when pinto, Great Northern and red kidney beans were soaked in distilled water for 18 hours at room temperature, the phytate content of beans was appreciably reduced (52.7%, 69.6% and 51.7%, respectively). However, they noticed somewhat less phytate hydrolysis when the beans were soaked in a mixed salt solution (2.5% sodium chloride plus 1.0% sodium tripolyphosphate plus 1.5% sodium bicarbonate plus 0.5% sodium carbonate) at pH 7.0 and a room temperature at 22^0c.

Cooking: The Correlation of phytate with the cooking quality of legume seeds has been reported. Cream and Haisman (1953) studied the interaction between phytate and the divalent cations, calcium and magnesium, during the cooking of dried peas. They found that phytate in dried peas exists wholly as a water-soluble salt (probably potassium phytate), but on cooking some, of it combine with the calcium and magnesium in the pea to form insoluble calcium and magnesium phytate. Cooking processes decrease both water and acid-extractable phytate-phosphorus in legumes. Sathe and Reddy (2002) did not find any breakdown of phytate during cooking. Whatever the losses in total phosphorus and phytate phosphorus they observed during short time cooking, they were due to leaching of these components into the cook water. Cooking for 45 minutes at 115^0C caused small losses in total phosphorus and phytate contents into the cooking water which may have been due to reabsorption of phytate by beans from cooking water.

Fermentation: Fermentation of cereals and legumes appreciably reduces the phytate content owing to endogenous phytase of legumes and that of added mould and/or other useful microorganisms (Azeke *et al*., 2005; Azeke *et al*., 2007). Greiner and Konitzny (1998) studied the changes in phytate during tempeh preparation by fermenting boiled soybeans with *Rhizopus oligosporus*. Boiling of soybeans resulted in a reduction (14.0%) of phytate. Phytate was reduced by about one third in soybeans as a result of fermentation with mold (*R.oligosporus*). The decrease in phytate was accompanied by an increase in inorganic phosphorus. They concluded that the reduction in phytate obtained was due to the action of the enzyme phytase, which was mixed with salt solution produced by mold during fermentation. These results have also been confirmed by Azeke *et al*. (2007) fermenting the African yambean (*Sphenostylis stenocarpa*) with the same fungus.

Germination: Sprouting grain legumes and cereal seeds has been used for a long time as a means of reducing phytate and many other antinutrients. This is due to the fact that a rise in phytase activity during germination is accompanied by a reduction in phytate content. In cereals and legumes, the cause of the rise in phytase activity during germination is in some dispute. Some studies suggest ***de*** *novo* synthesis (Bianchetti and Sartirana 1967), while others simply suggest activation of pre-existing enzymes as the cause of the rise in activity (Eastwood and Laidman 1971). During germination, phytase activity may be controlled by the action *of* gibberellic acid and phosphate, respectively. It is claimed that gibberellic acid affects phosphate mobilization merely by increasing the secretion of phytases but does not stimulate their synthesis (Gabard and Jones 1986).

THE PHYTATE DEGRADING ENZYME: PHYTASE

Phytases (myo-inositol hexaphosphate hydrolases), a class of phosphatases, are the primary enzymes responsible for the hydrolysis of phytate. They catalyze the sequential hydrolysis of phytic acid (or phytate) to less phosphorylated inositol phosphates and, in some cases, to inositol (Jog *et al*., 2005).

TYPE OF PHYTASE ENZYME

Phytases have been classified on the basis of pH optima (acid and alkaline), catalytic mechanisms (histidine acid phosphatase-like phytase, purple acid phosphatase-like phytase, and β-propeller phytase), and specificity of hydrolysis (3-phytase, EC.3.1.3.8, 6-phytase, EC.3.1.3.26, and more recently 5-phytases, EC.3.1.3.72) (Jog *et al*., 2005). Although acid phytases have been extensively studied, investigations of alkaline phytases have been relatively few.

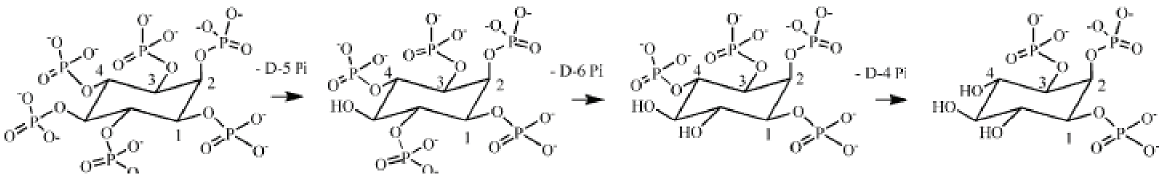

Figure 2: Hydrolysis of phytic acid by alkaline phytase

These phytases initiate the dephosphorylation of IP6 at different positions on the inositol ring and produce different isomers of the lower inosital phosphates (Beers and Jongbloed, 1992). The 3- 5- and 6-phytases intiate the dephosporylation of IP6 at the 3rd, 5th and 6th position repectively, yielding 1,2,4,5,6-, 1,2,3,4,6- and 1,2,3,4,5-pentakisphosphate respectively in addition to inorganic phosphate (Pi). The 3-phytases do not always completely dephosphorylate IP6, whereas the 6-phytases do (Konietzny and Greiner, 2002). It has been stated that micro organisms normally produce the 3-phytase while the 6-phytases are found normally in plants (Nayini and Markakis, 1986). However, exceptions to this general rule have been reported. For example an enzyme with 3 phytase activity has been reported in soya bean (Beers and Jongbloed, 1992) and an enzyme with 6-phytase activity has been reported in *E. coli* (Konietzny and Greiner, 2002). Microbial phytases tend to have pH optima in the range of 2 to 6, whereas plant phytases tend to have a pH optimum near 5 (Beers and Jongbleod, 1992).

THE NEED FOR PHYTASE SUPPLEMENTATION IN ANIMAL FEED

According to Bedford and Schulze (1998), the primary objective of adding exogenous enzymes to poultry diets is to improve the utilisation of nutrients in raw materials. This is achieved by one or more of the following mechanisms: (i) degradation of specific bonds in ingredients not usually degraded by endogenous digestive enzymes, (ii) degradation of anti-nutritive factors that lower the availability of nutrients, (iii) increased accessibility of nutrients to endogenous digestive enzymes, and/or (iv) supplementation of the enzyme capacity of young animals.

Use of Phytase: Effects on Body and Production Parameters of Broilers

Currently, one of the most common methods of reducing phosphorus excretion in poultry is the supplementation of feed with microbial-derived phytase. Nelson *et al*. (1971) first showed that supplementing broiler diets with phytase from *Aspergillus ficcuum* improved phytate phosphorus utilization based on bone ash content. More recently, Zyla *et al*. (1999) found that supplementing broiler feed with phytase significantly increased bone ash content when using 600 and 1,000 phytase units (FTU)/kg and 0.15% nonphytate phosphorus when compared to no phytase supplementation and the same level of available phosphorus. Neither of these phytase levels improved bone ash content when compared to no phytase and 0.45% nonphytate phosphorus. Bone ash content, body weight gain, and tibia length have been shown to be improved by the supplementation of phytase in broiler diets (Qian, *et al*., 1996; Azcona *et al*., 2000; Qian *et al.,* 1997). Body weight gain and bone ash were increased by the supplementation of 600 FTU/kg diet with 0.45% total dietary phosphorus. Bone ash content, body weight, and tibia length have also been found to increase with the addition of 400, 600, and 800 FTU/kg phytase to 0.34%, 0.27%, and 0.20% nonphytate phosphorus diets, respectively (Qian, *et al*., 1996). When 600 FTU/kg was supplemented to broiler diets with 0.31% nonphytate phosphorus, feed intake and body weight increased. Azcona *et al*. (2000) also observed an increase in body weight when Natuphos 5000 was supplemented to broiler diets; however, nonphytate phosphorus levels were not reported in the abstract. Qian *et al*. (1997) observed that adding phytase at 300, 600, and 900 FTU/kg increased body weight gain and bone ash content linearly when diets contained 0.27% nonphytate phosphorus. Zanini and Sazzad (1999) showed that adding phytase at 500 FTU/kg to broiler diets with 0.40% nonphytate phosphorus produced increased tibia ash. At low (0.225%), but not at high (0.325%), levels of nonphytate phosphorus in the diet, phytase supplementation significantly increased body weight, bone mineral content, bone density, and livability of broilers (Sohail and Roland, 1999). It can be concluded that phytase supplementation to broiler feeds tends to increase body weight gain and improve bone structure of birds.

Use of Phytase: Nutrient Retention and Digestibility in Broilers

Phytate phosphorus has the ability to bind and form complexes with cations necessary in body functions and metabolism. Cations that are bound by phytate phosphorus cannot be properly used by the body. In broilers, the addition of phytase to the diet at 600 FTU/kg feed has been shown to increase retention phosphorus when nonphytate phosphorus is between 0.15 and 0.54% (Roberson and Edwards, 1994; Leske and Coon, 1999). A study by Broz *et al*. (1994) indicated that phytase supplementation to diets with 0.16% nonphytate phosphorus at the levels of 125, 250, or 500 FTU/kg significantly improved phosphorus utilization. Zanini and Sazzad (1999) also found that adding 500

FTU/kg phytase to 0.40% nonphytate phosphorus diets improved phosphorus utilization and reduced phosphorus excretion. Other necessary minerals, such as zinc, calcium, and nitrogen, have been shown to have improved retention and utilization with the supplementation of phytase, because they are freed from the complex that phytate phosphorus forms with them. Phytase supplemented to broiler diets with 0.40% nonphytate phosphorus at the level of 500 FTU/kg also improves calcium, zinc, and nitrogen utilization (Zanini and Sazzad, 1999). The digestibility of proteins and amino acids may be affected by addition of phytase due to the purported ability of phytate phosphorus to bind certain gut proteases. The addition of 600 FTU/kg phytase to diets with 0.35% nonphytate phosphorus (Zhang *et al*., 1999) and 1,200 FTU/kg phytase to diets with 0.13% nonphytate phosphorus (Biehl and Baker, 1997) had no effect on amino acid digestibility. However, Namkung and Leeson (1999) and Ravindran *et al*. (1999) found that around 1,200 FTU/kg phytase added to diets with 0.35 and 0.25% nonphytate phosphorus improved amino acid utilization. Improvements in growth and feed conversion were observed by Henidl (2000) when up to 750 FTU/kg were added to lysine-deficient broiler diets (nonphytate phosphorus levels of the diets were not given in this abstract). Ravindran *et al*. (1999) also showed that the amount of digestibility of amino acids based on phytase supplementation varied widely depending on the feedstuff used and the amino acid being analyzed. This variation may be one reason for the lack of agreement between these studies.

Use of Phytase: Effects on Body and Production Parameters of Laying Hens

It has been shown by Van der Klis *et al*. (1997) that body growth, tibia ash, and bone mineral density of laying hens can be positively affected by supplementing their feed with 100, 200, or 300 FTU/kg when the diets contain 0.12% nonphytate phosphorus. Body weight gain and tibia bone ash can be increased by the supplementation of 600 FTU/kg to feed containing 0.10% nonphytate phosphorus (Carlos and Edwards, 1998). A positive effect on bone mineral density was also observed by Punna and Roland (1999) when phytase was added at the level of 300 FTU/kg to diets with 0.1% nonphytate phosphorus levels. No effects on egg weight or egg specific gravity were observed by Carols and Edwards (1998) when 600 FTU/kg was added to a 0.1% nonphytate phosphorus layer diet. Urn and Paik (1999) observed no effect on eggshell strength, egg specific gravity, or eggshell thickness when 250 FTU/kg was added to diets with 0.26, 0.21, and 0.16% nonphytate phosphorus but did find these parameters to be lower when diets with 0.11% nonphytate phosphorus were used. Urn and Paik (1999) showed that phytase supplementation could improve feed consumption when phytase was added at 500 FTU/kg to diets with 0.37 and 0.24% nonphytate phosphorus.

Use of Phytase. Nutrient Retention and Digestibility in Laying Hens

A study by Leske and Coon (1999), using 0.1% nonphytate phosphorus, has shown that the supplementation of layer feed with 300 FTU/kg improved total phosphorus retention. Absorption and retention of phytate phosphorus and calcium can be significantly improved with the addition of 250

FTU/kg of phytase to layer diets containing 0.12% nonphytate phosphorus (Van der Klis *et al*., 1997). Carlos and Edwards (1998) found that phytate phosphorus retention was improved with the addition of 600 FTU/kg to layer diets with 0.10% nonphytate phosphorus levels. Retention of calcium, magnesium, and copper was observed to be greater, and excretion of these minerals to be lower, in birds supplemented with 250 FTU/kg phytase when the diets contained 0.16, 0.21, or 0.26% nonphytate phosphorus (Urn and Paik 1999). Five hundred FTU/kg was supplemented to 0.37 and 0.24% nonphytate phosphorus layer feed by Um and Paik (1999) and was found to significantly improve retention of calcium, magnesium, iron, and zinc as well as reduce excretion of these elements. The amount of phosphorus excreted has also been reduced in laying hens with the supplementation of 250 FTU/kg and 500 FTU/kg (Urn and Paik, 1999). Thus, it appears that the supplementation of phytase to their diets has similar positive effects on broilers and layers.

SOURCES OF PHYTASE

A number of phytases with varying structural and catalytic properties have been found in plants, yeast, and bacteria. Many of these phytases have been successfully purified and characterized (Fugita *et al*., 2003; Steiner *et al*., 2007; Azeke *et al*., 2009). There are four possible sources of phytase that can be found in the digestive tracts of animals.

- Phytase present intrinsically in feed ingredients.
- Exogenous microbial phytases added to the diet.
- Intestinal mucosa membrane linked phytase.
- Phytase produced by microflora present in the GIT.

Phytase present in feed ingredients has been shown to improve phytate-phosphorus utilization by monogastric animals (Hatten *et al*., 2001). High levels of phytases are found in wheat, yet there is a large variation of phytase activity within the seeds of the different varieties of these plants (Konietzny and Greiner, 2002). Phytase in feed ingredients may be inactivated by temperature during feed processing (Konietzny and Greiner, 2002), by low pH that occurs in the upper portion of the GIT (Beers and Jogbleod, 1992) and by the action of pepsin on gastric secretions (Gibbins and Norris, 1963). It has been shown that there is decrease in the phytase activity when pelleting temperatures exceed 75^{o}C (Konietzny and Greiner, 2002) but this will be dependent on the form and type of the enzyme. The variability and instability of these natural phytases limit the use of plant ingredients as a reliable source of the enzyme in feeds. Of all the micro organisms studied, phytase production is highest in the fungi *Aspergilli* with the highest level of extracellular phytase produced by *Aspergillus niger* (Konietzny and Greiner 2002). *Aspergilli* tend to produce two different phytases, one with pH optima of 5.5 and 2.5 and one with a pH optimum of 2.0. The pH optima of these enzymes as well as their thermostability and resistance to inactivation by gastrointestinal proteolytic enzyme make them more suitable as feed additive to increase phytate phosphorus availability than relying on plant phytases.

PHYTASE ACTIVITY AND PHYTATE CONTENT OF SELECTED HOME-GROWN LEGUMES AND CEREALS

As stated in the previous section the phytases presently being used in the feed industry are of microbial origin and the phytase-supplemented poultry feeds are expensive. This is because the technology involved in the extraction, purification and thermo-stabilization of the enzymes is capital-intensive. The technology is unaffordable and thus unavailable in many developing countries especially in Africa. There is increasing interest in Nigeria on the use locally grown cereal and legume seeds in poultry feed as alternatives to soybean products. High native phytase activities are present in cereals and cereal by-products, whereas lower activities have been reported for legume seeds (Steiner *et al*., 2007). Whereas researches are ongoing in developed countries on the potential of cereal and legumes as alternative sources of phytase, very little is being done in Nigeria on the phytase activities in locally grown legume and cereal seeds.

Azeke, *et al*. (unpublished) screened four cereal and four legume species grown in Nigeria for phytase activities. They observed a reasonably high phytase activity in cereals, higher than in legumes (table 1). While phytase activity was higher in cereals, phytate and total phosphorus were higher in legumes screened. It should be noted that the higher phosphorus content of legumes may not necessarily mean higher nutritional value as most of the phosphorus may be in the phytate form and so are unavailable except it released by phytase. This could limit their use in the as raw materials for the feed industry. The implication is that cereals would be potentially better sources of the phytase enzyme for the poultry industry than the grain legumes. Many factors, apart from differences in species, account for the differences in phytase activity and these include location, year of cultivation, and climate.

EFFECT OF GERMINATION ON PHYTASE ACTIVITY, PHYTATE AND TOTAL PHOSPHORUS CONTENTS OF SCREENED SAMPLES

As shown in tables 2, germination resulted in marked increases in the activities of phytase degrading enzymes of all samples screened. Although this effect is more pronounced with the cereals than the grain legumes it however, shows that sprouting can be used to increase the activity of phytate degrading enzymes in legumes thus improving their potential for the feed industry. As expected, the phytate concentrations decreased markedly during germination (table 2). This may be due to the increased activity of the phytase enzymes produced during germination. There was also an increase in the total phosphorus contents of samples as result of germination. This may be due partly to phosphorus uptake from the growth environment and partly due to the release of inorganic phosphate from the phytates by the action phytase enzymes.

CONCLUSION

The growing trend in the phytase research and industry shows no sign of abating. This is expected considering the positively significant impact that the emergence of phytase has had on the environment: reduced phosphorus pollution of ground water. Lack of adequate infrastructure would make it difficult for many developing countries in Africa to key into this development. It would only be realistic to look inward. Locally grown cereals may contribute substantially to the gastrointestinal hydrolysis of phytate in non-ruminant animals due to high native phytase activities, whereas the contribution of legume seeds in terms of improving the availability of plant phosphorus seems to be almost negligible.

Table 1: The phytase activity, total phytate and total phosphorus contents of selected Nigerian grown grain legumes and cereals

Parameters	Legumes				Cereals			
	AYB	Lima Beans	Pigeon Pea	Cowpea	Rice	Maize	Millet	Sorghum
Phytase (U/g)	0.007 ± 0.001	0.009 ± 0.003	0.007 ± 0.001	0.138 ± 0.012	0.225 ± 0.078	0.166 ± 0.022	0.235 ± 0.076	0.151 ± 0.054
Phytate (mg/g)	11.29 ± 0.10	13.94 ± 2.20	9.87 ± 0.92	8.92 ± 0.11	5.27 ± 0.54	5.71 ± 0.76	5.33 ± 0.23	6.12 ± 1.01
Phophorus (mg/g)	8.89 ± 0.97	10.73 ± 1.01	6.72 ± 0.23	7.03 ± 0.19	4.19 ± 0.62	3.81 ± 0.65	3.67 ± 0.76	4.05 ± 0.99

*AYB: African yambean (*Sphenostylis stenocarpa*)

Parameters	Legumes				Cereals			
	AYB	Lima Beans	Pigeon Pea	Cowpea	Rice	Maize	Millet	Sorghum
Phytase (U/g)	0.021 ± 0.009	0.049 ± 0.012	0.388 ± 0.031	0.455 ± 0.022	2.981 ± 0.129	0.973 ± 0.077	1.101 ± 0.102	0.362 ± 0.044
Phytate (mg/g)	1.56 ± 0.12	0.91 ± 0.06	2.58 ± 0.22	1.03 ± 0.25	0.96 ± 0.27	0.72 ± 0.16	0.95 ± 0.11	0.70 ± 0.07
Phophorus (mg/g)	11.56 ± 0.91	13.77 ± 0.67	9.01 ± 0.73	9.61 ± 0.76	8.55 ± 0.44	6.09 ± 0.33	5.55 ± 0.19	6.11 ± 0.24

Table 2: The phytase activity, total phytate and total phosphorus contents of selected Nigerian grown grain legumes and cereals after 10 days germination

*AYB: African yambean (*Sphenostylis stenocarpa*)

Values in parenthesis show percentage change relative to values in table 1.

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AGRICULTURAL BIOTECHNOLOGY, FOOD SECURITY AND ECONOMIC DEVELOPMENT: IMPLICATIONS FOR POLICY IN NIGERIA

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Abstract

The problem of food insecurity is not new in Nigeria. However, various governments in Nigeria have shown great concern on how to address this challenge through the formulation of policies and development of strategies that can significantly reduce food insecurity. Agricultural research and development (R&D) institutions are known channels by which increased food productivity and security can be achieved through new and improved technologies. However, poor national Science and Technology (S&T) policies and inadequate agricultural research management are fundamental to achieving food security and economic development. Climate change has been identified as a key factor that influences poverty and food insecurity; however one of the major approaches that have been put in place to overcome this national challenge is biotechnology. The planned biotechnology R &D programmes in Nigeria were clearly stated in the country's biotechnology policy document which includes agriculture, food, health, industry, environment and bio-resources development. This paper therefore attempts to review the extent at which agricultural biotechnology had brought remarkable progress in food security and by extension economic development in Nigeria. The paper recommends that emphasis should be placed on building strong collaborations between research institutes, knowledge-based institutions and policy makers to contribute to the nation's economy.

Keywords: Agricultural biotechnology, Food security, Nigeria, Policy, Economic development.

INTRODUCTION

Among Nigeria's biggest challenges are food security and environmental sustainability. The problem of food insecurity is not new in Nigeria. However, various governments in Nigeria have shown great concern on how to address this challenge through the formulation of policies and development of strategies that can significantly reduce food insecurity. One of such major approaches that have been put in place to overcome this national challenge is agricultural biotechnology. Agricultural biotechnology holds the promise of improving food security and better nutrition. (Juma and Serageldin, 2007). The application of biotechnology-based products to respond to critical needs in the agrifood and environmental management sectors of developing countries is an integrated set of activities designed to identify opportunities for biotechnological innovations, and to overcome key bottlenecks to their effective application (Duduyemi and Omitogun 2007). Traditional biotechnology products and practices have been adapted over generations in response to changing demands of the market-place.

The main goal of agricultural science has been to increase the yield potential and desirable traits in plant and animal food products. That is still the goal of agricultural biotechnology, which can be an important tool in reducing hunger and feeding the planet's expanding and longer-living population, while reducing the adverse environmental effects of farming practices and climate change (Veneman, 2003). Biotechnology has the potential to play a large role in more rapidly advancing agricultural productivity in developing countries while protecting the environment for future generations (Penn, 2003). In a supportive policy and regulatory environment, agricultural biotechnology has enormous potential to create crops that resist extreme weather, diseases and pests; require fewer chemicals; and are more nutritious for the humans and livestock that consume them. Agricultural biotechnology is one of the most promising new technologies of our times. The expanding use and trade of agricultural biotechnology-derived products is enhancing prosperity and well-being both in developed and developing countries (Larson, 2003).

The biotechnological revolution has been characterized by the rapid pace of discovery in the biological sciences, which has tremendously impacted on both fundamental and applied research. Multidisciplinary in its nature, biotechnology encompasses microbiology, biochemistry, chemistry, genetics, molecular biology, immunology, cell and tissue culture and physiology, as well as genetic engineering. After a slow start, many developing countries are now investing in agricultural biotechnology as the hope for increasing crop and livestock production to address national food insecurity. There is however, the need to invest in developing a systematic policy that would impact positively on the economy in order to obtain sufficient benefits and allay against the potential negative impacts for effective contribution to increasing food security demands.

This paper presents what the making of agricultural biotechnology policy means in practice especially as it affects food security in Nigeria and as a key to future economic development, and central to the hi-tech, science-driven, “new Nigerian economy”.

Agricultural Biotechnology

Biotechnology is a science that deals with the use of micro-organisms, plant cells, animal cells or parts of cells such as enzymes to produce commercial quantities of useful substances. It also deals with the construction of micro-organisms, cells, plants or animals with useful traits by recombinant DNA techniques, tissue culture, embryo transfer and other methods besides traditional genetic breeding techniques. Biotechnology also involves the application of molecular biology to understand how cells and organisms work, so that the activities of cells and organisms can be altered. Agricultural biotechnology; relates to the use of microbes, plants and animals to produce useful products or improved species (Figure 1). Global agriculture today is a major user of this application and worldwide developments in this technology continue to be rapid (Juma and Serageldin 2007). The economic potential for wider applications of agricultural biotechnology can be seen from the fact that in 2005, the global area approved crops that use biotechnology increased to 90 million hectares from 81 million hectares in 2004 representing an annual growth rate of 11 percent (Juma and Serageldin, 2007).

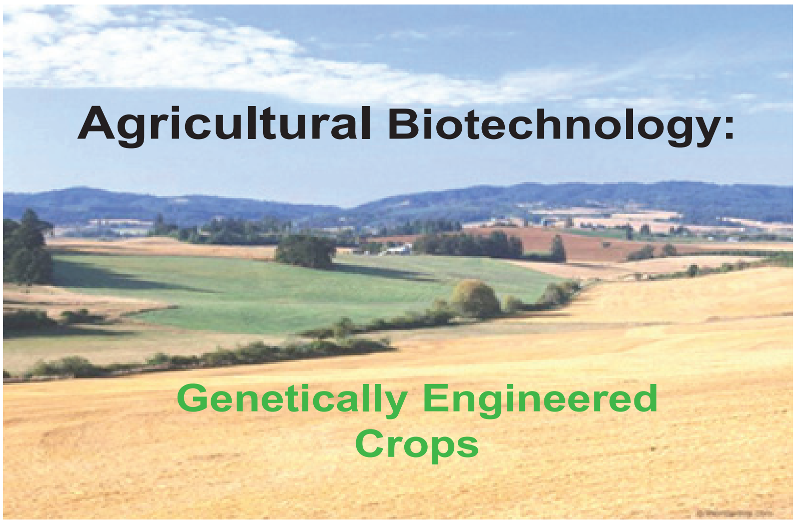

Figure 1: Genetically Engineered Crops using Agricultural Biotechnology
Source: NABDA, Abuja – Nigeria.

This science integrates disciplines such as biology, genetics, molecular biology, biophysics, biochemistry, chemical engineering and computer science. Public debates have not only concentrated in highly developed biotechnology research nations but has also moved to emerging economies of Sub Saharan Africa including Nigeria. On the whole, there is global concern for the establishment of regulatory (legal, institutional and policy) measures to control the generation and use of biotechnologies that have negative ecological and socio-economic effects. For example, most countries of the European Union (EU) have adopted regulations which ban the application of certain biotechnological processes used in the manipulation of life forms. At the international level concerns on managing technology to avoid ecological and socio-economic catastrophes are reflected in Agenda 21. The need to develop these capabilities in biotechnology becomes especially important because of the need of these countries to confront their own regional and local problems. Benefits of Agricultural Biotechnology are inexhaustible. These include among other more food, better food and better environment (Figure 2).

Figure 2: Benefits of Agricultural Biotechnology
Source: Council for Biotechnology Information, 2003

AGRICULTURAL RESEARCH IN NIGERIA

The role of science and technological innovation in economic change and sustainable development is increasingly recognized. The contribution of science and technology (S&T) to economic development has become increasingly important as a result of new waves of technologies with generic characteristics that enable them to affect almost all facets of human endeavour (Adeoti and Adeoti, 2005). Increasing agricultural productivity and food security will require new and improved technologies and their broad dissemination. Agricultural R&D institutions are the channel through which this occurs. Evidence has shown that agricultural research capacity is one of the important factor in building food security and economic stability. Furthermore, new and better-targeted technologies are essential to this process, and a well-developed and well- supported agricultural research system is a prerequisite not only for the design of these technologies but also for their dissemination and adoption. The antidote to the increasingly scarce, irregular, and donor-dependent circumstances which are often accompanied by poor national S&T policies and inefficient and ineffective agricultural research management in Nigeria is the institutional reforms and sound S&T policies needed to improve the efficiency and effectiveness of agricultural research.

Nigeria has been recorded to have the largest population of over 140 million people in Sub-Saharan African (SSA) (NBS/CBN, 2006). The agricultural sector provides the primary means of employment for Nigerians, accounting for one-third of both total GDP and labour force (FAO, 2003). In the past, the Nigerian government's strategy for stimulating agricultural production was protecting the sector with bans on agricultural imports and subsidies on inputs. Agricultural research in Nigeria is performed by, and mostly funded by, the government. More than 81 government and higher-education agencies engaged in agricultural research. About two-thirds of Nigeria's research capacity rests with the 22 government agencies, 15 of which fall under the responsibility of the Agricultural Sciences Department (ASD) within the Federal Ministry of Agriculture and Rural Development (FMARD). 4 ASD is responsible for the coordination, planning, and evaluation of the activities of these 15 research institutes. Five agencies fall under the responsibility of the Federal Ministry of Science and Technology (FMST), the Forestry Research Institute of Nigeria (FRIN) is housed within the Federal Ministry of the Environment, and the Nigerian Institute for Social and Economic Research (NISER) falls under the National Planning Commission within the Office of the President. Each of the 22 government agencies is semiautonomous and is governed by a Board. The Nigerian agricultural research performance was strong until early 1980s when it weakened significantly due to the boom in oil sector. Restructuring occurred and funding dropped sharply and became insecure, in turn affecting infrastructure and resources. Management problems arose as well, manifesting in lack of priority-setting; administrative overlap; poor coordination, monitoring, and evaluation; and late and slow adoption of information technologies and management information systems (FMARD, 2000).

In 2002, FMARD prepared a "New Agricultural Policy, "again aiming to rationalize the agricultural research system, making it more focused and demand-driven. This new strategy is based on public funding for agricultural research, including biotechnology. Nigeria presently has 94 universities. Several schools, faculties, institutes, and departments are conducting agricultural research. The faculties of agriculture and veterinary medicine under the four oldest universities—Ahmadu Bello University, the University of Ibadan, the University of Nigeria, and Obafemi Awolowo Universities—are the primary higher-education agencies involved in agricultural research. In addition, the 3 Federal Universities of Agriculture, 6 universities of technology also play significant roles in Nigeria's agricultural research.

Private-sector involvement in Nigerian agricultural research is negligible and remains unchanged. Some seed companies has small research activities, mainly varietal testing. This low private-sector involvement stems from lack of incentives in terms of returns on investments because public research agencies share their research results at no charge (Voh, 1999). Political instability in Nigeria has also hindered private-sector involvement, and lengthy release and approval process for new varieties act as further disincentives to the initiation of research activities by private companies (FMARD, 2000). Collaboration is occurring between some government agencies and a number of the centers of the Consultative Group on International Agricultural Research (CGIAR), particularly with the International Institute for Tropical Agriculture (IITA), located in Ibadan, Nigeria.

In financing, agricultural research in Nigeria is mainly funded by the government, although there was a considerable funding from the World Bank during the implementation of Nigeria Agricultural Research Projects (NARP) in the 1990s. NARP commenced in 1992, initially running until December 1998, after which it was extended one year. In recent years, the Nigerian government has become more flexible in allowing institutes to generate their own income. Nigeria's budgeting process has been described as complex and lacking transparency (Herz, 1996). Each institute provides a workplan with an associated budgeted to FMARD. FMARD submits a consolidated budget to the Ministry of Finance, which makes its own adjustments, then the budget is sent to the National Assembly by the president to be passed as an appropriation bill. The final, approved budget often bears little resemblance to the planned budget, and long delays and shortfalls in the disbursement of funding can occur.

Despite the growth in the total number of higher-education agencies related to agricultural sciences in Nigeria, the agricultural research activities in these higher-education sectors have even more severe funding and infrastructure shortages. Research activities are often associated with university graduate programmes and are mainly funded through small research grants from university sources, but some obtained funding from external sources as well (FMARD, 2000). Over the years, the quality of staff at the government research agencies has deteriorated, with many senior scientists, particularly those with PhD degrees, moving into the university sector or abroad. These well-qualified scientists could not be replaced because of a freeze on government recruitment and lack of funding for training. Consequently, there is a doubt as to whether the current policies and research institutions can move the country to the required pace for agricultural transformation and food security through the development, adoption and application of biotechnology in agriculture. The existing biotechnology policies are implicitly built in Science and Technology (S&T) policies. The importance of S&T in agricultural production in this respect cannot be overemphasized. The need to develop explicit biotechnology policies is important for driving ahead the biotechnology revolution. There also still exist gaps in national capacities required for assessing risks associated with the agricultural biotechnology that may undermine national aspirations for effective competitions and capabilities.

For Nigeria to continually benefit from agricultural biotechnology for increased food production for ensuring food security, the need to increase awareness among stakeholders on the safe handling of agricultural biotechnology food products is imperative. It has already been believed that agricultural biotechnology will supplement conventional agriculture in contributing to food demands. Food security policy issues also need to be explicitly integrated into biotechnology development policies while establishing more sustainable institutions for safe development of biotechnology and thereby contributing to food security in Nigeria.

Biotechnology Policy in Nigeria

Biotechnology R&D activities are still in infancy stage in Nigeria. More than 90% of biotechnology research in Nigeria is still in the public domain. There is clearly need for institutional articulation and collaboration between diverse actors, which would imply public-public and public-private institutional articulation to ensure that there are synergistic interactions between diverse biotechnology actors. The development of biotechnology in most Nigeria is mainly hindered by the lack of basic equipment and expertise. However, agricultural biotechnology R&D is in no doubt moving along the development path and is involved in advanced tissue culture and animal biotechnology activities (Figures 3, 4, 5 and 6) and is already experimenting with Genetically Modified Organisms (GMOs). Many indigenous biotechnology outcomes have been developed by some R&D institutions in Nigeria, however, most of these research outcomes are yet to be exploited by biotechnology firms in Nigeria. The role of co-ordinating biotechnological research and as the institutional framework for implementing the Biotechnology Policy in Nigeria is been performed by the National Biotechnology Development Agency (NABDA), an agency of the Federal Ministry of Science and Technology. NABDA currently has six regional centres, which are adequately located all over the country, networking and sensitising all the institutions of higher learning to form Biotechnology R&D Groups.

Some selected Agricultural Biotechnology Project initiatives by NABDA for accelerated National development include; Promotion and Development of Tissue Culture Facilities all over the Nation for Mass Propagation of Food, and Economic plants using state-of-the-art biotechnological tools. Examples include Cocoa, Cassava, Banana & Plantain, Oil Palm, Grape vine, Irish potatoes, Baobab, Gum arabic, etc (Figure 3). Development and backcrossing of 5 genetically improved crops in the country - These crops include: Bt-Cotton, Cowpea, Cassava, Bt-corn and Bio-fortified Sorghum; and development of road map for introduction of genetically modified crops in Nigeria. Other current activities of NABDA are included in grasscutter production, Mushroom production, Snail production among others as shown in figures 4 -6 below.

Tissue Culture

Tissue culture is the in-vitro propagation of explants. Tissue culture allows for the reproduction of disease-free planting material for crops, improve crop performance in the field by conferring pest and disease resistance, herbicide resistance, or tolerance to environmental stresses, develop products with enhanced value, such as improved post-harvest life, nutritional value, or other health benefits and rapid micropropagation of crops.

Figure 3: Utilisation of tissue culture in selected crops in Nigeria.
Source: ***Source: NABDA, Abuja-Nigeria***

Grasscutter rearing

Annual biotechnology had been known to help develop tests and vaccines for livestock and infections that risk food insecurity. Annual biotechnology also provides information for managing indigenous annual genetic resources, improves nutritional quality of feeds and fodder; enhances reproductive efficiency of livestocks; and increases the production of meat and milk through techniques such as cloning (Juma and Serageldin, 2007). Figure 3 shows activities of NABDA in grasscutter rearing. The grasscutter is a mammal that is naturally available in Nigeria. Some of its local Nigerian names are ***jebji*** *or* ***jawji*** **(**Hausa) **Nchi** (Igbo) **Oya (**Yoruba).It is a delicacy in the menu of many Nigerian tribes. Its meat is much sought after. It feeds on a wide range of grasses which are available in all parts of Nigeria. Although presently collected from the wild it is also easily domesticated and there are at present in Nigeria some successful grasscutter enterprises. In addition to labour, rearing cages are the main input needs of domesticated grasscutter enterprises. A grasscutter enterprise producing about 500 to 1000 grasscutters per annum will require about Eight hundred thousand naira ₦800,000 ($5,333 @ ₦150 per $1) of initial investment. The enterprise will provide income between One million five hundred thousand naira (₦ 1, 500,000) and 3 million naira ₦3, 000,000 ($10,000 and $20,000 @ ₦ 150 per $1) depending on the capacity of production. Rate of returns will be in the order of 60% to100% (NABDA). Vaccine research is also carried out extensively by the University of Ibadan, Nigeria. The university has a collaborative research project on DNA sequencing of vaccines for the prevention of the infectious Bursal disease (Gumboro disease), which is a major source of poultry death worldwide (Juma & Serageldin, 2007). There is at present no known cure. The Ibadan research project attempt to develop new vaccines and involves sequencing the DNA of the Nigerian strain of the Gumboro virus.

Giant Male Grasscutter ready for Market

Grasscutter Building which can house 200 families (i.e. 1000 grasscutters)

Figure 4: Activities in NABDA Grasscutter rearing
Source: NABDA, Abuja-Nigeria

Mushroom Production

Mushroom is a vegetable food source that is consumed all over Nigeria. It grows easily in tropical rain forest ecology. It is presently commonly collected in the wild, which also limits its wide consumption as many species are poisonous. Thus it requires experience in the identification of edible species for its consumption. Mushroom is also imported into Nigeria. Yet with some training and technical assistance, it can be produced commercially in Nigeria in small scale. A small scale mushroom enterprise would cost about Four hundred thousand naira ₦400, 000 ($2,666 @ ₦150 per $1) to establish. It will provide an annual income of about Two hundred and fifty thousand naira ₦250, 000 ($1,666 @ ₦ 150 per $1) per annum. The rate of return is between 60% and 100%.

Oyster Mushroom before harvest Mushroom Harvesting

Figure 5: Activities in NABDA Mushroom production
Source: NABDA, Abuja-Nigeria

FISHERY

Fisheries biotechnology finds applications in aquaculture which is developing rapidly in Africa (Juma and Serageldin, 2007). Biotechnology applications can be fund in helping to improve fish feeds, for example, Tilapia farming, for example is subjected to biotechnology Fisheries and Aquaculture studies (Juma & Serageldin, 2007). Biotechnology techniques have the potential to reduce the genetic diversity of fish populations. Fisheries biotechnologies can help to understand taxonomy and population structure questions in fishes, improve reproduction, health and nutritional quality of fish feeds (Juma and Serageldin, 2007). The NABDA focus in fisheries and aquaculture is primarily on increase growth rate, for disease resistance, aesthetic value especially for ornamental fish and increasing environmental tolerance. However Nigeria therefore needs to invest more in fisheries biotechnology in order to develop evidence based fish management programmes and improve efficiency of producing fish in aquaculture.

New Recirculatory System for fingerlings Development *Stocked Fish Pond*

Fishes in Pond

Figure 6: Developments of Modern Aqua culture Techniques
Source: NABDA, Abuja-Nigeria

Nigeria considers biotechnology as a powerful tool that can be used to tackle the issue of food insufficiency, to promote greater improvement in human health and welfare, and to enhance environment-friendly industrial development as well as being an engine for driving the industrialization of the nation. Another significant biotechnological landmarks by the Nigerian government is the establishment of the Sheda Science & Technology Complex (SHESTCO), Abuja, which comprises, amongst others, the Biotechnology Advanced Laboratory.

The planned biotechnology R&D programmes were clearly stated in the country's biotechnology policy documents (FMST, 2004). This includes agriculture, food, health, industry, environment and bio-resources development. The activities include the development of a biotechnology policy that is multi-sectoral and multidimensional, mobilizing investment for biotechnology, creating awareness in the public and private sectors, capacity development, R&D, bioresources development and collaboration in biotechnology development. The Mission Statement of Nigeria's Policy on biotechnology read thus: "Nigeria shall, as a matter of priority, initiates appropriate steps to explore the use of biotechnology for the benefit of Nigerians and thus ensure that Nigeria becomes one of the international leaders in Biotechnology, through the provision of an enabling environment that responds to the needs of the biotechnology industry, the R&D communities and the relevant national and international concerns". The National Biotechnology Policy underscores the need to accord any high-tech programme a priority attention by government. As such, this policy is designed to address such issues as: The indigenous acquisition and development of easy and affordable requisite biotechnology in Nigeria. Indigenous R&D to generate copious innovations in biotechnology as well as for the sustenance and growth of the biotechnology industry among others.

The brief sketch of biotechnology activities in Nigeria indicated above shows that Nigeria has no explicit policies and plans governing biotechnology R&D activities. Most of the on-going activities are treated in the broader framework of science and technology policy.

AGRICULTURAL BIOTECHNOLOGY AND ECONOMIC DEVELOPMENT

For the past 2 decades, biotechnology has been at the centre of global conversations in public policy. Agenda 21, the action programme of the UN Conference on Environment and Development held in Rio de Janeiro, stated that biotechnology "Promises to make a significant contribution in enabling the development of, for e.g, better health care, enhanced food security through sustainable agricultural practices, improved supplies of portable water, more efficient industrial development processes for transforming raw materials, support for sustainable methods of aforestation and reforestation, and detoxification of hazadous wastes".

In 2000, the world's population was about 6 billion. It is expected to increase to 9 billion by 2050. As a result, there will be more people to feed on an increasingly crowded planet. Food production will have to increase, and it must increase in an environmentally sustainable way. Biotechnology, while not a panacea, can make an important contribution. In 2007, about 7 million Chinese farmers grew biotechnology crops, or close to 60% of all farmers who grew biotechnology crops worldwide. In 2007, biotechnology crop production in the USA was approximately 57.7 million hectares or 50% of global biotechnology area. The global market value of biotechnology crop in the same period was USD 6.9 Billion representing 16% of the USD 42.2 billion global crop protection market in 2007 and 20% of the approximate USD 34 billion 2007 global commercial seed market. Of the USD 6.9 billion biotech crop market, $5.2 billion (76%) was in industrial countries and $ 1.6 was in developing countries (James, 2008).

Agricultural biotechnology achieves enhanced crop productivity in a more environmentally sustainable way. In the United States for instance, the growing use of agricultural biotechnology is resulting in reduced use of pesticides and increased adoption of environmentally friendly farming practices such as "no-till" farming, which reduces soil erosion and fertilizer run-off. Enhanced productivity means that more food can be raised on the same amount of land. As population pressure grows in the coming years, the ability to grow enough food for the world's burgeoning population without encroaching on vital habitats such as tropical rainforests will be of enormous benefit to the environment. New crops derived from biotechnology are being used in developing countries such as Argentina, South Africa, China, the Philippines and India. The attraction of biotechnology in these countries lies in the direct benefits these varieties bring to the developing country farmer. In China, for example, where small farmers grow biotechnology-derived insect resistant cotton varieties in great numbers, these varieties require fewer pesticides, which not only reduce costs, but also significantly reduce exposure to dangerous chemicals.

As a result, farmers are healthier and have expanding incomes that let them buy better food for their families or send a child to school rather than have that child work in the fields. Such results, spread over the population of an entire country where farmers are by far the largest percentage of the population, provide the opportunity for development and improved prosperity. Biotechnology may also offer a quicker route for undernourished populations to get access to a better diet. For example, a Vitamin A enriched rice variety known as "golden rice" is under development to help fight blindness caused by malnutrition. The potential benefits of this new technology should not be thrown away or delayed unnecessarily. In 2002, a few African nations balked at receiving badly needed food aid— food most Americans eat every day — because of unscrupulous and unscientific fear mongering. This must stop. Rather, the international community should reach out to developing countries — as the United States is doing — to explain how safe biotechnology-derived products can be regulated, used domestically, and traded abroad to the benefit of all. Biotechnology has the potential to play a large role in more rapidly advancing agricultural productivity in developing countries while protecting the environment for future generations. Since its commercial introduction in 1996 and the widespread adoption of bioengineered crops by farmers in the United States and other countries, agricultural biotechnology has been changing the face of agriculture (Penn, 2003).

According to the U. S. Department of Agriculture (USDA), in the United States approximately 80 percent of soybeans, 38 percent of maize and 70 percent of cotton were planted to biotech varieties in 2003. The United States is not alone in experiencing this evolution in agriculture. Adoption rates in other countries, such as Argentina, Canada and China, where biotech varieties are approved, have been similarly rapid. All these illustrate enormous decreases in pesticide use, with corresponding environmental enhancement, along with equally dramatic increases in production and savings in production costs. While biotechnology results vary by farm, the economic benefits obviously have been significant. These benefits are realized not only by farmers, but also by the environment and to consumers in general. The reduced reliance of biotech varieties on chemical inputs means less water pollution; reduced chemical usage results in safer water supplies and higher quality drinking water as well as a better environment for wildlife. Higher yielding biotech crops can help ease the strain on land resources, reducing the need for expansion onto more fragile areas and thus allowing for greater conservation of natural habitats. Energy usage on biotech crops is lower because there are fewer passes through fields in applying chemicals. Less fuel use means less carbon entering the atmosphere as carbon dioxide (CO2). Herbicide-resistant crops encourage the adoption of conservation tillage, especially no-till, which reduces erosion of topsoil.

CONCLUSION POLICY RECOMMENDATIONS

Agricultural biotechnology provides goods and services that are crucial to our well-being and survival although these goods and services are neither widely recognised nor properly valued in economic or social terms. The application of biotechnology on our resources therefore has the potency to provide us with food security, improved health care, better environment and gainful employment (Ayoola, 2009). To address long term issues such as nutrient deficiency, and needed improvement to overall biotechnology productivity however, there is the need for Nigeria to:

- **Collaborate among Key Stakeholders**

There is clearly the need for institutional articulation and collaboration between diverse actors, which would imply public-public and public-private institutional articulation to ensure that there are synergistic interactions between diverse biotechnology actors. Such should place emphasis on building strong collaborations between research institutes, knowledge-based institutions and policy makers to contribute to the nation's economy, for instance, National Centre for Technology Management (NACETEM), an agency of the Nigerian Federal Ministry of Science and Technology Annual Expert Forum (AEF). The AEF is usually designed to bring together both the Senate and House of Representative Committees on Science and Technology and Federal upper and lower house Committees on Appropriation. The AEF is designed to interact between the policy makers and the policy researchers to inform them on the state-of-the-art management of Science, Technology and Innovation (STI). Such collaboration would provide for effective and efficient implementation of the biotechnology policy in Nigeria. There is also the need for public awareness and engagement in agricultural biotechnology. This will allow for individual and collective discussion, priorities setting and then exploiting economic and other opportunities offered by agricultural biotechnology.

- **Strengthen Public-Private Partnership For Biotechnology R&D**

The rhetoric of public-private partnerships for R&D now dominates standard thinking on how research will be organised and paid for in the future. Biotechnology advances can be made much faster through private sector involvement. Private sector and industry have also the comparative advantage in multiplying, provisioning, and marketing the end products ensuring required benefits to the end users. We need to create viable, legal, remunerative, and enabling environment for participation of the private sector in biotechnology in order to realise our goals of food, nutrition, and environmental security (Paroda 2001). Collaboration with the private sector and relevant national and international agencies will advance the course of the biotechnology industry.

- **Reform The Role Of Universities**

Nigerian government should initiate measures that could strengthen the role of universities as centres of research, training and biotechnology diffusion. Doing so will entail fundamental reforms in the role of higher technical training in economic development. The reforms should include bringing research, teaching and community outreach together to support technology development goals.

- **Invest In Agricultural Biotechnology Research**

There is the need for more funding of Agricultural biotechnology. For instance, China spent $500m on biotechnology research in 2004 in over one hundred laboratories and research institutes. Funding for this vital technology will pay off in the near future on our economic development aspirations.

- **Provide Adequate Infrastructure**

Poor and inadequate infrastructure services are an obstacle to Nigerian development. The Nigerian government needs to leverage all available capacity from all sources to help build and maintain infrastructure for biotechnology research.

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GENDER PERSPECTIVE OF THE IMPACTS OF CLIMATE CHANGE ON AGRICULTURE IN NIGERIA: IMPLICATION ON FOOD SECURITY

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Abstract

Climate change impacts most on agricultural system; hence its devastating effect is felt more on the developing countries (which are basically agrarian), than the developed nations. Nigeria is an agrarian nation, where agricultural production is highly dependent on climatic factors. Women farmers are the majority of the Nigerian agricultural workforce and care providers at the house-hold and community levels; hence bear the impacts of the climate change most. The paper discusses the causes of climate change, the gender perspectives of the impacts of climate change on agriculture in Nigeria, identified the coping strategies practiced by Nigerian farmers to mitigate the effects of climate change, and infer the implication of climate change on food security in Nigeria. There is need for more awareness creation about climate change, especially among the farmers, majority of who are women in Nigeria. In addition gender responsive strategies should be adopted to mitigate the negative consequences of climate change on agriculture for feasible food security in Nigeria.

Keywords: Gender, Impacts, Climate change, Agriculture, Women farmers, Food security, Nigeria.

INTRODUCTION

Climatic change refers to alterations in climatic pattern, brought about possibly by global warming. The consequences of climate change have social and economic effects on human livelihood, although with regional variations. Likewise the concern to alleviate the consequences through the control of the human initiated factors has been at the center of the discussions in many international forums. The concern about solving the problem of climate change was first brought to the international forum for discussion in 1988 when the Intergovernmental Panel on Climate Change (IPCC) was established as an adhoc committee under the United Nations Environmental Program (UNEP) in collaboration with the World Meteorological Organization (WMO) with the primary mandate to investigate the causes and consequences of climate change. Two years later, the IPCC submitted a report of their preliminary investigation on climate change and global warming confirming that it is universal in scope. This report caused more international concerns, which resulted in the International convention for climate change and themed the United Nations Framework Convention on Climate Change (UNFCCC), which was ratified by over 150 countries at the Rio Earth Summit in 1992.

Series of conferences of the parties (COP) to the UNFCCC were held and following is a report by Anup Shah (2009):

In 1997, COP to the UNFCCC meeting was held in Kyoto, Japan, and centered on mandate to reduce green house gas emission to 5.2 %. The next meeting of the COP to the UNFCCC took place between November 2 and November 13, 1998 in Buenos Aires, Argentina, to discuss trading of carbon emissions and equity between the rich and the developing nations on the issues bothering climate change. The sixth conference was organised to discuss extensively on the success stories from the three years implementation of Kyoto mandate, and the way forward. This conference took place from November 13 to November 24, 2000 in Hague. The seventh conference took place in Marrakesh from October 29 to November 9, 2001. The discussion during the conference centered on identifying the position of the individual member nation on the legal text covering outstanding technical aspects of the political agreement reached in Bonn in July 2001 about how to implement the Kyoto protocol. The eighth conference themed Delhi Climate Conference held in Delhi, from October 23 to November 1, 2002, which aimed at evaluating the progress so far in reducing greenhouse gas emission in the member countries.

The tenth conference was called Buenos Aires Climate Conference, which coincides with the 10^{th} anniversary of the Kyoto protocol on climate change; took place in Buenos Aires in December 2004. The participants discussed the adaptation measures, and the entry of the Kyoto protocol into force, and issues on post Kyoto was also extensively discussed.

The eleventh COP to the UNFCCC came up in Montreal, when the meetings of the parties of the protocol (MOP 1) took place in early December, 2005. The central goal of the meeting was to conclude on appropriate strategies for reducing greenhouse emissions in industrialised countries and ways to help developing countries to cope with the problems of climatic change.

The twelfth COP to the UNFCCC held in December 2007, in Bali, Indonesia, was themed "Bali Roadmap". Issues on launching of adaptation fund, technological development and transfer, as well as mandates to reduce emission from deforestation were extensively debated during the conference.

The fourteenth conference of the parties (known as Poznan Climate conference) was the most recent meeting of the UNFCCC, held in Poznan, Poland, in December 2008. The meeting touched on adaptation fund raising and reviewed the previous agreement on climate change.

Developing countries were exempted from the initial green house gas emission, with the understanding that the emission from the highly industrialised countries account for the highest portion of the emitted greenhouse gases accumulating in the atmosphere. The accumulated gases trigger the warming of the atmosphere resulting into climate change. Other contributing factors are fumigants (use in postharvest grain handling), deforestation, high population density, gas flaring, etc, which are prominent activities in the developing countries. The negative consequences of climate change have most impact on agricultural sector of human systems. Agriculture is the basis for human survival, health, and socio-economic livelihood, and at the same time at the center of both the direct and indirect negative consequences of the climate change, thus implying food insecurity and poverty will be enhanced if the phenomenon is not urgently curbed.

Food security occurs when the supply is more than the demand of food required for sustainable living by the people. At the household level it means availability and affordability of and easy access to quantitative and qualitative food required for the normal healthy life by all the members of the household from all age categories on daily basis. Hunger, starvation and malnutrition are symptoms of food insecurity, which enhance ill-health, low productivity, and sometimes death if not timely curbed. Food insecurity and poverty are interwoven and interrelated, and are most common in the developing countries of the world characterized by low technological power and gender inequality, including Nigeria. There is a chain of action and reaction among food insecurity, poverty, low technological power, and gender inequality. Globally, about 852 million people are chronically hungry due to extreme poverty, while up to 2 billion people lack food security intermittently due to varying degree of poverty (FAO, 2003). Within the context of the developing countries, gender inequality in accessibility to resources and participation in decision making breeds gender polarized poverty, with fundamental consequence of food insecurity because the majority of the people concerned were farmers and women. Hence the poorest of the poor are the women, majority of who are the small scale farmers living in the rural areas. Poverty, within the context of developing countries has gender and geographical delineation; feminized and rural poverty.

Objectives of the Study

The specific objectives of the study are to:

Review the causes of climate change;

Describe the gender perspective of the impact of climate change on agriculture in Nigeria;

Identify the stakeholders in effective alleviation of climate change;

Identify the coping strategies mostly practiced by Nigerian farmers to mitigate the effects of climate change; and

Infer the implication of climate change on agriculture in Nigeria.

CAUSES OF CLIMATE CHANGE

Climate change is cause by natural and human induced activities. All the identified natural and human factors influencing climate change are interrelated, hence scientists found it difficult to prescribe a single solution to the problem.

Natural factors: This includes plate tectonics, solar output, orbital variation, volcanism, and ocean variability.

Plate Tectonics: This refers to the natural reconfiguration of global land and ocean areas, and generates topography (Anonymous, 2009a) of different features- mountainous, lowland, etc. Furthermore, areas around the newly formed mountains through plate tectonics often experience higher precipitation from orographic precipitation (rainfall induced by mountain). Consequently, the change in the climatic conditions of the area around the newly formed mountain resulting from orographic precipitation, leads to change in the flora and fauna ecosystem of the area.

Solar Output: The energy emitted by the sun presently, is known to be 30% stronger than the one being emitted during the early period of the Earth's history (Anonymous, 2009a). However, the cyclical nature of the sun's energy output is not yet fully understood; it differs from the very slow change that is happening within the sun as it ages and evolves, with some studies pointing towards solar radiation increases from cyclical sunspot activity affecting global warming (IPCC, 2001). Annual variations in solar radiation although may seem insignificant, accumulates to substantially induce climate change on the earth's surface because sun is the primary source of energy heat on the earth's surface.

Orbital Variations: Refers to the difference in Earth's axis angle in relation to the sun, which determines the amount of solar energy that reaches a particular place on the Earth's surface over a period of time. It comprises Earth's eccentricity, tilt in Earth's axis of rotation, and precession of Earth's axis, which altogether produce Milankovitch cycles that leads to glacier and interglacial periods, as well as advance and retreat of Sahara (Anonymous, 2009b).

Other natural causes are: volcanism (eruption of hot liquid materials from within the Earth to its surface along with gases and particulates to the atmosphere thereby enhancing greenhouse gases effect); and ocean variability such as El-Nino –Southern Oscillation, the Pacific oscillation, the North Atlantic oscillation, and the Arctic oscillation, which on a larger scale is called thermohaline circulation (Anonymous, 2009a) and distribution of cold and hot ocean water from one point to the other. The entire natural phenomenon alters the surrounding atmospheric condition and on a large scale leads to climate change.

Human (Anthropogenic) Factors:

Presently the scientific consensus on climate is that human activities (Anthropogenic factors) is very likely the cause for the rapid increase in global average temperatures over the past several decades (IPCC, 2007), consequently debate has largely shifted onto ways to reduce further human impact and to find ways to adapt to change that has already occurred (Anonymous, 2009a). The identified anthropogenic factors influencing climate change are: emissions from fossil fuel combustions and gas flaring, aerosols (particulate matter in the atmosphere), cement manufacturing, land use, use of chemicals such as fumigants (not included in the original list), animal agriculture, deforestation; all of which contribute to the increase in CO_2 level in the atmosphere (Steinfeld, *et al.,* 2006).

The major greenhouse gases are water vapor (not including clouds), which causes about 36-70 percent of the greenhouse effect; carbon dioxide (CO_2), which causes 9-26 percent; methane, troposperic ozone, chlorofluorocarbons (CFCs) and nitrous oxide (Kiehl and Trenberth, 1997; Gavin, 2005). Human activity since the Industrial Revolution has increased the amount of greenhouse gases in the atmosphere, leading to radiative forcing from CO_2, methane, tropospheric ozone, CFCs and nitrous oxide (Anonymous 2009a). Fossil fuel burning has produced about three-quarters of the increase in CO_2 from human activity over the past 20 years, while most of the rest is due to land use change, particularly (IPCC, 2001). Accordingly, the IPCC Special Report on emissions scenarios gives a wide range of future CO_2 scenarios, ranging from 541 to 970 ppm by the year 2100 if coal, tar sands or methane clathrates are exploited (Nakicenovic, 2001).

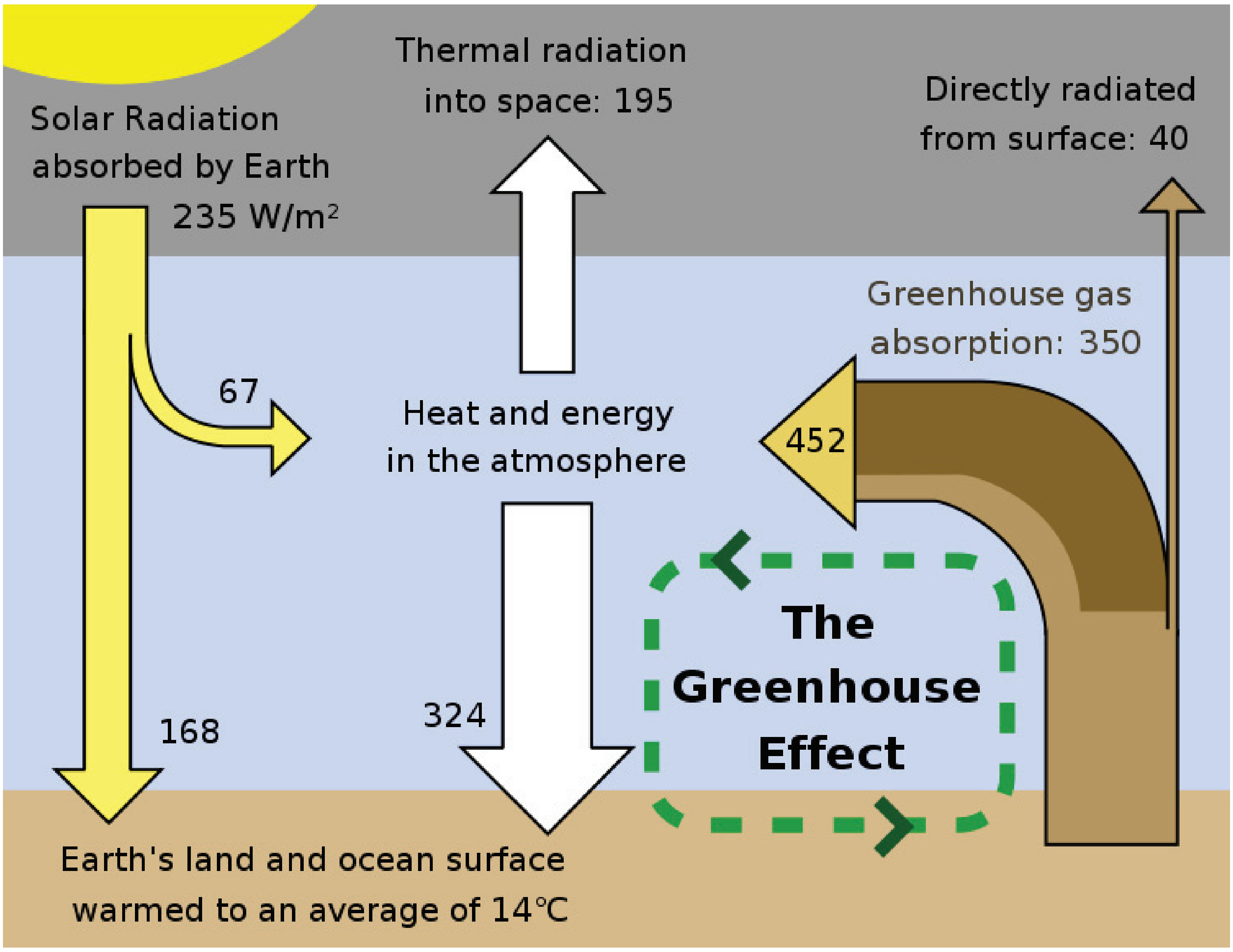

Figure 1: Diagram of Greenhouse Effect (Robert, 2009).

Figure 1 is a simplified, schematic representation of the flows of energy between space, the atmosphere, and the Earth's surface, and shows how these flows combine to trap heat near the surface and create the greenhouse effect. Energy exchanges are expressed in watts per square meter (W/m^2) and derived from Kiehl and Trenberth (1997). The sun is ultimately responsible for virtually all energy that reaches the Earth's surface. Direct overhead sunlight at the top of the atmosphere provides 1366 W/m^2; however, geometric effects and reflective surfaces limit the light which is absorbed at the typical location to an annual average of ~235 W/m^2. If this were the total heat received at the surface, then, neglecting changes in albedo, the Earth's surface would be expected to have an average temperature of -18 °C (Anonymous, 2009a). Instead, the Earth's atmosphere recycles heat coming from the surface and delivers an additional 324 W/m^2, which results in an average surface temperature of roughly +14 °C (Hansen *et al.*, 2005). Of the surface heat captured by the atmosphere, more than

75% can be attributed to the action of greenhouse gases that absorb thermal radiation emitted by the Earth's surface. The atmosphere in turn transfers the energy it receives both into space (38%) and back to the Earth's surface (62%), where the amount transferred in each direction depends on the thermal and density structure of the atmosphere.

This process by which energy is recycled in the atmosphere to warm the Earth's surface is known as the greenhouse effect and is an essential piece of Earth's climate. Under stable conditions, the total amount of energy entering the system from solar radiation will exactly balance the amount being radiated into space, thus allowing the Earth to maintain a constant average temperature over time. However, recent measurements indicate that the Earth is presently absorbing 0.85 ± 0.15 W/m^2 more than it emits into space (Hansen, 2005). This increase, associated with global warming, is believed by some to have been caused by the recent increase in greenhouse gas concentrations.

Nigeria is the World's largest flarer and Nigerian flaring has contributed more to the greenhouse gases than all the other sub-Saharan sources combined (Simms, 2005). Furthermore, in the mid-1990s, daily oil production in Nigeria amounted to approximately two million barrels; 17 billion m^3 of associated natural gas was estimated to be flared annually, generating an estimated 2,700 tons of particulates, 160 tons of sulphur oxides, 5,400 tons of carbon monoxide, 12 million tons of methane, and 3.5 million tons of carbon dioxide. Nigeria flares 75 percent of the gas it produces, which is the highest amount in any OPEC member nation and accounts for about 19 percent of the total amount flared globally. The flares contain widely recognized toxins, such as benzene, and carcinogens such as dioxin, which fill the air and covers everywhere with a fine level of soot. Exposed to this cocktail of toxins, local people who live and work alongside the flares in the Niger Delta Region of Nigeria, with no protection, complain of respiratory problems such as asthma, bronchitis, etc. Gas flaring had led to the complete destruction of crops within 200 meters radius from the station in the Niger Delta region of Nigeria; 45 % crop destruction at 600 meters; 10 % destruction at 1 km radius distance from the station. Gas flaring is also an expensive waste of resources costing Nigeria-where 70 percent of the people live on less than 1 dollar a day and commonly cook on open fires- an estimated $2.5 billion annually (Simms, 2005).

There is need for urgent step at all levels to curb the greenhouse gases emission and other consequences of human activities that influence climate change. The Gallup polls in 2007/2008, surveyed 127 countries on awareness of global warming. Over a third of the world's population is unaware of global warming, developing countries more unaware than developed, Africa the lowest (Anonymous, 2009a). However, awareness does not equate to belief that global warming is a result of human activities. Of those aware, Latin America leads in belief that temperature changes are a result of human activities while Africa, parts of Asia and the middle East, and a few countries from the former Soviet Union lead in the Opposite (Pelham, 2009).

Developing countries have roles to play in creating the awareness about climate change and also adopt and implement strategies that could alleviate climate change, put in place effective adaptive measures to mitigate the already initiated climate change consequences, especially on agriculture in order to alleviate food insecurity. An effective change program start from the awareness level, awareness strategies should be established at all levels, especially at the local community level, using extension agents. Information about climate change should also be disseminated through the curriculum to the students for wider and effective coverage and feasible result. Nigerian government has a significant role to play, being a country with the highest gas flaring in Africa. Effective gender responsive strategies should be organized to restore normal human livelihood in the Niger Delta region of Nigeria where the gas flaring is concentrated, and adopt strategies to reduce further emissions from the gas flaring. Gender responsive program/strategies are those that carries the concerns and perceptions of the people along from the planning , to the execution and even monitoring and evaluation stages without any gender bias, and has the potentials to reverse all the related past gender inequity.

GENDER PERSPECTIVE OF THE IMPACT OF CLIMATE CHANGE ON AGRICULTURE IN NIGERIA

Climate change has most impact on agricultural sector of human systems because it is climate dependent and the source of food required for human life sustainability. The impact is more devastating with little or no success of adaptation in the developing countries possessing low technological power. The impact of climate change spans through the agricultural production stages-production, harvesting and post harvesting. Water scarcity, extreme and unpredictable climate conditions are consequences of climate change that impact negatively on agricultural production. Farmers, especially in the developing countries find it most difficult to practice farming since they depend traditionally on their experience on weather condition to set pace for their annual crop and livestock production.

Social consequence: This includes water scarcity, water borne diseases, heat stress, extinction of some plants and animal species, an increase in the number of people exposed to vector-borne (e.g. malaria), an increase in heat stress mortality, and decreased water availability for populations in many water-scarce regions, particularly in the sub-tropics. Disruption of food web due to extinction of some plants and animal species and ocean acidification due to the absorption of some of the surplus CO_2 in the atmosphere by the ocean lead to change in marine ecosystems with negative effects on the people depending on marine ecosystem services (Caldeira and Wickett, 2005). Climate change leads to glacier melting and water scarcity in many regions of the world, thereby making irrigation farming difficult and costlier. Women spend more time looking for water for drinking and other domestic activities in the farm-families. Water borne diseases are common in such areas where there is water scarcity, which further reduce the production capacity of the farm families.

According to a UN climate report, the Himalayan glaciers that the principal dry season water sources of Asia's biggest rivers- Ganges, Indus, Brahmaputra, Yangtze, Mekong, Salween, and Yellow- could disappear by 2035 as temperature rise (National Research Council, 1994). Approximately about 2.4 billion people live in the drainage basin of the Himalayan Rivers (Hansen, 2002). By inference, many rivers that provide water for agricultural and domestic purposes during dry season in the tropical regions of the world would dry up soon during the season, hence making agricultural production difficult and life uneasy for the people. The consequences of water scarcity are water borne epidemics, higher food prices, and food scarcity. Women are at the center of all these consequences, being the most stable care giver at the household and community levels, thereby making their lives also more vulnerable to diseases. Agricultural workforce will be adversely affected especially in the developing nation such as Nigeria where family labor is the most popularly used in agricultural production.

Economic consequence: This includes low agricultural production, cost of adapting to climate change, increase in energy demands, etc, a general reduction in potential crop yields in most tropical and sub-tropical regions for most projected increases in temperature; a general reduction, with some variation, in potential crop yields in most regions in mid-latitudes for increases in annual-average temperature of more than a few °C; and increased energy demand for cooling due to higher summer temperatures and heating due to earlier and higher precipitations in some regions of the world. In 2005, the average social cost of carbon from the 100 peer reviewed estimates is US$3 to $9 s/t CO_2 (Anonymous, 2009a).

Extreme cold and hot weather brought about by the greenhouse gas emission increase the demands for fuel for heating and cooling spaces, which enhance deforestation and extinction of many tee species, which has negative implication on cash crop farming. Furthermore the unknown changes in soil temperature and moisture conditions will lead to dramatic change in the timing and length of the growing seasons, when farmers plant their crops, according to the United State Department of Agriculture –USDA ; leading to low grain yields in the developing countries (Sloan and Wolfendale, 2008). Prices of grain will rise; and every 2- 2.5 % price hike will increase the number of hungry people by 1% (Lockwood and Fröhlich, 2007), thereby compounding the problem of low yields and inadequate drying and storage facilities facing the farmers in Nigeria, especially women, like in some other developing countries

Physical/Environmental consequence: This includes flooding, desert encroachment, infrastructure destruction due to flooding and wind storms, a widespread increase in the risk of flooding for many human settlements (tens of millions of inhabitants in settlements studied) from both increased heavy precipitation events and sea-level rise, and migration from coastal regions and flood prone areas to the inland. Desert encroachment and flooding due to rise in sea level, are consequences of climate change which reduce the land available for agricultural production. Women farmers, traditionally, don't possess free access to land in most developing countries; hence suffer most from the reduction of farming land due to the effect of climate change. Men farmers are also affected by this escalating landlessness, but are traditionally favored by culture to acquire land easily through other means, such as purchase, lease, and inheritance; which are not easily accessible to the women in the Developing countries.

The social and economic impacts of climate change are exacerbated by growing population densities in Nigeria. Women more than men are hit harder by all these consequences at the household and community levels, due to their triple roles reproduction, production, and community development. Women spend more time in search of water, and fuel for family use everyday due to persistent water scarcity created in some regions by climate change. Women are the majority of the agricultural workforce; hence they suffer more economic loss from low agricultural production as an outcome of climate change. Men farmers are equally faced with the challenge of low agricultural production, but often migrate to other communities where they could find other sources of income, leaving their wives and children behind in the farming communities. Rural-urban migration of the able-bodied men is a major factor contributing to increase in female-headed households in Nigeria.

Furthermore, women are the care-givers at the household and community levels; hence they bear the health implications of climate change on their family members more than men, because they are always around their family members, even when the husband has migrated to elsewhere. They take care of the sick family members including their husbands and relatives, and most of the times, do that at the detriment of their own health. Women are the poorest of the poor, and the most vulnerable to sicknesses and diseases. Women interact with the environment more than men at the house hold and community levels because they spend most of their time around the household, hence environmental problems hit harder the women than men.

Women are most affected by the food and water scarcity that are consequences of climate change, because they are the daily providers of food and water to the family members. Even where men provide resources required for purchasing the food needed at the family level, it is the women's responsibility to search for the food and water and make it available for their family consumption. Female heads, in female-headed households, carry double responsibilities of providing the money and also procuring the food and water required for their family survival.

COPING STRATEGIES PRACTISED AMONG NIGERIA FARMERS TO ALLAY THE NEGATIVE CONSEQUENCES OF CLIMATE CHANGE

Nigerian farmers have devised several strategies to ameliorate the effects of climate change on their agricultural production and livelihood. Coping strategies that are mostly practised among Nigerian farmers to mitigate the negative consequences of climate change include the followings:

Diversifying into non-farming jobs to secure more economic strength;

Adoption of mixed farming practice: Rearing animals alongside with crop cultivation;

Use of organic manure to increase the resistance of the crops to drought and disease infestation;

Adoption of irrigation system of farming, especially during dry months;

Membership of cooperative societies: to boost their financial strength against economic loss usually caused by uncertain climate, irregular rainfall pattern, and drought, insect and diseases invasion of crops;

Establishment of community based farmers' associations as a network for financial and social supports;

Use of locally available alternative fuel sources: to cope with firewood scarcity due to intensive deforestation;

Dual residence among the people living on the coast, mostly fishermen and women: they relocate upland, especially to larger communities during flooding period;

Adoption of water conservation techniques during raining period e.g. rain harvest technology locally constructed for storing rain water that would be used during the dry period; and

Cultivation of highly economical crops (tree crops such as cacao, oil palm, citrus, etc) and most valued crops (vegetables and crops that are of high demand in the community), usually to cushion losses due to poor/adverse climatic conditions.

IMPLICATIONS OF CLIMATE CHANGE ON FOOD SECURITY IN NIGERIA

About 70% of the population in the developing countries lives in the rural areas, have agricultural as their major occupation; agricultural development among smallholder farmers and landless people provides a livelihood for people allowing them the opportunity to stay in their communities (Anonymous 2009a).

The Intergovernmental Panel on Climate Change (IPCC) predicts that " the effects of climate change are expected to be greatest in developing countries in terms of loss of life and relative effects on investment and economy" (Hulme, *et al., 2001)*. Africa is exceptionally vulnerable to the uncertainties and weather extremes of global warming because it overwhelmingly depends on direct rainfall (Simms, 2005). If not addressed, climate change is estimated to place an additional 80 – 120 million people at risk of hunger; 70 to 80 percent of these will be in Africa (McCarthy, 2001).

Climate change fundamentally contributes to the prevailing food insecurity and rural poverty in developing countries, including Nigeria. The irregular climate conditions, which is the typical feature of climate change, leads to poor agricultural harvest, which further compounds food scarcity in most developing countries that depend on climatic factors for their agricultural production like Nigeria. Agricultural production activities are practically at nil in the Niger Delta region of Nigeria, because of the air and land pollution from the oil drilling and flaring in the area. Most of the populace in the Niger Delta region of Nigeria relies on food produced from other parts of the nation for their daily survival.

CONCLUSION

Agriculture is the principal targets of climate change, hence developing countries, whose populace depends on agriculture for livelihood, such as Nigeria, should be most concerned about curbing the phenomenon. The negative consequences of climate change impacts mostly on the women in Nigeria; hence gender responsive strategies should be adopted for effective alleviation of the phenomenon. Awareness is the first stage for an effective change program; all strategies should be employed as much as possible to create awareness about the impact of climate on agriculture among Nigerian populace, in order to alleviate food insecurity and poverty ravaging the country.

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MUNICIPAL SOLID WASTE (MSW) MANAGEMENT OPTIONS AND THEIR CONTRIBUTION TO CLIMATE CHANGE

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Abstract

The waste sector is an important contributor to climate change. The gases produced at municipal solid waste disposal sites contribute approximately 3-4 percent to the annual global anthropogenic green house gas emissions. These emissions from solid waste are expected to increase with increasing global population and gross domestic product (GDP). And this in turn is expected to result in a significant warming of the earth's surface and other associated changes in climate. The green house gases that are making the largest contribution to the global warming are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The three are produced during the management and disposal of wastes. This article therefore examines climate change impacts in terms of net fluxes of green house gases from various combinations of options used for the management of municipal solid waste (MSW). The waste management options considered are Landfill of untreated waste, Incineration, Mechanical Biological Treatment (MBT), Composting, Anaerobic digestion (AD) and Recycling. The different steps / processes through which the waste options assessed in this study impact upon climate change is also brought to the fore.

Keywords: municipal solid waste, greenhouse gas, climate change, management options.

INTRODUCTION

Municipal solid waste (MSW), also called urban solid waste, is a waste type that includes predominantly household waste (domestic waste) with sometimes the addition of commercial wastes collected by a municipality within a given area (Sridhar, 2005). They are in either solid or semisolid form and generally exclude industrial hazardous wastes (US EPA, (1998; OECD, 1999).

The waste sector is an important source of greenhouse gas emissions. According to recent global estimates this sector produces on average 2-4 per cent of national greenhouse gas emissions (UNFCCC, 2005). Solid waste disposal is a significant source of methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2). Waste management options alone are estimated to contribute about one fifth of global anthropogenic methane emissions (US EPA, 1998; IEA, 2005).

Incineration and open burning of waste containing fossil carbon are the most important sources of CO_2 emissions in the waste sector.

The principal non-carbon greenhouse gas of interest to waste management is N_2O. Nitrous oxide is formed in trace amounts from nitrogen gas in the air and from compounds of the element present in waste during combustion in incinerators, landfill gas flares and combustion engines. In addition, N_2O is produced as an intermediate gaseous product of microbial nitrogen cycling. N_2O emissions depend on the type of waste treatment as well as conditions during the transport, storage and treatment (US EPA, 1998). Increased methane (CH_4) concentration in the atmosphere contributes to climate change (NOAA, 2005). Its contribution to climate change is about one third to a half of that of carbon dioxide (US EPA, 1998; Hansen & Sato, 2001).

The effects of solid waste management options on GHG emissions vary. For example, plastics do not degrade in landfills, but are stored yielding no GHG emissions. In combustion, fossil C in plastics is oxidized and yields fossil CO_2 emissions. On the other hand, food and paper contain no fossil C and generate no fossil emissions in combustion, but degrade anaerobically in landfills causing CH_4 emissions. According to IPCC (2001), GHG emissions are roughly comparable from landfilling and composting for yard waste, but for food waste, composting yields significantly lower emissions than landfilling. In case of paper, landfilling causes higher GHG emissions than either recycling or incineration with energy recovery (Coopers & Lybrand, 1997; US EPA, 1998).

STEPS IN THE WASTE MANAGEMENT PROCESS

The waste management options assessed in this article impacts upon climate change through a number of different steps. These fall into the following categories:

· **Mobilization.** Climate change impacts of waste mobilization are mostly indirect emissions associated with collection, sorting, processing and transporting waste. The main greenhouse gas is fossil derived carbon dioxide from vehicle fuels.

· **Process.** Process or treatment emissions include greenhouse gases derived from the waste itself (direct emissions) and from fuel used in its treatment (indirect emissions) prior to disposal of any residue. Examples of direct emissions include carbon dioxide emitted from waste combustion during incineration. Indirect emissions include those originating from fuel use in composting etc.

· **Disposal/use.** Greenhouse gas emissions result from the ultimate disposal of the waste in landfills or the use of materials derived from the waste. One of the main greenhouse gas impacts of waste management originates from methane emissions from biodegradable wastes in landfills. In addition, some short-cycled carbon is locked up in the landfills and prevented from being returned to the atmosphere. This carbon is classed as being stored or sequestered. Waste management options in which sequestration is significant are landfill MBT and the use of compost from AD and composting plants.

· **Displaced emissions.** Emissions avoided as a result of useful energy or materials being recovered from waste displace emissions that would have happened if alternative energy or materials had been used elsewhere in the system. When energy is recovered from waste, either as electricity, heat or both in combined heat and power (CHP applications), it displaces an equivalent amount of energy elsewhere in the system. Waste management options which have an energy recovery component include incineration and other thermal treatments, AD and landfill where the gas is recovered for energy production. Recycling also displaces materials, together with their associated greenhouse gas impacts.

Table 1: Some environmental impacts of the main waste management options

Option	Main environmental impacts
All options ·	Emissions of carbon dioxide, nitrous oxide, methane and other pollutants, noise, odour and congestion from vehicles transporting waste and by-products to and from treatment plants
Landfill ·	Methane emissions from biodegradable waste, contributing to global warming and local hazards such as the risk of fires and explosions · Risks of water pollution from leachate (liquor) formed as waste decomposes · Land use – non-sustainable use of resources · Noise and odour · Some carbon compounds may be retained in the landfill for long periods (sequestered) and so not returned to the atmosphere as CO_2
Incineration ·	Emissions of harmful airborne pollutants such as NOx, SO_2, HCl, fine particulates and dioxin · Emissions of carbon dioxide from fossil-derived waste (e.g. plastics) and N_2O contributing to global warming · Energy recovered can replace fossil fuels thus avoiding emissions of carbon dioxide · Fly ash and residues from air pollution control systems require stabilization and disposal as hazardous waste · Bottom ash may be reused as a secondary aggregate - metals may be recovered for recycling from bottom ash
Recycling ·	Saves energy (generally less energy is required to manufacture products from recycled feedstocks) and hence emissions of greenhouse gases and other pollutants · Prolongs reserves of finite resources (e.g. metal ores) – contributes to the sustainable use of resources · Avoids impacts associated with extraction of virgin feedstock (e.g. quarrying of ores and sand, felling of old growth forest to produce wood for paper)
Composting ·	Avoids methane production from degradation of organic waste in landfills (as degradation is aerobic) · Compost can be used as a soil improver and can replace fertilizers and peat to some extent (both have negative environmental impacts) · Potential for carbon sequestration through increasing the store of soil organic matter · Improvements in soil fertility and soil organic matter content leading to possible down- stream benefits from reduced need for inorganic fertilizers, reduced need for irrigation and lower soil erosion rates. · Needs careful control of the composting process to avoid bio-aerosols.

Anaerobic Digestion · As for composting, plus energy recovered can replace fossil fuels thus avoiding emissions of carbon dioxide

Mechanical Biological Treatment

· Reduces methane and leachate production from degradation of treated organic waste in landfills (as biological fraction is composted before disposal)

· Materials may be recovered for recycling and/or energy recovery

· More effective use of landfill void space since pre-treatment reduces bulk of waste needing disposal

· Still dependent on landfill as repository of final waste, so not as sustainable as recycling or composting.

LANDFILL PROCESS DESCRIPTION

Landfill can be defined as the managed disposal of waste on land. As such, it is distinguished from dumping, which is characterized by the absence of control of the disposal operations and lack of management of the dump site.

In managed and unmanaged landfills, anaerobic degradation of organic material occurs, causing CH_4 emissions. Management of landfills typically increases anaerobic conditions. Methane emissions from landfills depend on waste characteristics (composition, density, and particle size), conditions in landfills (moisture, nutrients, microbes, temperature, and pH), design and maintenance of cover material, landfill operation and maintenance and special landfill gas controls. Landfill gas (LFG) is about 50-60% methane with the remainder CO_2 and traces of non-methane volatile organics, halogenated organics and other compounds (IPCC, 2006; IPCC, 2001).

In a modern landfill site, decaying wastes use up the oxygen entrained within the waste mass, creating anaerobic conditions. The depths of wastes typically employed means that oxygen is used up faster than it can diffuse in from the air. Under anaerobic conditions, the waste continues to degrade to produce landfill gas, which contains roughly 50% methane and 50% carbon dioxide (Christiansen, & Kjedsen, 1989)). In sites with no gas control, the gas migrates to the surface of the landfill site and is released. In sites with gas control, a low permeability cover prevents gas release and a system of wells and pumps is used to extract the gas. The collected gas is either flared or combusted for energy recovery – in either case it is converted to short-term carbon dioxide. Uncollected gas migrates through the cover, or restoration layer if present, where some of it is oxidized to carbon dioxide.

Mobilization emissions

Waste is collected direct from households and taken either straight to the landfill site (in rural areas) or via a refuse transfer station (RTS) in urban areas. The proportion of the population living in an area (Philips Geographical Digest, 1994) determines the fraction of waste using each route.

Treatment emissions at the landfill

Operations at the landfill site involve the following steps:

· Weighing the waste on the delivery vehicle as it enters the site;

· Waste is taken to the working area and tipped out;

· Waste is then spread and compacted using a bulldozer or landfill compactor;

· Daily cover of soil or clay is moved to the working area at the end of each day;

· Daily cover is spread and compacted;

· Final cover material is delivered, spread and compacted after the working area reached the desired waste depth.

· Electricity is used for operating leachate and gas collection pumps but this is often generated on site by diesel generators.

The fuel used in each of these steps results in CO_2 emission. The most energy intensive step is the spreading and compaction of each load of waste. The amount of fuel used depends very much on local site practices.

Disposal emissions

In landfills, waste degrades and gas is released slowly over time. When organic matter is landfilled, some of this matter decomposes anaerobically and releases CH_4 (Bognor, Matthews, Katzebstein, Blake & Carolan, 2000). (Landfilling of metals and plastics does not result in CH_4 emissions or carbon storage.) Over a period of 100 years, which is the time scale typically used for greenhouse gas studies, most of the landfill gas will have been released from landfilled waste (IPCC, 2006).

Landfill and climate

– Landfilling biodegradable wastes will lead to methane production

• Some of this can be captured, and energy generated from the landfill gas

• Much will not be captured, and will contribute negatively to climate change

– Landfilling of material that could be recycled, e.g. aluminium cans, creates climate emissions when materials have to be replaced.

INCINERATION PROCESS DESCRIPTION

The purpose of thermal treatment of waste (which in the narrow sense usually means combustion in incinerators) is to reduce the bulk of waste needing ultimate disposal in landfills to an inert inorganic ash residue. Organic carbon compounds are oxidized to CO_2 and water vapour, which are discharged to the atmosphere in the stack gas (Corey, 1969). Incineration of fossil carbon in plastics (for example) therefore makes a net positive contribution to global warming, but incineration of short-cycle carbon compounds (in paper, food, vegetation etc) is neutral in global warming terms. Residual organic matter remaining in the ash residue should be reduced to a very low level if the combustion process is carried out efficiently. The ash will therefore have virtually no capacity to form organic leachates or gas after disposal in landfills.

Mobilization emissions

Waste is collected direct from households and taken either straight to a mass-burn incinerator (in rural areas) or via a refuse transfer station (RTS) in urban areas. The proportion of the population living in urban areas determines the fraction of waste using each route. Bottom ash is transported either to landfill or market depending on the proportion sold. Fly ash and flue-gas cleaning residues are transported to a hazardous waste landfill site. Recovered metal is taken to a re-processor.

Treatment emissions

The carbon present in waste is converted to carbon dioxide during incineration. For biogenic materials, this is short-term carbon dioxide whereas for plastics and synthetic materials it is derived from fossil fuels. As for other complete combustion processes, nearly all of the carbon content in the waste is emitted as CO_2 to the atmosphere. MSW contain approximately the same mass fraction of carbon as CO_2 itself (27%), so incineration of 1 ton of MSW produce approximately 1 ton of CO_2 (Coopers & Lybrand, 1997). In the event that the waste was landfilled, 1 ton of MSW would produce approximately 62 cubic metres (2,200 cu ft) methane via the anaerobic decomposition of the biodegradable part of the waste. This amount of methane has more than twice the global warming potential than the 1 ton of CO_2, which would have been produced by incineration (Coopers & Lybrand, 1997). Nitrous oxide is also a green house gas that is emitted during incineration as a result of the burning of fossil fuel.

Incineration and climate

- Incineration creates a demand for residual waste
- Incineration generates energy inefficiently, whilst emitting fossil fuel-derived CO_2

– Incinerators are designed to dispose of rubbish, and need a lot of air pollution control equipment.

– Much of what is burned in incinerators is fossil-fuel derived - e.g. plastics, synthetic textiles etc. When burnt, this produces fossil fuel derived carbon dioxide.

– Therefore, the power generated from incinerators is not ‘green energy’ or ‘renewable energy’ (IPCC, 2000).

MBT PROCESS DESCRIPTION

Mechanical-biological treatment involves the mechanical sorting of whole waste into a biodegradable fraction and a reject fraction. The biodegradable fraction can then be composted (or anaerobically digested) prior to landfill to reduce methane generation.

The system generally operates by sorting the waste prior to composting to remove the non-biodegradable components, typically in a homogenization drum where the waste is tumbled in a rotating drum for periods of several hours to several days. The degradation is assisted by the addition of water. The material is then screened to remove the materials that have not broken down. These are principally textiles, plastics and metals. Metals are removed for recycling, and the remainder of the 'reject fraction' is either landfilled or used as landfill cover/restoration material or incinerated (Paar, Brummack & Gemende, 1999).

The 'biodegradable fraction' which passed through the screen is either composted or anaerobically digested. The composted residue from the MBT process is volume-reduced and has a much reduced capacity to produce landfill gas and leachate after disposal in landfills than untreated waste (Paar, Brummack & Gemende, 1999).

Mobilization emissions

Emissions associated with transporting MSW to the MBT plant, the reject fraction to thermal treatment, and recovered metals to market or re-processor varies depending on the journey distance.

Treatment emissions

There is a slight difference for the composting phase – typically the composting period is shorter in MBT plants and so degradation will be less complete and less CO_2 will be emitted. However, emissions from the composting phase are all short term carbon dioxide with no greenhouse gas impact (Paar, Brummack & Gemende, 1999).

COMPOSTING PROCESS DESCRIPTION

Composting is the aerobic degradation of waste to produce compost which can be used as a soil improver. It is the purposeful biodegradation of organic matter, such as yard and food waste. The decomposition is performed by micro-organisms, mostly bacteria, but also yeasts and fungi. In low temperature phases a number of macro-organisms, such as springtails, ants, nematodes, isopods and earthworms also contribute to the process, as well as soldier fly, fruit flies and fungus gnats (Felipo, 1996) .

Mobilisation

The transport routes considered are:

Household → composter → market for marketable compost → landfill for unmarketable compost and rejects

Or household → household waste collection site → composter → market for marketable compost → landfill for unmarketable compost and rejects

For home composting there are no transport emissions.

Treatment emissions

When organic materials are composted, the anaerobic decomposition of materials produces CH_4. Similarly, the collection and transportation of organics produces non-biogenic emissions. Although composting may result in some production of CH_4 (due to anaerobic decomposition in the center of the compost pile), compost researchers believe that the CH_4 almost always oxidizes to CO_2 before it escapes from the compost pile.

Since the CO_2 emissions from composting are biogenic, and well-managed compost piles are not believed to produce CH_4, the only GHG emissions from composting result from transportation of compostable materials to composting facilities and mechanical turning of the compost piles (Felipo, 1996).

Use / disposal and displaced emissions

After the compost is produced and applied to land, it continues to degrade, releasing more carbon dioxide and forming humic compounds that then mineralize much more slowly than the organic matter originally applied in the compost. Compost applications may therefore increase the store of soil organic matter. The use of compost may also displace peat or inorganic fertilizers, with associated emissions benefits (Johnston, 1997).

COMPOST AS A CARBON SINK

The IPCC has identified carbon sequestration in soils as one of three carbon mitigation measures for agriculture, the other two options being a reduction in agriculturally related emissions and the replacement of fossil fuels with bio-fuels (IPCC, 1996). The loss of organic carbon in soils has been one of the major environmental consequences of industrial agriculture.

ECAF (1996) suggest that over about 20 year tillage, most agricultural soils will have lost about 50% of their organic carbon. This is largely because of the reliance of industrial agriculture on inorganic fertilizers, rather than organic composts and manures, as a source of crop nutrients, and the extensive use of tillage. Thus the input of plant-derived materials that break down to form soil organic matter is reduced, whilst high rates of tillage increase the exposure of the organic matter to erosion and loss through oxidation. Compost may provide a useful source of soil organic matter, contributing to improvements in soil physical structure and fertility (Carter, 1999).

AD Process Description Anaerobic digestion involves the biological decomposition of waste in air-tight vessels under anaerobic conditions to produce a methane-rich biogas. The temperature, pH and moisture content are controlled to optimize methane production and the gas produced is collected and burnt for heat or electricity production. As for composting, source-separated waste is essential if the solid residue 'digestate' is to have value in agricultural or horticultural applications, as opposed to use as landfill cover or site restoration (Hauke, & Stoeppler-Zimmer, 1996).

Mobilization

Emissions from mobilizing waste for AD are considered to be the same as for composting.

Treatment emissions

Anaerobic digestion (AD) produces a gas rich in methane - the remainder being short-term carbon dioxide as it originates from degradable organic matter. Most of this methane is converted to short-term carbon dioxide during combustion of the gas for energy, but a little may escape through leakage before combustion, resulting in the release of methane.

Use / disposal and displaced emissions

AD compost is credited with avoided emissions due to carbon sequestration and displacement of peat and fertilizers (Hauke, & Stoeppler-Zimmer, 1996). However, in addition to these factors, the AD option also allows energy recovery from the biogas which is not available for aerobic composting.

Utilizing anaerobic digestion technologies can help to reduce the emission of greenhouse gases in a number of key ways:

- Replacement of fossil fuels
- Reducing methane emission from landfills
- Displacing industrially-produced chemical fertilizers
- Reducing vehicle movements
- Reducing electrical grid transportation losses

Methane and power produced in anaerobic digestion facilities can be utilized to replace energy derived from fossil fuels, and hence reduce emissions of greenhouse gasses. If the putrescible waste processed in anaerobic digesters was disposed of in a landfill, it would break down naturally and often anaerobically. In this case the gas will eventually escape into the atmosphere. As methane is about twenty times more potent as a greenhouse gas as carbon dioxide this has significant negative environmental effects.

RECYCLING PROCESS DESCRIPTION

Recycling involves processing used materials into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution (from incineration) and water pollution (from landfilling) by reducing the need for "conventional" waste disposal, and lower greenhouse gas emissions as compared to virgin production (Prognos, 2000). Recycling is a key component of modern waste management and is the third component of the "Reduce, Reuse, Recycle" waste hierarchy.

When a material is recycled, it is used in place of virgin inputs in the manufacturing process. Recycling of materials from the municipal solid waste stream generally involves the following steps:

1. Collecting the separated materials from individual households and transporting to a place for further treatment

2. Sorting, baling and bulking for onward transfer to re-processors (e.g. at a Materials Recycling Facility)

3. Reprocessing to produce marketable materials and products

The costs of reprocessing depend largely on the material to be processed, the scale of the process used, the complexity of the reprocessing technology, and the quality of the input materials (Prognos, 2000).

SORTING PROCESS DESCRIPTION

A typical Materials Recycling Facility (MRF) operation employs manual processing and/or semi-automatic processing for sorting recyclables from waste and preparing them in a form suitable for use by a materials re-processor. A MRF is typically equipped with conveyors, trommel (rotary screen) separators (for removal of fine particles and permitting size separation) picking lines where manual operators remove recyclable materials, and baling equipment (Prognos, 2000).

Other equipment includes weigh-bridges, storage containers, fork-lift trucks, and some MRFs may be equipped with magnetic separators, eddy current separators and machines for the detection and separation of plastics by polymer type. There are various options for the equipment layout of a MRF depending on the degree of source-separation already performed by the householder. Generally, well separated recyclables require less processing at a MRF than unsorted, mixed recyclables.

Greenhouse Gas Emissions from sorting

Emissions arise from transport of materials to the MRF and from the MRF to the re-processor, and from energy use at the MRF.

CONCLUSION

The disposal of municipal solid waste produces greenhouse gas emissions in a number of ways. First, the anaerobic decomposition of waste in landfills produces methane, a greenhouse gas 21 times more potent than carbon dioxide. Second, the incineration of waste produces carbon dioxide as a by-product. In addition, the transportation of waste to disposal sites produces greenhouse gas emissions from the combustion of the fuel used in the equipment. Finally, the disposal of materials indicates that they are being replaced by new products; this production often requires the use of fossil fuels to obtain raw materials and manufacture the items.

Municipal solid waste management decisions, however, can reduce GHGs by affecting one or more of the following:

(1) Energy consumption (specifically, combustion of fossil fuels) associated with making, transporting, using, and disposing the product or material that becomes a waste.

(2) CH_4 emissions from landfills where the waste is disposed.

(3) CO_2 and nitrous oxide (N_2O) emissions from waste combustion.

(4) Carbon sequestration, which refers to natural or manmade processes that remove carbon from the atmosphere and store it for long periods or permanently.

The first three mechanisms add GHGs to the atmosphere and contribute to global warming. The fourth—carbon sequestration—reduces GHG concentrations by removing CO_2 from the atmosphere. Therefore, the following are suggested-

- Waste management practices with high GHGs emissions (e.g. landfilling of untreated waste and incineration) should be discouraged
- Composting and anaerobic digestion end products should be used as soil conditioner to replace inorganic fertilizers which is also a source of GHGs
- Recycling method that discourages the manufacture of some products from virgin inputs and reduce waste volume should be practiced
- Public enlightenment on the contribution of various waste management options to climate change should be carried out
- Government and policy makers should seriously consider environmental sustainability issues when making waste management decisions.

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THERMOCHEMICAL CONVERSION OF MIXED CROP RESIDUES AND CRUDE GLYCEROL TO PRODUCE BIO-OIL

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Abstract

Bio-energy produced from biomass is an alternative to petroleum and has received the greatest interest in recent times due to rapid depletion of crude oil, skyrocketing energy price and environmental concerns associated with fossil fuel resources the world over. Biomass feedstock informs of forestry wastes, agricultural residues and animal wastes are abundant primary source of energy for direct heat production. Amongst the thermochemical conversion processes, pyrolysis is one of the most promising as it can be used as an independent process for the production of solid, liquid and gaseous energy fuels and or chemicals from biomass materials. The kinetics of the process is influenced by the values of the main process parameters of temperature, solid residence time, pressure, particle size, and heating rate. By changing the operating conditions during pyrolysis, it is possible to modify and alter the actual course of reactions to increase the yield of the desired product. To maximize the yield of liquid products, a low temperature, high heating rate and short gas residence time process is required. This is favored with fast and flash pyrolysis processes at moderate temperatures. Catalyzed pyrolysis is fast gaining popularity in the thermochemical conversion process, especially for lignocellulosic biomass. Some research and development aspect pertinent to bi-oil production through pyrolysis and fast pyrolysis process design are presented.

Keywords: Bio-oil, Pyrolysis, Biomass, feedstock, Reactor.

INTRODUCTION

Energy production and consumption are important human endeavors. They are prerequisites for the growth and development of every society. The conversion and utilization of energy in the required forms are therefore critical issues amid declining fossil fuel reserve, skyrocketing energy price and increasing environment concerns (Yu *et al.,* 2006). In agriculture and other agro-allied processing activities energy is needed in a form suitable for each process. However, agricultural energy technology is an extremely intensive process made possible only by relying heavily on large amount of energy inputs, specifically from fossil fuel resources such as oil, natural gas, coal etc. More than 80% of the world primary energy, estimated at about 400EJ per year is from the fossil fuels sources alone (Henrich *et al*, 2000). The Nigerian primary energy consumption estimated at about 26.65×10^6 toe is also mainly fossil fuel based (Jekayinfa and Scholzb, 2007). The availability of low cost forms of energy for agricultural activities is however a major challenge in most developing countries including Nigeria. The key to future life is owned to the provision of clean, domestic and renewable energy (Babu, 2008).

The dependence on the fossil fuels the world over is the subject of the international discourse in recent times. The major concerns are for their non sustainability and effects on global environment

(Henrich *et al.,* 2000). The prices of these commercial energy sources have increased sharply and there is a continuous depletion of these scarce resources. In view of the challenges, energy planners are already developing alternative energy sources that are sustainable and environmental friendly. Since the global energy crisis of the 1970s, the trend has been towards the use of renewable energy sources to replace fossil fuel worldwide (Czernik *et al*., 1995). As an alternative to the global energy crisis several renewable energy resources such as solar, wind, geothermal, biomass and hydropower energy sources were been investigated. Amongst the natural resources, biomass energy resources have the highest potential towards sustainable development and in satisfying environmental concerns over fossil fuel usage (Van de Velden *et al.,* 2007; Bridgwater, 2003). And in addition it is abundant, inexpensive and renewable and has emerged as an attractive alternative in producing easy-to-handle forms of energy such as solid, liquid and gaseous fuels (Demirbas, 2001).

Nigeria is rich in fossil fuel resources such as crude oil, natural gas and coal and renewable energy resources like solar, wind, biomass, and has large scale hydropower energy sources. The per capita energy consumption is however low, far below the world average. This is not unconnected to the under utilization of her vast energy resources especially in the rural areas. Though, the national energy supply is dependent on fossil fuels and fuel wood. These energy resources are not readily available and or are inefficiently used at the rural areas where majority of the Nigerian population resides. And in addition only about 40% of the population most of who resides in the urban centers is connected to the national electric grid. The physical infrastructure to provide fuel and electricity to the rural poor at low cost is lacking and demand in urban areas is outpacing the ability to generate power. The security of energy from the conventional sources is inadequate, hence stressing the need for alternative sources. Agricultural field operations and other farming activities including most processing and handling operations are therefore largely performed manually in spite of the continued emigration of the farm labor to the urban areas.

Biomass resources such as forest residues, low-grade plants, agricultural residues, and municipal solid wastes are composed of organic raw materials that can be converted to energy. In addition, biomass wastes have negligible contents of sulfur, nitrogen and ash which give lower emissions of SO_2, NO_2 and soot compared to conventional fossil fuels, thus keeping the environment and the public's health safe (Aquino *et al.,* 2007). Effective utilization of these waste products will not only reduce excessive pressure on the use of firewood which usually leads to the attendant effects of deforestation and soil erosion, but will also free women and children from the burden and time wasted in fetching fuel wood for other useful ventures.

When a biomass material is combusted, it breaks down into its molecules with the release of heat. Therefore the energy in biomass is a form of renewable energy which does not add carbon dioxide to the environment in contrast to the fossil fuels. With the application of thermochemical conversion processes on biomass, fuels with higher heating values could be produced efficiently and economically, rather than just burning the biomass directly to produce heat or power (Caglar and Demirbas, 2000). Pyrolysis is one of the most promising thermochemical processes, producing pyrolytic char, gas and oil, all of which have potential end uses. Certain factors determine the amount and variety of these output products so that pyrolysis conditions can be optimized for the production of char, gas, or oil (Aquino *et al.,* 2007).

BIOMASS RESOURCES IN NIGERIA

Nigeria is blessed with both human and material resources, and has rich biomass resources including forests, agricultural products and other organic wastes. Substantial valuable wastes are also generated from the animal husbandry, industrial and domestic processes. The Nigerian forest cover is about 9.7 million hectares or 10 % of the total land area (FAO, 2005). A wide variety of by-materials (residues) that have the potentials of being used as fuels such as corded wood, sawdust, barks, straw and pellets having different characteristics are generated from the solid biomass production chain. Up to 86 % of the wood production from the forest is used as fuel wood (FAO, 2005). The forest resource is however being threatened by high depletion rate caused by its competing uses as fuel wood for domestic and industrial purposes, for charcoal production, for construction and other uses. The forest covers is being depleted at an annual rate of 3.5 % and with the Sahara Desert encroaching southward at a rate of about one kilometre per year (FDF, 2001).

Substantial agricultural residues are also derived annually from some major agronomic crops. The energy potentials of some of these residues were recently assessed and were found to be comparable with some conventional biomass fuels. Most can therefore be processed into a useful energy resource (Jekayinfa and Omisakin, 2005). Residues generated were estimated to vary from 311,000 tonnes for oil palm shells to 14 million tonnes for sorghum straw in 2004. In total more than 70 million tonnes of agricultural residues were potentially produced, out of which only 58 million tonnes are energetically available in that year (Table 2.1). The residue availability projection for 2010 is about 80 million tonnes with an energy potential of 23.93 million toe. With only about 34 million hectares or 35 % of Nigeria cultivable land presently under cultivation, Nigeria has great agricultural potentials from which biomass resources can be produced (Jekayinfa and Scholz, 2007).

PYROLYSIS PROCESS

Pyrolysis is a process by which a biomass material is thermally degraded in the absence of oxygen or air, resulting in a solid (char), liquid (tar and bio-oil), and volatile gases (CO, CO_2, CH_4, and H_2). It is often employed in the upgrading of biomass feedstock or waste into chemicals and energy. Its study is gaining increasing importance, as it is not only an independent process, but it is also a first step in the gasification or combustion process. By changing the operating conditions during pyrolysis, it is possible to modify the actual course of reactions towards increasing the yield of the desired product.

The basic phenomena that take place during pyrolysis are: a) heat transfer from a heat source, leading to an increase in temperature inside the fuel; b) initiation of pyrolysis reactions due to this increased temperature, leading to the release of volatiles and the formation of char; c) outflow of volatiles, resulting in heat transfer between the hot volatiles and cooler unpyrolyzed fuel; d) condensation of some of the volatiles in the cooler parts of the fuel to produce tar; and e) autocatalytic secondary pyrolysis reactions due to these interactions (Babu 2008). It is important to note the secondary reactions which result from the interaction of volatiles and gases with the char, to form secondary products. These secondary volatiles, gases, and char may be undesirable, and their production is affected by gas/volatile retention time in the reaction zone.

Table 1. Estimated Amount of Crop Residues in Nigeria in 2004 and projection for 2010

Crop	Crop Yield (10^6t)	Types of Residues	PRP	Residue Amount for 2004 (10^6t)	Residue Amount for 2010 (10^6t)
Maize	4.78	Cob	0.273	1.30	1.59
		Stalk	2.000	9.56	11.62
		Husk	0.200	0.96	1.16
Cassava	38.18	Stalks	0.062	2.37	1.09
		Peelings	0.250	9.54	6.60
Millet	6.28	Stalks	1.750	11.00	5.42
Plantain	2.42	Peels	0.400	8.44	1.39
		Trunks/Leaves	0.500	1.05	1.17
Groundnuts	2.94	Husks/Shells	0.477	1.40	3.09
		Straw	2.300	6.76	14.92
Sorghum	8.03	Straw	1.700	14.05	23.15
Oil Palm	4.78	Shell	0.065	0.31	0.17
		Fibre	0.140	0.67	0.31
		Empty Bunches	0.230	1.10	0.60
Palm Kernel	8.70	Shells	0.45	3.92	3.76
		Cake	0.250	2.18	0
Cowpea	2.32	Shells	1.750	4.05	4.41
Total				69.56	80.51
Energy Potential (toe)				20.81	23.93

Source: Jekayinfa and Scholz, 2007

The general pyrolysis of biomass is divided into three phases; the moisture evaporation, corresponding to temperatures below 130°C, the main devolatilization, occurring at temperatures below 450°C and the continuous slight devolatilization at temperatures above 450°C (Chen *et al.,* 2003). Biomass is believed to officially starts to pyrolyze at a temperature of 200°C, releasing volatiles. The main constituents in biomass, hemicelluloses, cellulose and lignin are found to pyrolze at different rates and by different mechanisms and pathways. The rate and extent of degradation of each of these components depends on the process parameters of reactor type, temperature, particle size, heating rates and pressure. The main devolatilization is due to the decomposition of cellulose and hemicellulose, while the continuous slight devolatilization is due to lignin and the remaining cellulose and hemicellulose. The hemicelluloses break down first at temperatures of 470 to 530 K, cellulose follows in the temperature range of 510 to 620 K, and lignin is the last component to pyrolyze at temperatures of 550 to 770 K (Shaw, 2006).

Depending upon the operating conditions, the pyrolysis process can be divided into three subclasses: conventional pyrolysis (carbonization), fast pyrolysis and flash pyrolysis. The conventional pyrolysis is the pyrolysis that occurs under a slow heating rate, thus permitting the production of solid, liquid and gaseous pyrolysis products in significant proportions. The ranges of the main operating parameters for each of the pyrolysis processes are as presented in Table 2.2 (Bridgewater and peacock, 2000).

The first stage of biomass decomposition which occurs between 395 and 475 K is called pre-pyrolysis. During this stage, some internal rearrangement, such as water elimination, bond breakage, appearance of free radicals and formation of carbonyl, carboxyl and hydroperoxide groups takes place. The second stage of the solid decomposition corresponding to the main pyrolysis process is believed to proceeds at a high rate and leads to the formation of the pyrolysis products. During the third stage, the char decomposes at a very slow rate and carbon-rich residual solid forms (Chen *et al.,* 2003).

Table 2. Range of Main Operating Parameters for Pyrolysis Processes

Parameters	Conventional pyrolysis	Fast Pyrolysis	Flash Pyrolysis
Pyrolysis temperature (K)	650 – 950	850 – 1250	1050 – 1300
Heating rate (K/s)	0.1 - 1.0	10 – 200	< 1000
Particle size (mm)	5 – 50	< 1	< 0.2
Solid residence time (s)	450 – 550	0.5 – 10	< 0.5

Source: Bridgewater and peacock, 2000.

The reactions directly involving the feedstock material are termed primary pyrolysis reactions, whereas secondary pyrolysis reactions refer to those involving intermediate pyrolysis products (e.g. the decomposition of volatiles or levoglucosan). Accordingly two general pyrolysis pathways are recognized: one, involving dehydration and charring reactions leading to the formation of charcoal, CO_2 and H_2O and the second involving depolymerization and volatilization, and leads to the formation of combustible volatiles. These competitive schemes help to explain the extreme sensitivity of the pyrolysis products distribution on the type of feedstock and process conditions.

Factors Affecting Biomass Pyrolysis

In general the products from the pyrolysis of biomass include a solid carbon-rich residue (charcoal) and a range of volatile products (condensable and non-condensable). The amount and quality of the char and the composition of the volatile fraction are strongly dependent both on the physical and chemical properties of the feedstock material. The kinetics of the pyrolysis process is also influenced by a no of process parameters such as temperature, solid residence time, particle size, heating rate, pressure, type of reactors and catalyst employed (Shaw, 2006).

Catalyzed pyrolysis is fast gaining popularity in the thermochemical conversion process, especially for lignocellulosic biomass. Aquino et al (2007) reported a catalytic pyrolysis of grape and olive bagasse using sulfuric and phosphoric acids under different conditions. A cylindrical stainless steel reactor with a ceramic furnace was used to pyrolyze the raw materials under the temperatures of 400–800 °C. They observed that, in the presence of catalysts, char fraction was increased while the liquid decreased. However, the gases (i.e. H2, CO, CO2 and CH4) were unaffected except when Fe or Al was used. The influence of temperature was also determined such that when an increase in temperature led to decreased solid yield and increased gas yield, the optimum temperature was determined at 600 °C. In a parallel study, Putun *et al.,* (2005) used catalyzed pyrolysis on air-dried cottonseed cake using natural zeolite content while varying the pyrolytic temperature, zeolite content and sweeping gas flow rate. A 316 stainless steel Heinze retort was used as a reactor heated by an electric furnace. The maximum liquid produced was 30.84%, under a pyrolysis temperature of 550 °C, sweeping gas flow rate of 100 cm^3min- 1, and in the presence of clinoptilolite molecular sieve. It was also found that increasing the pyrolysis temperature also increased the yield of conversion while decreasing the yield of char; on the other hand, increasing the zeolite content resulted in only a slight change in the pyrolysis conversion.

In a similar study Gan and Yuan (2008) conducted a catalytic hydrothermal pyrolysis of corn cobs using sodium hydroxide (biomass based) and glycerol at the optimal operating conditions for corncobs, which were 305 ^{0}C operating temperature, 20min retention time, and 10% feedstock loading. They found that the oil yield increased from 23.7% to 59.2% as the crude glycerol ratio increased from 0 to 80%. Crude glycerol had no significant effect on gas yield, but decreased the char yield. In addition, the bio-oil floated on the aqueous products when the crude glycerol ratio was beyond 70%. It indicated that the density and viscidity of the bio-oil decreased, the use of crude glycerol could improve the oil quality. It was also found that increasing the pH of glycerol improved the conversion of biomass into bio-oil.

Tsai *et al.,* (2006), on the other hand, used induction heating for the lab-scale pyrolysis system of rice husk and were able to produce pyrolytic oils and chars. The process parameters that were examined include pyrolysis temperature, heating rate, holding time, nitrogen gas flow rate, condensation temperature, and particle size on the pyrolysis' product yields and their chemical compositions. A horizontally tubular reactor was used for the fixed-bed fast pyrolysis experiment. The heating rate used was 100–500 °C in the high-frequency generator. Like in the previous studies, the char yield had a decline trend as the final pyrolysis temperature is increased while the oil yield also increased. The optimum condensation temperature for effectively collecting gas products was found at - 10 °C. The optimal oil yield of > 40% was achieved at a pyrolysis temperature of > 500 °C, heating rate of > 200 °C, holding time of > 2 min, condensation temperature of < - 10 °C and particle size of < 0.5 mm.

A laboratory study of cotton gin waste pyrolysis was conducted by Zabaniotou *et al.,* in 2000. The effect of temperature (350–800 °C) on the product yields was determined using a captive sample batch reactor heated at a rate of 80–100 °C s- 1. It was found that high temperature favored gas production (i.e. CO, CH4, CO2, H2, and C2H4) while it gave very low yields of tar and liquid (almost negligible) which, the authors say, was probably due to the slow pyrolysis process.

FAST PYROLYSIS PROCESS DESIGN

To maximize the yield of liquid products, a low temperature, high heating rate and short gas residence time process is required. This is favored with fast and flash pyrolysis processes at moderate temperatures. A fast pyrolysis system consists of an integrated series of operation starting from the preparation of feedstock. Depending on the capacity of the system, it may be necessary to have a reception and handling and some storage units. This may include a weighbridge, tipping units, Conveyor and reclamation (Bridgewater and Peacock, 2000).

Feedstock material is typically conditioned to moisture content around 10%. This corresponds with the biomass moisture content required by pyrolysis. Depending on the pyrolysis reactor, the material may have to be milled for efficient pyrolysis in the reactor. This is due to the fact that the particle sizes of the feedstock material are generally much larger than that recommended for fast pyrolysis, and will therefore reduce the feedstock heating rate significantly. Size specification ranges from less than 200μm for the rotating cone reactor to less than 2mm for fluid beds and less than 6mm for transported or circulating fluid beds. The ablative reactor can utilize whole tree chips as its mechanism of heat transfer is different (Bridgewater and Peacock, 2000). The raw biomass is sometimes rinsed (i.e. with water) to remove alkali that can cause corrosion of equipment in contact with bio-oil, even at very low concentrations (Sandvig *et al.,* 2004).

The basic requirement of a fast pyrolysis system is to inject heat into the biomass particle quickly and collect the condensable from the exiting stream quickly and efficiently to maximize liquid yield. The process conditions and desired final product will dictate the selection of an appropriate reaction vessel. There is no best reactor yet with most giving between 65-75% liquids based on dry wood input. The pyrolysis process produces char and vapours. Condensing the vapours will yield the liquid product, and the non-condensable vapours are the pyrolytic gases. Therefore, methods of collecting and handling the pyrolysis products are required. Char production contributes to secondary cracking by catalyzing secondary cracking in the vapor phase. Rapid and complete char separation is therefore desirable (Sandvig et al., 2004; Bridgewater and Peacock, 2000).

MATERIALS AND METHODS REQUIRED FOR PYROLYSIS EXPERIMENT

- Design and fabrication of a pyrolysis system consisting of a retort (reactor vessel), an electric heating insulated oven (Furnace), a condenser, a condensate receiver and a gas storage.
- Feedstock material must be readily available for products of pyrolysis to be economical.
- Selection and pretreatment of feedstock materials into appropriate sizes and moisture contents to facilitate pyrolysis process.
- Pyrolysis of known weights of the treated feedstock and glycerol with the designed pyrolysis system, with the time and temperature of the operation monitored.
- Measurements of the heat supplied, moisture content of the feedstock and char, volume of gas and quantities of condensate, tar, pyroacid and char.
- Analysis of the parameters from the measurements to determine effect of the operating conditions and catalysis effect of glycerol on product yields.
- Kinetic modeling of the pyrolysis process

CONCLUSION

1. Low cost forms of energy sources is a major challenge for agricultural operation in rural Nigeria
2. Agricultural and other agro-allied operations are still performed manually in spite of the vast energy resources in Nigeria.
3. Large amount of residues from some major crops, maize, groundnut, cassava, millet, sorghum are locally available for energy purpose
4. As a result of 1 to 3 above, it is a welcome development to convert some of the vast energetically available agricultural residues into useful chemicals and fuels.
5. The outcome of this experiment is expected to enhance the production of energy sources from readily available biomass waste materials and provide means of its utilization for alternative energy production from agricultural residues in a decentralized form.

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CRIMINALIZATION OF HARMFUL ENVIRONMENTAL PRACTICES AS PANACEA TO ENVIRONMENTAL CRIMES IN NIGERIA

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INTRODUCTION

Environmental crimes have been defined in various ways by different scholars and relevant institutions. Environmental Investigation Agency defined environmental crimes as illegal acts which directly harm the environment. (EIA, 2008). Some common acts which constitute environmental crimes include illegal logging of trees in the forest, illegal fishing and killing of wildlife, trans-border movement and dumping of waste products, smuggling of ozone depleting substances among many others. However, most environmental crimes are crimes are not quickly considered as social problems in Nigeria and many other developing countries of the world, hence many areas of harm to human, environs and non-human animals are usually not criminalized. In fact it has been noted that environmental concerns rarely formed an integral part of the development plan of most developing countries, particularly in Nigeria (Okafor *et al*, 2008). But the recent rise in the concerns for the effect of climate change is gradually revealing certain areas of harmful environmental practices which were hitherto unrecognized. There is a body of laws aimed at regulating environmental crimes in Nigeria but several of these laws are either moribund or existing only in the books. Also, considers as crime is socially constructed and harmful environmental practices will not be considered as crime as long as the society does not define them as such. This paper therefore attempts to proffer solutions to the problem of environmental crimes in Nigeria by suggesting that the myriad of activities which constitute the crimes be criminalized and enforced. The paper uses mainly secondary data from different literature sources.

THEORETICAL BACKGROUND

In sociology, theories are abstract and complex analytical frameworks used in explaining social patterns and relationships between social variables. This paper is anchored on two theories in sociology and these theories are the labeling and system theories.

Labeling theory

This theory originated in the writings of Frank Tennenbaum, who expressed the opinion, that deviance and criminality might be a social product (Tennenbaum 1938). The theory was later developed in the writings of Howard Becker and Edwin Lemert (Hassim, 1973). Labeling theory is also called societal reaction theory. This emphasizes the fact that crime is a reaction to an act described by the society as deviating from the norm. This suggests also that before any act is described as crime, there must a consensus on what constitutes the acceptable norms or behaviour. The theory also suggests that not all members of the community are in the position to project a label and have the same impact on individuals, some people have the power to label an act as criminal and some people are more likely to apply a label and have it stick, these people Becker calls Moral Entrepreneurs (Becker, 1963). In relation to this paper, the labeling theory is used to described societal reaction to most of these environmental degrading practices and it is observed that most of these are not criminalized due to the fact that the society does not perceive some of these acts as criminal in nature and also the moral entrepreneurs (the various agencies responsible for regulating or enforcing such laws) do not enforce such laws, hence perpetrators of such acts usually go scot-free and are not considered as criminals. The moment all environmental degrading acts are criminalized, the beginning of the solution to such acts and their concomitant effects on the environment will be in view.

Secondly, the **system theory**, which is actually an interdisciplinary theory, focuses on complexity and interdependence of relationships. A system is composed of regularly interacting or interdependent groups of activities/parts that form the emergent whole. In sociology, Systems theory was developed by Niklas Luhmann (1996), who stressed the importance of communication in any organization. The system theory is actually an outshoot of functionalism which state that for the organism (society) to survive, all parts of the organism (human and environment) must contribute effectively. Hence there must be a healthy relationship between the environment and the human residents.

In this paper, the systems theory is used to examine the relationship between the environment as a part of the society and sustainable development. Here, the system theory is modified to emphasize the need for the society to foresee the environmental consequences of certain environmental unfriendly activities and make efforts to nip such in the bud.

ENVIRONMENTAL CRIMES AND ENVIRONMENTAL DEGRADATION: CONCEPTUAL CLARIFICATIONS

The environment has been described as the natural world in which animals and plants live (Oxford Advanced Learners Dictionary). The natural environment can also be described as the territory in which human actions occurs and as itself modified by human agency (Oxford Dictionary of Sociology). Also, Section 38 of the Federal Environmental Protection Agency Act defines the environment as including water, air, land and all plants and human beings or animals living therein and the inter-relationships that exist between and among them. In this paper, the environment describes the inter-relationship between man and his physical environment, particularly as his actions and inactions affect the environment. Crime on the other hand is held to be an offence which goes beyond the personal and into the public sphere, breaking prohibitory rules or laws, to which legitimate punishments or sanctions are attached and which requires the intervention of a public authority (either state or a local body) (ibid.). Criminalization of any behaviour is however a social product. What a society defines as crime is socially constructed and highly relative and can be influenced by ideas of morality and competing scientific claims to its aetiology (causes). In other words for an act to be seen as crime, the society must not only frown at such but there must visible efforts aimed at discouraging such acts, which could be in form of establishing statutes and body(ies) to try such acts whenever they occur.

Degradation on the other hand means the situation where something is damaged or made worse (Oxford Advance Learners Dictionary). Environmental Degradation can thus be described as the process of reducing the quality of the environment. Okafor *et al* (2008) defined environmental degradation as making the environment worse or to pollute it. Environmental degradation can therefore be classified as a crime in that it renders the environment unsafe for human habitation in the long run.

Furthermore, in discussing key issues concerning the different harms and violations of the rights within the context of an eco-justice framework, White (2003) identified three critical issues viz:

- Environmental Rights and environmental justice: He sees environmental rights an extension of human or social rights so as to enhance the quality of life.
- Ecological citizenship and ecological justice: This acknowledges that human beings are merely one component of the complex ecosystem that should be preserved for their own sake.
- Animal rights and species justice: Here, environmental harm is constructed in relation to the place of non-human animals within the environments.

In all, the sustainability of the environment is crucial for the survival of both human and animals and efforts must not be spared in ensuring a safe environment for all.

Environmental Laws in Nigeria

In Nigeria, there is a myriad of environmental laws aimed at regulating and improving the environment, but as Toy and Leffler (2001) observed, though criminal provisions have always been part of environmental laws, criminal prosecutions arising from these laws are very rare. The regulatory framework for environmental protection in Nigeria is contained in the 1999 Constitution of the Federal Republic of Nigeria. In section 20, the state is empowered to protect and improve the environment as well as safeguard the water, air, land forest and wildlife of the country (Adejonwo-Osho, 2008). Apart from the provisions of this constitution, other laws have been promulgated to regulate the safety of the environment. One of these includes the Environmental Impact Assessment Act of 1992 (hereafter referred to as EIA Act). Section 2 of the EIA Act provides that the public or private sector of the economy shall not undertake or embark on or authorize projects or activities without prior consideration of the effect on the environment. The law makes it mandatory for EIAs and environmental audits to be carried out by polluting industries. In fact, an EIA report must be prepared in respect of all major projects and approved by the Federal Ministry of Environment as well as the environmental agency of the state, where the project is to be sited. However, the Department of Petroleum Resources is responsible for granting environmental permit and issuance of Health and

Environment Safety Guidelines for oil and gas projects (CPI, 2003). Another law promulgated to regulate and safeguard the Nigerian environment is the Federal Environmental Protection Agency Act (FEPA Act) of 1988, which requires the Federal Environmental Protection Agency to collect and make available information pertaining to pollution and environmental protection regulations through publications and other appropriate means and in cooperation with both public and private organizations. The FEPA Act has other inherent regulations and some of these include:

- National Environmental Protection (Effluent Limitation) Regulations,
- National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes) Regulations; and
- National Environmental Protection (Management of Solid and Harzadous Wastes) Regulations.

The FEPA Act also provides that each state and local government in the country may set up its own environmental protection body for the protection of the environment within the state. This has led to the creation of some state-based EPAs like LASEPA (in Lagos), Abuja Environmental Protection Board, Osun State Environmental Protection Agency (OSEPA), among many others. Ogunba (2004) also identified two other laws bordering on environmental protection. These include the Petroleum of 1969 and the Town and Country Planning Decree 88 (1992).

However, despite the laudable provisions of these regulations, the effectiveness of these bodies and laws has been hindered by corruption and political bigotry among other drivers. This is evident by various reports on activities of different industries particularly those involved in oil and gas. The Niger Delta imbroglio is a fall out of the non enforcement of environment laws in Nigeria. But this is only a tip of the ice- berg in terms of environmental degradation in the country. Many communities, especially where mineral resources are being exploited are in similar deplorable situations and only time will tell when theirs too will become a national issue.

Driving forces of environmental crimes in Nigeria

The fight against environmental crimes in Nigeria can only be seen to have been completely won if the drivers of these crimes are nip in the bud. This section therefore highlights some of these, while attempting to proffer likely answers.

Ignorance

This is one of the major drivers of environmental crimes in Nigeria. Though the ignorance of environmental responsibilities does not excuse criminal culpability (Toy and Leffler, 2001). Many of the effects of environmental degrading activities are actually unintended causes on the part of the perpetrators. On the part of the public, many individuals may not link their activities with environmental crimes since they are oblivious of the effects of such acts. In proffering probable explanation to this, Jarrel (2007) noted that lack of attention by the news media and other relevant agencies to public enlightenment may lead to public misunderstanding and ignorance of the causes and consequences of environmental crime. It is sad to note that many policy makers from the National Assembly to the state and local governments lack the requisite knowledge of the effects of these activities on the environment. A cursory examination of the number of policy statements and laws on environmental protection made by these bodies will corroborate this fact. Unfortunately, many people who are supposed to know better often do not fare better in terms of environmental degrading activities as many policy makers are themselves guilty of the offence. This is not peculiar to people in the corridors of power alone, it cuts across those in parastatals and even in the ivory towers.

Official Corruption

The problem of corruption has taken its toll on virtually every aspect of Nigerian society. In the economy, politics and other spheres of life (Asa, *et al*), corruption seems to be the rule rather than the exception. Official corruption among the custodians of the law, particularly those vested with the responsibility of regulation and enforcing environmental protection laws and implementation of policies which will guarantee a safe environment for all. For instance, those saddled with the responsibility to ensure compliance with environmental laws like the various environmental protection agencies have compromised in their duties. Likewise, official corruption enables the massive exportation and theft of timber which is often orchestrated by cross border organized criminal syndicates. The Koko incident of 1988, which contributed to the rise in international prominence of the problem of hazardous waste trade (Liu, 1992), was facilitated by official corruption as drums containing the waste were allegedly imported through one of the sea ports in the country.

Rapid Urbanization

The effect of urbanization on the environment in developing countries has been well documented by various studies (Mabogunje, 1981; Mabogunje, 2002; Maiti and Agrawal, 2005). The rate at which most Nigerian cities are urbanized could be described as disturbing. This actually brings about a lot of policy questions bordering on rural development and migration. However, for the purpose of this paper, our focus is on the effect of rapid urbanization on environmental degradation. Urban centers (especially the organic types, which are mostly unplanned) are usually faced with two major problems; development of shanty towns or slums and unplanned housing system as a result of increase in demand for housing facilities Mabogunje (2002). The slum areas are often characterized by low income dwellers who try to evade the high cost of rent in the metropolis Akinbode (2002). Most of these areas are usually deprived settlements characterized by very high residential density, largely uninhabitable housing, and absence of sanitation, basic infrastructure and social services (Shaw and McKay, 1942, Hughes *et al*, 1999; Aina, 1990).

Secondly, the increase in demand for housing facilities in urban cities in Nigeria often results from rural-urban migration demand. In order to meet this demand, houses are built along drainage or flood run off lines. This culminates into flooding as the run off produced during rainy seasons overwhelms the drainage system. This explains the situation in Lagos State, where the problem of flood seems intractable to successive administrations over the years. To address the issue of unplanned urbanization, the government will have to embark on massive development of the rural areas and stem the rural-urban flow. Also, the laws which regulate urban planning and development must be revisited and updated to cater for contemporary challenges emanating from population explosion in the urban centers.

Porous nature of most Nigerian borders

In most industrialized nations of the world, there is a strong and active environmental awareness among the citizenry and there are equally environmental pressure groups that monitor industrial activities. The immediate implication of this is that hazardous wastes from industrial processes from these nations have to be exported to countries with porous and least resistant borders. It is a known fact that most of Nigerian borders are porous. This is caused *inter alia* by the size of the country and exacerbated by official corruption on the part of various agencies responsible for monitoring the movement of people and goods across the borders (Oni, 1999). Odubela *et al noted that* apart from porous borders, contraband CFCs and toxic chemicals find their ways into the country because of the economic downturn, which compels industrialists in Nigeria to seek for cheap and secondary raw materials and goods; the poor awareness of existing enforcement agencies as well as bureaucratic bottlenecks in the enforcement of these regulations.

The Environmental Investigation Agency also revealed that corrupt traders and exporters often find available markets for their contraband goods in African countries, including Nigeria. Some of the various ways devised by these unscrupulous traders to confuse customs at the borders include false labeling on documents and concealment of counterfeit goods (EIA, 2008). To corroborate this fact, Anyadike (1988) noted that the toxic waste imported into Nigeria through the Koko Port in 1988 were actually labeled “building materials” and “agricultural chemicals”.

Lack of proactive laws and poor implementation of existing laws

Most of environment laws in Nigeria have been described as reactive rather than being proactive (Liu, 1992). In fact, the Koko waste dump of 1988 led to the promulgation of most environment laws in Nigeria. The Koko incident raised the initial awareness of the government and the people to the importance of protecting the environment. After an Italian company dumped about 2,000 tons of hazardous wastes in Koko land, the Federal government saw an urgent need to pass legislation and establish an Environmental Protection Agency in the country. This was followed by the FEPA Act of 1988. Despite the availability of these laws, other environmental crimes are still being committed by individuals and organizations in the country without reprisal. The Ogoni people of Nigeria are still struggling to preserve their ethnic identity and protect their physical environment which sustains their traditional means of subsistence and this has pitted them against the “Almighty” Federal government who has used various repressing methods including military invasion to quell this struggle. Furthermore, the implementations of some of these laws have been enmeshed in some controversies. For instance Olokesusi (1998) identified some problems with the implementation of the FEPA Act. Public involvement and participation have been deliberately restricted by proponents of the Act as well as their consultants. Members of the public (particularly, the concerned community members) are often denied access to the final reports of the EIA.

Consequences of Harmful Environmental Activities

The consequences of harmful environmental practices are many and dire. Some are with immediate effects while others have enduring consequences. Some of these can be summarized as follow:

- Deforestation activities contribute to global warming.
- Waste and pollution contribute to the diminishing of clean water.
- Unplanned urbanization contributes to environmental problems like flooding etc.
- Transborder movement of toxic wastes and environmental-unfriendly vehicles contribute to pollution and other harmful effects.
- Relaxed or non-existent cabotage laws allows for importation of environmental-unfriendly products.
- Unregulated fishing and hunting of wildlife leads to extinction of some important species

Policy Implications

The policy implications deducible from this paper are highlighted as follow:

- More attention paid to environmental issues: The growing global awareness on climate change and the need to check activities which contribute to environmental degradation deserves more attention than paying lip service to the myriad of harmful environmental practices rampant in the country. The fight against corruption being canvassed in the country should be extended to environmental issues, just like it is being done to the financial sector.
- Constitutional amendments where necessary: There is an urgent need in the country to review some of the environmental laws in the country. Moribund laws should be replaced with more time-relevant ones and adequate punitive measures prescribed to different environmental crimes. Also, environmental law should be proactive in nature rather than waiting for deplorable environmental incidences to occur before making one.
- Environmental auditing of organizations: Organizations should be made to be socially responsible and one way to do this is by environmental auditing. This consists of "a regular, independent, systematic, documented and objective evaluation of the environmental performance of an organization" (Welford and Strachan, 200; Okafor *et al*, 2008). It provides information which can help the organization to control harmful environmental practices with the ultimate aim of safeguarding the environment and minimizing the risk to human health resulting from industrial activities. This must be followed by environmental review whereby the organization sets standards to be assessed in future auditing.

- Mass advocacy involving all agents of socialization: All agents of socialization must be involved in the advocacy for a cleaner and safer environment. Most importantly, environmental awareness should form a basic part of the school curricular form the primary to the tertiary levels.
- Environmental law enforcement agencies: Lastly, more environmental law enforcement agents must be established, while the existing ones should be well equipped with necessary facilities to cub environmental crimes. Also customs officials should be trained and re-trained in the detection of toxic wastes and other harmful goods imported into the country.

CONCLUSION

In conclusion, the enforcement of environment laws and regulations is an important ingredient in protecting the environment and reducing environmental harm. Environmental safety should be the concern of all and sundry. Environmental law violation should be considered as a serious crime and the criminal justice system should beam its focus on harmful environmental practices given the adverse effects. Also, the twin devil of ignorance and official corruption which have been the core of environmental crimes in Nigeria should be tackled with the twin concepts of advocacy and enforcement. Finally, to stem the tide of insurgencies whereby community members take to exra judicial means to press home their demands, organizations should be socially responsible. Organizations whose activities are detrimental to the host community must be made to compensate such communities in commensurate terms. Nigeria as country can not afford to be left behind in the move for a cleaner and safer environment.

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MAN AND HIS ENVIRONMENTAL CHALLENGES IN THE NIGER-DELTA SINCE THE EARLIEST TIMES: A HISTORICAL ANALYSIS

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Abstract

The impact of environment on people's ways of life cannot be over-emphasized. Indeed, man is said to be a product of his environment. The people of Niger-Delta region of Nigeria are no exception to this fact. The ways of life of the people of the Niger-Delta region have greatly reflected their environmental peculiarities. Against this background, this paper gives a historical account of the dependence by the autochthonous peoples of the Niger Delta on their environment as a source of livelihood. It is discovered that, across the Niger-Delta, fishing, farming, gin distillation, lumbering and canoe carving are some of the numerous traditional occupations from which the people earn their living. The aforementioned activities of the indigenous people were, and are still being determined by the environmental factors such as climate, topography, rainfall and so on ever before the advent of the Europeans and subsequent discovery of oil. The discovery and exploration of oil in the region since the 1950s have posed serious environmental challenges and have had a great impact on the peoples of the region. This paper examines some of the environmental changes within the region as a result of both internal and external factors and their attendant effects upon the inhabitants of the region. The paper also analyses how the peoples of the Niger-Delta have responded to their environmental challenges in the pre-oil period as well as to the environmental challenges posed by oil-related activities. These responses vary from occupational change-over, fishermen and farmer's movement/migration and violent reactions against foreign companies in form of pipeline vandalisation, abduction and other vices. This paper concludes that there is a lot to be learned in the history of the Niger-Delta peoples in our efforts to solving the lingering environmental problems of the region.

INTRODUCTION

Environment makes man and man resembles his environment more than his parents. In other words, what a man does for a living is conditioned by his environment and whatever man is able to achieve is made possible by his environmental peculiarities. This is due to the fact that human ingenuity and resourcefulness are not space-bound but the nature of the environment conditions their manifestation and development (Mabogunje, 1976: 1). Since environment makes man, scholars have held rightly that there is a close and enduring relationship between geography and history (Ogen, 2007: 205). This is because while history studies the activities of man in a particular environment over a period of time, geography studies man and his relationship with his environment. This implies that what history studies are determined by geography which determines the nature of the environment. As a matter of fact, the study of history of peoples at different ages has shown that environment played a great role in the ways of life of the inhabitants. This implies that a close interaction exists between the people and their land, between the course of history and the elements of environment (Mabogunje, 1976: 1)

Since environment plays a great role in human life and survival, it is imperative that people protect and manage their environment properly. Based on the series of scientific findings which indicated that poor environmental management endangers human life, the importance of environmental management dawned on many Nigerians, particularly the peoples of the Niger- Delta region where environmental degradation is at its peak due to oil exploration and exploitation (Preboye, 2005: 86-99). Babawale (2006) succinctly describes how environmental degradation peculiarly affects the people of oil-producing areas in these words: "When there is industrial pollution, it endangers the health of the people resulting in diseases while oil pollution in oil producing areas may rob the people of the right to work as farmlands are destroyed and rivers polluted" (Babawale, 2006: 144). This excerpt aptly describes the current situations of the environmental problems faced by the peoples of the Niger Delta which have received reactions and counter-reactions from the inhabitants of the region and the federal government respectively.

Indeed, access to, and control over natural resources is at the centre of the Niger-Delta crisis. This is more complicated by the fact that this access to, and control of natural resources popularly known as environmental entitlements are determined by the political institutions of the state (Oyesola, 1998: xv). In the case of the Nigerian Niger-Delta region and its oil mineral resources, there is little or no political leverage for the region to enjoy its environmental entitlements by the political institutions that reserve the power to grant such leverages This absence of political leverage coupled with the environmental degradation that is associated with the exploitation of the oil minerals and the almost total neglect of the development of the region have influenced the violent reactions of the peoples of the region to the political institutions through such vices as kidnapping, abduction, pipeline vandalisation and so on (Adesina, 2000: 78) This is the root of the crisis in the Niger-Delta region of Nigeria.

Against this background, this paper seeks to examine the nature of the environmental problems and challenges facing the peoples of the Niger-Delta and how they have been responding to these challenges since the earliest times till date. These challenges and problems may either be natural or man-made/human-induced challenges. This paper is provoked basically by the current unfortunate dynamics of the Niger-Delta environmental problems culminating into such vices as kidnapping, pipeline vandalisation, abduction and a host of others on the part of the inhabitants and the military sanctions, direct bombardments/destruction of communities and lately, the amnesty offer to the militants on the part of the federal government (Adesina, 2000: 78; Ebiri and Etim, 2009: 16). It is argued in the paper that while the government amnesty is good and appreciated, finding adequate solution to environmental degradation in the Niger Delta and providing infrastructural facilities in the region are the only ways out of the crises. This will provide opportunity to enhance security and development in the region. It is also posited that finding these solutions will depend greatly on the presence of sincere political will on the part of the government and positive human accommodation on the part of the peoples of the Niger- Delta.

From a historical perspective, this paper takes a critical look at the roots of these environmental problems and shows that restoration of peace and tranquility to the region depends greatly on tackling of the root causes of the problems. The paper is divided into six major parts. The first part introduces the theme of the paper while the second part gives a geographical description of the area referred to as Niger-Delta and some of the peoples who occupy the region. The third part of the paper describes the nature of the environmental challenges faced by the people of the Niger-Delta in the pre-colonial period and how the people responded to them. Part four of the paper examines the challenges of the environment of the Niger Delta region and the responses of the inhabitants to them in the colonial era between 1900 and 1960. The fifth part analyses the environmental challenges facing the people of the Niger Delta since the 1960s particularly those related to oil exploration and exploitation and the nature of the responses of the people. The last part concludes the paper by pointing out some of the historical lessons that are useful for successful restoration of peace and tranquility to the Niger- Delta region of Nigeria.

NIGER DELTA REGION OF NIGERIA: A POLITICO-ECONOMIC USAGE OF A GEOGRAPHICAL TERM

Without mincing words, it could be said that the geographical term ‘Niger-Delta Region’ has been, and is being greatly abused in its general usage in Nigeria. This is because the term is no longer being used in strict geographical sense but in political and economic terms. In strict geographical sense, the term Niger Delta region should denote only the communities that lie within the Delta of the River Niger (Ogen, 2005: 92). This is the basis of the categorisation of the Niger Delta into three - Western, Central and Eastern Delta. The area and communities between the Forcados and Pennington rivers are referred to as Western Delta, the area between the Pennington and Nun rivers are referred to as the Central Delta while the area between the Nun and Bonny rivers are Eastern Delta (Alagoa, 1972: 11-12). If taken as that, only communities in Bayelsa, Rivers, Delta and perhaps Akwa Ibom and Cross River States would properly and geographically be situated in the Niger-Delta region (Ogen, 2005: 92). As stated earlier, economic and political considerations relating to the exploration of crude oil and national sharing of its revenues have coloured what and who constitutes the Niger-Delta region in the national economic and political discourse in Nigeria.

In the contemporary Nigerian state, the term Niger-Delta is politically and economically used to denote all the crude oil producing states in the country such as the coastal oil producing states - Bayelsa, Delta, Rivers, Akwa Ibom, Cross River and Ondo as well as the inland, non-coastal oil producing states like Edo, Abia and Imo (Ogen, 2005: 92). These nine states belong to the Niger Delta Development Commission (NDDC). The Niger-Delta region as described in this political and economic terms is said to cover a coastline of some 560 kilometres and it is estimated to have more than 20 million inhabitants with about 40 ethnic groups and distributed into 3,000 communities (Nyong and Oladipo, 2003: 194-195). In its description of the geographical coverage of the Niger Delta, the Niger Delta Development Commission (NDDC) once stated that the region that constitutes the Niger-Delta extends from the Mahin Creek to the Bight of Benin and from Apoi to Bakkasi. If this is considered, then the people of the Niger-Delta region would include the Igbo, Ilaje, Ijaw, Urhobo, Isoko, Itshekiri, Ibibio, Annang, Andoni, Efik, Ekpeye, Kalabari, Ogbia, Abua, Odual, Engenni, Edo, Ishan, Etsako, Epie, Ogoni and a host of others (Nyong and Oladipo, 2003; 195). It must be noted that while some of the peoples mentioned here are found on the delta of River Niger, some are not. However, they, and others not mentioned here, are all considered the peoples of the Niger-Delta. The determining factor in this consideration is oil minerals found in the communities which these people inhabit.

With this brief description of the Niger-Delta region, our usage of the term in this paper would mean all the oil mineral producing states and communities in the southern part of Nigeria. This usage is adopted because, though the term 'Delta' is not coterminous with oil-bearing areas, all the oil-bearing areas face the same environmental problems and hazards.

HISTORICIZING ENVIRONMENTAL CHALLENGES IN THE NIGER DELTA: EARLIEST TIMES TO 1900

The settlement of human beings in a particular place is said to be both a geographical and a historical phenomenon (Ogen, 2007: 213). This is why the economic and political development of a particular group of people is closely related to, and is conditioned by the peculiarities of their climatic and physical environments (Udo, 1980: 7). The climate of the Niger-Delta region, like other parts of Nigeria, is divided into two: dry season and rainy season (Preboye, 2005: 55). A major climatic challenge facing the people of the Niger-Delta during the rainy season is the excessiveness of the rain particularly between June and September. During this period, the people witness natural hazards such as acidic rains, thunderstorms, squalls and winds which often led to wiping out of crops, fish ponds or even complete houses by floods (Preboye, 2005: 56). This period was a period of hunger for the people as they could not go out for fishing and other productive activities. Also, in the short dry season between October and March, there was a lot of haze and severe cold in this region and people find it difficult to see clearly in the ocean and on the seas. But since fish was abundant during this time, the people would go out for fishing and in most times, they got missing for days in the vast Atlantic Ocean while some even lost their lives (Preboye, 2005: 56). It must however be said that there is hardly a rain-free month in this region (Akpoghomeh and Badejo, 2002: 189). In both dry and rainy seasons, since the peoples have adequate knowledge of their climatic vicissitudes, they devised ways of coping with the natural challenges of their environment without much ado.

The physical environment of the Niger-Delta region can be divided into three belts of vegetation. These are the sandy beach ridges, the salt water swamp and the fresh water swamp area (Alagoa, 1972: 12-13). In all these areas, the traditional economy has been largely restricted to fishing, salt-making, and transportation has been mostly limited to the use of canoes, and in recent times, powered riverine boats (Udo, 1980: 7-8). However, the environmental differences between the different parts of the Delta as dictated by their geographical peculiarities such as the amount of climate, location, soil, vegetation, e.t.c. have influenced their ways of life - economic, social and political. E.J. Alagoa sums up the impact of environment on the economies of the different peoples of the Niger-Delta in these words:

From ancient times the inhabitants of the lower delta (sandy beach ridge and salt-water swamp) have had to exchange, mainly their fish and salt, for the vegetable produce of the upper delta (freshwater swamp). The lower delta people never produced more than a few plantations and coconuts in backyards garden. The groups of the upper delta, on the other hand, farmed their river banks after the floods receded each year, depositing rich silt. They farmed water yam (discorea alata linn), plantain, bananas, cassava (manioc), cocoyam (taro) and, more recently, swamp rice; as well as peppers, okro, sugar cane, maize and other crops in smaller quantities (Alagoa, 1972: 13-14)

From this excerpt, it is discernible that one of the major ways by which the people of the Niger-Delta have been coping with their environmental challenges was and is still occupational specialization. The people engaged mostly in the production of what their environment favoured and exchanged them for what they needed but could not be produced locally with their neighbours (Alagoa, 1972: 14)

Significantly, migration has been identified as one of the major instruments of environmental survival adopted by different peoples in human history all over the ages and in different parts of the world, particularly West Africa (Mabogunje, 1976: 1-32). The peoples of the Nigerian Niger-Delta are no exceptions to this basic fact. This is because migration is central to the early history of their settlement in the present environment of theirs. Various traditions of the people also point to the fact that the different peoples stopped and settled at different places within the region and at different times before they finally arrived at where they are today (Alagoa, 1972). Several factors may account for the migration of human groups from one geographical area to the other. These may include socio-political factors like the desire of princes to found their own independent settlements, the need for a better defensive position against enemies, the need to flee from the consequences of a fight between lineages and so on (Alagoa, 1972: 189). It is important to stress that all these factors that influence human migrations are not unconnected with the desire to exploit and control environmental resources of different areas.

However, the early history of the settlement of most Niger-Delta communities shows that migrations were largely due to social and political factors such as succession disputes and contest for fertile environments (Jones, 1963: 34). For instance, among the Apoi, some of their early migrations took place during interregnum caused by political problems and misunderstanding. The Nkoro traditions relate that their founders left Okrika and first settled at a place called Iyoba where they killed the Andoni and the Ogoni. These peoples fought back and forced the Nkoro to move to their present site now called Olom Nkoro (Alagoa: 1972, 166). Examples of such migrations abound in the early history of the settlements of other communities in the Niger-Delta. What is however must be noted is that majority of the peoples and communities in the Niger-Delta provided a pattern of migration and expansion within the Niger-Delta (Alagoa, 1972: 188). This shows that the peoples are autochthonous to the Niger-Delta region. Instances of reference to Benin or Ife are suspected to be as a result of socio-political affinities noticed between the Edo and the Yoruba which could be an influence of close economic contacts between these peoples in the past.

As indicated earlier, local and inter-state trade was another way by which the people of the Niger-Delta have adapted to the challenges of their environment. The various peoples of the Niger-Delta region maintained cordial relationship with both their immediate and distance neighbours (Alagoa, 1976: 354-358). The contacts between the various peoples of the Niger-Delta and the neighbours ranged from economic, social and political contacts. Apart from the contacts among the various Niger-Delta peoples, historical evidence show that the people of the Niger Delta such as the Apoi, Egbema and Ijaw maintained economic relations with their Edo and Ijebu Yoruba neighbours to the west and the Itshekiri to the east (Lloyd, 1967: 236). Since no human group can sufficiently provide for all its needs, the internal trade between groups within the Delta and their neighbours was basic to the life of the peoples of the Niger-Delta.

It is significant to state at this juncture that coastal piracy among the peoples of the Niger-Delta much popularized by the European writers is not only baseless but also misleading. This is because its origin could only be historically traced to the emergence of the European trans-Atlantic slave trade (Alagoa, 1972: 26-27). It continued well into the 19th century when the legitimate commerce in palm oil and European manufactures thrived. Piracy among the peoples of the Niger-Delta emerged as a result of the attempt of the peoples to participate in the distribution of goods resulting from the European overseas trade which was organized around state system at the expense of the stateless groups of the Niger-Delta. Thus, the Benin Kingdom through its famous Gwato port and Arbo as well as the Itsekiri and Warri ports benefited immensely from the European trade (Ikime, 1980: 89-108). This made the stateless societies of the Niger-Delta to resort to forcible entry into the trade through the so-called piracy exaggerated by the Euro-centric writers. This is However, not to say that there was no incidence of attacks on trading canoes and other categories of traders on the Niger-Delta before the advent of the Europeans. Since conflict is an unavoidable phenomenon in human co-existence (Abraham, 1982: 105), there were instances of clashes and attacks between and among the peoples of the Niger-Delta region in the pre-colonial era of the people's sojourn in their environment. However, the fact remains that piracy among the peoples of the Niger-Delta has been greatly exaggerated by European writers who claim that the Niger Delta peoples are innately militant.

The argument in this section is that the early history of the settlement of the Niger-Delta communities reveals that the peoples have adapted socially and economically to their environment. Their adaptation strategies range from occupational specialization, migration and internal as well as long distance trade with their neighbours. It is also shown that the peoples related cordially with their close and distance neighbours safe from skirmishes and conflicts which are unavoidable among human groups. The people of the Niger-Delta began to resort to piracy and other violent/militant methods in their attempts for environmental survival in the face of foreign exploitation of their resources first by the Europeans during the palm oil trade in the colonial era and currently by their local acolytes at the helms of the country's political affairs exploiting the oil minerals of the region.

NIGER DELTA AND ENVIRONMENTAL CHALLENGES IN THE COLONIAL PERIOD: 1900-1960

As indicated earlier, issues such as militancy, resource control, derivation formula and environmental degradation usually take the centre stage in the Niger-Delta region discourse. However, it must be emphasized that all these problems take their root from the environmental resources of the region. Geographically, the Niger-Delta region is a coastal environment with a chequered history of environmental problems. Such environmental problems are usually but erroneously traced to the epoch of oil exploration in the region. However, it is absolutely wrong to trace the environmental problems of the region to the emergence of oil exploration in the region. All the same, the period of oil exploration was the height of human-induced environmental problems in the region. On the other hand, the natural environmental problems of the region preceded the era of oil discovery and exploration.

Economically, the importance of the environment cannot be underestimated. Indeed, the environment is the economic bedrock of any society (Iroju, 2007: 90) and human survival is dependent on it. Interestingly, man has a natural culture of adaptation to any environment he finds himself. Thus, to a large extent, the Niger-Delta region as a coastal environment restricted the people within the region to coastal economic activities and modern maritime commerce in the twentieth century. The peoples of the region entered into the twentieth century with the old subsistence economic order that had been their means of livelihood for centuries. They maintained a local economy of fishing and salt making (Udo, 1980: 8). Farming and hunting are also indigenous economic practices of the people. Interestingly, the twentieth century opened with the colonisation of the country and the economy of the country was tied to that of Britain. Therefore, the Niger-Delta peoples, like other peoples of Nigeria, became suppliers of products for both local inhabitants and the European markets. These economic practices depended on the exploitation of the environmental resources such as land, water and forest resources (Uyigue and Agho, 2007: 9).

Obviously, the indigenous man's exploitation of the environment was the origin of environmental problems in the Niger-Delta region. Hence, it could be agreed that there was little knowledge about the effect of man's activity on environment. Perhaps, the low population of the region was yet to exhaustively compete for the abundant environmental resources of the region. Again, it could also be adduced to lack of awareness about man's activities and its attendant environmental damages in the region. The period of commercial petroleum ventures began in the middle of the twentieth century. Environmental damages were not pronounced before this period. Be that as it may, environmental degradation as a result of total dependence of the rural population on unsustainable agriculture, fishing, forestry and wild life exploitation was already a threat to the region (Uyigue and Agho, 2007:

11). These aforementioned human activities contributed to loss of vegetation in the region (Uyigue and Agho, 2007: 11).

In the opening decade of this century, the Niger-Delta environment played a dual economic role in caring for both the livelihood of the indigenous people, as well as the European markets. In furtherance of the economic role of the region to European markets, Sir Percy Girouard, the Royal Engineer in 1907 noted that the waterways were the axis of economic development (Kirk-Green, 1968: 81). Also, Ekundare stated that Nigeria depended largely on the natural waterways for the transportation of people and goods (Ekundare, 1973: 96). This however naturally afforded the Niger-Delta region another opportunity of commercial economic activities alongside the traditional economic activities. The major commercial economic resources were oil palm products and timber which were derived from the natural vegetation. Traditionally, the oil palm tree was a source of revenue for the people of the Niger-Delta during the European legitimate trade which followed the abolition of the Atlantic slave trade (Aghalino, 2000: 22), and thus its harvesting was unchecked. Beginning from 1900, palm produce constituted 89% of Nigeria's total export (Helleiner, 1966: 97). Since the primary aim of colonisation was economic exploitation, the colonial administration was with the intention to extract the region of her palm oil at the detriment of the environment. Hence, the large and unregulated harvesting of the natural palm trees drastically reduced the population of these natural trees, and in turn caused depletion in the vegetation. On the other hand, timber was a principal commodity of export (Geary, 1965: 129). Falola (1984: 169) has rightly asserted that: "the forest wealth i.e. timber was exploited as much as possible". During the period of commercial trade in timber, the Niger-Delta environment was a major supplier of timber to the tune of 50% of the nation's export. The demand for timber however worsened the indiscriminate and uncontrolled logging in the Niger-Delta region. These activities therefore ravaged the environment, and inevitably resulted in deforestation and change of vegetation (Uyigue and Agho, 2007: 8).

In addition, the argument here is that, since 1900, the Niger-Delta region was confronted with environmental menace resulting from man's natural exploitation of the environment for livelihood, as well as the quest to supply European markets with palm products and timber that were largely derived from the Niger-Delta region. The last years of the first half of the twentieth century was also the period ushering in oil exploration in the Niger-Delta region. Already by 1937, Shell D'Arcy arrived in Nigeria and embarked on exploration exercise (NAI O.K.D No 761/76). The constant search for oil concessions areas often led to massive felling of trees with no consideration for the communities where such was done. The felling of trees by this oil company was indeed a huge damage to the Niger-Delta natural environment. Where compensation was offered, it was mere stipends (NAI O.K.D No 761/76).

ENVIRONMENTAL CHALLENGES SINCE 1960: THE ERA OF OIL EXPLORATION AND EXPLOITATION

The development that accompanied the period 1960 upward was a new beginning of environmental challenges that had lasted about five decades in the Niger-Delta region. The environmental challenges that face the region are basically the outcome of the discovery of oil. Notwithstanding, the region was faced with tripartite level of environmental devastation. First, as earlier said, lumbering, oil-palm production, agriculture and fishing were the dominant occupations of the peoples of the region (Imasogie, Omofenwan and Obareti, 2009: 1). Therefore traditional pre-existing subsistence economic structure of symbiotic relationship between man and his environment and its attendant negative effect on the vegetation was still much felt during this period of oil exploration. Therefore both subsistence and commercial purpose exploitation endangered the region. Osuntokun (1999: 3) rightly observed that: "It was also one of the ironies of Nigerian conditions that we are the sixth largest producer of petroleum in the world and have the world's largest gas reserve, our people still resolve to wood for fuel". This however explains the environmental hazards of the Niger-Delta region as a result of gas flaring which equally contributes to global warming (Osuntokun, 1999: 9), as well as the indigenous use of wood for fuel with its attendant effect of vegetation destruction.

In the second instance, this period also witnessed the indiscriminate harvesting of palm oil and timber in the Niger-Delta region for local and international consumptions. However, attention was majorly shifted to oil exploration following the discovery of oil in commercial quantity in Oloibiri in 1958 (Preboye, 2004). Nevertheless, the earlier mentioned economic activities were carried out alongside oil exploration in the region. The disastrous impact of these on the natural environment cannot be over-emphasised. The exploration of oil and its attendant man-induced environmental destruction at Oloibiri had left the once flourishing community to be a shadow of its former self. Despite the environmental hazards inflicted on Oloibiri, the first oil concession community, oil search and drilling activities had been on the increase since then. Out of about two thousand communities in the Niger-Delta about one thousand five hundred Niger-Delta communities are testimonies to the consequences of oil drilling exercise since the 1950s (NDDC, 2004: 22). These communities play host to oil companies such as Shell, Exxon Mobil and Chevron over many decades, which in turn had caused tremendous environmental hazards such as oil spillage, gas flaring, acid rain, pollution of all sorts in the region.

Since the emergence of oil companies and oil exploration in the region, oil spillage has been a major hazard to both the inhabitants and the environment of the region. It must be stressed that oil spillage in the region is a problem that affects both host communities and their neighbouring communities. For instance, in January 1986, there was water pollution as a result of oil spillage of about forty thousand barrels of crude oils from Mobil offshore platform in Idoho which affected nine coastal states including Lagos (Tokun and Adegbola, 1998: 17). For about two decades of oil drilling in the region, that is, between 1976 and 1996, there were a total of 4,647 incidents of oil spillage (Nwilo and Badejo, 2006). This amounted to the spill of approximately 2,369,470 barrels of oil in the environment and thus causing water pollution with untold hardship for the people of the Niger-Delta. In addition, between 1997 and 2001, the Niger-Delta region recorded a total of 2,097 oil spill incidents. The continuous oil spillage has incessantly made the environment hostile to the people. Indeed, oil spillage has given rise to intense water contamination, forest loss, fisheries depletion and serious effects on the entire ecosystem. In the same vein, the constant pollution of the environment has caused 5-10% of the mangrove forest to disappear (Wikipedia, 2009). The penetration of the viscous properties of oil into the water has wiped out large areas of vegetation. The loss of mangrove forest is not only degrading life for plants and animals but also for human beings whose major sources of livelihood depend on the environment and not on the economic benefits from the oil extracted by the multinational oil companies.

Similar to the environmental hazards from oil spillage, the Niger-Delta region is equally under deteriorating environmental conditions resulting from gas flaring (Udia, 2005), acid rain and biodiversity. These hazards further aggravate the obstruction of the peasant economic dependence of man on his environment. Considering the substantive damage done to the environment by the oil industries, the region has experienced tremendous changes in the socio-economic life of the people. Essentially, there has been serious problem of rural-urban migrations, occupational changes, cultural erosion and health hazards for the people. The environmental problems also afford the youths an excuse to vandalize oil pipelines in order to access crude oil and make financial fortunes (Ibibia, 2003: 23). The act of vandalizing oil pipelines by the rural youths is another major cause of oil spillage that is greatly affecting the natural environment of the Niger-Delta.

Among the numerous environmental threats that confront the region in the 21st century, it is important to point at the activities of multinational oil companies and the infliction of flood on the region. A report by the Environmental Study /Action Team (NEST 2004) clearly shows that there is regular occurrence of sea level rise and repeated ocean surges. However, the rise in sea level is associated with flood. This is equally expressed in the views of (Uyigue and Agho, 2007: 9) that the associated inundation will increase problems of flood. The presence of oil companies in the region has prompted constant dredging activities which inevitably led to the intrusion of sea water into fresh water sources, and thus leading to destruction of the ecosystem such as the mangrove, fisheries and general livelihood. By the last three decades of the twentieth century, there emerged a profuse growth in aquatic weeds known as water hyacinth. The invasion by this aquatic weed cuts across a larger part of the region and is impeding economic activities. In other words, the weeds are contributing greatly to the impediment of the economic activities of the people such as fishing, movement of logs to markets and in general terms, transportation in the region.

By and large, it is important at this juncture to state that the overriding effect of the activities of the indigenous peoples and the multi-national oil companies in the Niger-Delta is the environmental degradation of the region. While the people could cope with the natural environmental challenges of their environment through several measures, the environmental hazards resulting from the activities of the oil companies operating in their region have been so enormous and daunting. The over four decades of oil exploration activities have seriously produced a deplorable environmental condition for the inhabitants of the region. To worsen the situation, the political institutions of the country which are the major beneficiaries of the oil minerals of the region have not been responding adequately to the developmental needs of the inhabitants of the region. Consequently, this developmental neglect of the region on the part of the political institutions of the country is a major factor leading to the demand for resource control, transparent fiscal policy, abduction and kidnapping, militancy by the concerned people of the region.

CONCLUSION

This paper has succeeded to provide a historical analysis of the environmental challenges facing the peoples of the Niger-Delta region of Nigeria from the earliest times to the present discussing both the early natural environmental challenges and the contemporary human induced environmental problems. Today, the issue of the Niger-Delta region of Nigeria is no longer a mere environmental issue but an important socio-economic and political issue which poses a great challenge to the generality of Nigerian state and its nationals. While the people of the region which gives the country great economic fortunes in terms of foreign exchange earnings are wallowing in abject poverty, the funds derived from the natural resources of the region are used for the development of other parts of the country to the almost total neglect of the region. As a consequence, the youths of the region, in their attempts to agitate for the provision of basic amenities for their people have continued to resort to violent reactions and vices such as pipeline vandalisation, abduction and kidnapping and other forms of militancy.

Erroneously, many commentators tend to argue that the peoples of the Niger-Delta are innately violent and that this is the reason for the continued violence in the region in spite of what the government has done for the people through the activities of the Oil Mineral Producing Area Development Commission (OMPADEC), the Niger-Delta Development Commission (NDDC), the Federal Ministry of the Niger-Delta Affairs and other governmental and non-governmental agencies. In contrast, this paper maintains that no human being is innately violent but that people tend to be violent when injustice is continued to be meted out to them and every peaceful option has failed to solve the problem. The root of the lingering problems in the Niger Delta is environmental degradation by the activities of the multi-national oil companies and the refusal of the concerned political institutions that benefit from these activities to provide infrastructures for the inhabitants of the region.

Premised on the above, this paper recommends that the concerned governments at all levels in the country should embark on an aggressive and an all-round environmental development of the Niger-Delta region of Nigeria. Also, government should embark on afforestation projects as well as devise workable environmental policy that would regulate oil companies' operations in the region. Therefore this paper is of the opinion that the ongoing "Presidential Amnesty" for militants may end up as a mere utopian agenda. Rather, the genuine implementation of environmental development policies is an assurance to ending crisis in the region. In actual fact, if the problems of oil spillage, water pollution and gas flaring are not objectively addressed in the region, the militant groups would continue to enjoy the sympathy and support of the people and the vices would continue to thrive and peace would not be achieved. In addition, since environmental protection is an issue of international importance, this paper posits that international environmental agencies should intervene in the environmental issues of the Nigerian Niger-Delta to ensure that the international environmental protection standard is maintained by the Nigerian government vis-à-vis the Niger Delta region.

On a final note, this paper posits if the Niger-Delta is developed infrastructurally, then the issue of militancy and its attendant socio-economic and political problems would be finally laid to rest. In other words, in infrastructural development lies the solution to the environmental problems of the Niger-Delta and their various dimensions over the years.

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BIOFUELS: PRIORITISING ENGINES OR HUMANS?[1]

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Abstract

This paper presents an overview of the current socio-economic, environmental and political debates on liquid biofuels solution. Applying the sociological perspective of networks and flows, the article identifies power actors and discusses power relations amongst them. It seeks to situate its propositions on contextual grounds and further argues that science and technology needs to find an integrated approach and a common ground for environmental, social and economic concerns. While it offers specific suggestions on alternative energy sources, the paper emphasises the need for considering the peculiar situations of both the poor, smallholder farmers and consumers of biofuels as an imperative for sustainable development in the 21st Century.

Keywords: Environment, politics, biofuels, socio-economic, science, technology, smallholder farmers, development

INTRODUCTION

Recent debates on *biofuels* have generated diverse opinions from many quarters. Various stakeholders have taken different positions on political, socio-economic and environmental grounds. Just like other human problems, the complex nature of issues surrounding biofuels is a reflection of the level of man's desperation to safe him or herself from self-destruction. An article published in *The Times* of Friday March 7, 2008 (pp. 6-7) speaks volume of the sentiments underlining recent global energy campaigns: biofuels as an alternative to fossil fuels. Despite their acclaimed potential negative impacts and possible failings, some government people believe '…We take this issue very seriously and we are not prepared to go beyond current target levels of biofuels until we are satisfied it can be done sustainably'[1]. It has been estimated by the US Energy Information Administration (EIA) that the 'global consumption of marketed energy is projected to rise to 71 percent (sic) between 2003 and 2030, from 421 quadrillion British thermal units (Btu) to 722 quadrillion Btu' (International Energy Outlook 2006 in von Braun and Pachauri 2006: 2). While climate change has been a critical issue of major concern, food and energy security, which is of similar time scale, has been aptly described as *an elephant in the room*[2]. This man-made 'monster' is seen as arising from some perceived government wrong policies:

> …President Bush called for a massive increase in the use of ethanol in America over the next decade. The US now devotes more acreage to growing corn than at any time since 1944. Farmers planted 90.5 million acres in 2007, 15 per cent more than a year before. If White House efforts to

double ethanol production this year are achieved, and in due course 40 per cent of that corn ends up in petrol tanks, the world will face a harder and costlier time feeding itself (The Times, March 7, 2008: 6).

Already, there are evidences that prioritising energy security at the expense of global food security may eventually lead to escalating social unrests with a far reaching effect. In early 2008, riots have been reported around the globe as a result of price increases in food staples[3]. Clearly, these crises have been linked to the diversification of feedstock to biofuels production. Nevertheless, biofuels such as fuel wood and charcoal are as old as human history [ever since man had learnt to kindle a fire to provide warmth[4] and then cook his dinner]. Not until after the civil war when coal became the energy source for heating and transportation, wood had been used primarily as energy source in America. Also, the first diesel engines that were manufactured at the end of the 19th Century were designed to run on vegetable oil. But as whale oil (used for lighting) became increasingly scarce and with the discovery of crude oil, petroleum quickly became a cheaper and easier means of energy generation (Iran Daily 2005).

The relatively recent emphasis on newer and cleaner biofuels like ethanol, biodiesel and biogas (processed from natural vegetation, energy crops, other agricultural wastes and residues) has continued to agitate stakeholders. Widely claimed, these products could contribute to mitigating global climate change if produced in a way that enhances their capacity to reduce net carbon emissions (von Braun and Pachauri 2006; Peskett *et al*. 2007; World Bank 2008). While ethanol is made from sugar (sugarcane and sugar beets); grains (maize, and wheat); cellulose (grass or woods); and waste products (crop residues or municipal waste), biodiesel is made from oilseed crops (such as oil palm, Jatropha, rapeseed and soy) and also from waste oils and greases. Regardless of any effort in enhancing global sustainable development, if pro-poor policies are inappropriately formulated, it might be difficult to achieve any progress. Using biofuels as one approach of mitigating global climate change is one thing, giving adequate attention to poverty and food insecurity[5] is another thing altogether. It has thus been reported that food prices will rise by 20 – 50 per cent by 2016 as a result of diversifying '…cereals, sugar, oilseeds and vegetable oils to satisfy the needs of a rapidly increasing biofuels industry…' (OECD/FAO 2007 in Doornbosch and Steenblik 2007: 10).

This paper employs a discourse analysis on the politics of liquid biofuels. It, therefore, provides reasons for increased interest in biofuels use and their inclusion in the agenda of international and public agencies; identifies power actors pushing biofuel solution; outlines the counter claims of the antagonists of biofuels solution; highlights the role of science and technology in ensuring a balanced approach to food and energy security; and provides possible alternative solutions to meeting global energy need in the 21st Century and beyond.

NEW ENERGY PARADIGM: A FORCED SHIFT?

Man has continued to search for solutions to diverse problems with which he is daily confronted in the contemporary world. Never in history has mankind been so naturally challenged. Given that most of these problems are man-made, they have continued to defile solutions. This dilemma is likened to the proverbial *Humpty Dumpty* whose fortune became hopeless after a great fall. Of course, scientists admitted that the damages done to the planet by human activities can no longer be reversed but could only be mitigated! Although coming under questions in the recent times, industrial activities and vehicular emissions from fossil fuels are said to have evolved an environment laden with greenhouse gases[6] (GHG) and Carbon-fluoro-carbon (CFC) leading to the depletion of ozone (0_3) layer of the stratosphere. The aftermaths are global warming, flood, *El Nino*[7] and *La Nina* phenomena. Awakened by the danger the situations portend, there have been so much hypes[8] on climate change and energy security in the recent times.

It has been reported that the 'Antarctic is cracking up!'[9] A report of the Intergovernmental Panel on Climate Change (IPCC) alludes to the environmental challenges, with which the earth is currently contending. The report read in part: 'Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level… and since 1975 the incidence of extreme high sea level has increased worldwide' (IPCC 2007: 2). The report further claimed that '[a]verage Northern Hemisphere temperatures during the second half of the 20th century were *very likely* higher than during any other 50-year period in the last 500 years and *likely* the highest in at least the past 1300 years'. If the doomsday theories are anything to go by, then there is need for apprehension. Essentially, environmental concern is one of the reasons why biofuels solution is being pushed.

The attendant energy crises of the 20th Century have brought a renaissance[10] of the need to seek for alternative renewable energy sources other than fossil fuels, which are in themselves non-renewable. Aware that oil wells are gradually being depleted and therefore may not last forever; finding alternative energy sources that are, in the long-run, sustainable has been stakeholders' pre-occupation : the UK government renewable transport fuel obligation (RTFO) is a typical example . The instability of oil producing and exporting regions/countries such as the Middle East, Russia and Venezuela on which the US and EU economies depend has informed a rethink amongst these importing nations. Not only that, with the current fluctuations in oil prices '... and with few alternative fuels for transport, Brazil, the member states of the European Union, the United States, and several other countries are actively supporting the production of liquid biofuels from agriculture – usually maize or sugarcane for ethanol and various oil crops for biodiesel' (World Bank 2008). Nigeria, for instance, falls within this category. Consequent upon the country's need for an increased fossil fuel demand, which stood at 30 million litres per day as at 2005, it was affirmed that an additional 3 million litres of ethanol was now needed to be blended with the current output (TheBioenergySite 2009). Box 1 below offers an insight to what Nigeria is doing to join the bandwagon:

Box 1: Nigeria joins the race in biofuels production

'There is no doubt that Nigeria is blazing the trail in renewable energy sector, which ethanol is the final product. The initiative is to stem the effect of global warming, which has become a matter of serious concern dominating local and foreign discourse. Interestingly, a Nigerian company is already making waves in this important sector, which is big business in developed countries of the world. The Global Biofuels Limited, the first biofuels refinery in Nigeria, endorsed by the Nigerian National Petroleum Corporation (NNPC), is the company facilitating biofuels production in Nigeria. The company's investments in ethanol projects have earned Nigeria international recognition. For instance, a reputable international organisation popularly known as Frost and Sullivan honoured Global Biofuels recently for its commitment to being a green energy company in Nigeria. Also, the company received yet another international recognition from African Business Owners Forum recently in Washington D.C.

'Moreso (sic), the company's choice of sweet sorghum as its feedstock has generated so much interest in the advanced countries as the feedstock is unique in the sense that it does not compete with the food chain in any way. Interestingly, the discovery of this exceptional feedstock has compelled developed economies like America and China to sign huge contracts to carry out in-depth research on the use of sweet sorghum by the Nigerian company…

'However, to maximise outputs in its production, the company has invested over $100million in ethanol project …and has put measures in place to build 10 refineries across 10 states in Nigeria, where its projects are located. Also, the company has signed a Memorandum of Understanding (MoU) for 25 per cent equity participation with African Business Owners Forum Incorporated, a recognisable group based in United States of America to expand its operations in renewable energy sector. The projects are strategically located in 10 States across the country such as Edo, Kogi, Osun, Ondo, Kwara, Niger, Kaduna, Ekiti, Oyo, and Plateau. The benefits for such states include creation of 58,000 jobs, 50,000 direct and 8,000 indirect employments in each state, electricity generation and community development through provision of infrastructures' (TheBioenergySite 2009).

The above case study shows that diverse exigencies are a factor driving the cravings for biofuels in Nigeria. Whether or not sweet sorghum is less competitive with crops like sugar beet and sugar cane in terms of fertiliser and water requirements (Renewable Energy World, 2000 in Lau *et al.* 2006: 2), the fact remains that sorghum is also consumed by human beings. Without doubt, unstable oil prices driving the push for biofuels solution at the moment might be a child's play when compared with the instability that food insecurity might eventually bring in different regions if the entire process is approached without the right model and is left unregulated.

Also, the *Kyoto protocol* (to which I shall later return); 'the implementation of national targets for biofuels in various countries; and Al Gore's campaign around his Oscar-winning movie *An Inconvenient Truth* (2006)' have continued to drive interested stakeholders' desire for liquid biofuels (Mol 2007: 300). Protagonists have also claimed that pushing biofuels solution could enhance socio-economic progress of smallholder farmers and consumers. Whether this is a sincere intention or a mere subterfuge is debatable. I shall return to this later in the discourse. Other seemingly plausible argument is that of enhancing third world economies in the era of globalisation. Countries in the tropics have been said to have a comparative advantage in the production of energy crops (Peskett, *et al*. 2007: 2). Developing economies' ability to participate within the global market space is acclaimed to become enhanced through the production of feedstock for the processing of liquid biofuels. Again, the truth or otherwise of this claim is another issue for debate, which shall also be addressed in this paper.

BIOFUELS AND SOCIAL CHANGE

Essentially, exigencies have been the driver of innovations. Societal move from the use of petroleum to that of biofuels is a form of social change. Thus, the clamour for biofuels is engendered by a range of certain compelling factors, some of which have already been identified; all seen as agents of social change. Nonetheless, social change is difficult to define because of the complex nature of human societies and that of change itself. Basically, while change may generally depict the '…alterations in the *underlying structure* of an object or situation over a period of time' (Giddens 2001: 42), social change has been conceived to mean the 'process by which alteration occurs in the structure and function of a social system' (Rogers 2003: 6). So, for a fundamental change to occur within a society, institutional structures need some reframing, and roles and responsibilities of the key component parts of the entire social system will have to be altered as well. This, of course, portends some consequences either in the short or long run. All intertwined, physical environment, political organisation, cultural and economic influences are major underlining factors of social change (Giddens 2001: 42-45). Brazil, for instance, has championed biofuels production for many years partly due to its naturally endowed ecosystem, which encourages the cultivation of energy crops (such as sugarcane and soy) and partly because of its socio-political zest, originally driven by economic reasons. United States and the European Union (EU), on the other hand, have become key players [alongside Brazil] perhaps because of the need to safe the environment and of course due to some economic reasons, too. Not until in 2006 when the US became the leading producer of bio-ethanol, Brazil used to be the world's largest producer of this product (Mol 2007: 298). Overall, the top five producers of bio-ethanol worldwide are the USA accounting for 39.0 per cent of the total; Brazil, 33.0 per cent; China, 8.0 per cent; India, 4.0 per cent; France, 2.0 per cent; and the rest of the world, 14.0 per cent (see Peskett, *et al.* 2007). It is noteworthy to say that while America's quest for biofuels is purely political, Brazil's is both economic and political in nature.

Nonetheless, opinions from various quarters have differed as to whether or not biofuels solution is the best alternative to safe the earth. Resentments, suspicions and skepticism abound in the debate. Despite the disenchantment associated with biofuels push, proponents have not relented in their pursuit. Institutional frameworks both at the international and national levels have, therefore, continued to influence energy policies. The following section will identify certain power actors and how they influence decisions on the push for biofuels solution.

POWER ACTORS AND POWER RELATIONS IN THE BIOFUELS CAMPAIGN

The *sociology of networks and flows* - fortified with *scapes* consisting of human capital and material infrastructures - has been conceived as a new perspective to understanding the contemporary globalised modern world (Mol 2007: 301). Rather than focus on economic, bodily and information flows and mobility in his analysis, Mol, building on the works of Spaargaren *et al.* (2006), Marvin and Medd (2006), etc., provided an interpretation of material and environmental flows. He used the dichotomous notions of Castells' (1996) *space of flows* and *space of place* to explain new social dynamics (in terms of time, space and power) and 'place-based spatial organisation of social life as …perceived and experienced by citizens' in both the West and South, respectively. Here, the dominance of the *space of flows* refers to the power elites who wield all paraphernalia of influence to operate in 'most crucial nodes of global influence' at the expense of the poor majority situated within the *space of place* (See Castells 2004). Protest, is therefore, the only weapon used by people in the *space of place* against the exploitative and oppressive idiosyncrasies that characterize the *space of flows*. Reworking Castell's dichotomy, Urry (2003) suggested that the networks of *space and flows* operate in three spatial modalities: regions, global integrated networks (GINs) and global fluids, all three having decreasing governability in that order. While the regions are perceived as networks within a nation-state container, constrained by geographical boundaries, GINs having '…enduring and predictable relations between nodes or hobs… cross regional boundaries and thus become deterritorialised, although place-based moorings ensure that they do not become footloose' (Mol 2007: 302). Examples are the conglomerates and civil society network organisations. Global fluids (such as the Internet, migrating people, social movements and financial capital, etc.) on their own are boundless, flexible and rarely controlled or influenced by nation-states. That said, the power relations in networks influence access, inclusion or exclusion and control over flows. The Global Integrated Biofuel Network (GIBN) and other networks (e.g. *Biofuelwatch*) have thus emerged at the wake of the campaign for biofuels solution.

The stage for pushing biofuels solution appeared set and [formally] legitimised when in 1997 the *Kyoto Protocol* was adopted by most member countries of the United Nations. The Protocol had stipulated that developed economies should cut down on their GHG emissions below a specified level [as it relates to each of those countries] within five years of signing the agreement starting from 2008. The amount of emission [measured as the equivalent of carbon dioxide required of members during the commitment period referred to as *Party assigned amount*] is not the pre-occupation of this paper. Of interest, however, is that the United Nations agencies have been mandated to review and enforce these commitments.

Thus, the UN agencies (UN-Energy, UNEP, UNCTAD, FAO etc.) have championed the biofuels solution. Also, GIBN; CGIAR; OECD; EU; IFPRI; ICRISAT; GVEP; GBEP; ILO; farmer organisations; agribusiness; influential individuals (e.g. Al Gore, Amory Lovins, etc.), all operating within the *space of flows* and acting under the purview of the UN have either tacitly or explicitly push biofuels solution[11]. Specifically, the GIBN interest is in homogenisation of products and process in integrating fossil fuel with biofuels. UNCTAD offers a facilitating hub for biofuels programmes. It aims at providing economic and trade policy analysis, capacity building and consensus building tools amongst others. While the GBEP brings all stakeholders together to jointly commit themselves to promoting bio-energy for sustainable development, the GVEP does support and help South countries in setting up energy action plans, financing and ensuring capacity building etc. for energy SMEs in the South. Apparently, commoners against the push for biofuels solution are those in the *space of place*! And their weapons are protests against those in the *space of flow*, the power elite! *Biofuelwatch* is, however, a network pressure group currently in stiff opposition against biofuels solution in the UK.

Without doubt, key biofuel sympathizers [as earlier observed] have politically and economically driven agendas. Whether the agendas are sensitive enough to people's needs is a debatable issue; part of which shall be addressed in the following section.

'WHOSE PRIORITY COUNTS?' - ENGINES OR HUMAN BEINGS?

The viewpoints of the opposition against biofuels solution are interwoven, complex but somewhat plausible. Social and environmental costs have been perceived to have greater negative impact on the poor and smallholder farmers in the South than the advantages that it is claimed to offer. Where national government policies encourage investment in biofuels, foreign direct investment (FDI) and private sector participation are given a boost. Nonetheless, the increase demand for land by investors in biofuels is likelihood for chaos between them and indigenous land owners. Land tenure problems are not uncommon in developing economies particularly so, in sub-Saharan Africa. Smallholder farmers [in the *space of place*] solely depend on land for their livelihoods. Their socio-economic lives become worsened in situations where they are displaced by private capitalist investors who have government backing (See for instance *Biofuelwatch* of April 2008).

Closely associated with this are environmental issues. Regardless of the benefits of biofuels, it becomes irreconcilable when tropical rainforest diversity [in terms of flora and fauna] becomes depleted as it is opened up for the cultivation of sugarcane fields and other feedstock. Biodiversity conservation is very vital. But there is much to this when hydrological functioning of carbon-rich tropical soils become altered and where soil becomes degraded due to direct exposure and over-exploitation (Scharlemann and Laurance 2008: 43-44). In a way, GHG emission soars thereby defeating the thrust of biofuels. The effect of forest depletion in the Amazon of South America [noted for its unparallel biodiversity] and the tropical rain forests of West Africa can better be imagined than experienced regarding climate change. *Figure 1* below shows a typical sugarcane field in Brazil, which is totally made bare of *in situ* natural vegetations.

Figure 1: A truck is loaded with organic sugar cane in a refinery's farm in Santa Rita do Passa Quatro, about 200-km (124 miles) southeast of Sao Paulo, Brazil September 6, 2005 (Courtesy of Reuters Photo).

Arguments against biofuels solution have also centred on the production of feedstock for biofuels, which presumably could jeopardise the production of staples for human consumption. Peskett *et al*. (2007: 4) had reported de Keyser and Hongo (2005) that while production of biofuels would present a 'win-win situation' for South countries through the creation of rural employment, increased income and thus, food security, diversification of maize to feed cars would trigger hunger condition for poor households. Rather than see it as a 'win-win' situation, I suppose this needs to be reframed as a 'win-loss' scenario because it is a case of gaining something from one hand only to end up losing it on the other hand! Government incentives provided for farmers to engage in the production of energy crops serve as stimuli for responding to the immediate economic gains arising there-from. In the US and OECD economies for instance, farmers have been heavily subsidised to grow feedstock for the production of biofuels while at the same increasing producer prices. It is indeed a veritable window for the economically viable large scale farmers to further their capitalist ambitions. Arguing on the basis of nation-wide benefits of biofuels, a UK grain trader had observed that '[f]or Britain's farmers, this anticipated shift towards bioethanol would be particularly good news…' (BBC News, Tuesday, 17 January 2006). On the other hand, farmers in the South economies have found it difficult to compete favourably with their Western counterparts in the international market. For the landless and poor smallholder farmers and consumers, this is by no means a small loss. The protectionist policies of western economies are worrisome, too. Whether this is an organised hypocrisy[12] (Brunsson 1989: 201-222) - where there is no congruence between talk, decision and action - is another discourse for debate to which no priority is given in this paper. Or how else can we reconcile the 'perverse incentive' of multibillion-dollar subsidies (Scharlemann and Laurance 2008: 44) for corn production in the US with a rational cost-benefit perspective for biofuels production? Whether it is acceptable to prioritise automotive/automobile engines at the expense of human beings is an issue that demands some reflexivity from powerful elites and policy-makers. Unless veritable scientific evidence is provided, those who are against the push for biofuels solution cannot in the shortest time possible be pacified.

Even when or where it is provided, the workability and sustainability of the entire process, which are context-specific may not provide any satisfactory respite. The success and benefits of biofuels cannot but be tied to science and technology. Advanced technological innovations may go a long way to ensure the efficiency and cost benefits of biofuels. It thus becomes a Herculean task to reap the gains of biofuels in those contexts where bio-energy technologies are still at a relatively rudimentary stage of development. Closely associated with this is good leadership of which most developing economies are bereft.

ENVIRONMENTAL AND COST IMPLICATIONS OF BIOFUELS

As argued, some energy crops could be potentially dangerous to the environment, too. For instance, Jatropha - although acclaimed to thrive on marginal soils - has been noted for its unrivaled water absorbing capacity. In a way, the plants could virtually contribute to lowering the water table of soil aquifer. It has been argued as well that ethanol derived from maize may contribute to the worst form of GHG emission, which in some cases could be higher than that from fossil fuels (Peskett, *et al.* 2007: 5). Apart from this, crops (such as corn and rapeseed) that mainly rely on nitrogen fertilisers for their cultivation are a source of GHGs. An example is Nitrous Oxide (NO_2). Scharlemann and Laurance (2008: 44) reported Crutzen *et al*. (2007) that '[w]hen nitrous oxide emissions are compared among ethanol-producing crops, grasses and woody coppice become more favourable, whereas corn or canola may be worse for global warming than simply burning fossil fuels'.

Also, researchers have been skeptical as to 'whether the net energy benefits of biofuels production may be negative for many crops because their energy outputs are less than the fossil energy inputs required to produce them' (Peskett *et al.* 2007: 2). In-depth analyses of life cycle GHG emissions are, therefore, desirable to determine the net climate benefits of any biofuel (See for instance Sagar and Kartha 2007; Hooijer *et al*. 2006; Borjesson and Berglund 2007; Tilman *et al*. 2006; Van Belle 2006; Wihersaari 2005). Indeed, Peskett and his colleagues saw biofuels as a 'Pandora's box', while questioning the socio-economic and environmental sustainability of large-scale biofuel production (2007: 1-6). In terms of water use, for instance, about 2 per cent of global irrigation accounts for biofuels crops. About 2700 litres of crop evapo-transpiration and 1200 litres of irrigation water are accounted for by the production of one litre of biofuel. Contextually, this ranges from 1150 litres for sugarcane in Brazil to 3500 litres in India! (de Fraiture *et al.* 2007 in CFC 2007: 39). It is also claimed that water consumption during processing is as high as 4 litres of water per litre of bio-ethanol in the maize bio-refineries in America (Turner *et al*. 2007). This of course has a serious implication for water resources. Bioethanol distribution is also said to be expensive as stainless steel tankers cost £120, 000: 00 each and the fuel itself costs 35 pence per litre to produce (BBC News, 17 January 2006). If anything, what role does knowledge infrastructure play in the new dispensation of biofuels production?

SCIENCE AND TECHNOLOGY: WHAT ROLES?

At the moment, genetically modified (GM) crops are perceived in some circles as the panacea for food insecurity. Although not central to this discourse, this is another issue that has generated some controversies in certain quarters. Apparently, critics have been concerned that the *market-oriented, technology-centric* approach is geared towards big agribusinesses and the production of genetically modified food, which to them is unethically appropriate. Of interest to this paper, though, is the emphasis on new seeds varieties that are dependent on intensive use of irrigation and chemical fertilisers. Yet, protagonists have continued to target sub-Saharan Africa and Asia for this initiative. What is worrisome about this seemingly conflicting motive is the earlier emphasis (by the West) on low-external inputs supply in agriculture (LEISA) as a way of achieving sustainable agriculture. This incongruous policy shift seems to suggest an 'organised hypocrisy' by multilateral agencies. Tied to this are biofuel schemes favouring the development of energy crops that are heavily dependent on agro-chemicals such as fertilisers and pesticides, which inherently are not environmentally-friendly.

Left with no other choice, science and technology has the onus of identifying and harnessing bio-energy potentials. Innovations with a human face are unarguably plausible if the West must convince the rest of the world about its sincerity. There is need to continue to search for better alternatives that take cognisance of the environmental, social and economic dimensions of human needs and development. It becomes mandatory to devise ways through which these needs are met without necessarily compromising any of the essential component sub-systems. Scientific research would need to go beyond the present level of investigations in order to come up with an acceptable mode for producing biofuels. Third generation[13] bio-energy technologies will need to devise production processes that lessen land-use intensity, water and chemical use if only to make biofuels and food security sustainable. Most importantly, any technologies that encourage fierce competition between humans and automobile/electricity generating equipment cannot be considered ideal for sustainable growth and development. Thus, second generation biofuel technologies, which have identified certain prairie grasses (such as the switchgrass), wood and algae if further improved might help to shift emphasis from the use of feedstock as a way of enhancing food security. Some second-generation biofuels have been acclaimed to be promising in terms of their environmental and cost benefits.

It is also important that scientists place special emphasis on other alternative sources of energy (such as the wind, electricity, solar energy, etc.) to alleviate the stress on global biodiversity. In a way, these technologies already have a relatively long standing use. There are vehicles that are powered by electricity. Examples are found in some [if not most] of European cities. In the UK and elsewhere, too, there are zero-emission automobiles also powered by electricity. This is particularly feasible in the Western world where electricity generation has not proved an albatross as in the case of some notable countries in sub-Saharan Africa. Solar energy is yet another resource that has not been fully tapped for this purpose.

CONCLUDING REFLECTIONS

By and large, this paper provides reasons why biofuels solution is being pushed as a better alternative for sustainable development [Section 2]. Having identified the networks and flows amongst power actors in the business of biofuels [Section3], the article presents critical arguments against biofuels and its sympathisers [Section 4]. Providing a common ground between the two opposing camps, this article highlighted the roles of science and technology particularly so in the third generation technology of biofuels production and suggested other alternatives [Section 5].

Essentially, as there seems to be no single modality for biofuels production, different pathways that are entirely holistic are plausible in finding a balance between human and mechanical needs. It is also important for energy stakeholders and policy-makers to see reasons for context-specific strategies that are needed to provide an all round solutions to the global energy demand in the 21st Century. To realise the full economic benefits of biofuels development and to minimise the risks associated with the process would mean building 'human and infrastructure capacity to support it at the national level' (UN 2007). It would be morally unjust to treat all regions with the same standard when socio-politico-cultural and economic factors in different locations are not similar and within the same *space of flows*. Most of all, research in science and technology would need to exhibit high ethical standards in this matter. Not only that, outright transparency and empathy is required of the West, too. If biofuels produced from residual products - such as bio-waste or recycled cooking oil, as well as cellulose - are more efficient than other feedstock [all factors considered] while at the same time able to lessen stiff competitions between humans and automobiles (as scientists have claimed), perhaps going the way of the *Big Lemon*[14] is a welcome idea!

Endnotes

1. The UK Government has supported a 'European Commission target requiring 10 per cent of all fuel sold in British service stations to be derived from plants within 12 years. Already biofuels attract 20p per litre reduction in duty to encourage their uptake'. A spokesman for Ruth Kelly, the Transport Secretary had insisted that they would continue with the biofuels policy [but with caution] regardless of the attendant problems that may be associated with biofuels use [The Times, Friday March 7, 2008: 6]. A British industry official spoke on the condition of anonymity thus: 'There's simply not enough foodstuffs available and not enough land to grow it on… E85 is good for raising awareness of biofuels, but on a worldwide basis it is a red herring. Eighty-five percent (sic) is not the solution,' insisted the official, adding that '…that the way it has been positioned as a solution to UK motoring is naïve.'
2. Professor John Beddington, the British Government's Chief Scientific Adviser, had said that '[t]he rush towards biofuels is threatening world food production and the lives of billions of people'. He had perceived imminent food insecurity warranted by the current clamour for biofuels as a rival to climate change. He opined: 'The supply of food really isn't keeping up. By 2030, the world population would have increased to such an extent that a 50 per cent increase in food production would be needed. By 2080 it would need to double. But the rush to biofuels – allegedly environment friendly – meant that increasing amount of arable land had been given over to fuel rather than food. The world population is forecast to increase from the six billion at the start of the millennium to nine billion by 2050.' The report further stated: 'Already biofuels have contributed to the rapid rise in international wheat prices and Professor Beddington cautioned that it was likely to be only a matter of time before shoppers in the United Kingdom faced big price rises because of the soaring cost of feeding livestock…' In

essence, '… the prospect of food shortages over the next 20 years was so acute that politicians, scientists and farmers must begin to tackle it immediately', claimed the Chief Scientific Adviser [The Times, Friday March 7, 2008: 6].

3. It was reported in *The Times* [Friday March 7, 2008: 6-7] that 'tortilla riots' of 2007 in Mexico was as a result of global increase in maize prices. The cost of maize used for making tortilla had quadrupled as a result of a policy shift in energy production in the US where in 2000, 'around 15m tonnes of America's maize crop was turned into ethanol and in 2007, it was 85m tonnes'. Riots had erupted in Senegal, Morocco, Mauritania and Burkina Faso over governments' decisions to increase the prices of staple food between November 2007 and February 2008. Also in September 2007, 'Italian consumers staged "pasta strike" against 20 per cent price increases caused by escalating cost of durum wheat'.
4. In the South and with reference to Africa, indigenous peoples have learnt to device heating systems at cold nights when they prepare fire place where they burn woods to provide heat for themselves. This has taken some similarities with the old Western culture, too, when advanced heating technology had not been devised. It is instructive to note that the bio-energy from woods is still being used for this purpose even in the contemporary rural African settings.
5. This *Yoruba* saying. A presumably poor man who eventually becomes food-secured has, to a large extent, surmounted the mystery of poverty. Hence all other problems in such milieu are mere secondary issues [The *Yoruba* people are a major tribe in Southwestern Nigeria].
6. Examples of GHG are Carbon dioxide (CO_2); Methane (CH_4); Nitrous oxide (N_2O); Hydrofluorocarbons (HFCs); Perfluorocarbons (PFCs); and Sulphur hexafluoride (SF_6).
7. In 1994, the effect of *El Nino* was so severe to the extent that there was a long dry spell but a strangely cold weather condition between June and September in tropical Africa when indeed farmers were supposed to be enjoying abundant rains and bumper harvest. Thus, agricultural productions were adversely affected during this period in Nigeria and many other countries.
8. Between 20:00 and 21:00 hours on Saturday, 29 March 2008, the world was literally plunged into man-made darkness. The Erath Hour, a brainchild of the World Wildlife Fund [WWF] charity, had advised all and sundry to switch off their light as a way of showing that the world is serious about climate change. The Fund 'urged governments, businesses and people worldwide to take part. It estimated 100 million people had switched off…' [Metro, Monday, March 31 2008: 3].
9. The *London Lite* of Wednesday, 26 March 2008 had reported: 'This Antarctic ice shelf, the size of Northern Iceland, is breaking up and unlikely to survive another year, say scientists…The Wilkins Shelf, on the south-west peninsula, is supported by just a thin strip of ice' [p. 4].
10. It is no longer news that Brazil has championed the push for biofuels solution for many years. 'It was a strategic decision taken by the military government that ran the country from 1964 to 1985, inspired by a desire to reduce its dependence on petroleum imports following the 1970s oil crises' [BBC News, Tuesday, 17 January 2006]. For many years, 'Brazil leads the world in production and use, making about 16 billion litres per year of ethanol from its sugarcane industry' [BBC News, Wednesday, 24 January 2007].
11. The full meanings of all acronyms, which featured under the discussion of power actors are provided in appendix 1.
12. Organised hypocrisy is a treatise on how international donor agencies go about doing aid and development business but with some political and secret undercurrent not in consonance with what they proclaim to do.
13. There have been first and second generations biofuel technologies. The progression in technology depicts an increased move towards more refined approaches/modalities that enhance the production of better quality bio-energy fuels that are cleaner and more cost effective. The so called second generation biofuels are '… made from the breakdown of plant cellulose or lignin, which could be produced from nonfood plants – such as prairie grasses or trees grown on marginal land' [Tilman et al. 2006 in Scharlemann and Laurance 2008: 44] or aqua-culturally cultivated algae.
14. The *Big Lemon* is a brand name for a fleet of luxury yellow buses that run on recycled vegetable oil in Brighton, East Sussex in the United Kingdom. Tom Druitt, a former care home manager, had set up the *Big Lemon* fleet to rival the successful Brighton and Hove Bus and Coach Company. The *Big Lemon* was registered as a community interest company.

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CLIMATE CHANGE, BIOTECHNOLOGY AND FOOD SECURITY THE CASE OF CASSAVA

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Abstract

The effect of climate change on the West Africa sub-region is not clear-cut. Increase in temperature accompanied by heat wave is a certainty. This effect will in turn melt some of the ice in the Polar Regions and mountain tops with concomitant rise in the sea level, putting the coastal towns and dwellers at risk of massive flood. In the hinterland, the effects of climate change have been projected to include flooding as a result of heavy rainfall during a short period of time resulting in sheet and gully erosion. Heavy rainfall for a short time followed by drought is bound to wreck havoc on Nigeria's agricultural productivity by decreasing yield. This problem can be mitigated by the application of biotechnology, which in the pure form refers to the use of living organisms or their products to modify human health and the human environment. This paper reviews the development of genetically modified forms of cassava and the wide application of its products.

Keywords: Linamarin, lotaustralin, transgenic cassava, utilization

INTRODUCTION

Cassava, *Manihot esculenta* Cranz is a tropical perennial plant that is propagated by stem to give roots that are enlarged by the deposition of starch cells. It grows up to about 1 - 3 metres high with tuberization starting between the 45th and 60th day after planting. In spite of the fact that cassava is produced mainly by the peasant farmers in small holdings of about 1-3 acres, Nigeria still remains the largest cassava producer in the world producing about 35 MT / annum. Nigeria's *primus inter pares* position is mainly due to the distribution of the high yielding, disease resistant varieties developed mainly by IITA, and other national research institutes like the National Root Crop Research Institute (NRCRI), as well as the Federal Government's effort in increasing food crops through their various programmes like the National Accelerated Food Production Programme, Operation Feed the Nation, the Agricultural Development Projects assisted by IFAD Cassava Multiplication Programme, which could give as high a yield as 80 - 90 tons / ha. The tubers constitute the highest weight of the whole plant, making up to about 50 %, followed by the stem, about 44 % and the leaves about 6 %.

CLIMATE CHANGE, CASSAVA AND FOOD SECURITY

Climate change in West Africa has been predicted to have the following effects: Rise in sea level resulting in coastal flood, rise in temperature resulting in heat waves, heavy rainfall within a short period with erosion as a consequence. Drought, especially in the Sahel region, is another outcome of climate change with increased rate of desertification as a result.

Cassava has many agricultural advantages and it is one of the best food security crops that can ameliorate the effect of climate change for the following reasons:

Cassava is the best C-3 crop in terms of calorie produced and its productivity is significantly higher compared to other staple food crops (Cassava yields 250,000 calories / ha / day compared to maize with 200,000 calories, rice 176,000 calories, sorghum 114,000 calories, and wheat 110,000 calories.);

Cassava is productive even on poor, eroded or acidic soils and under adverse climatic conditions where other staple crops fail;

Cassava is resistant to damage by locust and most pests;

Growth of cassava requires a low input of man hours compared to other crops;

Cassava adapts easily to traditional farming systems and can be intercropped with maize, beans and other food crops;

Cassava is sensitive to drought during the early period of growth; otherwise it requires no special planting or harvesting period;

The roots can be left in the ground for about three years; making cassava particularly useful as security against famine;

Flood is not a problem to cassava as long as it is before tuberization. Indeed, cassava will grow and thrive in aqueous solution but will not initiate the process of tuberization; and

Cassava can be easily propagated from stem-cutting, which is not edible.

Cassava is also regarded as the fourth most important crop in the world after rice, maize, and wheat. The only problem with cassava is that it contains two related cyanogenic compounds - linamarin and lotaustralin in ratio 93:7, which in themselves are not toxic but when ingested, they are hydrolyzed into one of the most toxic substances - cyanide. Cyanogenic compounds are believed to be protective in nature but that went haywire during certain periods of evolution.

CYANIDE AND ITS EFFECT ON MAN

Cyanide is responsible for many deaths in people consuming cassava and its products, especially when they are improperly processed. It has been estimated that about 80 % of a cyanide load in well-nourished subjects can be converted to the less toxic SCN (Rosling, 1994). Thus, we have seen that the toxic cyanide is detoxified to SCN using a dietary source of labile sulfur from methionine and cysteine but these sulfur amino acids are first limiting in legumes - the meat of the poor. The consequence is that the barely adequate dietary status in healthy subjects is reduced. The major question is the role of CN / SCN in the aetiology of certain diseases.

Tropical Ataxic Neuropathy (TAN): The commonest signs of this neuropathy are defective perception of sensory modalities usually at the lower limbs, bilateral optic atrophy, ataxic gait and impaired muscular coordination, bilateral perceptive deafness, weakness and wasting of the muscles.

Though plasma levels of thiocyanate, cyanide and urinary excretion of SCN were significantly higher in patients than in controls, the exact pathogenesis is uncertain. However, by strength of association, consistency, dose-relationship and biological plausibility, it seems that cassava diet is the major cause of TAN (Osuntokun, 1994).

Konzo or Spastic Paraparesis - meaning paralysis of one or both legs is another form of neurological disability. The onset is characterized by an abrupt paraparesis occurring within minutes or hours in a healthy person. Several epidemics of Konzo have been reported among rural populations of Mozambique, Tanzania, Zaire and Central African Republic (Howlett 1994, Tylesskar, 1994). Again, the epidemiology of Konzo is probably induced by cyanide derived from insufficiently processed cassava, in combination, with a deficiency of sulfur amino acids in the diet.

Thiocyanate (SCN): A preliminary survey by Oke *et al.*, (1988) showed that the incidence of goiter in Akungba and Oke-Agbe of Akoko division of Ondo State was as high as 20 %, while that of Erinmo and Ifewara in Ijesha division of Osun state (both in south-western Nigeria) was about 2 %. With the financial support of the U.S. Agency for International Development (USAID), the chemical, dietary and environmental factors that were responsible for the endemic goiter in Akoko in comparison with the Ijesha division were investigated. Urine was collected from all the locations and analyzed for thiocyanate (SCN), iodine, urea and creatinine. Blood was also collected, the serum separated and analysed for triodothyronine (T_3), thyroxine (T_4), thyroid stimulating hormone (TSH) and thyroxine - binding globulin (TBG). Water samples from the rain (stored for drinking), streams and wells were collected and analysed for iodine content. Raw and cooked foodstuffs as well as typical breakfast, lunch and supper of subjects were collected and analysed for iodine, crude protein, gross energy, cyanide and glucosinolate content. Commercial table salts sold in the open markets of all the locations were bought and analysed for iodine. We also carried out a model study using rat bioassay to test the hypothesis of low iodine - high cyanide - low protein synergism in the aetiology of goiter in Oke-Agbe and Akungba. For this purpose, *Amaranthus viridis*, a very popular vegetable in Akoko division, was included as a protein source at 10 and 3.5 % C. P. respectively.

The chemical and biochemical study (Akindahunsi, 1992, Akindahunsi *et al.*, 1999; Akindahunsi and Adewusi, 1999) confirmed significant regional variations in the urinary levels of iodine and thiocyanate while there was no significant difference in urea and creatinine levels. Urinary iodine level was higher in all Nigerian locations compared to other African locations where goiter is endemic and even some control populations. The same goes for the urinary iodine / creatinine ratio. Thus the important role of iodine deficiency as a permissive factor in endemic goiter does not seem to hold in the Akoko incidence.

A similar situation was found for urinary SCN / creatinine, I / SCN ratios the chemical parameters of goiter endemia summarized in their ratios, proposed and extensively used before this study may only hold for rural populations where subsistence farming is the only occupation. In villages with a mixed population like Akungba (Pop. 23,597 in 1986) and Oke-Agbe (Pop. 19,835), the presence of endemic goiter may be masked when the mean ratios for the whole population are used. A breakdown of the ratio may prove more informative about the thyroid status of the less privileged. (b) Thiocyanate overload seemed to be the major cause of goiter in Akungba; while that of Oke-Agbe could be attributed to low iodine ingestion in the presence of a relatively high thiocyanate overload (Akindahunsi *et al.*, 1994). (c) Protein malnutrition seemed to play an important role in the aetiology of goiter in both Akungba and Oke-Agbe and probably acts in synergism with low iodine and high thiocyanate load. (d) Finally that the incidence of goiter was low in the control area because cassava intake (cyanide exposure) was lower and iodine ingestion apparently higher than in the test locations. The control population however remained at risk of goiter endemia if they were more exposed to cyanide ingestion as could occur during drought and / or crop failure - a classical situation with climate change.

Fortunately, it is very easy to get rid of the cyanide by grating, which is the first process in gari making; by fermentation, a second step in gari making; and by heating, a third step in gari making. These are the three most efficient methods of getting rid of cyanide, and so, theoretically, gari should be one of the safest foods. However, during drought or crop failure, would the hungry man wait for the long processing method before eating the cassava?

This is where biotechnology comes in handy.

CASSAVA AND BIOTECHNOLOGY

The research in the biochemistry of cyanogenic glycosides started in the early 1950s in the laboratory of Professor E. E. Conn – the grandfather of cyanogenesis. The precursors for all the cyanogenic compounds were identified as amino acids and that of cassava are – valine and isoleucine - in the L configuration. It was also recognized that the biosynthesis of cyanogenic glucosides was “channeled” because the intermediate products could hardly be isolated during biosynthesis. Professor Moller and his group then discovered that the biosynthesis is catalyzed by a multi-enzyme system the cytochrome P-450 oxido-reductase system, which contains two distinct entities CYP79D1 and CYP79D2 (Anderson *et al.*, 2000) . The product from the multi enzyme system is the cyanohydrin, which is subsequently glucosylated by UDP-glucosyl transferase to yield the cyanogenic glucosides - linamarin and lotaustralin (Figure 1).

At the beginning of the cassanova project, which was part of the basic research into the production of acyanogenic cassava, two bold steps were conceptualized. The first was to purify the enzyme(s) involved in the biosynthesis of the cyanogenic glucosides. The second option, in the case of cassava, was to inhibit the transfer of the cyanogenic glucosides from the leaves where they were most produced, to the root where a substantial part of the cyanogenic glucosides were stored. The first hypothesis was based on the identification of the biosynthetic pathway of the glucosides while the second was based on the evidence of Selmar (1993) about the linustatin hypothesis. This hypothesis was based on the compartmentalization of the glucosides in the vacuole and the catabolic enzymes in the cytoplasm and the intracellular spaces, which made it impossible for the glucoside to be transported without its hydrolysis to give the aglycone and cyanide.

With the presence and identification of a diglucoside - linustatin - in cassava, Selmar (1993) proposed that linamarin produced in the leaf was further glucosylated to give linustatin which became resistant to linamarase and the diglucoside was the transport form of linamarin to the root. This hypothesis assumed the presence of a sequential diglucosidase, which is capable of converting linustatin to linamarin, which is then stored in the root. Such a diglucoside was found in the root of cassava but not in enough quantity to justify further work (Adewusi, unpublished).

The Moller group in Copenhagen isolated, purified and characterized the P-450 enzyme complex and finally determined the amino acid sequence and hence its genetic code. From there, it was a short step towards the expression of cyanogenic glycosides in vectors and *in vitro* using the PCR method and the production of the antisense. With the antisense, it was possible to produce the transformed cassava plant, which is acyanogenic. With the production of the transgenic cassava with less than 5 % of the original cyanide potential, the next step was to test its production efficiency in terms of root yield, resistance to diseases, drought and growth on poor soil; this again had been successfully carried out in the green house in Copenhagen. For instance, nitrate is now known to affect the cyanide potential in the transgenic cassava.

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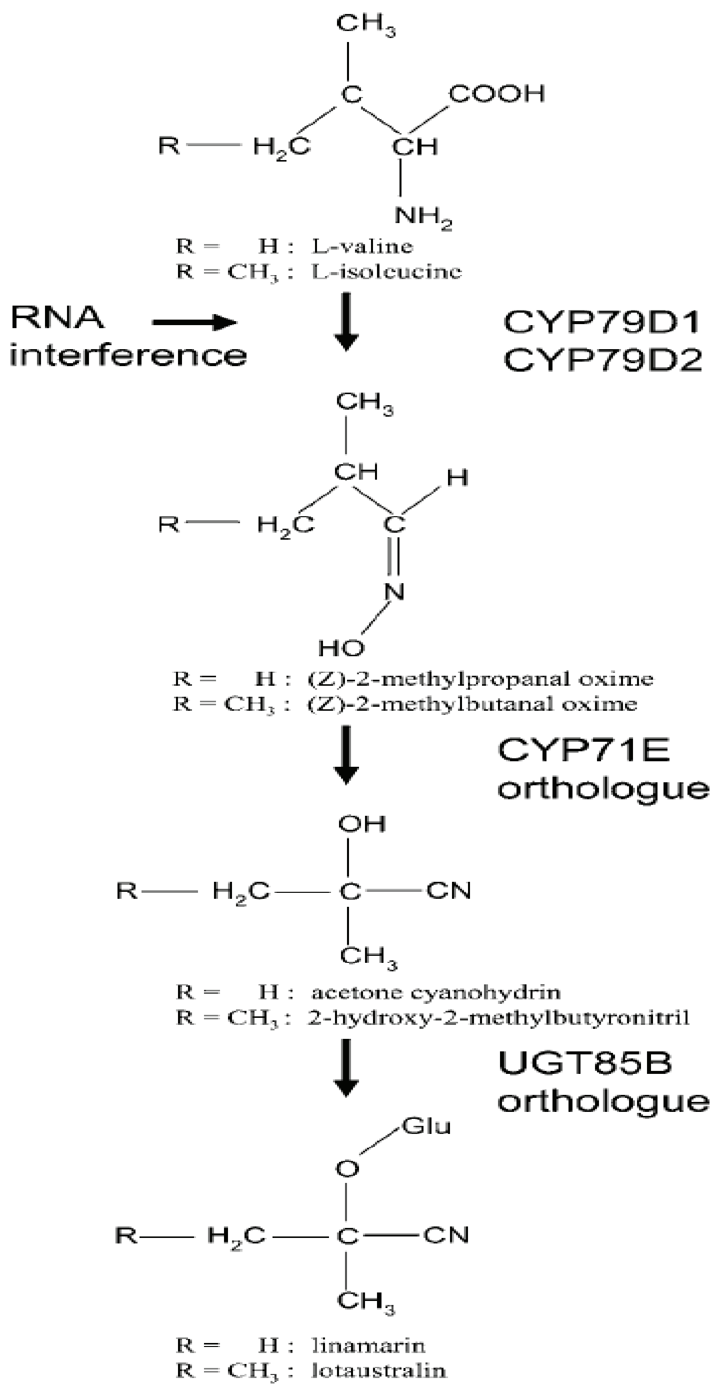

Figure 1: Biosynthesis of Linamarin and Lotaustralin in Cassava

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The second major application of biotechnology is toward the increase in the protein content and other nutrients in the root. Cassava root contains about 2 % crude protein, with very low essential amino acids' content. This makes cassava a poor source of protein thus exacerbating kwashiorkor in children. The first successful attempt in this direction was reported at the sixth conference of the Cassava Biotechnology Network. Zhang *et al.*, (2003) reported the development of a transgenic cassava plant, which could express an essential amino acid rich protein (ASP1) gene by the constitutive promoter CaMV 35S. Though there was no significant increase in the protein content of the root, a 30 % increase of the protein content of the leaves was recorded. Of recent, the group of Sayre in USA reported increasing the protein content of the root from the low 1 - 2 % to about 8 % thus competing with some grains with respect to protein content.

This same group has produced genetically modified cassava that contained 30 times as much beta-carotene, a precursor of vitamin A, as its normal counterpart; iron levels were increased ninefold, zinc fourfold and protein fourfold in other transgenic cassava plants. Thus far, the traits have been introduced individually into plants. The first product with multiple traits is likely to contain just elevated vitamin A, iron and protein as well as virus resistance while the introduction of other character traits is expected to be more challenging (Sayre *et al.*, 2007) .

A third major application of biotechnology is toward better yield of cassava by enhancing its starch production or its industrial application. The amylose content of cassava is controlled by the gbss gene (Thygesen *et al.*, 2003), while sss, sbe and gwd genes have been implicated in the synthesis of amylopectin and some of these genes have been isolated, characterized cloned (Munyikwa *et al.*, 1997; Nakamura *et al.*, 2003). It is therefore possible to suppress some to these genes by antisense inhibition, the use RNAi to silence some biosynthesis genes or to introduce new genes through *Agrobacterium tumefaciens* as the gene transfer agent. Whichever way, the result will be the production of transgenic cassava with either high amylose or amylopectin (waxy cassava) content. Indeed, cassava with a waxy root starch had been successfully engineered and produced (Ihemere *et al.*, 2006) and work on the African transgene is on-going (Opabode unpublished result).

UTILIZATION OF CASSAVA AND ITS PRODUCTS

Cassava can be made into many products. The stalk is used for vegetative propagation; the leaves are eaten in many parts of Africa and also serve as fodder for ruminants while the root becomes the all important source of calories and industrial chemicals.

1. Cassava as Food and for Job Creation: A good part of the 36 million metric tons of cassava currently produced in Nigeria is converted to food such as gari, fufu, kpokpogari and fast foods have been developed from cassava flour. By making cassava into fast foods, the urban population would be attracted to such as noodles, breakfast cereals, pies, etc. Presently, there is a regulation that all wheat flour in Nigeria should contain 10 % cassava flour and this presently requires 200,000 tons of cassava flour in which only about 10,000 tons have been supplied. This is partly due to the fact that there is not enough cassava for this product as a transition period is required for the establishment of the new high yielding variety just distributed to farmers. Also the standard of the required cassava flour is high (Oke, 2005). The market value of the cassava flour has been estimated at ₦32 billion / annum with an employment potential of about 800,000 jobs at 2 people / ton. In order to satisfy this demand, Nigeria may need about 400 small scale factories producing 2 tons of cassava flour per day. This means all the baked products would contain some cassava flour as it can now be used as a substitute for baking all the common cookies like chin-chin, biscuits, meat pies, meat fillings, sausage rolls, cassava chips, cocktail tidbits, queen cakes, coconut biscuits, drop cookies, doughnuts, buns, cassava flakes, salad cream, cassava fritters, croquettes etc. IITA has served these items at cocktails in which people enjoyed the taste and did not know the difference. All that is needed is to improve on these and popularize them. Cassava can also serve as a source of nutrient for the people, such as glucose syrup and food starch for the food industry and in the production of MSG and other food flavours.

2. Animal Feed – About 60 % of animal feed is the energy part of the ration which is maize. Most of the maize used for animal feed is imported at present as we cannot satisfy the demand due to high cost of fertilizer to produce high yielding maize, while the erratic exchange rate and high inflation has resulted in the high price of maize. The maize could therefore be replaced with the much less expensive cassava chips with comparable results thereby leading to the formulation of cheap animal ration and production of cheap animal products. For example, it is possible to replace all the maize with cassava: cassava leaves at ratio of 4:1, with the pigs attaining market weight of 100 kg by 195 days compared to 234 days with a maize ration. Even, the EU has recommended a substitution of 40 % of the maize with cassava chips in swine ration. In case of poultry, cassava at a level of 47 % of the ration gave a satisfactory response to egg production, body weight gain, egg yolk colour and very good cost saving, which is reduced by 13 % compared to maize. In the European Community, a substitution level of 20 % is recommended. The best results are with ruminants where cassava chips could substitute the entire maize ration and even the peels can also be used. Complete replacement together with nitrogen supplementation as urea gave similar milk yield and butter fats at a cost reduction of $10 / ton in dairy cattle. Presently, Nigeria uses about 1.2 million tons of maize as animal feed annually and, if this is replaced by cassava even at 10 % for chicks and 20 % for swine, we would require about 400 cassava chips factories processing 10 tons of roots per day to satisfy the demand. The European Communities use 80 % of dry chips with 20 % soybean meal for livestock ration to replace the maize or barley.

3. Alcohol – As stated earlier, alcohol is now produced cheaply from the fermentation of glucose derived from starch, using the yeast *Saccharomyces cerevisiae.* This is the anaerobic fermentation that follows the well known Kreb's citric acid cycle. The starch is first gelatinized at 90^{o}C with water to form a 10 % starch suspension to which sulphur dioxide is added to clarify the solution and is then saccharified and fermented. The solution is then pumped into setting vats to allow suspended yeast and other suspended particulates to settle out of the liquid. It is at this stage that the yeast cells stimulate the growth of *Lactobacillus* bacteria, which decarboxylate the malic acid formed to lactic acid. The vessel is then rocked for a while before being transferred to storage vats. Here, bentonite clay, gelatine or egg albumin is added to clump and precipitate tiny particles in the fluid and then allowed to age before the alcohol is distilled off, followed by fractional distillation to obtain absolute alcohol. In addition to this, sugar alcohols like sorbitol, xylitol, mannitol and erythritol originally obtained by catalytic hydrogenation of dextrose from corn starch, followed by chromatographic separation, are now obtained in a similar way. Also important organic acids like the most widely produced citric acid (the most widely used), are now produced by submerged fermentation of glucose. So also lactic acid, itaconic acid, gluconic acid etc. There are two grades of alcohol: the fuel grade and the industrial grade. In Nigeria, alcohol was produced initially from molasses from the once thriving sugar industry where a ton of the molasses produced 241 litres of alcohol. Later, the sugar factory started to slow down and the alcohol factory was closed down. Now this has been revived from the knowledge that alcohol can also be produced from cassava through fermentation, with one ton giving 420 litres of alcohol. Fuel alcohol is used in motor engines as an additive or oxygenating agent to improve combustion of the engine. Originally, a chemical – MTBE - was used at 10 % level, but it has now been found to be carcinogenic and so it is being phased out. In Nigeria needs 30 million litres of petrol, 10 million litres of diesel and 5 million litres of kerosene and 1.5 million litres of aviation fuel a day, which come to about 46.5 million litres a day. If 10 % of this is substituted with alcohol instead of MTBE, then Nigeria would require about 4.65 million litres of alcohol per day, which, in turn, would require about 16 million tons of fresh cassava to be converted to chips. If factories process about 2 tons of chips / day, then about 5,000 units of such factories would be required to satisfy the demand. This is apart from the 90 million litres / annum of the industrial alcohol used for insecticides, pharmaceuticals, disinfectant, chemical intermediates, inks and adhesives, personal care and perfumeries, hot drinks, liqueur, wines etc.

4 Starch – This is the starting point for so many important industrial products such as dextrin, glucose syrup etc. Cassava starch is particularly good because it has a good gelling property. The original source of starch was from wet milling industry of corn to produce dextrose and glucose in addition to starch. As stated earlier, starch has now become a very important raw material for the production of several industrial products and food. Traditionally, it is produced by first washing the peeled root manually and then grating to produce starch milk from which the fiber is separated through special strainers or sieved through muslin cloth and washed thoroughly and the starch will then collect and settle down. It is then filtered through a series of nylon screens of decreasing mesh size (50 - 250 mesh), and it then settles for 4-8 hours in settling tables before sun-drying on cement floors for about 8 hours during which the moisture content is reduced from 45 – 50 % to 10 – 12 %., before being ground into a fine form and packed. The modern method is similar except that the starch pulp is passed through rotary extractors to separate the starch granules from the fibrous materials before being subjected to continuous centrifuging, after which, it is washed and concentrated and then further refined in cyclone thickeners before passing through vacuum filters to reduce the moisture content from 40 – 45 % to 10 – 12 % within seconds to avoid thermal degradation. Although the quality is higher and the process shorter, it is more expensive and requires a lot of expertise, and facilities like electricity and plenty of water. The indicative price is about ₦58, 500 / ton, with a market value of about ₦2.9 billion, leading to the creation of about 150,000 jobs.

Starch is sold traditionally in the market in the wet form, which can only keep for about 3 - 4 days before discoloration and fermentation start. However, starch is the starting point of many food and industrial products.

(i) First of all, it can be modified to give other more useful derivatives with more useful properties like solubility, gel strength and retrogradation tendencies (stability) for other uses. This can be achieved through hydrolysis and acetylation with acetic anhydride. Dextrin is prepared from starch by mixing with dilute acid and heating to 110^{o} C and then transferred into first and second drum toasters where actual dextrinisation occurs with a temperature up to 170^{o} C, before transferring into drum coolers down to about 50^{o} C where it remains ageing for several hours until all the starch granules of all sizes are thoroughly and evenly acidified. It is then transferred into production and homogenizing containers. Similarly, cyclodextrin is made by incubating starch at 37^{o} C until the reaction is completed. Finally, starch granules swell reversibly in cold water and as the temperature rises, the process becomes irreversible and the granules' swell burst to form a paste (i.e. gelatinization). Advantage is taken of this process in the formation of adhesive by mixing starch slurry thoroughly in a vessel with a source of heat until it gelatinizes to form a paste.

(ii) It can be modified to form resistant starch which is similar to nutritional fibre that is not digestible in the small intestine and so it is used as a bulking agent, which is very useful in reducing sugar or reducing-fat food formulation. This has a very high value in the pharmaceutical industries and it is not yet produced in Nigeria, but this is being done on experimental basis by a research group in Nsukka (2004).

(iii) The nutritional quality can be improved significantly by blending it with sorghum or maize before pulverization and

(iv) It can be hydrolysed with glucoamylase enzyme isolated from rice bran, an agro-industrial waste, to produce glucose syrup.

Starch has a variety of uses, especially in the textile industries, wood, oil rigs, paper, adhesive, cosmetics and food industries. About 77 % of world starch comes from maize and only about 11 % from cassava, so this is a very good opportunity to develop the starch industry for both home and export markets. The requirement in Nigeria is put at 67,000 tons / annum.

5 Leaf Protein Concentrate - Although the tuber is very poor in protein, about 1 – 2 %, being mainly starch, the leaf is very rich in protein (about 30 %) and pro-vitamin A, (about 56,000 IU,) which compares favourably with alfalfa, (14,200 IU), which is used as hay in western countries., Cassava leaves can yield as much as 90 tons / ha / year if harvested thrice a year, but this will depress the yield of the tuber.

The protein in cassava leaves can be extracted mechanically by crushing the leaves to break the cells and squeezing out the resulting juice, which carries most of the proteins with it (about 90 %). The protein can then be precipitated by heating to about 90^{o} C and then filtered and dried to give what we call Leaf Protein Concentrate (LPC). This procedure can be carried out manually using mortar and pestle or a blender, and squeezing by means of a muslin cloth, after which the wet curd can be dried. For the mechanical extraction, there are two types of machines: small scale and industrial scale. The machine is very simple, and in both cases, consists of a pulper made from steel hammers, and a press, which can be a belt press. Steam can be used for precipitating the protein and the wet curd can be dried in an oven or through a solar dryer.

The efficacy of the LP is due to its high protein content and the high amounts of the essential amino acids, lysine and tryptophan as well as vitamins (A, E, K, B_6) and minerals (iron, iodine, calcium, magnesium). As it is well known, protein deficiency leads to stunted growth in children and slow development of the brain, which starts developing from birth to age 5, and by the age of 2 years when it is 80 % developed, if sufficient protein is not available, this will become serious, and if not corrected by age 5, there will not be sufficient development, leading to inability to learn, malformation of nervous tissues and decrease in immunity. This is a very serious problem affecting millions of children in developing countries. Next to this in its seriousness is Vitamin A deficiency, which leads to nutritional blindness (xerophthalmia) that affects an estimated 500 million children in developing countries of which an estimated 0.250 million would die within four months. This is responsible for a total death of about 4 million every year. Finally, iron deficiency leads to nutritional anaemia with its accompanying problems and hindrance to physical and mental growth. These three most severe diseases could be ameliorated by LPC and only about 2 teaspoons a day is sufficient to supply 300 % of the vitamin A requirement in the form of β-carotene; 100 % of the iron requirement; 50 % of the folic acid; 40 % of the vitamin E and 20 % of the protein requirement per day. The advantages in using LPC include being relatively easy to make, distribute and use; it is cheap with exceptional nutritive value; reproducible world-wide and dependent only on the enormous and inexhaustible supplies of leaves.

It is therefore a sustainable way of improving the protein intake and the development of children in the developing countries like Nigeria. With all these, the child will have the opportunity to grow well, have the resistance to illness i.e. better immune system and to develop a good brain and be able to gain from education and; hence, a better job. It is therefore not surprising that recently, LPC has now been extended to HIV/AIDS patients in Aboney in Benin Republic and with very good results. A similar trial of LPC on HIV/AIDS patients is soon to take off at the UCH, Ibadan.

6 Other Products – As indicated above there are many products that can be derived from cassava starch which are of economic importance and one can see a great future in this. This will become obvious if one goes into the details of the chemistry of starch.

With progress in the field of chemistry, it became easier to produce several kinds of food and other industrial starch products such as glucose syrup, flours starch components for plastics, textile, adhesive, special absorbents, paper and plywood industries, oil drilling and as an additive of tertiary oil recovery system. If in those days, so much could be achieved in the field of starch chemistry with very limited facilities and knowledge of the compound, then we should be able to do a lot more with the present facilities and ultra modern equipment and techniques available in our possession. So, in the discussion of the various aspects of cassava as industrial raw material, it is important to keep in view that we are dealing with the chemistry of starch, its production, processing and marketing.

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MICROBIAL STUDY ON THE CONCENTRATES PRODUCED FROM TROPICAL FRUITS USING DRY FREEZING AND ROTARY EVAPORATION

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Abstract

Developing nations, known for high level of production of tropical fruits, are recently encouraged to reduce fruit losses and add value to fruit products by further processing fresh fruits and juice to more durable and economic products such as concentrates and jam. In order to ensure the safety of such end products, it is essential monitor the level of micro organism presence and activities. This paper examined the total viable count, yeast/mould count, Coli form count and E Coli of the juice and concentrates produced from sweet orange, grape, pine apple and mango using freeze drying and rotary evaporation methods of moisture reduction, compared with imported juice/ concentrates. No Coli form was found in any of the concentrate samples. For the concentrate samples produced with the freeze dryer, total bacterial and yeast/mould counts (in CFU ml^{-1}) were found to be 1.00 x 10^2 and 1.35 x 10^2 for sweet orange, 1.87 x 10^2 and 3.18 x 10^2 for grape, 1.82 x 10^2 and 3.42 x 10^2 for pine apple and 1.66 x 10^2 and 3.0 x10^5 for mango respectively. For the concentrate samples produced with the rotary evaporator, total bacterial and yeast/mould counts were found to be 1.25 x 10^2 and 1.45 x 10^2 for sweet orange, 2.7 x 10^5 and 2.8 x 10^5 for grape, 1.70 x 10^2 and 2.30 x 10^2 for pine apple and 2.5 x 10^5 2.95 x10^5 for mango respectively. The implications of the results are discussed in respect of safety in the paper.

Keywords: Total bacterial count, Yeast/mould count, Coli form count, Tropical fruits, Rotary evaporator, Freeze dryer

INTRODUCTION

Fruits are ready source of minerals and vitamins, which are essential for building body cells and good health (Steven et al, 1997). Citrus are excellent sources of vitamin C containing more than the minimum daily requirement of 60 mg of vitamin C in 240 ml of juice (Naggy et al, 1993). Citrus fruit are also a good source of folic acid vitamin B, thiamine and potassium (Naggy et al, 1993). Pine apple fruit consist of 81.3 – 91.2% moisture 27.0 – 165.2 mg ascorbic acid, 0.003 – 0.055 mg carotene, 0.03 – 0.29 g ether extract, 0.3 – 0.6 g crude fiber, 0.038 – 0.098 g nitrogen, 0.21 – 0.49 g ash, 6.20 – 37.27 mg calcium, 6.6 -11.9 mg phosphorous, 0.27 -1.05 mg iron, 0.003 – 0.055 mg carotene, 0.048 - 0.138 mg thiamine, 0.011 – 0.04 mg riboflavin, and 0.13 – 0.267 mg Niacin (Atkins, 2000, Perez, *et al* 1998). Mango fruit consists of 83% water, 15% sugar (mostly sucrose), 1000-8000 I.U vitamin A/ 100g, 135 mg ascorbic acid/ 100g, carbohydrate 11.56 mg/ 100g, Fat 0.21 mg/ 100g, Protein 0.07 mg/ 100g, Folic acid 17 mg, Riboflavin 0.04 mg / 100g, thiamine 0.10mg / 100g (USNASFNB, 1990; Nanjundaswamy, 1992).

Grapefruit is an excellent source of many nutrients and phytochemicals, able to contribute to a health diet (Jorquera, 1996). It is a good source of vitamin C. Pink and red grapefruits are high in lycopene, an antioxidant that appear to lower the risk of prostrate cancer. (Craig, 1997; Bailey et al., 2004). Studies have shown that grapefruit help lower blood cholesterol levels and there is evidence that the seeds have high levels of antioxidant properties (Strobel et al, 1983). Its low glycemic index is able to help the body metabolized fat. A study found a correlation between eating a quarter of grapefruit daily and 30% increase in risk for breast cancer in post-menopausal woman (Monroe et al, 2007). Ingestion of grapefruit juice is associated with inhibition of CYP3A4 which may be due to effect of 6, 7-dihydroxy-bergamotin (Miller and Harris, 1998). Grapefruit juice significantly increases the activities of liver detoxification enzymes responsible for preparing toxic compounds for elimination from the body (Maier and Keller, 1995). Haringenin, a flavonoid concentrated in grapefruit, helps repairs damaged NDA in human prostrate cancer cells. Grapefruit, being rich in calcium, is associated with protection and maintenance of the health of bone (Faduka, 1997). Consumption of grapefruit juice has been found to result in lesser outpouring of mucus secretions from the nose (Faduka, 1997). It is also beneficial in maintaining the dental health of an individual and in keeping blood pressure under check mainly owning to the presence of magnesium (Jorquera *et al,* 1996).

Post harvest losses are common and highest in the tropic due to climatic conditions where incidences of transpiration and respiration are high, (Oluwole, 1983). Concentration of fruit juice is essential to ensure effective storage and prevent unnecessary loses and wastages. The changes that occur in harvest unprocessed fruits include water loss, conversion of sugar to starch, flavour change, color change, depreciation of the vitamin content, softening, decay and consequent loss of quality and quantity. Juice and concentrate can be prepared from natural fruit using different thermal processes. Concentration is traditionally carried out through the use of high temperatures. Scientific methods of juice concentration include evaporation techniques, reserve osmosis and dry freezing (Yiu and Jozsef, 2006; Elowe, 1991). Most industrial juice concentrators use a high temperature evaporator (thermal accelerated short time evaporation) and microbes are generally killed during the process (Nita, 2005). And, many of the survivors should be killed by the freezing process. High plate counts would indicate improperly cleaned equipment or product abuse in the processing operation following the evaporator. Thus frozen concentrated orange juice should have few if any microbes.

Micro organisms enter the processing plant on the surface of the fruit having originated from soil, untreated surface water, dust and decomposing fruit. The degree of contamination varies depending on how the fruit was handled from the field and in the processing plant. Proper grading, washing and sanitizing the fruit contribute to good product quality. The low pH of fruit juices greatly limits the number and types of bacteria that can survive or grow. Lemon or lime juice has pH range of 2.2 to 2.6 and no normal spoilage bacteria can grow or survive this low pH. Orange juice is pH 3.4 to 4.0 and *Lactobacillus* spp. and *Leuconostoc* spp. can survive and grow at these conditions. These bacteria can cause abnormal flavours and odours but they cannot grow at high sugar concentrations or low temperatures (45% sucrose, below 5°C) characteristic of concentrates. Acetic acid bacteria, yeasts and molds may be present and can grow when the juice is kept at temperatures conducive to their growth (Steven et al, 1997). Yeasts are primarily responsible for spoilage of non sterile chilled juice. The microbial population in fruit juices usually consists of yeasts, molds, lactic and acetic acid bacteria which are generally heat sensitive. Other organisms usually are inhibited by the acid in fruit juices (Banwart, 1979).

Nigeria is one of the leading nations in the production of tropical fruits (Adewumi, 2008). Due to the high perishable nature of fruits, production of concentrate in Nigeria will guarantee the availability of fruit products throughout the year at affordable cost. It will also improve the handling and transportation of the juice. Establishing of an indigenous firm that produces concentrates from fresh fruits will reduce the rate of unemployment in the country and enhance the exportation of the concentrates to other countries, which will serve as a source of foreign exchange for Nigeria. It is essential to processing fresh fruits and juice into more durable and economic products such as concentrates and jams. This will not only preserve and increase shelf life of product but add value. In order to ensure the safety of such end products, it is essential monitor the level of micro organism presence and activities.

This paper therefore presents the report of a study on the total mesophlic count of bacteria, yeast/mould count, E. coli coumt and Coliform count of the concentrates produced from these fruits using freeze drying and rotary evaporation methods of moisture reduction.

MATERIALS AND METHODS

High grade of fresh, fully ripped fruits of grape (red variety), pine apple ((smooth cayenne variety), sweet orange (local variety) and mango (Ogbomoso variety) were obtained for the study. Imported samples of fruit concentrates were obtained from local super markets. The fruits were washed, peeled, cut, aseptically squeezed into stainless steel bowls and sieved using sterile muslin cloth to obtain clear juice. The clear juice was concentrated using freeze dryer and rotary evaporator. Microbial analysis was carried out on juice from fresh samples, imported samples, rotary evaporated and freeze dried samples, and the imported concentrates to determined total mesophlic count of viable bacteria, yeast/ mould count and coliform count as described by Parish (1991) and Fawole and Oso (1990). The culture media used include potato dextrose agar for enumeration of yeast and moulds, MacConkey agar for coliform count, Eosin methylene blue agar for E.coli count and Nutrient agar for total viable count.

For the total viable count, the sample was thoroughly mixed to form homogenous solution. 1 ml of the sample was aseptically transferred into the sterile beaker and mixed thoroughly with a sterile glass rood for about 5 minutes. 20 ml of sterile distilled water was added and mixed until the sample form a uniform solution. 1 ml aliquot of the sample was pipetted into sterile 20 cm^3 test and serially diluted into two set of test tubes each containing 9 ml of sterile distilled water to dilution rate 10^{-2}. 1 ml portion of the diluent from the second dilution factor was asceptically separately pipetted into different sterile petridishes and 20 ml of the cool, sterile molten agar medium was added, swirled gently for even distribution of the innoculum, allowed to set and incubated at $37^0 \pm 2^0$C for 24 hrs. 20 ml of molten malt extract agar was asceptically mixed with 1ml aliquot of the sample, which had been serially diluted, in order to isolate for molds and yeast in the sample. The plate was allowed to set and incubated at $27^0 \pm 2^0$C for 48 hrs. At the end of the incubation period, microbial colonies were counted and recorded appropriately.

For the coli form count test, five 10 ml sample was discharged to 5 ml single strength medium. 5 of 1 ml sample were discharged into 5 ml single strength medium and another 5 of 0.1 ml were equally discharged into 5 ml single strength medium. The bottles were incubated at 37^0C and examined at 24 and 48hrs respectively for gas and acid production. The result was extrapolated. Tubes that showed positive presumptive test was streaked into Eosin methylene blue (EMB) plates and incubated for 35^0C for 24hrs. The plate was observed for the presence of coli form colonies with greenish metallic sheen which indicates the presence of *E. coli*.

RESULTS AND DISCUSSIONS

Tables 1-4 show of the microbiological analyses of fresh juice, freeze dried rotary evaporated and imported samples for orange, pine apple, grape and mango respectively. In preserving food by moisture reduction, one seeks to lower the moisture content of the food material to a level where the activities of food spoilage and food poisoning microorganisms are inhibited in order to increase the shelf life compared to the ordinary fresh ones and can keep for longer periods. Freeze drying and rotary evaporation are two of the methods that can be used to achieve moisture reduction in foods. In freeze drying, foods are first frozen before dried under a high vacuum. Due to the low temperatures involved, freeze drying is especially suited for the dehydration of heat sensitive foods. Freezing in the freeze drying system may lower the number of viable microorganisms in foods. Although the viable microbial load is decreased during drying, the dried product is not sterile, regardless of the system used for drying (Jay, 1978; Banwart, 1979).

Table 1: Microbiological Analysis of the Orange Concentrates (CFU mL^{-1})

Samples	Total Viable Count of Mesophli	Yeast and Mould Count	Coliform Count	*E-coli* Count
Fresh Orange Juice	2.02×10^2	2.50×10^2	2	NP*
Imported Concentrate	-	1.20×10^2	NP	NP
Rotary Evaporated Conc.	1.25×10^2	1.45×10^2	NP	NP
Freeze dried Conc.	1.00×10^2	1.35×10^2	NP	NP

* NP implies not present.

Table 2: Microbiological Analysis of the Pine apple Concentrates (CFU mL^{-1})

Samples	Total Viable Count Mesophlic of Bacteria	Yeast and Mould Count	Coliform Count	*E-coli* Count
Fresh Pine Apple Juice	2.89 x 10^2	2.70 x 10^2	NP	NP
Imported Conc.	2.70 x 10^2	2.89 x 10^2	NP	NP
Rotary Evaporated Conc.	1.70 x 10^2	2.30 x 10^2	NP	NP
Freeze dried Conc.	1.82 x 10^2	3.42 x 10^2	NP	NP

Table 3: Microbiological Analysis of the Grape Concentrates (CFU mL^{-1})

Samples	**Total Viable Count Mesophlic of Bacteria**	**Yeast and Mould Count**	**Colifor Count**	***E-coli* Count**
Fresh Grape Juice	1.90 x 10^2	2.50 x 10^2	NP	NP
Imported Conc.	2.90 x 10^2	2.70 x 10^5	NP	NP
Rotary Evaporated Conc.	2.70 x 10^5	8.80 x 10^5	NP	NP
Freeze dried Conc.	1.87 x 10^2	3.18 x 10^2	NP	NP

Table 4: Microbiological Analysis of the Mango Concentrates (CFU mL^{-1})

Samples	**Total Viable Count Mesophlic of Bacteria**	**Yeast and Mould Count**	**Coliform Count**	***E-coli* Count**
Fresh Mango Juice	1.80 x 10^2	2.70 x 10^2	NP	NP
Imported Concentrate	3.00 x 10^5	2.60 x 10^5	NP	NP
Rotary Evaporated Conc.	2.50 x 10^5	2.95 x 10^2	NP	NP
Freeze dried Conc.	1.66 x 10^2	3.00 x 10^5	NP	NP

From Tables 1-4, the total viable count of mesophilic bacteria ranged between 1.00 x 10^2 and 1.25 x 10^2, 1.82 x 10^2 and 1.70 x 10^2, 1.87 x 10^2 and 2.70 x 10^5; and 1.66 x 10^2 and 2.50 x 10^5 CFU mL^{-1} for orange, pine apple, grape and mango concentrates respectively. The two methods caused reduction in the viable counts of the samples as compared to the fresh juices; hence showing that elimination/ death of micro organism occurred during the processes.

Coliforms and *E.coli* were not detected in any of the samples because these are not usually part of the normal flora of fruit juices. The coliform (2 cfu ml^{-1}) detected in fresh raw orange was destroyed by the treatment methods because Gram negative bacteria, of which coliforms are included, do not survive freeze drying (Banwart, 1979).

The higher yeast and mold counts of the concentrates as compared to the total viable count of mesophilic bacteria may be due to the lowered water activity (a_w) of the concentrates which will favour the growth of fungi more than bacteria. In addition, yeasts and molds are usually more associated with fruit juices than bacteria because of low pH of fruit juices which is more favourable for growth and proliferation of yeasts and molds (Banwart, 1979).

Generally, counts of grape and mango were higher than those of orange and pineapple concentrates. This may be attributed to the differences in the consistency of the fresh juices during drying. According to Banwart (1979), the lethal action of drying on microorganisms may be influenced by certain factors which may include type of food or suspending medium. Due to the thicker consistencies of grape and mango juices, this may have imparted some protective factors on the microorganisms, hence the higher counts in these samples.

The values obtained in this study are within the range of 102-105 cfu/ml reported for microbial populations in fruit juices (Hatcher et al., 1992). However, the colony counts, which are within the high end of this range, could be an indication of spoilage. Also, high bacterial and mould counts may be indicative of improper hygiene and may perhaps be a result of poor quality fruit being used. The juices were acidic (pH 3.0-3.65), thereby creating a good condition for the growth of yeasts. The isolation of these yeasts from orange juice has been previously reported (Deak and Beuchat, 1993). The pH of fruit juices is usually too low for the growth of pathogenic bacteria (Hatcher et al., 1992), but the incidence of such bacteria in the juices used in this study might not be unconnected with the nature of the juices. All the juices are ready-to-serve fruit juices and the water activity (aw) values are sufficiently high to allow microbial growth (Harley et al., 1996). The presence of *Saccharomyces* can cause unusual flavour in the orange juices. Studies have shown that *Saccharomyces* can metabolize ferulic acid found in fruit juices to form 4-Vinylguaiacol, thereby producing the off flavours in the juices (Sutherland *e*t al., 1995). However, since many species of *Saccharomyces* are used in the production of food commodities (Ray, 1996). The genus is generally not considered a safety concern. Members of the genus are known to be useful sources of lipids, proteins and beta-carotene (Ray, 1996).

Maintenance of proper hygienic conditions and use of good quality fruits and water will certainly improve the microbiological quality of juices, and make them acceptable to quality conscious markets both locally and abroad. Establishment of quality control unit/ laboratory becomes imperative to detect contamination of either the raw materials or the products early enough. In addition, operators in this sector should utilize the technical assistance of NAFDAC towards attaining acceptable quality standard. Recent findings have shown that some NAFDAC approved sachet water produced by small-scale industries in Nigeria attained acceptable microbiological standard (Lateef and Yusuff, 2002).

CONCLUSION

In biotechnological development microbiological criteria are best applied as part of a comprehensive program. When criteria are not applied as components of a systematic approach to food safety or quality, the results are not satisfactory. In industrial production of fruit juice HACCP should always be taken into consideration in other to meet the microbiological standard for the product. The counts obtained for the samples compare favourably with those for the imported concentrate. Hence, the safety of the products is guaranteed. Freeze drying and rotary evaporation have been shown to not only be useful for reduction of moisture but also reduction of microbial load in fruit juices.

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