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 LEFT PANEL: INCREASING CLIMATE VARIABILTY AND A RESPONSE APPROACH FOR AFRICAN FARMERS

Stigter CJ[1*] and E Ofori[2]

Kees Stigter

Emmanuel Ofori

*Corresponding author email: cjstigter@usa.net

[1]Visiting Professor in Africa and Asia for Agromet Vision, Netherlands, Indonesia, South Africa, Zambia, Zimbabwe, Ghana

[2]Lecturer, Department of Agricultural Engineering, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. Email: ofori.emmanuel65@yahoo.com

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

ABSTRACT

In this paper 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 and this left panel is about (ii). This second panel starts with a compelling review of the present situation of food security, referring to African examples to improve the situation. Then the influence is discussed that the El Niño Southern Oscillation (ENSO) has on increasing climate variability as a consequence of climate change. It is indicated that, to date, climate models have been developed with little knowledge of agricultural systems dynamics. On the other hand one can illustrate that agricultural policy analysis has been conducted with little knowledge of climate dynamics. As a direct consequence of capricious behaviour of particularly rainfall in West Africa, the adaptation of its farmers has lagged behind enormously. This statement is valid for most farmers in sub-Saharan Africa. Within the climate science community there is an emerging effort to make findings more suitable for decision making, but as yet there is little consensus as to how data may be relied upon for decision making. Then a lot of attention is paid to how response farming, that is thoroughly defined, can play an important role in coping with the consequences of climate variability. Response farming is often limited envisaging rainfall events, but coping with weather and climate (and often soil) disasters as well as using windows of weather and climate (and often soil) opportunities are other forms of responding to weather and climate (and often soil) realities. Services such as in advice on design rules on above and below ground microclimate management or manipulation, with respect to any appreciable microclimatic improvement: shading, wind protection, mulching, other surface modification, drying, storage, frost protection and so on belong to such "response farming" agrometeorological services. Ideally, to get optimal preparations, farmers get advisories/services through extension intermediaries, backed by scientists, to properly understand decision options through discussions supported by economic analyses. Throughout the paper text boxes are used that illustrate local conditions that must be taken into account if one wants to understand the impacts/consequences of climate change for African farmers and how they may cope with them.

Key words: Climate variability, response farming, services

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

CLIMATE CHANGE, WHAT DOES IT MEAN FOR AFRICAN FARMERS?

Increasing climate variability **- General**

A thorough look is attempted at what climate change means for African farmers. The three panels of this triptych review are not set up as a traditional paper but in ways that are characteristic of a literature review combined with a view of own experiences. The livelihood of millions of vulnerable communities already depends on the availability of simple foodstuffs, and now climate change is further threatening that precarious existence, say four top opinion-makers [1]. Using a quote: **"Imagine a world where too much rain, or too little, means the difference between a life fulfilled and a life blighted by hunger and poor nutrition. Imagine, for a brief moment, measuring your children's chance of survival by the number of bags of grain you harvest or against a dwindling stock of rice. This is the reality for millions of vulnerable communities. Today, almost one billion people suffer from hunger, most of them women and children. Globally, almost one in three children grows up lacking the nutrients they need to fend off disease and to develop to their full potential. And now, climate change is exacerbating the hardships they face daily. The links between climate, hunger and poor nutrition are becoming increasingly clear: a recent report for the Committee on World Food Security warned that climate change could significantly change the amount and quality of food consumed – with potentially devastating consequences for those most at risk of hunger. The report also cautioned that climate change may hinder people's capacity to earn a living and provide proper nutrition for themselves and their families. In many parts of the world, four out of five people depend on farming to survive. These traditional farmers, many of them women, live in regions where they are perilously exposed to the tiniest shifts in weather patterns"** [1].

For some case studies, illustrating the above and what is needed to fight it at the grassroots in Africa- see Magee [2], CSD-i [3] and Magee [4]. What these examples have in common is that they are working; they are also small-scale. Scaling up such important knowledge transfer experience poses challenges, as is also the case in Indonesia [5, 6]. The Center for Sustainable Development-Tools-Training (CSD-i) has produced a series of simple field guides that will assist this knowledge transfer upscaling in climate adaptation programmes [7, 8, 9, 10, 11, 12]. In carrying this out, locally, the dilemma has to be solved that was explained in the middle panel [No. 1, "Introductional matters and consequences of global warming for African farmers"] of this triptych [13] on choosing between extension intermediaries close to the farmers and their communities [14, 15] or farmer facilitators from among these communities or both [15].

In this middle panel [No. 1] of the triptych, after introductional matters, under the relation between climate and rural society in Africa, difficulties were considered in determining the climate vulnerabilities of African farmers. The role of applied science in improving human welfare and the environment under the present and future conditions of neglected agricultural production in Africa was also considered [13].

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

The basis of the approach is listening to the farmers concerned in a "farmer first" paradigm in a participatory approach. However, applied scientists cannot do that all by themselves. They should basically be the connection between applied science and the actual production environment. To that end they in fact would be most useful to back up well educated extension intermediaries and/or farmer facilitators [16]. Below, mainly increasing climate variability (and the role of ENSO in these matters), as another consequence of climate change, as well as the response potential of African farmers are dealt with. The third and last panel of this triptych review [No. 3, "Climate extremes and society's responses, including mitigation attempts as part of preparedness of African farmers"] starts with another serious consequence of climate change in the form of more (and possibly more serious) climatological extreme events. This leads to considering increasing the preparedness of farmers to survive under the conditions of a changing climate. Part of this higher preparedness may also be carried out in a role to diminish the contributions of agriculture to the increase of greenhouse gases in the atmosphere under win-win conditions, that is, while improving the efficiency of production, changing its inputs and improving its outputs.

Agricultural production in rather some sub-Saharan African countries is strongly influenced by the annual cycle of precipitation and year-to-year variations in that annual cycle of precipitation caused by the El Niño-Southern Oscillation (ENSO) dynamics [17]. The combined forces of ENSO and global warming must be expected to have dramatic and currently largely unforeseen effects on agricultural production and food security in sub-Saharan African countries [18, 19, 20].

For example in Ghana and other parts of western Africa, the dominant wind direction in regions south of the ITCZ is southwesterly, blowing moist air from the Atlantic onto the continent [21]. North of the ITCZ the prevailing winds come from the north east, bringing hot and dusty air from the Sahara desert (known as the 'Harmattan'). As the ITCZ migrates between its north and south positions over the course of the year, the regions between those northern-most and southern-most positions of the ITCZ experience a shift between the two opposing wind directions at the time. This pattern is referred to as the West African Monsoon [21, 22]. For example, the climate of Ghana is tropical, and strongly influenced by this West African Monsoon [21]. Now a significant part of the West African Monsoon interannual variability appears to be explained by the remote influence of the ENSO [17]. The seasonal rainfall in this region varies considerably on inter-annual and inter-decadal timescales, due in part to variations in the movements and intensity of the ITCZ, and in part to variations in timing and intensity of the West African Monsoon [21]. The most well-documented other cause of these variations is the ENSO. El Niño events are associated with drier than average conditions in West Africa [21].

Some specific problems

To date, climate models have been developed with little knowledge of agricultural systems and their dynamics (see for Africa [23]; for Asia [24]). For African conditions, Ziervogel *et al*. [23] stated that the science of climate modeling is complex and efforts to communicate its results and consequences to agricultural users

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

"remain rudimentary and fraught with what are perceived to be contradictory and unreliable messages". "Within the climate science community there is an emerging effort to make findings more suitable for decision making, but as yet there is very little consensus as to how data may be relied upon for decision making" [23]. This situation has not changed.

On the other hand, agricultural policy analysis has been conducted with little knowledge of climate dynamics (examples for improvement in Africa [25] (Box 01); more generally [26]; for Asia [24]). Integration proposed of what is known of climate dynamics and what has been collected in agricultural systems models, will permit an assessment of climate-related uncertainty associated with global warming and ENSO dynamics. In such integration, detailed crop dynamics models can be run with climate model forcing [27, 28]. However, recently climate models were found inadequate for field-scale agricultural studies [29]. This integration will ultimately also demonstrate how the treatment of uncertainty affects the choices and consequences of agricultural policies [24].

BOX 01

AFRICAN CLIMATE DYNAMICS TO BE UNDERSTOOD [25]

Human activity is supposed to affect the earth's climate mainly via two processes: the emission of greenhouse gases and aerosols and the alteration of land cover. While the former process is well established in state-of-the-art climate model simulations, less attention has been paid to the latter. However, the low latitudes appear to be particularly sensitive to land use changes, especially in tropical Africa where frequent drought episodes were observed during recent decades. (……). The authors find a prominent surface heating and a weakening of the hydrological cycle over most of tropical Africa, resulting in enhanced heat stress and extended dry spells. In contrast, the large-scale atmospheric circulation in upper levels is less affected, pointing to a primarily local effect of land degradation on near-surface climate. In the model study, it turns out that land use changes are primarily responsible for the simulated climate response. In general, simulated climate changes are not concealed by internal variability. Thus, the effect of land use changes has to be accounted for when developing more realistic scenarios for future African climate.

More El-Niño Southern Oscillation (ENSO) details

The ENSO actually can swing beyond the "normal" state to a state opposite to that of El Niño, with the trade winds amplified and the eastern Pacific colder than normal. This phenomenon is often referred to as La Niña. In a La Niña year (when a La Niña period occurs), many Asian regions, such as Indonesia, that are inclined toward drought during an El Niño, are instead prone to more rain. Both El Niños and La Niñas vary in intensity from weak to strong [30].

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

The intervals at which El Niños return are not exactly regular, but used to vary from two to seven/eight years. Sometimes an El Niño subsides into a "normal" pattern. At other times it gives way to a La Niña. In many ways, the ENSO cold phase is simply the opposite of the warm phase, but without any symmetries in durations or severity. This often holds true also for the climate impacts of the two. El Niño (warm phase) tends to bring drought to countries like Indonesia and Australia, at the west end of the Pacific [30], but also in West Africa/Ghana [21]. The latter influences in Africa are so-called teleconnections [21], meaning that we don't know how or why. However, the strong influence of La Niña at the west end of the Pacific, with abundant rainfall and frequent floods, does not have its parallel in West Africa.

Now it appears that the frequency of these phenomena has changed in recent times and also the way they follow each other. However, neither these ENSO internal climate variabilities nor their present changes can be simulated with the models that summarize the existing understanding that apparently is at this moment still very insufficient [31].

As a consequence of this ENSO behaviour, simple growing season rainfall scenarios are almost impossible to derive from existing raw or already simplified climate predictions (such as determined in climate outlook fora). For example in West Africa, such predictions are often extremely difficult to make with sufficient skill to be of much value in farming. It must, therefore, be much further explored how the West African monsoon is remotely influenced by the ENSO events [17]. As a direct consequence of this capricious behaviour of particularly rainfall in West Africa, the adaptation of its farmers has lagged behind enormously. This statement is valid for most farmers in sub-Saharan Africa. Still, there are other reasons that African farmers have been slow to adapt. The lack of attention paid to practicing response farming consistently, by scientists, NGOs and farmers alike, is one of the main other reasons [32]. Difficulties as noted with making accurate and reliable regional/local climate predictions hopefully will resort to more response farming. It can also easily be combined with climate predictions of sufficient skill [32, 33].

Response farming to combat increasing climate variability

Response farming is a method of identifying and quantifying, statistically or otherwise, seasonal rainfall variability and (un)predictability, and related risks, addressing these risks at the farm level. Response farming means adapting cropping to the ongoing rainy season by guidance of agronomic operations. This must be done using experiences of the past, preferably from interpretations of meteorological rainfall records, with support from traditional expert knowledge where available (BOX 02).

Now there is the advantage that in agrometeorology, response farming was developed decades ago. It has been further developed into a Farm Adaptive Decision Optimization by widening its fields of operation but keeping the village as a focus [33]. Response farming, as an early set of agrometeorological services, was created

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

and promoted by Stewart (WHARF) in the 1980s and strongly supported by (among others) Gommes (FAO), Stigter *et al.* [32] (TTMI/CAgM/Agromet Vision) and Weiss *et al.* [34] over the last decades.

Given the indications for increasing climate variability and change in terms of rainfall, this will have to be adapted to those new conditions, limiting the period in the past over which the experience can be used, and adapting the information to local soils and topography. The hypothesis is that solutions to farming problems may be found by this improved forecasting/prediction of expected rainfall behavior in the cropping season(s) [34]. A recent example of Zimbabwean farmers trying to cope with the 2013 and future floods shows what is possible [35].

BOX 02

BRINGING RESPONSE FARMING TO AFRICAN FARMERS

Response farming must be brought from undercurrent to mainstream [36]. Response farming for African farmers may be summarized as follows (after Mellaart, pers. comm.): **"We want to use response farming to cope with climate and weather risks. It is precision farming at a temporal scale. Precision farming (spatial scale): adapt management to soil type. Response farming (temporal scale): adapt day-to-day management to weather. It is not a new technology. It is a new method, a way of thinking. We need response farming because the climate is slowly warming up and because there are increasing differences from year to year, from week to week and from day to day. Response farming is adapting the crop planning to the climate and adjusting the day-to-day management decisions as function of the existing crop situation and the medium range weather expectations (forecasts/predictions). It is not a new way of farming but a way of planning and adjusting, taking into account the past and the future for making better decisions. We use response planning at the start of the season, modifying according to the weather. We use response management during the whole season. All farmers, either small-scale, emerging or commercial farmers, particularly dry-land farmers, can use response farming. We apply response farming by looking at the crop (status, development), looking at the soil (soil water content), looking at the weather (medium forecast)".**

Response farming is often limited envisaging rainfall events, but coping with weather and climate (and often soil) disasters as well as using windows of weather and climate (and often soil) opportunities are other forms of responding to weather and climate (and often soil) realities [34]. Services such as in advice on design rules on above and below ground microclimate management or manipulation, with respect to any appreciable microclimatic improvement: shading, wind protection, mulching, other surface modification, drying, storage, frost protection, et cetera, belong to such "response farming" agrometeorological services [32, 34, 36]. The developments in Low External Input Sustainable Agriculture (LEISA) research of the last twenty years show what is possible if norms and values in science show a paradigm shift. A shift towards valuing the basic issues in the undercurrent: realistic assessments of the environment and considerations of the plights of poor people [36].

Climate change brings complications to organized response farming but farmer and farming system differentiation is the real issue in agrometeorological services under conditions of a changing climate [34]. It has been argued that agricultural decision makers would realize the potential benefits of climate information only if farmers are prepared for viable decision options [37, 38].

Consequences of applying response farming

Effective forecast/prediction applications impose intensive demands on coping skills, as they are implemented through adjustments of possibly many interrelated decisions [36, 37]. Coping decisions that are realistic and adoptable by farmers need to be investigated for associated risks. Recently adopted insurance schemes for small farmers against calamities make such matters even more feasible [36, 38].

Ideally, to get optimal preparations, farmers get information, through extension intermediaries, backed by scientists, to properly understand decision options through discussions supported by economic analyses [36]. A case study from Zimbabwe (BOX 03) illustrates this approach.

The purpose then is to increase, with farmers as decision makers, the awareness on potential climate hazards and climate related hazards and their mitigation in general, first for monocropping, including its dangers in particular, with a strong wish to reduce vulnerability by preparedness. The role of applied agrometeorology in combating disasters is to use the understanding that basic science has reached on the most important hazards endangering crop growth in a region as well as on possibilities for their mitigation, to have extension make these farmers aware of these hazards and their own vulnerability [36].

The logistics and the policy environment to make this happen - availability of a strong supply of appropriate seeds and other farm inputs, on which farmers can immediately fall back as the need arises - must be in place. Funding and development of a strong supply/marketing system are necessary ingredients. This response farming approach was never sufficiently recognized as such. The weakness of this capability in most farming communities is itself seen as an important problem. This is mainly due to misunderstanding of the response farming that African farmers developed themselves in many places. Intercropping, adapting crops, crop varieties and crop densities to the expected season and the traditional use of trees are examples [36, 39]. New response farming approaches must be built on traditional knowledge and indigenous technology, using climate science as connections.

BOX 03

RESPONSE FARMING IN ZIMBABWE: A PROPOSAL [40]

Agro-climatic information and advisory services play a big role in enhancing smallholder farmers' resilience to climatic variability. This study, using a case of Makonde in Zimbabwe, has shown that, though an abundant amount of climatic information is being captured at the local meteorological station, this information is not effectively accessible for local farmers. The authors noted that extension personnel have limited knowledge about how to derive the benefits of locally available climate observational data, and their advisory services are mainly guided by sensory perceptions. The authors, therefore, recommend that university scientists practicing agrometeorology and agroclimatology be involved in deriving response farming approaches. On the other hand, the results of the precipitation analysis, showing inter-annual variability and correlations to the Southern Oscillation index, highlight the potential of adopting response farming in this region where the majority of farmers rely on rain-fed agriculture. Local precipitation data can be used to interpret SARCOF seasonal outlook forecasts that are often given in probability estimates of above normal, below normal or normal conditions, and covering hundreds of kilometers. The authors also demonstrated the use of local daily precipitation in determining the variability of onset, length and cessation of rainfall seasons. Apart from relying on rainfall measurements from just one station in the district, it is recommended that farmers and farmer groups be involved in making observational measurements in their fields as this will make them to practically experience climatic variability, and will also give a useful density of rainfall observations. A participatory approach is therefore recommended involving farmers, scientists and agricultural extension in Zimbabwe, following the success case studies from Mali and Indonesia. Moreover, training of extension personnel in agrometeorology should be emphasized so that they can better articulate the needs of the farming communities for weather services, and also be able to bring response farming approach advisory services to farmers for participatory applications in their fields.

The need for response farming for South Africa follows from Gbetibouo and Hassan [41]. Many climate change impacts would induce (or require) distinct shifts in farming practices and patterns in different regions (of South Africa). This includes major shifts in crop calendars and growing seasons, switching between crops to the possibility of complete disappearance of some field crops from some regions [41]. Indeed "climate change urgently needs to be assessed at the level of the household, so that poor and vulnerable people dependent on agriculture can be appropriately targeted in research and development activities whose object is poverty alleviation" [42, 43].

ACKNOWLEDGEMENTS
See Paper [13].

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

REFERENCES

1. **Consortium** Climate change is worsening hunger, 2013. Found at http://www.cgiar.org/consortium-news/climate-change-is-worsening-world-hunger/ Accessed on 4th March, 2013.

2. **Magee T** Kenya: Climate smart agriculture for extreme weather events and changing seasons, 2013. Found at http://www.csd-i.org/csdi-blog/2013/1/3/kenya-climate-smart-agriculture-for-extreme-weather-events-a.html Accessed on 4thMarch, 2013.

3. **CSD-i**. Kilimanjaro: Extreme weather events and recurring drought create food insecurity for 1300 households, 2013. Found at http://www.csd-i.org/csdi-blog/2013/3/4/cba-climate-change-news-south-sudan-vietnam-pakistan-surinam.html Accessed on 4th March, 2013.

4. **Magee T** South Sudan: Environmentally sound agriculture. Found at http://www.csd-i.org/csdi-blog/2013/2/26/south-sudan-environmentally-soundagriculture.html Accessed on 4th March, 2013.

5. **Winarto YT** and **K Stigter** (Eds) Agrometeorological Learning: Coping Better with Climate Change. Saarbrucken, Germany, LAP LAMBERT Academic Publishing GmbH & Co. KG, 2011; 250 pp.

6. **Stigter C (K) J** and **YT Winarto** Considerations of climate and society in Asia(II): Our work with farmers in Indonesia. *Earthzine* **4(6)**, posted 17thApril, 2012 at: http://www.earthzine.org/2012/04/17/considerations-of-climate-and-society-in-asia-farmers-in-indonesia Accessed on 17th April, 2012.

7. **CSD-i.** Participatory capacity & vulnerability assessments, 2012. Found at http://www.csd-i.org/csdi-blog/2012/4/18/participatory-capacity-vulnerability-assessments.html%20 Accessed on 4th March, 2013.

8. **CSD-i.** Field Guide: Participatory mapping for soil and water resources**,** 2012. Found at http://www.csd-i.org/csdi-blog/2012/4/18/field-guide-participatory-mapping-for-soil-and-water-resourc.html Accessed on 4thMarch, 2013.

9. **CSD-i**. Field Guide: Simple techniques for soil and water conservation, 2012. Found at http://www.csd-i.org/csdi-blog/2012/4/18/field-guide-simple-techniques-for-soil-and-water-conservatio.html Accessed on 4th March, 2013.

10. **CSD-i.** Field Guide: Developing a community based disaster risk reduction plan, 2012. Found at http://www.csd-i.org/csdi-blog/2012/4/18/field-guide-developing-a-community-based-disaster-risk-reduc.html Accessed on 4th March, 2013.

11. **CSD-i.** Field Guide: Diversifying livelihoods—Alternative income generation, 2012. Found at http://www.csd-i.org/csdi- blog/2012/4/18/field-guide-diversifying- livelihoodsalternative-income-gener.html Accessed on 4th March, 2013.

12. **Magee T** A Field Guide to community based adaptation, 2012. Found at http://www.routledge.com/books/details/9780415519304/ Accessed on 4thMarch, 2013.

13. **Stigter C (K) J** and **E Ofori** What climate change means for farmers in Africa**:** A triptych review. Middle Panel [No. 1]: Introductional matters and consequences of global warming for African farmers, *AJFAND* 2014; **14(1):** preceding paper in this issue.

14. **Nanja DH and S Walker** Handbook for Community Agrometeorological Participatory Extension Service (CAPES), 2009. Found at http://www.agrometeorology.org/files-folder/repository/HandbookCAPES.pdf Accessed at 15th November, 2012.

15. **Stigter K** and **YT Winarto** Extension agrometeorology as a contribution to sustainable agriculture. *New Clues in Scs.* 2012; **2(3)**: 59-63.

16. **Stigter C (K) J** and **YT Winarto** Science Field Shops in Indonesia. A start of improved agricultural extension that fits a rural response to climate change. *J. Agr. Sc. Applic.* 2013; **2(2)**: 112-123.

17. **Joly M** and **A Voldoire** Influence of ENSO on the West African monsoon: Temporal aspects and atmospheric processes. *J. Clim.* 2009; **22**: 3193–3210.

18. **Vogel C** "Seven fat years and seven lean years"? Climate change and agriculture in Africa*. IDS Bull.* 2005**; 36(2)**: 30-35.

19. **Dinar A, Hassan R, Mendelsohn R** and **J Benhin** (Eds) Climate change and agriculture in Africa: Impact assessment and adaptation strategies. London and Sterling, VA, Earthscan Climate, 2008; 200 pp.

20. **Somorin OA** Climate impacts, forest-dependent rural livelihoods and adaptation strategies in Africa: A review. *Afr. J. Environm. Sc. Techn.*2010;**4(13)**: 903-912.

21. **NCSP.** UNDP climate change country profile: Ghana. National Communications Support Programme, 2008. Found at http://ncsp.undp.org/document/undp-climate-change-country-profile-11 Accessed on 15th November, 2012.

22. **Romain R, Bouniol D, Guichard F, Hourdin F and J-L Redelsperger** The present and future of the West African Monsoon: A process-oriented assessment of CMIP5 simulations along the AMMA Transect. *J. Climate* 2013; **26**: 6471–6505.

23. **Ziervogel G, Cartwright A, Tas A, Adejuwon J, Zermoglio F, Shale M** and **B Smith** Climate change and adaptation in African agriculture,2008. Stockholm, Environment Institute, 53 pp.

24. **Falcon WP, Naylor RL, Mastrandrea MD, Batisti DS, Vimont D** and **M Burke** Agricultural decision-making in Indonesia with ENSO variability: Integrating climate science, risk assessment, and policy analysis. Freeman Spogli Institute for International Studies at Stanford University, 2011. Found at http://cddrl.stanford.edu/research/agricultural_decisionmaking_in_indonesia_with_enso_variability_integrating_climate_science_risk_assessment_and_pol-icy_analysis/ Accessed on 12th January, 2012.

25. **Paeth H, Born K, Girmes R, Podzun R** and **D Jacob** Regional climate change in tropical and northern Africa due to greenhouse forcing and land use changes. *J. Clim.*2009; **22**: 114–132.

26. **Popovich CJ, Simonovic SP** and **GA McBean** Use of an integrated system dynamics model for analyzing behaviour of the social-economic-climatic system in policy development. Water Resources Research Report no. 067, 2010. London/Ontario, Canada, Facility for Intelligent Decision Support, Department of Civil and Environmental Engineering, 37 pp.

27. **Reddy KR** and **HF Hodges** (Eds) Climate Change and Global Crop Productivity, 2000. Wallingford/New York, CABI Publish., 472 pp.

28. **Rivero Vega RE** A set of logical steps in order to make an assessment of climate change impacts on agriculture, 2011. Found at http://www.agrometeorology.org/files-folder/repository/logical_steps.pdf Accessed on 19th February, 2012.

29. **Ramirez-Villegas J** and **A Challinor** Assessing relevant climate data for agricultural applications. *Agric. For. Meteorol.* 2012; **161**: 26-45.

30. **Stigter C (K) J** and **YT Winarto** Considerations of climate and society in Asia (I) What climate change means for farmers in Asia. *Earthzine* **4(5),** posted 6th April 2012 at http://www.earthzine.org/2012/04/04/what-climate-change-means-for-farmers-in-asia/ Accessed on 6th Apr 2012.

31. **Stigter C (K) J** Unusual climate conditions of 2010/11 & pest/disease outbreaks. Lecture at the Faculty of Social and Political Sciences, for the Centre for Anthropological Studies, Department of Anthropology, as a visiting professor at the Universitas Indonesia, Depok, Indonesia, on 3rd February, 2012. Available at: http://www.agrometeorology.org/files-folder/repository/UNUSUALCLIMATECONDITIONS.pdf Accessed on 17th August, 2012.

32. **Stigter C (K) J** and **YT Winarto** Coping with climate change: an active agrometeorological learning approach to response farming. Invited opening keynote presentation on the first day of the APEC Climate Symposium 2012 "Harnessing and Using Climate Information for Decision Making: An In-Depth Look at the Agriculture Sector", St. Petersburg, Russia. Extended Abstract in Proceedings, 2pp. Posted at http://www.apcc21.org/eng/acts/pastsym/japcc0202_viw.jsp Accessed on 12thJanuary, 2013.

33. **Gommes R, Acunzo M, Baas S, Bernardi M, Jost S, Mukhala E** and **S Ramasamy** Section II.D: Communication approaches in applied agrometeorology. **In:** K Stigter (Ed) Applied Agrometeorology. New York/Berlin/Heidelberg, Springer, 2010; pp. 263-286.

34. **Stigter K** Agrometeorological services under a changing climate: old wine in new bags. *WMO-Bull.*2008; **57(2)**: 114-117.

35. **Mwando M** Zimbabwe's farmers dig in to capture the deluge, 2013. Found at http://www.trust.org/alertnet/news/zimbabwes-farmers-dig-in-to-capture-the-deluge Accessed on 7th March, 2013.

36. **Stigter K** (Ed) Applied Agrometeorology. New York/Berlin/Heidelberg, Springer, 2010; xxxiv + 1101 pp.

37. **Hansen JW** Realizing the potential benefits of climate prediction to agriculture: issues, approaches, challenges. *Agric. Syst.* 2002; **74**: 309-330.

38. **Njagi K** Kenya's urban poor feel the rural pull as insurance makes farming viable, 2013. Found at http://www.trust.org/alertnet/news/kenyas-urban-poor-feel-the-rural-pull-as-insurance-helps-makes-farming-viable/ Accessed on 7thMarch, 2013.

39. **WMO.** Communicating agroclimatological information, including forecasts, for agricultural decisions. Chapter 17 in "Guide to Agricultural Meteorological Practices (GAMP)". WMO 134, Third Edition, Geneva, 2010. Found at: http://www.wamis.org/agm/gamp/GAMP_Chap17.pdf Accessed on 20th October, 2012.

40. **Mberego S** and **K Sanga-Ngoie** Using locally captured climatic information for guiding local-level agriculturalists in Africa: a case study of Makonde district in Zimbabwe. *J. Land Use Sc.* 2013; in print. DOI:10.1080/1747423X.2012.758787.

41. **Gbetibouo GA** and **RM Hassan** Measuring the economic impact of climate change on major South African field crops: a Ricardian approach. *Glob.Planet. Change* 2005; **47:** 143–152.

42. **Jones PG** and **PK Thornton** The potential impacts of climate change on maize production in Africa and Latin America in 2055. *Glob. Environm. Change* 2003; **13:** 51–59.

43. **UNEP.** Malawi changes course after analyzing the real costs and benefits of policy choices. In: E Benson (ed) Stories of Change. From the joint UNDP-UNEP Poverty-Environment Initiative, 2013, pp. 17-24.