Working Paper

Mainstreaming Climate Change into Agricultural Education:

Challenges and Perspectives

Sebastian Chakeredza, August, B. Temu, Aissetou Yaye,
Steven Makungwa, John, D.K. Saka

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Foreword

Good education should provide solutions to development challenges. There is a strong positive correlation between levels of education and economic development in any given country. The major challenges facing humanity currently are associated with the negative effects of climate change, particularly in sub-Saharan Africa (SSA). Climate change is adversely affecting practically all economic sectors. Africa is projected to have a future associated with scarce water, declining agricultural yields, encroaching desert and damaged coastal infrastructure. The prognosis on the negative effects of climate change for SSA is therefore very grim.

It is gratifying to note that African educators themselves are taking a leading role in assessing what needs to be done for our educational institutions to make a significant contribution in providing solutions to the challenges posed by climate change. This Working Paper is an outcome of a symposium organized to share information on climate change challenges for agriculture in SSA; explore methods of mainstreaming climate change knowledge into agricultural education; and identify recommendations on effective policies, institutions and capacity.

The Working Paper lays down the key issues in climate change: who is affected and what direction we are taking if the negative effects presented by climate change are not checked. It presents a compelling argument on the role of tertiary education in making meaningful contributions and goes further to present a very reasonable action plan to be followed if we are going to keep on track with climate change adaptation and mitigation strategies.

The recommendations proposed in this Working Paper should be taken seriously by tertiary agricultural and natural resources management institutions in the whole of SSA and indeed governments in the sub-continent on mainstreaming climate change. Only if the educational institutions, in tandem with governments in Africa, take a leading role in combating the challenges posed by climate change to rural livelihoods, can we begin to see progress in this area.

The symposium was a first of its kind where tertiary agricultural and natural resources management institutions in SSA have taken a leading role in exploring mechanisms by which climate change can be integrated in our institutional curricula. I congratulate ANAFE and our educators for being pro-active and would like to take this opportunity to recommend that governments and development institutions provide all the necessary support to ensure that the implementation plan suggested in this Working Paper bears fruit.

Professor Z.D. Kadzamira
Vice Chancellor University of Malawi

Acknowledgements

This Working Paper highlights the key outputs from the work presented by various scientists at the Climate Change Symposium of the African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE), held in Lilongwe from the 28th of July to the 1st of August, 2008. We are glad that so many scientists found the issue topical and were willing to make stimulating contributions. Over 100 participants from across sub-Saharan Africa and beyond participated in this symposium.

We are grateful that the University of Malawi through Bunda and Chancellor Colleges managed to host this symposium in Lilongwe. We thank the Organising Committee headed by Prof V.W. Saka of Bunda College, University of Malawi for working tirelessly to ensure that the symposium was a success.

We also thank our many sponsors including but not limited to the following: University of Malawi; ANAFE; ICRAF; CTA; FARA, ITOCA and UNDP for generously sponsoring the conference in various ways.

This Working Policy contains information which will remain a useful reference point for workers in the area of Climate Change.

Acronyms and formulas

ANAFE	African Network for Agriculture, Agroforestry and Natural Resources Education
AU	African Union
CBD	Conservation of Biodiversity
CDM	Clean Development Mechanism
CFC	Chloro-fluoro carbon
CGIAR	Consultative Group on International Agricultural Research
CH_4	Methane
CO_2	Carbon Dioxide
COMESA	Common Market for Eastern and southern Africa
COP	Conference of Parties
CTA	Technical Centre for Agriculture and Rural Cooperation, The Netherlands
ECOWAS	Economic Community of West African States
FAO	Food and Agricultural Organisation
FARA	Forum for Agriculture Research in Africa
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
ICRAF	World Agroforestry Centre
IPCC	Intergovernmental Panel on Climate Change
ITOCA	Information Training and Outreach Centre for Africa
MEA	Millennium Ecosystem Assessment
NAPA	National Adaptation Plan of Action
NARI	National Agricultural Research Institute
NEPAD	New Partnership for Africa's Development
NRM	Natural Resources Management
R&D	Research and Development
REC	Regional Economic Communities
SADC	Southern Africa Development Community
SASACID	Strengthening Africa's Strategic Agriculture Capacity for Impact on Development
SSA	sub-Saharan Africa
TAE	Tertiary Agricultural Education
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

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Introduction

Climate change is global in its causes and consequences. Through advanced modelling, patterns of change in the world climate have been observed over time. These model results have shown that compared to the pre-Industrial era, the world temperature has warmed by half a degree centigrade. The major causes for this warming have been attributed to the rising stocks of greenhouse gases in the atmosphere including carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), chloro-and fluoro-carbons and a number of other gases that arise from industrial processes. The current level or stock of greenhouse gases in the atmosphere is estimated to be equivalent to 430 parts per million (ppm) of carbon dioxide compared to 280 ppm before the industrial revolution (Stern, 2006). If we continue with business as usual, it is predicted that by the end of 2035, there would be a 2°C increase in temperature. It is clear that climate change will impact heavily on agriculture and renewable natural resources. This means that our current practices may have to change significantly to adapt to and mitigate the changes.

It has long been perceived throughout the world, that Higher Education plays a critical role in preparing and providing the leadership to meet these challenges and to stimulate sustainable development (Bloom et al., 2005). In SSA, Higher Education in agriculture and natural resource management (NRM) in particular is well placed to contribute to this process.

Despite past investments by African governments in Higher Education, the hope that Universities would provide solutions to Africa's problems is yet to be realized. There has been an enormous loss through emigration of talented faculty to other continents. It is estimated that 23,000 qualified academic professionals emigrate from Africa each year in search of better working conditions (BASIC, 2006). Many of these are in agriculture and natural resources—areas that are of crucial economic importance for most African countries. In addition to these challenges, it is also accepted that the current curricula, teaching and learning methods are unsuitable for achieving the objectives of agricultural education.

The African network for Agriculture, Agroforestry and natural Resources (ANAFE) whose assigned mission is to improve the quality, relevance and application of tertiary agricultural education organized this symposium with the support of various partners.

The symposium objectives were to:

1. Understand the climate change challenges for agriculture in SSA
2. Discuss mechanisms for mainstreaming climate change knowledge into agricultural education and
3. Identify recommendations on effective policies, institutions and capacity.

One hundred participants comprising policy makers, financiers, educational managers and teachers at tertiary level in agriculture, forestry or NRM and those from agricultural research and industry participated in the symposium. Their thoughts on the issues of climate change and the associated issues of conservation of biodiversity and global shift towards bioenergy and how all these can be integrated in the curricula of tertiary agricultural institutions are contained in this Working Paper.

The purpose of this Working Paper is to inform, guide and support the development of responsive teaching programmes and capacity, and to stimulate more research to address climate change issues. Policy makers, education managers and the academia will need to establish a common platform for an integrated and coordinated response. Inter-sectoral cooperation and regional collaboration are also important.

Climate Change: the key issues

Global warming and implications on livelihoods

Climate change across the globe is real. The causes have now been documented and each day, the body of knowledge on the causes and consequences of climate change is being expanded. It is known that global warming which is the major cause of climate change is caused by the accumulation of greenhouse gases in the atmosphere (Saka, 2008). Figure 1 shows worldwide total emissions by industry in 2000.

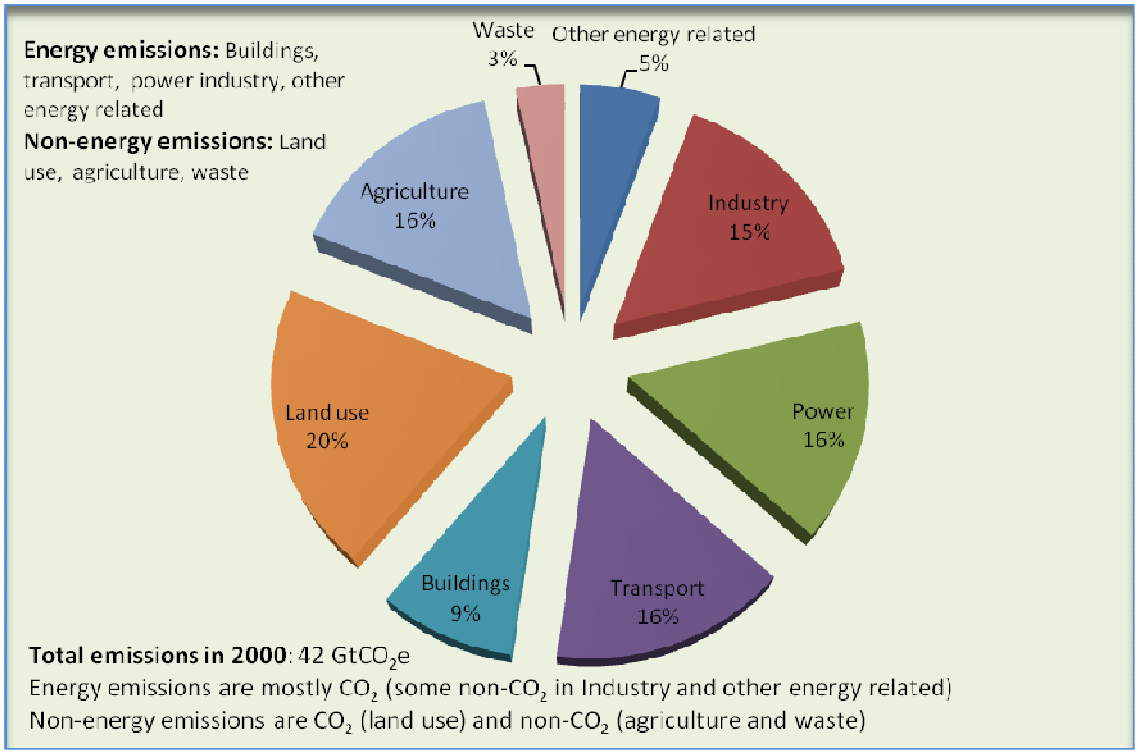


Figure 1. Greenhouse gas emissions in 2000, by source. Data adapted from Stern (2006)

With the current accelerating levels of emissions with fast-growing economies investing in high carbon infrastructure and as the demand for energy and transport increase, it is envisaged that there is between a 77-99 per cent chance that by about 2035, the world would have warmed by greater than 2°C (Stern, 2006). These changes are likely going to negatively impact on food production, health and the environment around the globe.

Over the 1900-1999 period, the emissions of anthropogenic CO_2 from fossil fuel combustion show that Europe and the United States were the greatest contributors (Figure 2).

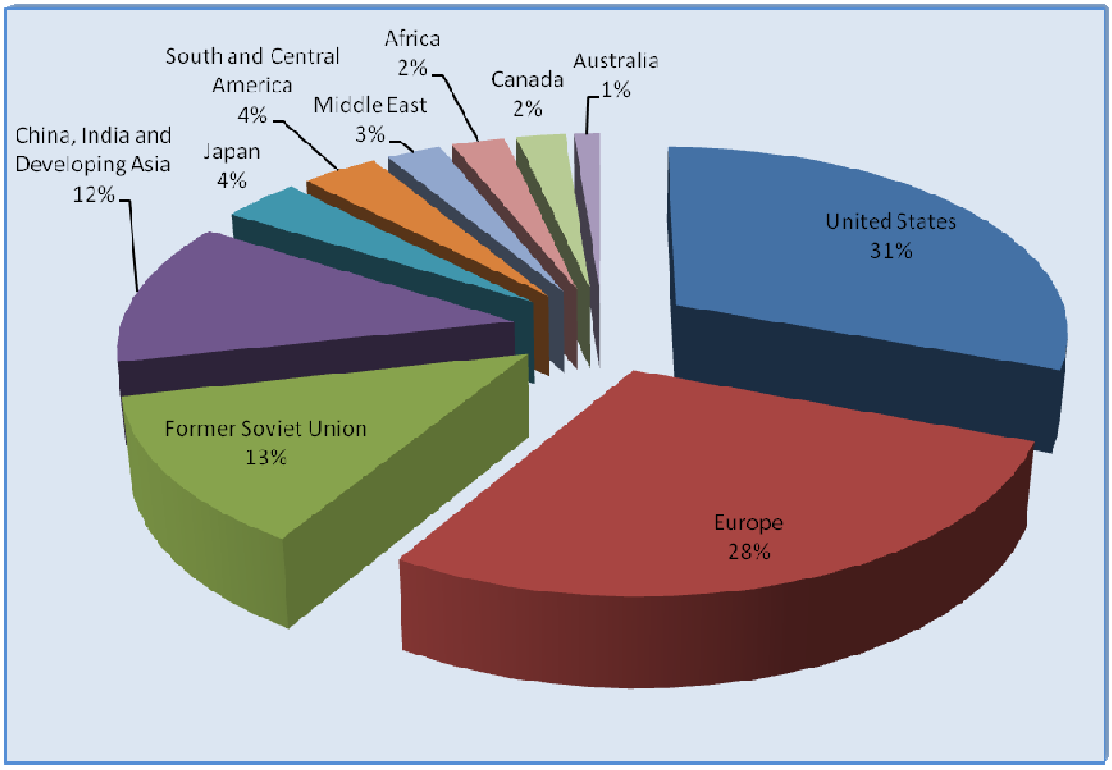


Figure 2. Anthropogenic CO_2 emissions by different countries/continents from 1900-1999. (**Data Source:** Saka, 2008)

Africa's contribution of 2 % is very small when compared with the industrialized countries. In any case, the major contributors are perhaps South Africa, Egypt and Nigeria. With increasing human activities, it is projected that greenhouse gas emissions will increase considerably over the coming years and by the year 2035, out of an estimated 11.7 billion tonnes of carbon that will be emitted, developed countries will contribute 50 % and developing countries the other 50 % (Saka, 2008). This significant shift in greenhouse gas (GHG) emissions has important implications for Africa and the world at large.

Warming may induce sudden shifts in regional weather patterns such as the El Niño phenomenon. These are changes that would have severe consequences for water availability and flooding in tropical regions and threaten the livelihoods of millions of people.

Most countries in SSA are already experiencing a number of adverse climatic hazards including dry spells, seasonal droughts, intense rainfall, riverine floods and flush floods. Some of these, especially droughts and floods have increased in frequency, intensity and magnitude over the last two decades, and have adversely impacted on food and water security, water quality, energy and the sustainable livelihoods of rural communities (Kandji *et al.,* 2006).

Agriculture is a very important sector in the whole of SSA in terms of subsistence, contribution to Gross Domestic Product (GDP), employment and foreign exchange earnings (Diao *et al.,* 2006). It is common knowledge that farmers in SSA, are struggling to cope with the current climate variability. With continued adverse climate change therefore, there will be decreased food production. It is predicted that the declining crop yields in SSA could leave hundreds of millions without the ability to produce or purchase sufficient food.

In addition to the effects on food production, vector borne diseases such as malaria and dengue fever could become more widespread if effective control measures are not in place. This could increase the already negative impact of HIV/AIDS on food production. Rising sea levels will also result in tens to hundreds of millions more people flooded each year. Ecosystems and biodiversity will be particularly vulnerable to climate change, with around 15-40 % of the species potentially facing extinction after only 2°C of warming. Ocean acidification, a direct result of the rise in CO_2 will have major effects on marine ecosystems, with possible adverse effects on fish stocks.

We cannot continue with business as usual approach if we want to stabilise the GHGs. Stabilisation at whatever level requires that annual emissions be brought down to the level that balances the earth's natural capacity to remove greenhouse gases from the atmosphere. In the long term, annual global emissions will need to be reduced to below 5 $GtCO_2e$ (gigatonnes of carbon dioxide equivalent emission), the level that the earth can absorb without adding to the concentration of the GHGs in the atmosphere.

Reversing the historical trend in emissions growth is a major challenge. Greenhouse-gas emissions can be cut in four ways:

- Reducing demand for emissions-intensive goods and services
- Increased efficiency which can save both money and emissions
- Action on non-energy emissions, such as avoiding deforestation and ecosystem degradation
- Switching to lower carbon technologies for power, heat and transport

Graduating students in tertiary agricultural institutions in SSA need to have a good grasp of the science of climate change, its effects on the livelihoods of the communities including the mitigation and adaptation options available for cutting the GHG emissions.

Agro-biodiversity

Agricultural biodiversity can be defined as: "the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of an agricultural ecosystem, including its structure and processes" (adapted from CBD, 2000). Agro-biodiversity is central to human existence. It is the basis of humankind's ability to feed, clothe and heal itself. Farmers, rural communities and indigenous people around the world maintain the diversity of crop, forages, livestock, tree products and fish and the many other plant, animal and microbial species found in and around their production areas and depend on it to provide food, fuel, medicine and other products (Rudebjer *et al.,* 2008). Thus biodiversity is recognized as a strong foundation for livelihood support and sustenance. Any threat to biodiversity will have impact on livelihoods.

The Millennium Ecosystem Assessment (MEA, 2005) has established that to meet demands for food, fresh water, timber, fibre and fuel, human activity in SSA has altered ecosystems. The report concludes that about 60 % of the "ecosystem services" in SSA are being degraded or used unsustainably. These trends will present challenges and can be devastating for ecosystem function services and small-scale farmers in Africa because loss of agro-biodiversity results in the loss of many products which are used as part of farmers' livelihood strategies.

Climatic changes, in combination with other drivers, are expected to substantially alter agricultural biodiversity. At species level, biodiversity which is already endangered or vulnerable will face an increased extinction rate. There will also be a loss of intra-specific diversity and disappearance of marginal plant populations. This can be particularly serious for wild relatives of crops, which may

contain valuable genes for plant breeding programmes for increasing heat and drought resistance or resistance to pests and diseases.

In 2007, Bioversity International commissioned a survey to evaluate how plant genetic resources and agro-biodiversity are being taught in universities in eastern and southern Africa (Muluvi *et al.,* 2008 cited by Rudebjer *et al.,* 2008). The countries surveyed included Kenya, Zimbabwe, Malawi, Zambia and Uganda. The results showed that none of the surveyed universities offered comprehensive agrobiodiversity programmes at undergraduate or graduate level. There is an urgent need to incorporate agrobiodiversity in the tertiary agricultural education programmes.

Bioenergy production

There is a drive worldwide to find alternative fossil fuels. This is in an effort to reduce carbon emissions and also to find new markets for agricultural products (Van Zyl *et al.,* 2008). The major focus has been on the production of biofuels. By definition, a biofuel is any solid, liquid or gaseous fuel produced directly or indirectly from biomass, such as straw or grasses. Agro fuels are obtained as products of agriculture biomass, by-products of farming and or industrial processes of agriculture linked raw materials. The term covers mainly biomass materials derived directly from crops and agriculture, agro industrial and animal by-products such as dung, maize and soya. As a nearly carbon-neutral source of energy, most bio-energy systems can contribute to climate change mitigation through the carbon sequestration of bioenergy plantations. Agrofuels are made from sources which often represent major staples in Africa.

Charcoal production is causing irreparable damage to the environment

A current debate in SSA involves the extent to which the sub region should embrace biofuel production. It is projected that the production of agrofuels can lead to further clearing of land as well as the reduction of human food production. For instance, a 10 % substitution of petrol and diesel is estimated to require 43 % and 38 % of current cropland area in the US and Europe, respectively. These figures are not likely to be different for SSA. Substitution at this level would require in addition to existing arable land, clearing of forests and grasslands. It is argued that clearing of forest would create a large upfront emissions cost that would outweigh the net reduction in carbon emissions from fossil fuels. Jatropha (*Jatropha curcas*), a widely acclaimed biofuel crop touted as ideal for growth on “degraded land” is widely considered a weed and is potentially an invasive species. Experts must assess ecological risks before introducing biofuel crops.

There is a need for SSA governments to approach the issue of biofuels cautiously (Jumbe and Msiska, 2008). It is recommended that SSA needs to:

- Develop comprehensive national biofuels policies and plans in consultation with stakeholders including regional economic communities (RECs) such as SADC, ECOWAS, and COMESA, and with AU/NEPAD;
- Make wise selection of biofuel species and develop appropriate agronomic standards for guaranteed productivity, profitability and with minimal negative effects,
- Raise the resources for infrastructural development for production, processing, storage, transporting and marketing of biofuels products,
- Commit resources for research and development (R&D), capacity-building and technical support, and
- Establish regulatory and institutional frameworks that provide the incentives for private sector participation in the development of the biofuel industry.

Bioenergy is a new area which integrates different disciplines. There is a need to integrate Bioenergy into agricultural learning so that graduating students appreciate its socio-economic role in the livelihoods of communities in SSA.

Adaptation strategies

To deal with the negative effects of climate change there are a number of adaptation strategies that can be adopted in different situations. Adaptation to climate change is a process through which people reduce the adverse effects of climate on their health and well-being and take advantage of opportunities that the environment provides. Saka (2008) notes that adaptation measures to climate change among communities have been considered with two broad activities in mind: i) measures that reduce vulnerability and ii) Measures that increase resilience through the utilization of the available common assets.

At the national level, there is a need to implement policies and strategies that avert the undesirable effects and impact of climate change on different sectors of economic growth. At local farm level, these can be distinguished for the crops, forestry and livestock sub-sectors. Changes in land-use and changes in crop and livestock management strategies will have to take place. Examples include a) changes in cultivated land area, b) changes in crop types, c) growing crop species or varieties with higher thermal requirements or those that are tolerant to drought and floods, d) changes in crop location, e) intensive and extensive use of irrigation water and improved fertilizer use efficiency to counter the effects of droughts, periodic water stress and low soil fertility conditions, f) control of insect pests and diseases associated with floods and droughts, g) improvements in soil management practices to reduce surface runoff and soil erosion h) establishment and creation of food grain reserves at farm and community levels for safe-keeping and storage of harvested produce, and i) diversifying species and intercropping crops with trees to benefit from improved micro-climate and tree products and services. These adaptation strategies need to be taken in tandem with government policies and strategies of poverty alleviation and food security.

A number of organisations worldwide, for example FAO are promoting the use of indigenous and locally adapted plants and animals as well as the selection and multiplication of crop varieties adapted or resistant to adverse conditions. The selection of crops and cultivars with tolerance to abiotic stresses (e.g. high temperatures, drought, flooding, high salt content in soil, pest and diseases) allows harnessing genetic variability in new crop varieties. National programmes should have capacity built and long-term support to use these options.

Agroforestry can enhance adaptation to climate change through provision of diversified tree products and services

Mitigation strategies

Since it has been demonstrated that GHG emissions resulting from man's activities are responsible for global warming and subsequent changes in the climate system, there is a need to identify measures for limiting greenhouse gas emissions into the atmosphere. There is a need to use cleaner technologies that do not emit a lot of GHGs or provide sinks for the emitted GHGs. Most of the mitigation measures will be in the energy sector through use of cleaner technologies, forestry sector through reafforestation and the agriculture sector through improved fertilizer application, crop and livestock management.

In the forestry sector strategies include planting of tree species in woodlots, forestry plantations, on-farm boundary planting and other agroforestry systems. In the energy sector, strategies would include biomass-based technologies such as use of i) wood fuel in improved mud stoves and ceramics, ii) biogas fuel from bio-wastes to produce biogas for cooking and heating, and iii) briquettes for cooking instead of wood. The non-biomass based strategies would include i) rural electrification through grid extension, ii) mini-hydropower, iii) compact fluorescent lamps for lighting, iv) renewable energy sources (solar cookers and heaters) and v) wind power for pumping water.

For the agriculture sector, strategies to reduce the GHG emissions include: i) incorporation of crop residues into the soil instead of burning, ii) good management of livestock manure to reduce methane emissions and proper management of nitrogenous fertilizers in rice and upland agricultural soils to reduce nitrous oxide emissions.

Some scientists think mitigation of climate change needs a more radical approach. The Royal Society Academy in England has written a series of papers in "Philosophical Transactions" proposing "geoengineering" as a way of buying time for the transition to a low-carbon economy to take place in an orderly manner (Schneider, 2008). Broadly the ideas fall into two categories: one is to remove excess CO_2 from the atmosphere while the other is to compensate for climate-warming greenhouse effects the CO_2 and other gases cause, by reducing the amount of sunlight reaching the ground. The strategies include increasing photosynthesis to wipe out excess CO_2 through planting more trees and also through encouraging increased phytoplankton growth which eventually will sink to the bottom of the ocean and not release the carbon. The CO_2 can also be recycled into fuel through a reaction with H_2 or it can be ejected from the atmosphere using the planet's magnetic field. The stratosphere can also be deliberately polluted with sulphate in order to reflect solar heat into space. These ideas are all being tested and if they can be proven to be satisfactory, with predictable long-term effects, they could offer mankind the space and opportunity to think through more sustainable mitigation strategies to the challenges posed by climate change.

It will be important that students in tertiary agricultural institutions have a good understanding of the issues surrounding climate change mitigation and the new concept of geoengineering.

Fuel efficient stoves are being promoted to reduce the rate of deforestation

Status of climate change in agricultural higher education

Education to development linkage

Temu *et al.* (2003) describes the linkage between education and society. Education can be described as the process of preparing an individual to become a functional and acceptable member of society. Two concepts are inbuilt in the definition of education, namely: creation of knowledge and experience, and growth and development. Unless tertiary agricultural education (TAE) is able to respond to societal challenges and expectations, society will also have difficulties in understanding the roles of TAE (Figure 3).

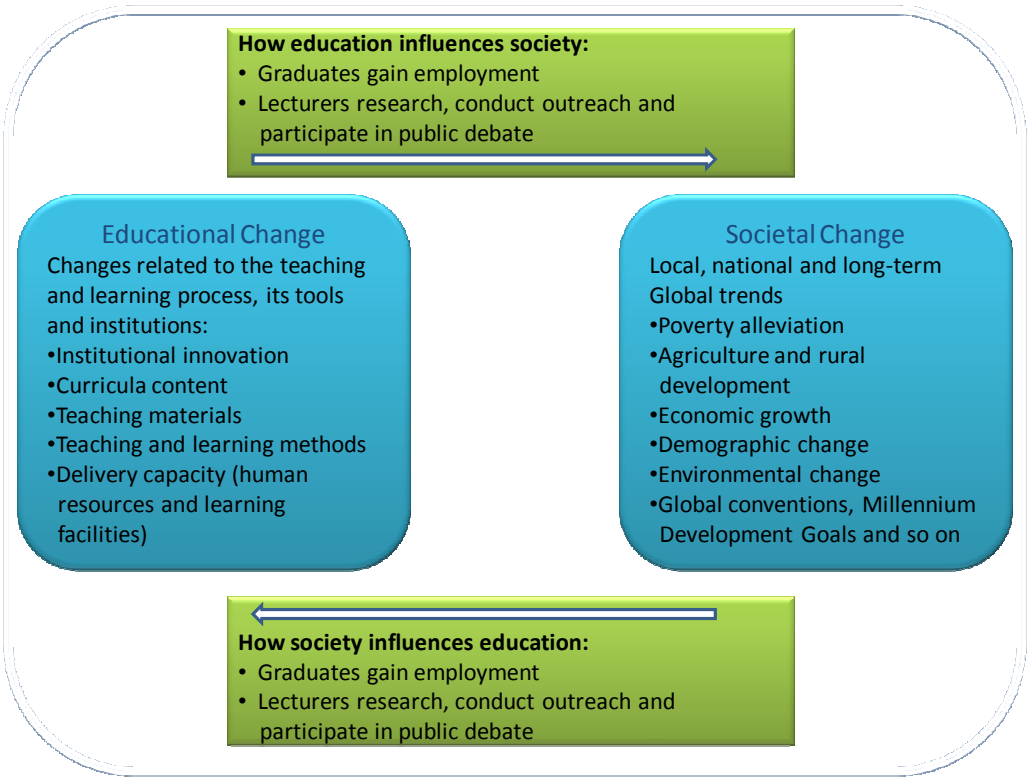


Figure 3. Responding to and influencing change; a model of the dynamic interaction between society and education. **Source:** Rudebjer *et al.* (2005).

Society is today presented with climate change challenges. If education is going to make a contribution to the current challenge then there should be institutional innovations and changes to ensure that graduates produced from the tertiary agricultural institutions are abreast with the climate change issues including mitigation and adaptation strategies. The curricular content, teaching materials and methods and delivery approaches should be designed in such a way as to equip the student with the necessary skills and knowledge to tackle these global challenges and their interpretation in specific local situations. ANAFE has noted that learning materials are generally not adequately contextualised in the local African environment. This is true for many agricultural subjects and for climate change. This implies that the tertiary education institutions are not responding adequately to societal challenges.

Shortfalls in current Tertiary Agricultural Education

The shortfalls in tertiary agricultural education have been described by for example by Temu *et al.* (2003) and Chakeredza *et al.* (2008). Against the background of the current brain drain, it is observed that among other problems, the major constraints in tertiary agricultural education are as follows:

- Poor staffing of institutions to meet the desired curriculum coverage
- The training is predominantly based on curricula adopted from countries that had colonies in Africa. The curricula were founded on an agricultural philosophy that aimed at the production of cash crops for consumption by the colonising countries.

- Teaching mode is not learner-centred
- There is very little interaction with farming communities. In fact, most of the universities are located in towns where there are no farming communities to work with nearby. In most cases the farming community is not involved in the design and delivery of agricultural curricula, and
- There is absence of Private Sector involvement in the design and delivery of agricultural curricula

As a result, it is not surprising that SSA tertiary agricultural institutions have so far done very little in the integration of climate change issues into tertiary agricultural education. There is a need to rethink and transform the tertiary agricultural education system so that it becomes responsive to the needs of the society. From the ANAFE symposium of 2003, Temu *et al.* (2003) suggested a framework which could be followed to address shortfalls in tertiary agricultural institutions. The findings and recommendations are still relevant today as they were in 2003 and need to be addressed as we move into the future. Through its network of universities, ANAFE has further developed a new programme dubbed SASACID (Strengthening Africa's Strategic Agricultural Capacity for Impact on Development). This visionary programme addresses all the major key weaknesses in African agricultural education (http://www.anafeafrica.org). The challenge is for countries to play their roles in the transformative programme.

The need for climate change in the curricula

Increasingly, climate change is becoming a challenge to agricultural production because it increases risks and uncertainties for farmers. There is a need for graduating agricultural students to be well-versed with the challenges posed by climate change if they are going to advise the communities they will be working with appropriately. They also need to understand the implications of climate change to economic development and international trade.

Educating those currently at school about climate change will help to shape and sustain future policy-making. Studies on climate change have so far been limited to adaptation and mitigation intervention strategies. Faculty and students should be able to contribute to the development of the body of knowledge as regards climate change.

Students should be aware of the various International Conventions and Protocols surrounding climate change. These include UN Framework convention on climate change (UNFCCC), Kyoto protocol and a range of other informal partnerships and dialogues that provide a framework that supports co-operation, and a foundation from which to build further collective action. The challenges are to develop good curricula, produce relevant learning resources and capacitate educators.

The way forward

Implementation of global agreements relating to climate change

The world needs to cooperate if climate change challenges are going to be addressed. In 1992, many countries signed the United Nations Framework Convention on Climate Change (UNFCCC) which obliges parties to periodically update and publish inventories of anthropogenic emissions of all GHGs. The aim of the UNFCCC is to stabilise GHG concentrations in the atmosphere at a level that would prevent dangerous human-induced interferences with the climate system. This information is communicated to the Conference of Parties (COP) in the form of "National Communications" based on five broad considerations: i) National circumstances/context, ii) National GHG inventory, iii)

Vulnerability and adaptation assessments, iv) Greenhouse gas mitigation and abatement analyses and v) Constraints and gaps and related financial, technical and capacity needs. Further, concerted efforts are needed to mainstream climate change into various sectoral policies, strategies and programmes, including agricultural education at all levels of learning.

It is also clear that many conventions, agreements and protocols have aspects relating to climate change. In Table 1 we present some of the more important and related conventions and their main functions.

Table 1. International Institutions and Processes concerning climate change

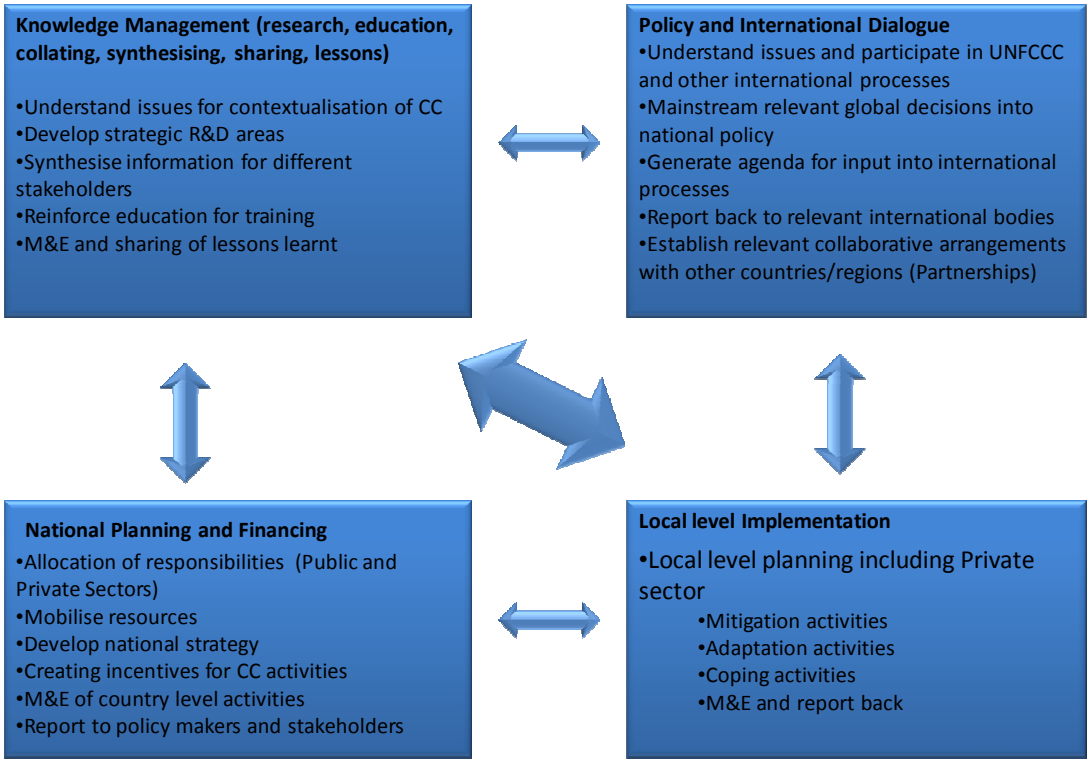
Convention	Functions
IPCC, Intergovernmental Panel on Climate Change	Puts together data concerning climate change and guides UN actions and negotiation processes.
UNFCCC, United Nations Framework Convention on Climate Change (1992)	The UNFCCC provides a framework for policy to deal with climate change.
Kyoto Protocol (1997)	Highlights adoption of climate change convention and specific commitments developed by individual countries. It deals with reduction of greenhouse gas emissions from developed countries through non-domestic sources. Development of mechanisms for carbon trading and joint implementation activities. Also highlights adoption of climate change conventions and specific commitments by countries.
COP, Conference of Parties	Convenes meetings of stakeholders with interest to implement mitigation and adaptation activities. COP 1 up to 11 have been conducted. COP is interested in institution structures and financial mechanisms including social networks, and access to resources. Has particular interest on climate change impact on the rural poor, particularly looking at ways of reducing environmental risk, strengthening of livelihood activities and minimizing stress to social institutions.
CDM, Clean Development Mechanism	This was created by the Kyoto Protocol as the formal channel for supporting low-carbon investment in developing countries. It allows for both governments and private sector to invest in projects that reduce emissions in fast-growing emerging economies and provides one way to support links between different regional emissions trading schemes.
UN adaptation fund	Created under the UNFCCC, this is an instrument under the Global Environmental Facility to assist developing countries to adapt to climate change

Source: Temu and Chakeredza (2008)

There is a need to ensure that these protocols are enforced and the agreements are binding. Within each country there is a need for a common system for supporting and monitoring implementation.

Institutional arrangements

There is a need to identify the key players at country level regarding climate change knowledge management issues. The key issues identified at the symposium include: **knowledge management** (research, education, collating, synthesising and sharing lessons); **Policy and international dialogue**; **National Planning and Financing**; and **Local level implementation**. The key issues under each area are presented in Figure 4. There is also a need to ensure coordination, synergy and regional collaboration on climate change education and research.



CC, climate change; M&E, Monitoring and evaluation; R&D, Research and development; UNFCCC, United Nations Framework Convention on Climate Change.

Figure 4. Framework for climate change Institutionalisation in SSA

Source: Temu and Chakeredza (2008)

Integrating climate change into agricultural curricula

Climate Change should be integrated into the curricula of tertiary agricultural institutions as a matter of urgency. There is need for concrete scientific data based on African experiences to be infused into the curricula. The suggested areas of emphasis are as presented in Table 2. The curricula can be handled as a separate subject or infused and integrated into the various agricultural and natural resources management subjects. The recommended teaching and learning methods should be lectures (including guest lectures), seminars, group discussions, visits to sites demonstrating the impact of climate change and or adaptation and mitigation work in progress, on-farm discussions and surveys. eLearning enhanced with research repositories can also be pursued where possible.

Disciplines could also be selected with the greatest potential to deliver on mainstreaming climate change into tertiary agricultural and natural resources management education. The objective will be to ensure that graduating students in agriculture and natural resources management fully understand and grasp the implications of climate change on the whole global economy. The thrust should be towards building a cadre of academics and researchers with appropriate knowledge and skills on the key issues affecting society and be in a position to advise policy makers, educational establishments and practitioners.

Table 2. Integrating climate change into the curriculum

Area	Aspects to be covered
Introduction to Climate change	Implications of climate change to people's livelihoods and the world economy.
Global warming	The causes of global warming and projections under different scenarios.
Agrobiodiversity	The need to maintain agrobiodiversity under climate change threat; Impact of land use change on agrobiodiversity at ecosystems, species and within-species levels; Adaptation to climate change: agrobiodiversity options; Approaches for putting adaptation strategies into practice in research, extension and policy implementation.
Biofuels	The need for reduced carbon emissions. Alternative fuel production with special focus on biofuels. Socio-economic implications.
Adaptation Strategies	Options available to adapt to the adverse effect of climate change by different groups of people.
Mitigation Strategies	Current thinking on climate change mitigation strategies. Reduction of carbon emissions; Geo-engineering concepts and practices
Global policy issues on climate change	Global policy framework. UNFCCC; Kyoto protocol; CDM; NAPA

CDM, Clean Development Mechanism; NAPA, National Adaptation Plan of Action; UNFCCC, United Nations Framework Convention on Climate Change.

Action plan

The symposium participants formulated an action plan detailing what needs to be done, when and by who to address the key issues raised. These are elaborated in Table 3 by subtheme. It will be important that all key institutions in SSA are brought on board to champion this implementation framework plan suggested at the symposium.

- Coping with climate change and building the capacity to compete globally
- Conservation of biodiversity and sustainable agricultural production
- Global shift towards bioenergy production and
- Effective agricultural institutions

Table 3. Schedule for proposed action plan

Recommended Actions	When[1]	Responsibility	Comments
Coping with climate change and building the capacity to compete globally			
Develop and adjust policies at all levels to ensure that climate change is integrated in tertiary agricultural education	Short term	Policy makers at the local, country and regional levels; Universities and Colleges teaching agriculture and NRM	A significant development that will place the climate change agenda into proper context
Develop climate change curricula to be offered either as a standalone course or integrated within other courses	Medium term	Universities and Colleges teaching agriculture and NRM	This will form the basis of course delivery and modification with acquisition of new knowledge
Support educators to develop relevant teaching materials in climate change	Medium term	Universities and Colleges teaching agriculture and NRM; Investors; NARIs; CGIAR.	This will be a necessary backup for course delivery
Promote research to enhance the knowledge base on climate change	Medium to long term	Universities and Colleges teaching agriculture and NRM, Private Sector, Investors	The knowledge base on climate change needs to be continually developed and updated
Promote collaborative research projects for enhanced agricultural productivity in SSA	Medium to long term	Universities and Colleges teaching agriculture and NRM; CGIAR, Investors; NARIs.	This will provide a foundation on which farmers in SSA can be competitive on a global scale
Conservation of biodiversity and sustainable agricultural production			
Adjust policies at all levels to take into account the importance of agro-biodiversity for sustainable agricultural production in SSA	Short term	Policy makers at the local, country and regional levels; Universities and Colleges teaching agriculture and NRM	Will place into perspective options for future sustainable agricultural production
Integrate agro-biodiversity into the developed climate change curricula	Medium term	Universities and Colleges teaching agriculture and NRM	The place for agrobiodiversity given climate change challenges will be given prominence
Support educators to develop climate change curricula that integrates agro-biodiversity	Medium term	Universities and Colleges teaching agriculture and NRM, Private Sector, Investors; NARIs; CGIAR.	This will form the basis for course delivery
Promote research that maximises the contribution of agro-biodiversity to sustainable agricultural production in SSA	Medium to long term	Universities and Colleges teaching agriculture and NRM; CGIAR, Investors	The knowledge base on use and conservation of agrobiodiversity will be expanded
Global shift towards bioenergy production			
Develop policies that take into account the mitigatory role to climate change and socio-economic impact of bioenergy production	Short term	Policy makers at the local, country and regional levels; Universities and Colleges teaching agriculture and NRM	Will place into perspective the biofuel option for mitigation climate change and for improved livelihoods
Integrate bioenergy production into the developed climate change curricula	Medium term	Universities and Colleges teaching agriculture and NRM	The role of biofuel given climate change challenges will be given prominence
Support educators to develop climate change curricula that integrates bioenergy production	Medium term	Universities and Colleges teaching agriculture and NRM, Private Sector, Investors; NARIs; CGIAR.	This will form the basis for course delivery
Promote research that maximises the contribution of bioenergy production taking into account the socio-economic impact	Medium to long term	Universities and Colleges teaching agriculture and NRM; CGIAR, Investors	The knowledge base on biofuel production will be expanded
Effective agricultural institutions			
Encourage the development of institutional arrangements that link tertiary agricultural education with the communities they serve	Medium to long-term	Policy makers at the local, country and regional levels; Universities and Colleges teaching agriculture and NRM; NARIs; CGIAR.	The perception of the relevance of the Universities and colleges from the stakeholders perspective will be enhanced
Encourage the development of	Medium	Policy makers at the local and	This will ensure continuity of

[1] Short-term is 0-5 years, medium-term is 5-10 years and long term is beyond 10 years.

institutional arrangements that stem emigration of staff members	to long term	country levels; Universities and Colleges teaching agriculture and NRM	institutional management and programmes offered and provide room for expansion.
Promote institutional networking within SSA and also worldwide focusing on climate change and other emerging issues	Medium to long term	Universities and Colleges teaching agriculture and NRM; Investors; NARIs; CGIAR.	This will leverage on capacity available within the network for the benefit of the institutions
Encourage inter- and multidisciplinary approaches to tertiary agricultural education	Short term	Universities and Colleges teaching agriculture and NRM; Private sector	The graduates will develop capacity for integrative thinking
Promote the development of sustainable mechanisms for funding tertiary agricultural institutions.	Medium to long term	Policy makers at the local, country and regional levels; Governments; Universities and Colleges teaching agriculture and NRM; African regional organisations (AU, FARA etc)	Could enable institutions embark on for example, experiential learning and incorporate practical entrepreneurship skills to their students.
Ensure that students studying agriculture and natural resources management have a vocation in those areas.	Short to medium term	Governments; Universities and Colleges teaching agriculture and NRM; African Regional Organisations.	Ensures value for money on investment in training

Conclusions

It is recognised that although tertiary agricultural educational institutions in SSA are expected to advise on solutions to the climate change challenges facing the continent, in their present state these institutions are ill-equipped to move with speed to address these issues. There is currently an urgent need to integrate climate change into the curricula whether as a full-fledged course or as a component within other courses. The graduates of tertiary agricultural education need to have a full grasp of the science of climate change and its implications on the livelihoods of the communities they will be serving. Equipped with the necessary knowledge, the graduates will be able to advise on adaptation and mitigation strategies depending on situation. The graduates will also be able to contribute to the research needs on climate change so that the knowledge base in this area is expanded. At global, regional and local levels, aspects which are key to tackling climate change challenges are those to do with knowledge management; policy and international dialogue, local level implementation and national planning and financing. These need to be streamlined to strengthen the African voice in international environmental negotiations.

"Tertiary agricultural education objective must be to produce graduates who are technologically competent and relevant, equipped with the necessary "soft skills" and business skills and able to work with local, especially rural communities"

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