ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 14 No. 1
March 2014
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

WHAT CLIMATE CHANGE MEANS FOR FARMERS IN AFRICA: A TRIPTYCH REVIEW
MIDDLE PANEL: INTRODUCTIONAL MATTERS AND CONSEQUENCES OF GLOBAL WARMING FOR AFRICAN FARMERS

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Volume 14 No. 1
March 2014
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ISSN 1684 5374

ABSTRACT

Climate change seriously influences the livelihoods of African farmers. It was, therefore, felt useful to make an inventory of what climate change really means for them. In this review in three parts, climate change is approached by dealing with the three sides from which the danger comes: (i) global warming, (ii) increasing climate variability, (iii) more (and possibly more severe) meteorological and climatological extreme events. These are the three panels of this triptych review. Vulnerable communities already suffer. They are, therefore, urgently in need of assistance aimed at building resilience, and at undertaking climate change adaptation efforts to survive and to maintain their livelihoods. Climate change adaptation projects - especially if implemented in the context of adaptation strategies at the macro level - often mobilize public and private stakeholders, engaging them in the problem-solving process. Scientists have an important role to play in these projects. One of the major problems in guiding rural change, in a rural response to climate change, is the low formal level of education that most farmers have and for which governments have done very little to upgrade it. Improved climate literacy is needed among farmers and a better trained extension that can guide farmers in further rainfall monitoring and rainfall interpretation. Further agro-ecosystem observations that, with the rainfall distribution, explain yields and yield differences are also needed. While it is relatively easy to define technical messages that can be communicated, one must look beyond "adaptation to current climate variability". The basic vulnerability factors of communities must be targeted. One of the problems faced is that experts on climate variability and climate change do not really know what information the grassroots need in the short- and medium-term. However, people assisting vulnerable communities do not know what science generated products are available and how to use them. In this first part of the paper, the consequences of global warming are dealt with at length. Increasing temperatures and changing rainfall patterns get attention first. Other consequences of increasing atmospheric carbondioxide contents and how they influence agricultural production in Africa are also discussed. Ten text boxes distributed over the three parts illustrate local conditions that must be taken into account to understand the impacts/consequences of climate change for African farmers and how they may cope with them.

Key words: African farmers, climate change, vulnerabilities

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 14 No. 1 March 2014 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

CONSIDERATIONS OF CLIMATE AND RURAL SOCIETY IN AFRICA

Introduction

Climate change seriously influences the livelihood of African farmers. In recent literature, on how climate change influences the livelihood of rural people, it is discussed, as illustrated below, what climate change really means for farmers in Africa (see also [1]). The three panels of this triptych review are of course not set up as a traditional paper but in ways that are characteristic for a literature review combined with a review of our own experiences. The causes and consequences of climate change will be considered and the impacts they have on the livelihood of farmers. The issues are: (i) global warming, (ii) increasing climate variability, (iii) more (and possibly more severe) meteorological and climatological extreme events. It will also be argued that under certain conditions fighting causes of climate change demands contributions from African agriculture in diminishing greenhouse gases that are generally seen as the main atmospheric contribution to climate change [2, 3].

Vulnerable communities across the world are already feeling the effects of a changing climate. These communities are really in need of assistance aimed at building resilience, and at undertaking climate change adaptation efforts to survive and to maintain their livelihoods [4, 5, 6]. They are in need of an urgent rural/agrarian response to climate change [1]. The reality of climate change calls for a better understanding of "how it might affect a range of natural and social systems" (that is existing natural and social communities), and it demands to better identify and evaluate options to respond to these effects [7, 8]. Climate change adaptation projects are important for two main reasons: firstly, they offer the possibility to cope with the impacts or consequences of climate change in the short and medium term, hence alleviating the pressure on people and on ecosystems suffering from it, especially in developing nations. Secondly, climate change adaptation projects - especially if implemented in the context of adaptation strategies at the macro level - can serve the purpose of mobilizing public and private stakeholders, engaging them in the problem-solving process [9].

One may argue that scientists have an important role to play in these projects [10]. The tasks ahead of us are about: (i) "What natural and what agricultural eco-systems are going to be affected and to what extent" [11, 12]? When a situation sounds alarming and it is understood as such, those concerned, supported by governments, NGOs, civil societies may give it the needed attention [6, 8]; (ii) What social systems are going to be affected and to what extent [13]? The same applies as under (i); (iii) Systematic ways of identifying the effects and their consequences that need to be established. That is what climate change science and supporting sciences are supposed to do in impact assessments [14]; (iv) Vulnerability analyses that have to be made in participatory approaches [15]; (v) Systematic ways of designing and evaluating available options for adaptation that have to be developed and applied [11, 12, 16]; (vi) Adaptation impact assessments that will complete the exercises [17].

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Assessments of vulnerabilities and adaptations to climate change have already become central to climate science, policy and practice in countries where agriculture has become pure business. In most sub-Saharan African countries and other poorer countries and regions, however, the capacity to conduct vulnerability and adaptation assessments is still limited [18, 19, 20]. This is mostly due to little social research done in rural areas anyway [14, 15, 16].

Difficulties in determining the climate vulnerabilities of African farmers

In a world that is developing fast, Africa's relative stagnation is a human tragedy that challenges the development profession. Although climate and geography, and their effect on local institutions, are not in much of Africa's favour, inappropriate policies (including neglect of agriculture [21]**)** and weak institutions figure more prominently in the explanation of slow economic growth. Recent evidence, however, points to accelerated growth in many parts of Africa. Analysis of agriculture shows "that adverse effects of nature can be handled effectively, that efforts to develop and apply technologies for intensification in a variety of farming systems are under way, but that sustained adoption by the mass of smallholders has not sufficiently taken place" [16].

It is necessary for researchers to understand African farmers' vulnerabilities the way they see them. Certain problems, as specified below, complicate this:

a. Getting farmers to come out and express their needs. Experience in Indonesia and South Africa shows that a research group must build closeness to and trust with a group of farmers to be able to organize local field meetings in which farmers are willing to discuss their needs and vulnerabilities [15, 22, 23]. Such temporary meetings in Indonesia were baptized "Science Field Shops" [24].
b. Getting extension officers to understand farmers' concerns after a thorough updating of their extension training regarding the consequences and impacts of climate change [23, 25].
c. Assisting farmers to articulate their concerns on what climate change means for them (see a.).
d. Getting research and academia to support both extension and farmers in this drive [14, 23, 26].

One may also look at the consequences of climate change from the other end:
What may we expect from the farming communities threatened by climate change?

i. Ecosystem services (reduced land degradation, reduced greenhouse gas emissions, carbon sequestration et cetera, but in win-win situations only).
ii. Food security (farmer households, national/community food baskets), but with suitable government policies regarding agricultural development,

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crop diversification and environmental protection in place and carried out without political flaws.

iii. Organizing their livelihoods as good as possible, but again with suitable land distribution, land reform, land protection and rural infrastructural policies not only promised and voted for, but also realized, with markets being allowed to work for all.

The role of applied science

For example, the International Research Institute for Climate and Society (IRI, Columbia University, USA) declares to use a science-based approach to enhance society's capability to understand, anticipate and cope with the impacts of climate in order to improve human welfare and the environment [27]. This approach should be extended to the rural communities of Africa. The core of that approach is listening to the farmers concerned in a "farmer first" paradigm in a participatory approach [1]. Decision support must be generated with them and for them to be able to face the consequences of global warming, increased climate variability and other climate change related factors in their livelihoods [14].

However, relevant applied scientists cannot do all that by themselves. They should basically be the link between their applied science and the actual production environment [14]. To that end, they in fact would be most useful to back up well educated extension intermediaries. The latter must train, on an almost daily basis, farmers, farmer facilitators and ultimately farmer trainers and farmer communities. Unfortunately, extension services are virtually absent. Where they still do exist, they have received little or no upgrading about the fast changes that are occurring in the agricultural production environment and about the actual crises in the livelihood of farmers [25, 28], including those related to climate change.

A recent review on the performance of the converted extension system in Malawi reports that government extension services are characterized by limited resources and an over-abundance of under-educated field staff [29]. "Non-governmental extension organizations, on the other hand, have limited staff but only at higher levels, thus thrusting the responsibility for grassroots connections onto government officials once more. For both, linkages with education and research institutions are weak, which begs the question: Just where are extension officers in Malawi getting their advice from?" [29]. Most dubious of all, the majority of these extension organizations are working in a top-down fashion with decision-making and prioritization coming from those in power, quite opposed to the objective of farmer engagement and empowerment desired by Malawi's new extension policies. It is unlikely, assert the authors of the review, that the demands of smallholder farmers are being met using such methods [29].

One of the major problems in guiding a rural response to climate change, is the low formal level of education that most farmers have and for which governments, local as well as federal, have done very little to upgrade it. This makes it even more difficult to improve the highly needed climate literacy among farmers and to use a better trained extension that can guide farmers in further rainfall monitoring and interpretation. Further agro-ecosystem observations are definitely needed so that, with the rainfall distributions, they can explain yields and yield differences [1, 22]. They should also explain the necessity of crop diversification and crop replacements in the light of a continuing climate change [11, 12]. Much improvement in observing plant growth response to meteorological/climatological disasters as well as pests and diseases is still required. The same applies to much fine tuning of soil fertility improvements, understanding of soil moisture conditions and understanding of soil erosion and changes in soil conditions under floods and droughts [30]. Once the period of a few years of "Science Field Shops" is over [24], scientists may return to their back-up functions in extension. As soon as extension officers got enough training to guide the above issues, it will become their task to train farmers in these rural responses to climate change.

Traditional knowledge and indigenous technologies should always be taken seriously and they should always be tried out in a participatory approach to find their new limitations under changing conditions [19, 24, 31]. It is often also a good way to come on speaking terms with local farmers, doing together some local experiments on comparing traditional and modern scientific approaches [14]. Managing climate change adaptation should be considered a matter for farmers and their communities, as well as of extension (for government) and applied scientists.

SOME BOUNDARY CONDITIONS FOR PROBLEM SOLVING

Adaptation financing

As financing for climate change adaptation in developing countries begins to flow, it is essential that the governance of funding at the global and country level be shaped so that the needs of the most vulnerable can be met [5]. The core issue is country-level ownership of adaptation finance. "Providers of adaptation finance must put developing countries in the driver's seat, while the countries themselves must exercise good leadership and respond to the needs of those most affected by climate change" [5] (BOX 01). "Most importantly, civil society and vulnerable communities must be able to steer and be held accountable for the way adaptation finance is used" [5]. The latter issue is even more important in African countries with high levels of corruption and/or low budgets at the levels of central and local authorities [32].

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BOX 01

PROMOTING A VALUE CHAIN APPROACH TO CLIMATE CHANGE ADAPTATION IN AGRICULTURE IN GHANA (Partly based on UNFCC [33])

From an evaluation report on the first phase of the Root and Tuber Improvement Project (RTIP) in Ghana, lessons could be learned for a second phase [34]. These are examples about financing climate change focused projects in which the financiers give a free hand to the major stakeholders to manage the projects based on their own structures (governance), priorities and circumstances. The overall objective of this Special Climate Change Fund (SCCF) operation is to reduce the vulnerability of the root and tuber food supply system to the deleterious impacts of climate change. The specific objective is to reduce climate-induced risks in the cassava value chain to the achievement of food security and income generation for pilot rural communities in Ghana, as was the approach of the RTIP. This SCCF intervention will be articulated around three components: (i) awareness raising on climate change and capacity to address its impacts along the cassava value chain and other complementary food production; (ii) support adaptation to climate change of cassava production; (iii) promote innovative adaptation solutions along the agriculture value chain. It will address climate change adaptation needs and options along the value chain linkages to increase resilience to climate change through "Land and water management"; "Crop production"; "Processing and marketing". Stakeholders who play a major role in the cassava value chain are: (i) Regional and district governmental agents (extension, agriculture, forest, district planning, education, health, et cetera.), researchers/academic staff, NGO's and media operators; (ii) All the regional and district beneficiaries of the RTIP programme; (iii) Small-scale cassava producers, processors and traders who are most likely to be affected by climate change impacts; (iv) All the district and regional beneficiaries of the RTIP. (v) Asset-poor, food insecure and labor deficient cassava farm households. They will all be targeted to jointly identify and apply climate change adaptation measures by selection of crop varieties and production techniques, as well as sustainable land and water management. At the local level, the project will involve modern community leadership as: (1) Regional coordinating councils and district assemblies; (2) Traditional community leaders including Chiefs (with major stakes in land tenure issues); (3) Extension staff; (4) Research institutions and universities; (5) Non-governmental Organizations; (6) Health centers; (7) Commission for civic education; (8) Staff of the Department of Meteorology; (9) Media managers.

The approach used

"While it is relatively easy to define technical messages that can be communicated, one must look beyond "adaptation to current climate variability". The basic vulnerability factors of communities must be targeted. Communication also aims at improving the learning process and creating capacity to cope with climate variability" [35]. Measuring rainfall and observing the agronomical/agro-ecosystem consequences by farmers in their plots have been a great success in Mali for such communications [14, 36, 37]. Exemplified below are the most important impacts/consequences that African farmers face because of climate change.

CLIMATE CHANGE, WHAT DOES IT MEAN FOR AFRICAN FARMERS?

Introduction **- Climate change**

The discussion whether climate change exists does not need to be taken up here. The evidence is rather clear (also confirmed below). The discussion on causes of climate change must be considered to be largely irrelevant for those suffering the consequences, but some level of understanding of the causes will help in the appreciation of the problems and their solutions that are dealt with below. Even if one would be able to at least reduce apparent sources of climate change or find other geophysical ways to reduce global warming, they would continue to take place and only in the course of time at a reduced speed [1].

Problem definition

Experts on climate variability and climate change do not really know what information the grassroots people need in the short- and medium-term [38, 39]. However, the people working with vulnerable communities do not know what science generated products are available and how to use them [39]. An important example of what the agricultural sector could do to mitigate climate change, in a win-win situation, is that of large scale agroforestry (BOX 02) with food security components [28, 40].

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BOX 02

AGROFORESTRY AND CLIMATE CHANGE [41]

The International Council for Research in Agroforestry (ICRAF, now World Agroforestry Centre) defined agroforestry as a dynamic, ecologically based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production, enhancing social, economic and environmental benefits for land users at all levels. For the time being, methods that are low-cost and affordable by farmers must be found to redress the degradation of the natural resources base, particularly soils and forests, while farmers and rural communities need institutional mechanisms so that their voices and concerns can be acted upon. Tree planting may, depending on selection and pattern, among others reduce salinity, improve soil fertility, control erosion, control water logging, reduce the greenhouse effect (by carbon sequestration), reduce catchment eutrophication, possibly check acidification and probably increase local biodiversity. Woody plants can play a significant role in the transition phase of agrosilvopastoral systems in semi-arid regions from extensive systems to intensified systems. Woody plants provide buffering functions, stabilize ecosystem dynamics, and allow effective use of additional nutrient and water inputs, or allow effective use of these resources where they occur naturally. So far woody plants have been predominantly used for productive purposes. Substantial changes are required to extend the focus to their protective and supportive functions.

The main issues that have to be accepted as causes and consequences of a changing climate will now be discussed, underscoring the consequences for African farmers.

***Global warming* -Temperature**

Many tropical regions in Africa, Asia and South America could see the permanent emergence of unprecedented heat in the next two decades. According to projections, large areas of the globe are likely to warm up so quickly that, by the middle of this century, even the coolest warmer seasons will be hotter than the hottest ones of the past 50 years [42]. Historical data from weather stations around the world were also analyzed to see if the projected emergence of unprecedented heat had already begun. It turns out that when one looks back in time, using temperature records, it is found that extreme heat emergence is already occurring [43, 44], while climate models represent the historical temperature patterns remarkably well [42]. This dramatic shift in seasonal temperatures could have severe consequences for human health, agricultural production and ecosystem productivity.

Rising temperatures are not uniformly bad: they will lead to improved crop productivity in parts of the tropical highlands, for example, where cool temperatures are currently constraining crop growth [12]. Average temperature effects are important, but there are other temperature effects too. For example, increased night-time temperatures reduce rice yields, by up to 10% for each 1°C increase in minimum temperature in the dry season. Increases in maximum temperatures can lead to severe yield reductions and reproductive failure in many crops. In maize, for example, each degree day spent above 30 °C can reduce yield by 1.7% under drought conditions [12].

It must also still be observed that part of the poverty-alleviation rationale for participatory crop research is that improved crop production will give farmers greater flexibility in their use of land and labor. This could be made possible by promoting varieties that yield better, mature earlier, or tolerate drought and (much more difficult) heat, or by taking up new cropping systems. This in turn will allow farmers "to more easily diversify into other crops, without completely losing their present food security" [1]. The economic and nutritional arguments that are used for the diversification of agricultural production in Africa are now joined by climatological ones (compare [1] for Indonesia). In other words, improved cropping/farming systems are needed of which the selection should be based on evidence of scientific evaluations of their suitable ecological criteria [8].

Rainfall

Global warming also changes rainfall regimes, which then cause great suffering, particularly in semi-arid areas. In Malawi, for example, farmers are so much aware of the difficulties that maize and rice are giving lately, due to changing local rainfall patterns, that:

- "they now also grow cassava, sweet potatoes, Irish potatoes, millet and sorghum to add to or replace their present diets" [45];

- "new farmer-led innovations combine agro-ecology and nutrition, using legumes such as pigeon peas and groundnuts as local sources of nitrogen and food" [46].

"Diversified – crop and community – nutrition programmes have improved corn yields and child nutrition in Malawi" [46]. In Zimbabwe, for the same reasons of changing rainfall patterns and longer dry spells and drought periods, farmers reintroduce more and more traditional non-hybrid maize varieties [47, 48, E. Mashonjowa, personal communication, 2012]. These are known to be much more drought and disease resistant than the presently often favored hybrid varieties. The latter give high yields under relatively high inputs only, while most farmers can't afford the inputs [47]. The former give relatively low yields under many conditions [48]. However, a recent study concluded that the currently available maize germplasm in Zimbabwe is not suitable for projected climate change conditions [49]. Such conclusions may be generalized for sub-Saharan Africa as a whole [12].

Carbon dioxide

After all, the current concentration of CO_2 in the atmosphere is 25 percent higher than in the 1960s. The positive effect of elevated CO_2 concentration on plant growth is well known [50]. However, it has now been discovered that "an increase in carbon dioxide levels could cancel out the beneficial effects of dwarf varieties of C_3 rice and wheat" [51]. These recent results have implications concerning the action of the Green Revolution genes in future environmental conditions [50]. For example, a variety of rice called IR8, which has now disappeared almost completely from the market, caused quite a stir in the 1960s. The plant saved on nutrients and energy through the lack of vertical growth and was even more productive as a result. Everything that was not required to grow longer stalks was made available to the rice grains. The cultivation of dwarf varieties is not only common in the case of rice; farmers also prefer short-stalked varieties of wheat. Both cereals are the staple food consumed by a majority of the global population. In the meantime, however, the yields from IR8 have declined by around 15 percent, and the cultivation of this previously very promising plant is no longer seen as worthwhile. Although nothing has changed in the genetic make-up of the IR8 rice plant in the past 50 years, its yields have declined continuously [51]. Dwarf varieties of rice and maize were also used as soon as they became available in Africa [52], be it only on a very small scale because of the high inputs they need [53]. So expansion in Africa of these varieties, under irrigation and with other inputs, should not be stimulated anymore as a consequence of their yield decreases with increasing CO_2 content of the atmosphere.

ACKNOWLEDGEMENTS

This paper was written in Africa when the senior author was a visiting professor in ongoing programmes at the Kumasi National University of Science and Technology (KNUST, Kumasi, Ghana) from mid-October till early December 2012, at the University of the Free State (Bloemfontein, South Africa) from early December 2012 till early February 2013 and at the University of Zimbabwe (Harare, Zimbabwe) from early February till the end of March 2013. He wishes to thank these Universities and their staff concerned for having been able to work on this paper among the many other tasks he had and has at these and other African institutes. Your hospitality and the many discussions we had on farmers, food security, climate change and development were much appreciated, as always. The material was used in a three days Roving Seminar, with the same umbrella title as the three panels of this triptych review, at the Physics Department of the University of Zimbabwe, in March 2013. It will be used in the same way in other African countries from now onwards.

ajfand SCHOLARLY, PEER REVIEWED
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Volume 14 No. 1
March 2014
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ISSN 1684 5374

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Volume 14 No. 1
March 2014
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

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March 2014
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