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Assessing the role of climate-smart agriculture in combating climate change, desertification and improving rural livelihood in Northern Nigeria

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Worldwide emphasis has been placed on designing approaches with regard to the needs of sustainable development. Climate-Smart Agriculture (CSA) is one key agricultural development approach aimed at sustainably increasing productivity and resilience, while also reducing/removing emissions of greenhouse gases. Although many countries will be expected to adopt this approach, its applicability in an African context is not very clear, well studied nor has its sustainability been assessed. We used the Sustainability Assessment of Energy Technologies Framework to assess the applicability of CSA in combating climate change, desertification and improving rural livelihood in an African context. We also assessed the opportunities and constraints to the adoption of this approach in Northern Nigeria. Data was collected using key informant interviews and field observation to assess the current status of agriculture in Northern Nigeria. The results showed that CSA is strong in aspects such as participation and sustainable use of resources but weak in aspects of compensation and equal distribution of benefits and costs. Many small-holder farmers have inadvertently practiced CSA as part of the traditional farming system. While the existence of CSA in current practice is a major element in its favour, the lack of a coherent climate mitigation approach and poor institutional structures are both detrimental. Sustainable agriculture will require a wider societal change towards appreciating the balance between agriculture and environmental change. We suggest four main areas in need of urgent change: political commitment, human and financial investment, incentives and information.

Key words: Climate-smart agriculture, sustainability assessment of energy technologies, desertification, rural livelihoods, northern Nigeria.

INTRODUCTION

Agriculture has been high on the political agenda as it is increasingly recognized as one of the biggest drivers of environmental change (Smith et al., 2007; Liverman and Kapadia, 2010; Foresight, 2011). Agricultural lands occupy about 40 to 50% of the Earth's land surface (Smith et al., 2007). It is estimated that agriculture is responsible for about three-quarters of tropical deforestation (Carr, 2004; Skutsch et al., 2007; Wollenberg et al., 2012) and accounts for about 10 to 12% of the total global anthropogenic emissions of

greenhouse gases (GHGs) in 2005 (Smith et al., 2007). Yet, the world needs more food than ever before to sustain the increasing population of people living in extreme hunger, especially in Africa where about 70% of the people are engaged in some sort of agricultural activity (African Union (AU, 2012). While there is need to redouble efforts in agriculture in order to fight hunger, there is adequate evidence for us to be wary of its environmental sustainability.

The need for a more sustainable approach to agriculture has led to suggestions that agriculture is the key and holds enormous potential to contribute to any strategy to adapt to climate change and reduce emissions particularly in an African context (Garrity et al., 2010; Beddington et al., 2011). To this end, over the last decade, there has been development and promotion of several initiatives aimed at promoting sustainable agriculture (Lichtfouse et al., 2009; Beddington et al., 2012). Many of these have emphasized the need for African farmers to engage in an agricultural system that ensures food security whilst at the same time addressing and adapting to climate change. Also emphasized is the need for policy makers to recognize the nexus between agriculture and environment change, which needs to be balanced and taken into account on decision making for agriculture.

Climate-smart agriculture (CSA) is one approach that has been championed as the “holy grail” of agricultural development (Naess, 2011) ensuring that agriculture is key to climate change adaptation and mitigation (Wollenberg et al., 2011; Beddington et al., 2012). Climate-smart agriculture is derived from the acronym SMART, where S stands for specific, M stands for measureable, A for achievable, R for reliable and T for timely (McCarthy et al., 2012). According to the Food and Agriculture Organization (FAO) (2010), CSA is a method of agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation) while enhancing the achievement of national food security and development goals. There are three main pillars to any CSA approach: the sustainable increase in agricultural productivity and incomes; adapting and building resilience to climate change; and reducing and/or removing greenhouse gases emissions. As such, agriculture is considered to be “climate-smart” when it achieves these three objectives. This concept is therefore a good way to unite the agendas of agriculture, development and climate change under one brand (Neufeldt et al., 2013).

The CSA approach has been widely championed with a rapid uptake of the concept by the international environments and cultures to ensure such community, national entities and local institutions. There is need, however, to assess its applicability in diverse recommendations are more than panaceas (Ostrom et al., 2007). It is not uncommon for similar initiatives to be introduced as a “panacea” encouraging many developing countries to invest scarce resources only to realize the approach is rather not suitable for their society. Having said that, CSA has been applied with positive outcomes in some African societies, namely Yatenga, Burkina Faso; northern Cameroon; and the Nile Delta, Egypt (Food and Agriculture Organization, 2010; Branca et al., 2011). There is even the suggestion that the adoption of CSA practices in northern Nigeria will improve indigenous/traditional agricultural systems as well as encourage the practice of agro-ecological agricultural systems (International Assessment of Agricultural Knowledge, Science, and Technology for Development (IAASTD, 2009). This, however, has not been empirically proven and there are few studies supporting this assertion. Establishing the potential applicability of climate-smart agriculture in the context of developing societies is critical to creating its wide uptake by farmers and enhances the political will required to motivate deep transformations within the policy sector. Yet, there have been no studies assessing the potential of this approach in Nigeria, which is the most populous country in Sub-Saharan Africa.To this end, we ask two fundamental questions: first, to what extent can CSA be said to be sustainable based on sustainability assessment measures? It is important for this to be appraised in terms of its potential influence on the environment, its implications for sustainable development and the potential cultural and socio-economic consequences. Our second question is site specific as we seek to understand what are the enabling political, social and economic conditions needed for the adoption of climate-smart agriculture in Northern Nigeria.

This is a major challenge in itself, considering that great policies have often been undermined by cultural and political factors. Thus, the focus of this paper is to explore the state of agricultural climate change mitigation in Northern Nigeria, with a focus on identifying the feasibility, opportunities and challenges for adopting climate-smart agriculture in the region. Knowledge generated from this assessment will be useful in location-specific information for building knowledge and capacities in climate-smart interventions in similar societies. Lessons learnt will also aid the future adoption of climate-smart agriculture in the region and serve as practical guidance for the implementation of agricultural emissions reduction initiatives, based on experience and best practices. The ultimate purpose is to accelerate efforts

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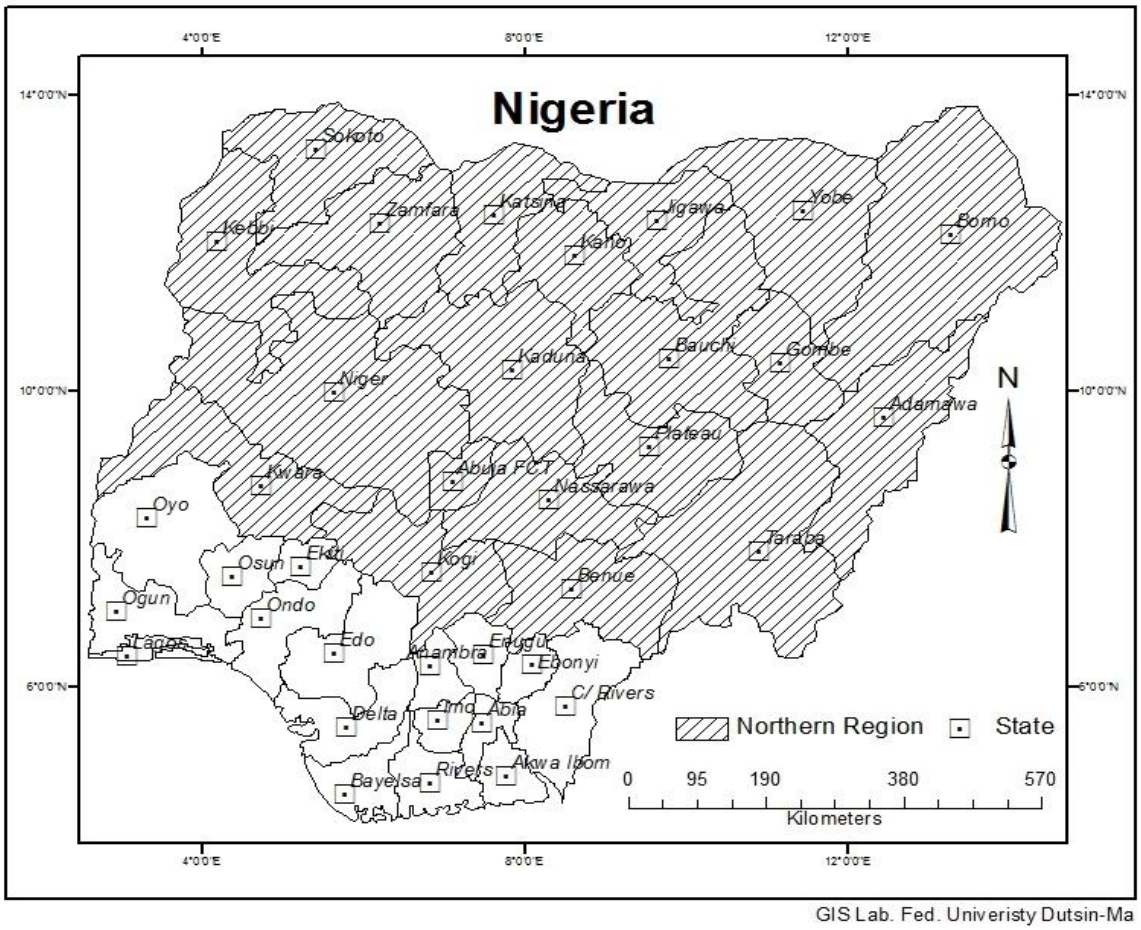

Figure 1. Map of Nigeria showing Northern Region.

towards mitigating agriculture-based climate change while at the same time enhancing livelihoods and food security.

METHODS

Study area

It is estimated that about 70% of the land area in Nigeria geographically belongs to the Northern region of the country (Oladipo, 1993). The region which lies between latitudes 06° 27^{l} N to 14° 00^{l} N and between longitudes 02° 44^{l} E and 14° 42^{l} E is predominantly agrarian, engaging especially in grain farming and cattle rearing. This provides the means of livelihood for the majority of the people. The people of the region, however, are generally regarded to be poorer both in financial and educational terms, than other parts of the country (Omonona, 2009). There are three major climatic belts in northern Nigeria: Guinea Savannah, Sudan Savannah and Sahel Savannah. Rainfall and temperatures vary significantly across the three climatic and ecological zones. Generally speaking, the mean monthly maximum temperature varies between 28 and 40°C. In the semi-arid zones comprising the Sudan and Sahel, the maximum temperatures could be as high as 40°C between March and May while at the lower end the maximum temperatures of 28°C are experienced between December and January (Akor, 2012). According to the Nigerian Meteorology Agency (NIMET)(2008), the northern region has been experiencing lower than normal rainfall but progressively became wetter thannormal in the year 2010 (Figure 1). The annual rainfall in the region ranges from 300 to 1000 mm. There is further evidence suggesting that climate is fast changing. A comparison of the mean temperatures of previous years from 1941 to 2000 was carried out and revealed evidence of long-term temperature increase across the country, especially in the North Nigerian Meteorology Agency (NIMET, 2008). The most significant increases recorded were in the North with average temperatures rising by 1.4 to 1.9°C. Similarly, a comparison of rainfall records from 1971 to 2000, using the combination of the late onset and early cessation of rainfall revealed that the length of the rainy season had shortened in most parts of the country (Building Nigeria's Response to Climate Change (BNRCC), 2011). Also, the study found that between 1941 and 2000, the annual rainfall in most parts of Nigeria has decreased by 2 to 8 mm. Seasonal rainfall and drought are recurring and have become a permanent feature of Northern Nigeria. The dry season, which lasts almost ten months, is very pronounced with rainfall occurring only seasonally but is often intensive, making it necessary for farmers to employ soil moisture conservation techniques.

This paper is based on a case study conducted in the Dutsin-Ma Local Government Area (LGA) in Katsina State, Northern Nigeria. The majority of the inhabitants there are poor, living below the US$1 per person per day threshold. The Local Government Area has a population of 169,829 in about 18,800 households with an

average household income of N18, 989 (US$122). The dominant occupation for people is farming, engaging in the cultivation of crops such as millet, sorghum, cowpea, beans and maize.

Agricultural practice and environmental change in Northern Nigeria

The most common agricultural system in Northern Nigeria has been traditional bush fallowing (Adams and Mortimore, 1997), in which the farmer cultivates a plot, usually for one to three years, and then abandons it temporarily (for a period of three to ten years) to allow the plot to regain soil fertility. Rapid population growth and land shortage, however, have drastically reduced the amount of arable land available to farmers, reducing fallow periods considerably and in most cases, continuous cultivation has emerged. Farmers have thus continually engaged in slash-and-burn by cutting down the vegetation on plots and then setting fire to the remaining foliage, using the ashes to provide nutrients to the soil for planting food crops. This system of agriculture is a main source of deforestation and a major cause of draught, desertification and climate change in northern Nigeria (Farauta et al., 2011). This situation is further aggravated by the overgrazing of lands by nomads moving southward from the ravaging draught in the Sahara Desert. The rate of desert encroachment in the region is put at 0.6 km per annum while the rate of deforestation is about 350,000 ha p/a (Federal Ministry of Environment (FME), 2000). There is little doubt that agriculture as practiced currently in the region contributes to climatic change (Chianu, 2004).

Successive Nigerian governments have attempted to mitigate the impacts of climate change and desertification in the region by formulating and implementing policies. Recent policies include: the National Erosion and Flood Control Policy; the National Environmental Sanitation Policy; the National Forestry Policy; the National Drought and Desertification Policy and the National Policy on E-Waste Control and Management (Medugu, 2012). These policies, however, have failed to yield the required results. There are a number of reasons adduced to explain the failure of past policies. Firstly, the policies only focused on mitigating the immediate impact of desertification without addressing it holistically, including the causes of desertification, which comprise over-exploitation of natural resources, especially natural vegetation and water sources for domestic and commercial purposes (Oladipo, 1993; Audu, 2013), and unsustainable agricultural practices which result in decreased crop productivity and emission of greenhouse gases in the atmosphere (Farauta et al., 2011; Ifeanyi-Obi et al., 2012). Secondly, there was a lack of provision for long-term measures and opportunities for the people and in particular the most vulnerable groups, such as women and children, in the region to cope with the impacts of climate change and desertification (Andrade et al., 2011; Falaki et al., 2012). Lastly, there was a lack of incorporation of indigenous livelihood practices and initiatives in agricultural policies, especially those aimed at combating climate change and desertification phenomena in the region (Enete and Amusa, 2010). Therefore, any agricultural development policy to address the problem of desertification cum climate change in northern Nigeria will require a comprehensive approach that incorporates the abilities to increase agricultural productivity and incomes sustainably now and in the future; adapts and builds resilience to climate change and reduces or removes greenhouse gases emissions using local knowledge and initiatives. These are some of the pillars of climate-smart agriculture.

Conceptual framework and research methods

Stakeholders, especially policy makers, have to make decisions about the technologies/initiatives that are adopted to ensure that agricultural practices are sustainable. In order to make the best decision with regard to the needs of sustainable development, sustainability assessments are necessary. There are a number of assessment methodologies, such as the Sustainability Assessment of Technologies (United Nations Environmental Programme (UNEP), 2012) and the Social Assessment of Conservation Initiatives (Schreckenberg et al., 2010); however, this study will adopt the Sustainability Assessment of Energy Technologies (SAET) framework (Grunwald and Rosch, 2011) because of its emphasis not only on ecological aspects but also on issues important in an African context, such as questions of conservation of cultural functions, participation, autonomous self-support and equal opportunities, including aspects of human health. The SAET framework aims to integrate social and environmental factors into sustainability considerations which are currently dominated by economic concerns. This framework also recognizes the weakness of previous assessment methodologies, which have depended on assumptions about the future, and assessment criteria based on the available data (Scrase and MacKerron, 2009) without resource to societies where there is paucity of data. One of the strengths of the framework is its ability to reduce arbitrariness in the assessment process using the concept of integrative sustainability. The initial focus of application is on energy management related issues. We do find, however, that this framework is applicable in this case because of its holistic nature and emphasis on rules important for sustainability in an African context.

The framework is based on three general goals of sustainable development, being the condition precedent to sustainability. These are: securing human existence; maintaining society's productive potential (comprising natural, man-made, human and knowledge capital); and preserving society's options for development and action. Each of these are further broken down into rules which need to be fulfilled for each goal to be achieved.

Data collection

The assessment of CSA was made by analysing secondary source data. As the concept of CSA is relatively new, there is little relevant research conducted so far; hence, we are limited on the number of published literature we can rely on. This means that most of our analysis is based on the CSA source book (Food and Agriculture Organization, 2013). An effort was made to include other sources such as peer-reviewed materials presented in journals, books and national and international conference presentations. These sources were collected through an extensive literature review using academic reference databases including Web of Knowledge, Science Direct and Cambridge Scientific Abstracts (including databases such as Aqualine, Aquatic Sciences and Fisheries Abstracts, Biological Sciences, Conference Papers Index for life, environment and aquatic sciences, GeoRef, International Bibliography of the Social Sciences, Oceanic Abstracts and Sociological Abstracts). Internet-based search engines (e.g. Google scholar, scirus.com) were also used to identify relevant 'grey literature'. A structured search using Boolean logic was conducted using a wide range of terms related to the CSA. Sources were investigated and information collated, with particular reference to the principle of sustainability.

Primary data was collected using unstructured interviews, which contained questions that could be changed or adapted to match the respondent's intelligence, understanding or beliefs. Unlike structured interviews, they do not offer a limited, pre-set range of answers for a respondent to choose from but instead rely on listening to how each individual responds to the questions. Interviews were conducted with respondents drawn mainly from two categories: government officials – policy makers including agricultural extension workers at both state and local government

level, and local community respondents which included small-holder farmers and key informants, such as chiefs and elderly people within the communities. Interviews with government officials were conducted in English The majority of local community respondents, however, could not communicate in English or even Pidgin English; hence, interviews were conducted in the local dialect of Hausa. Respondents were questioned to obtain information on the status of CSA knowledge in the region. In total, fifteen respondents were interviewed directly (face-to-face) between August 2013 and November 2013 using a structured questionnaire. The sample was made up of ten local community stakeholders and five government officials. The questionnaire was structured into three sections: the first section captured the demographic and socio-economic characteristics of respondents; the second dealt with general information about current farming practices; and the third asked questions regarding their challenges and expectations. These interviews were complemented by direct field observation.

RESULTS AND DISCUSSION

Sustainability assessment of climate-smart agriculture (CSA)

In the following presentation, we provide neither a detailed nor an overarching assessment but instead the descriptive assessment of the sustainability of CSA in an African context that has been lacking in the literature. Our review, specific to the Sustainability Assessment of Energy Technologies Framework, was judged from the literature (mainly the CSA sourcebook) and personal knowledge and observations from the field. Although it was not practical to test the veracity of information presented in the available sources systematically, we did seek to ensure that, wherever possible, results were based on data presented across multiple sources.

Securing mankind's existence

The first goal is securing mankind's existence, under which there are five major rules to be fulfilled in order to achieve sustainability. These are: protection of human health; securing the satisfaction of basic needs; autonomous self-support; just distribution of opportunities for using natural resources; and compensation of extreme differences in income and wealth (Table 1).

CSA emphasis the need to ensure the protection from dangers and intolerable risks for human health due to anthropogenic environmental impacts. This rule, however, needs specific emphasis in order to underscore its importance. Currently, it is mentioned alongside ecosystem health in which case its emphasis could be diminished. This rule is important in Nigeria because of the growing concern for heavy metal contamination of agricultural lands under long-term application of inorganic fertilizers and organic wastes, which also has serious deleterious effects on human health (Agbenin, 2002). Achieving this rule will no doubt help reduce risks and deaths from agricultural land contaminations. The second goal has to do with the ability of CSA to contribute in securing the satisfaction of basic needs for the people.

The emphasis of CSA is on the provision of food, with little mention of other basic needs, such as shelter and clothing. While it is true that 'food is not only a basic need', it is pivotal for maintaining livelihood. It is important, nonetheless to emphasise the significance of other basic needs, such as shelter and clothing, in any sustainable initiative. In many African cultures external appearance matters as much as the internal. Many people believe that the inner peace will be disturbed when the external appearance is weak. In addition, adequate clothing and shelter will help protect against health challenges, such as farmers contacting water-borne diseases because they lack shoes. Achieving autonomous self-support is the third rule. CSA supports and emphasizes education to raise environmental awareness especially with the farmers. The biggest emphasis has been on sending children to school. There is no emphasis on education for the farmers and their household in order to enhance their future potential. It is important to emphasise preparation for ageing populations, as many agrarian African societies are losing young ones to the towns. This has left many elderly farmers without support in their old age.

The need to ensure a just distribution of opportunities for using natural resources is another rule for sustainability. CSA emphasises the need to ensure the fair and equitable sharing of benefits (and cost) arising from the use of genetic resources. What has been left out is emphasis on the need of any such initiative to ensure that people's access to the necessary resources is assured. Currently, this rule is often being fulfilled through the traditional ownership structure. When this, however, is usurped by the formal state institutions, poor farmers can be displaced and denied access to their farm lands under the Land Use Act of 1978, which nationalised all land and vested its management to the state. The law provides that occupancy can be revoked if the land is required for other activities (Constitutional Rights Projects (CRP), 1999). This is often done without compensation. The final rule, which is also linked to the previous, is to ensure compensation of extreme differences in income and wealth. This is to guarantee that farmers who experience temporary loss of profits are not left on their own but are adequately compensated to reduce disparity among farmers. There is little or no mention of this rule in CSA; however, the approach did emphasise payments for environmental services (PES), a mechanism for compensating farmers and farming communities for maintaining ecosystem services.

Upholding society's productive potential

The second goal is made up of five rules (Table 1). The need to ensure sustainable use of renewable and non-renewable resources through the use of diverse energy

Table 1. Sustainability Assessment in Northern Nigeria.

Goals	Rules	Weight as a sustainable strategy	Remarks	Implications in the African context
Securing mankind's existence	Protection of human health	xxx	Emphasised alongside ecosystem health	Can help reduce risk from misapplication of fertilisers
	Securing the satisfaction of basic needs	xx	Emphasis on food with little mention of shelter and clothing	Ensures food security and reduces risk of sickness from inadequate clothing and shelter
	Autonomous self-support	x	Little emphasis on preparation for old age in the face of rapid flow of youths in urban areas	Prepares support for farmers in their old age
	Just distribution of opportunities for using natural resources	xx	Emphasis on benefit and cost sharing, but less on access to resources	There are changes needed to formal laws in order to reduce usurpation of farmlands for other uses
	Compensation of extreme differences in income and wealth	x	Emphasis on payment for ecosystem services and little or no mention of compensation for income differentials	Reduces exploitation among farmers
Upholding society's productive potential	Sustainable use of renewable resources	xxx	Emphasises efficiency of available energy, as well as increasing the proportion of renewable energy	Can help create a good balance between increasing emphasis on fertilisers and organic manure through mixed farming
	Sustainable use of non-renewable resources	xx	Advocates reducing reliance on non-renewable external inputs	Attempts to stem the tide of possible move from renewable to non-renewable resources
	Sustainable use of the environment as a sink	xxx	Emphasises role of aquatic ecosystem, forests and tree planting as environmental sinks	Can aid conservation of wetlands, which are often cleared in many African societies. Also serves as a good platform to encourage tree planting
	Avoidance of unacceptable technical risks	xx	Emphasis centres on concerns with long-term potential impacts of biotechnology	With the rapid uptake of biotechnology, directs emphasis to negative impacts
	Sustainable development of real, human and knowledge capital	xxx	Emphasises promotion of integrated systems that incorporate scientific and local knowledge sources	Aids promotion of indigenous knowledge
Keeping options for development and action open	Equal access to education, information and occupation	xxx	Emphasises social protection including access to social services for education, health, nutrition	Helps enhance societal organisation through reduction in disparity between rich and poor in society
	Participation in societal decision-making processes	xxx	Emphasises the need to broaden stakeholder participation with due consideration to cross-sectorial negotiations and planning processes	Ensures local people have a say in their development

Table 1 contd.

	Conservation of nature's cultural functions	x	Less emphasis placed on cultural factors	May lead to a situation where culture is seen as entirely 'good' or completely 'bad'
	Conservation of 'social resources'	x	Emphasises the interactions between sectors.	Need to encourage inter-personal interactions especially among farmers.

sources is one of the rules mostly emphasised by CSA. The approach recognises the role of renewable and non-renewable energy through integrated food and renewable energy production. It is emphasised in the CSA source book that in promoting energy-smart food, a balance needs to be maintained between improving access to energy sources and increasing the efficiency of available energy, as well as increasing the proportion of renewable energy. This balance must be based on local conditions and the economic trade-offs between different options. CSA also emphasises a crop production that looks at reducing reliance on non-renewable external inputs, and capitalizing on/enhancing natural biological processes to improve production in a more environmentally friendly way, avoiding the degradation of production's relevant natural resources. Currently, many societies in Africa practice mixed farming in which case animal manure is used to complement soil nutrients. However, there is a gradual decline in this practice leading to the use of non-renewable resources gaining more ground. CSA also emphasises the sustainable use of the environment (especially aquatic ecosystems and forests), as an important sink for carbon and nitrogen fluxes on the planet. There is also emphasis on the role that tree planting can play in mitigating climate change through carbon sequestration. Apart from concerns with the long-term potential impacts of biotechnology, CSA does not really envisage many potential technical risks that may be associated with the adoption of this approach, as other such technical risks are given very minimal focus. One main technical initiative of CSA is encouraging biotechnology. It rightly emphasises the need for a sound and integrated approach to bioenergy, particularly biofuel development, that is required to reduce the risks and harness the opportunities related to bioenergy development. This emphasis is also appropriate for developing societies where there is a growing uptake of biotechnology in the agricultural sector and can act as a guide against any potential negative impacts. The final rule under this goal is to ensure sustained real, human and knowledge capital, which CSA recognises through its emphasis on building and mobilising knowledge capital as essential for sustainable development. The approach also emphasises the importance of indigenous knowledge, which is often ignored in many western developed concepts and has become an important factor in sustainable development.

Keeping options for development and action open

Finally, the third set of rules aims to achieve the goal of keeping options for development and action open. The rules include equall access to education, information and occupation, participation in societal decision-making processes, and conservation of nature's cultural functions, 'social resources' and cultural heritage and diversity. Aside from the emphasis on the need to ensure access to natural resources, CSA strongly advocates for access to information (especially information on CSA) to be made available to all stakeholders especially the poorest and the most insecure in society. Besides access to information, CSA proposes three main types of social protection: labour market policies; social insurance, such as health insurance; and social services (e.g. access to social services for education, health, nutrition). This is an important rule, which will enhance societal organisation through a reduction in the disparity between rich and poor. Participation in societal decision-making processes is another of the strongest points of CSA.

The approach emphasises the need to broaden stakeholder participation with due consideration to gender in cross-sectoral negotiations and planning processes. It also underlines that participation should go beyond presence and should include information sharing which will warrant that all sides, including locals, are aware and have access to equal levels of information. In most African societies, however, ownership of resources and societal hierarchies are a crucial precondition for being able to participate in societal processes. One weakness of CSA is its almost near absence of emphasis placed on cultural factors, which are often more important than physical, and even economic and social, characteristics in determining sustainability in an

African context where people hold diverse cultural values. Lack of emphasis can lead to situations where culture is seen as entirely 'good' or completely 'bad'. In other words, in dealing with cultural factors people may blindly accept everything or dismiss cultural values as totally harmful. The final rule is to ensure the conservation of social resources. Social resources in this case refer to the means through which interactions take place. CSA emphasises the interactions between sectors and the needs of the different involved stakeholders in order to maintain close communication. In an African context where the informal is often more important than the formal, it is essential to place emphasis on interpersonal relationship especially among farmers.

It is important to highlight the fact that there is cross-cutting of goals between rules on different levels. For instance, access to goods and services is seen as a prerequisite for all members of society in order to have the same opportunities to realise their own talents and plans for life.

Awareness of climate-smart agricultural knowledge in Northern Nigeria

The study examined awareness of the CSA approach among government officials including extension workers and field researchers, and local communities including farmers and chiefs. We interviewed both groups of respondents as we wanted to find out more about people's awareness and knowledge, which are crucial factors in the success of the CSA. The research found that none of the respondents were aware of the term 'climate-smart agriculture' and that younger farmers in the 20 to 35 age group were most interested in knowing more about this approach, while the older farmers appeared to be uninterested. One of the younger respondents stated that:

"I am hearing about this (CSA) for the first time. What is it all about?"

After briefly explaining the concept to him, he went further to say:
"If it is a new technique that will help us, we need to know so that we can also tell our (other) farmers about it and how they can go about practicing it."

This lack of awareness is not restricted to local people but also to government officials interviewed from the Ministry of Agriculture, the Ministry of the Environment and various research/academic institutions. It is noteworthy that these are the people charged with the responsibility for educating farmers about appropriate agricultural practices in the region. During the interview session, the representative of the agricultural extension workers said:
"I am aware of the need for sustainable agriculture. I was not aware of this new process (CSA) […] I do communicate with federal ministry in Abuja and many NGOs […] When we communicated with them, they never mentioned this to us."

Once the concept is explained, most of the respondents tend to equate CSA with traditional practices such as incorporation of hoodlums and crop residues in soils to boost fertility. According to one respondent:

"This thing (CSA) is just another name for the way we practice our traditional agriculture."

Another respondent equated CSA with the practices his father taught him:

"These are some of the things we have inherited from our forefathers […], to us it is normal and we see nothing new about it."

From such responses, it is clear that there could be a possible misconception of the tenets of CSA; hence, there is a great need to create awareness of the CSA approach in the region. The results also showed that while there is general lack of awareness of CSA among locals and policy makers in the region, the practice is already entrenched in some of the practices. Almost a third of those interviewed are currently practicing elements of CSA and the remaining have done so in the past. All of the respondents aged 50 and over have practiced and are still practicing aspects of CSA. This reflects depth of agricultural knowledge, particularly among the older age groups (above 55). Most of the respondents were aware of some CSA practices that increase yields and subsequently income for farmers. For example, one of the officials in the local department of agriculture said that:

"Seeing the problem of increased dryness which has shortened the duration of soil to retain rain water from 90 days to 30 days […] this is gradually reducing farm output in our Local Government Area (LGA) […] we use animal dung, incorporation of hoodlums in soils during tillage and encourage short fallow systems."

An officer of the local farmers association also said that:

"We have been practicing mixed farming, mono-cropping and mixed cropping systems. I usually rear animal such as cows, sheep and goats alongside crops on the same farmlands. The crops produce food for the flocks and the flocks provide manure for the crops from the animal dung."

The ten farmers interviewed were also asked to rank what factors they felt were the most important in a new

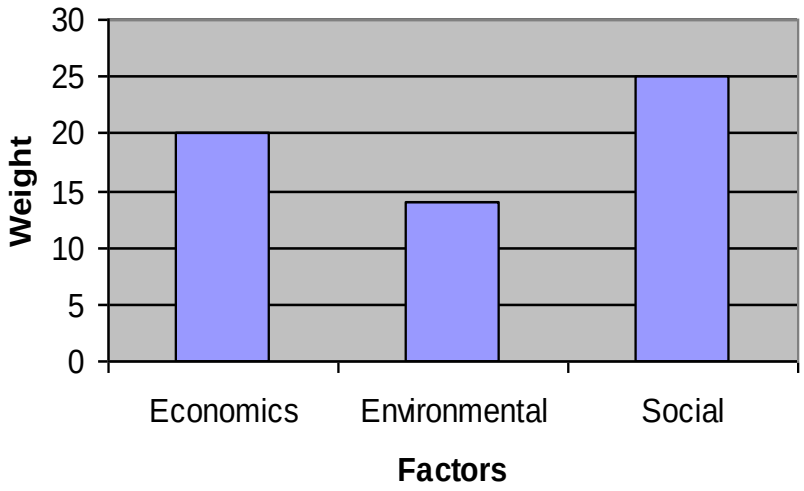

Figure 2. Important factors to consider in a new agricultural approach.

approach. They had to rank economic, environmental and social considerations with three being assigned to the highest rank and one to the least. The results showed that socio-cultural factors ranked highest followed by economic and then environmental factors (Figure 2). Interestingly, despite the strong focus of many on technology, economics and others on the environment, the most important social consideration mentioned was the possibility of them adapting any new initiative with their current practices.

Towards adoption of CSA in Northern Nigeria

We identified four major aspects in which current practices in the region stand to benefit with regards to CSA.

Suitability of climate-smart agriculture practices for Northern Nigeria's agricultural lands

Northern Nigerian agricultural lands are generally characterized by barren landscapes, having little or no vegetation cover. As a result, they are susceptible to high rates of evapotranspiration, rainwater runoff, water and wind erosion, water scarcity, soil nutrients leaching and decreasing soil fertility (Junge et al., 2007). The practice of no-tillage systems, the use of organic manure and agroforestry will improve both the quantity and quality of agricultural lands. This practice has potential to reduce encroachment into marginal lands and the clearing of scarce vegetation. This is because farmers utilise farmlands hitherto considered unprofitable for both crops and animal production due to infertility. Furthermore, CSA practices have the potential to enable small farm holders to achieve agricultural intensification in the region, which can be viewed as the capacity of the farmers to cultivate existing farmlands for a longer period of time without necessarily clearing virgin lands. At the same time they can also be cultivating more farmlands already considered suitable for crops and animal production due to increased yields and income.

Sustainably increasing agricultural productivity and incomes in Northern Nigeria

There is no denying the fact that the general wellbeing of farmers in Northern Nigeria is tied to the productivity of their crops and livestock (Carswell, 1997). Therefore, it was not a surprise that a third of respondents ranked economic considerations highest in the choice of agricultural practice they would embark on. Farmers have found that practices, such as the use of cover crops, crop rotation and intercropping, no-tillage, organic manures, water harvesting and management systems and improved pasture management, are cost-saving. These CSA practices are capable of mitigating the immediate challenges of water scarcity, soil erosion and decreased soil fertility, which often result in inadequate and/or outright lack of quality pasture for livestock, ultimately leading to decreased crops and livestock output, and by extent farmer incomes in Northern Nigeria. These practices are proven to improve agricultural productivity and income levels for rural farm households as well (Food and Agricultural Organisation, 2010; Branca et al., 2011). For example, cover crops have the ability to reduce weeds and grain losses due to pest attacks constantly experienced by farmers in the region. Adoption of water harvesting and management systems will solve the problem of water scarcity experienced by farmers in the region, as well as provide farmers (both crop and livestock farmers) with opportunities to increase their

yields and hence their incomes. Water management techniques such as ridge system, terrace and contour farming, and runoff collection and water storage technologies such as conversion of land mines, ditches and pits to water tanks can be employed in the region to make water available for both crops and livestock uses increasing the yields and income of farmers (Ngigi, 2009. Branca et al., 2011).

Adapting and building resilience to climate change in Northern Nigeria

Adapting and building resilience of rural farm households to climate change and desertification in Northern Nigeria requires the application of on-farm management and technology and diversification practices (Below et al., 2010). Doing the above may not be without constraints. This is because farmers in the region are poor, devoid of basic education and often reliant to cultural and traditional farming techniques that make it difficult for them to adapt easily to modern farming practices (Enete and Amusa, 2010).

On-farm practices are applied to increase the productivity of crops and livestock. The application of on-farm diversification practices in the region is important to provide opportunities for farmers to adapt and build resilience to climate change and desertification. On-farm diversification in Northern Nigeria includes fisheries and aquaculture, bee farming, mushroom farming, orchard and plantation agriculture, urban and peri-urban farming and garden farming (Below et al., 2010; Food and Agricultural Organization, 2010). These practices, if adopted in a widespread manner, have the potential to provide additional food and income to rural farmers in the region and also improve their wellbeing. This is because these often act as a backup to the conventional rain-fed farming system. For example, in a case whereby the rain-fed conventional agricultural system (in which crops and animals in the region depend on the prevailing rainfall conditions in a particular farming season) fails, these modern farming systems which do not depend on rainfall as such but mostly on irrigation and underground water may prove resilient to climate change and desertification and hence provide alternative support to rural farm households to cope with the adverse impacts of climate change and desertification (Below et al., 2010).

Reducing and/or removing greenhouse gases emissions (GHG) in Northern Nigeria

Application of farm management and technologies, such as agroforestry, the use of organic fertilisers (legumes and composting), will go a long way to reduce GHG emission. Practices such as farming with trees on contours, intercropping, multiple cropping, bush and tree fallows, the establishment of shelter belts and riparian zones/buffer strips with woody species, will create an adequate sink for GHG. Agroforestry can contribute to environmental management in the region by protecting the soil from wind and water erosion, acting as a sink for greenhouse gases emissions and protecting the environment from further desert encroachment and climate change. The use of organic fertilizers such as forage legumes/grass mixture and composting can decrease methane emissions while the use of composting manures and crop residues will reduce dependence on synthetic fertilizers which through their production and transportation contribute to GHG emissions (Food and Agriculture Organization, 2010).

Opportunities and challenges towards CSA adoption

A major strength in favour of the adoption of CSA in the northern part of Nigeria includes the fact that many aspects of the approach are already embedded in the current agricultural practices of the region. Most of these already address critical issues such as the farmers' engagement in micro-finance savings, which can help enhance their autonomous self-support or even mixed farming which will ultimately enhance sustainable use of renewable resources and reduce dependence on non-renewable resources. The existence of these long-standing practices should be considered as a first step in a long-term process.

Even though some of these practices exist in the region, they have not been integrated into the broader local and national strategies, policies and planning processes. This lack of an existing link of this approach with any government document translates to no budgetary allocation and, hence, the lack of funding for such initiatives. This is a potential weakness that will need to be addressed in the adoption of CSA. Another weakness towards the adoption of CSA was revealed during the interviews and concerns the little or no knowledge of CSA and the fact that the approach is poorly understood even by extension officers, who would be expected to champion the approach and explain it to the locals. This may be unrelated to another weakness, which is the lack of active non-governmental organisations in the region promoting sustainable agriculture. While there are few organisations promoting tree planting many have failed to address the main cause of desertification, thus treating the symptoms rather than addressing the cause. A further weakness is the limited opportunities for local managers to participate in the international policy that has led to the formulation of this approach.

There are a number of opportunities for the adoption of CSA, chief among these being the willingness of the local farmers and government officials alike to take on this initiative. Moreover, the CSA addresses a number of

social factors, which were found to be paramount for local farmers. One major threat is the possibility of the initiative being left to ministries supporting conservation objectives alone. This might lead to a half-hearted and distorted application of CSA. Non-governmental organisation will need to be encouraged. This might also help to address another threat which is the lack of a permanent budget greatly limiting the ability of CSA to act in the medium- and long-term.

There are four main factors that stand out as important for any adoption of CSA in Northern Nigeria. These are: political commitment, human and financial investment, incentives and information. Political commitment is needed to give CSA the necessary backing and integration into current agricultural and environmental policies in Nigeria. This will also go a long way in addressing the issue of human and financial investment through the provision of budgetary allocation. Part of the financial allocation may have to be channelled into creative incentive mechanisms to encourage farmers who adopt sustainability rules. Finally, there is need to ensure the timely and adequate dissemination of information.

Conclusion

We have argued that introducing noble approaches as though giving orders to a subordinate is not what is needed for sustainable development in Africa. There is need to ensure that the approach is apt and has potential for success. In this line of thought we have argued for the sustainability of Climate-Smart Agriculture for adaptation in Northern Nigeria. Climate-Smart Agriculture has been proposed as an approach that can combat climate change and desertification comprehensively by emphasising adaptation to climate change. Having assessed the approach through the prism of the SAET framework, we found that broadly speaking it fits with what can be termed as a sustainable technology. Admittedly, there are many aspects, such as the emphasis on cultural functions, that will need to be addressed. CSA in societies like Nigeria where the poor are often cheated out of programmes should integrate all the needs of the disadvantaged into the policy before its final adoption. Such a review has become necessary because the approach, as currently conceived, does not do enough justice to some of the critical issues in the agricultural sector in Nigeria. There is need for an all-inclusive approach that would not only enhance environmental protection for the country but also respect social values. The outcomes of some of the current practices adopted to manage adverse environmental impacts were found to provide coping strategies that fit with the concepts of CSA. These, however, are still not very widespread. Specifically, farm management and technology practices such as the use of cover crops, crop rotation and inter-cropping, the use of improved seed varieties, tillage systems, water harvesting and management systems, improved pasture management systems and agroforestry are recommended. It is expected that, if consciously adopted by farmers in the region, the adverse impact of climate change and desertification on the people shall be greatly mitigated. Secondly, CSA shall enable farmers in the region to adapt effectively to the adverse impacts of climate change and desertification and hence, improve the wellbeing of rural farm households (which constitute the majority population) and help Northern Nigeria attain food security and sustainable development.

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