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Climate Change: Mitigating Effects of Climate Change by Evolving Sustainable Agricultural System in Nigeria

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Abstract: This paper explore how we arrived where we are, pointing out the role of energy utilization (to drive development) in climate change complications, emphasizing that this single need possess difficulties in the reversal processes. It also emphasizes time factor required to achieve 'environmental healing' process, thus postulating mitigation processes within the short or long run, as the case may be, alongside attempts to cut down on Carbon emission. The paper calls for urgent need to provide cropping strategies that will both mitigate challenges pose by climate change as well as be acceptable, affordable and practicable within limits of available farmers' resources. Noting that concerns on issues that bother on climate change are global and real and more so in Africa, where most farmers are desperately poor, often at the mercy of weather elements and where bulk of crop husbandry is rain fed and subsistence production is the norm. It observed that as communities try to adjust to the challenges of their local climate, they are becoming more aware of the local peculiarities in observed climatic elements. Such peculiarities make universal mitigation processes difficult to achieve. Thus, any drastic change in weather elements will have a reciprocal effect on agricultural activities. The paper pointed out that of recent climate change is posing new challenges for Africa's efforts at attaining food security as it threatens its food baskets as rain falls become more unpredictable and irrational. It concluded that whilst farmers in some regions may benefit from longer growing seasons and higher yields, the general consequences for Africa are expected to be adverse, and particularly so for the poor and the marginalized, who do not have the means to withstand drastic changes, thus the need to do something about their cropping systems.

Keywords: Agriculture, Climate Change, Cropping Systems, Poverty, Crop Mixtures And Subsistence

Background Information

Energy consumption has been basic to human advancement, with the most developed countries consuming the most energy. The desire to attain and sustain development necessitates sourcing for more efficient energy means - at times at the detriment of the environment. One may wonder, with global warming couple with the anticipated doom that may accompany climate change, why cannot the world reverse the whole processes leading to climate change? In a world where 'might' is measured by scientific advancement, to jettison such recognition for environmentally friendly options, which are often slower or expensive is a sacrifice difficult to make. Thus there is a slow response to cutting down on activities leading to Carbon and greenhouse gas emission, even with the devastating consequences of such activities on the environment; as such move is seen as against sustainable development. Even where commitment on reducing carbon emission is followed through, the corrective impact will not be immediate. Besides it takes time, and money to evolve a new technology. The implication is that the effects of climate change will be with us for quite some time even in the face of corrective measures. The importance of this reality to us in Africa, where the main stay of most house hold economy is agriculture, is that we need to do something about our current farming system to cope with the changing climatic situation. However, ability to adjust to changes is often a product of ones' financial well-being.

If the world's Carbon emission and greenhouse gas generation continues at the current pace with its reciprocate effect on climate change, rough estimates suggest that over the next 50 years or so, climate change may pose a serious threat on global food than other constraints on agricultural production (IPCC,

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2007; BNRCC, 2008). While Ziervogel *et al*. (2006) had observed that climate change is one of the most serious environmental threats facing mankind worldwide; stressing that it affects agriculture in several ways, besides its direct impact on food production. This paper discusses mitigation of the effects of climate change on agricultural production with focus on Nigeria through adapting farming/cropping systems that may cushion the effects of climate change. Adaptation is widely recognized as a vital component of any response to climate change, and the adaptive capacity of any system or society describes its ability to modify its characteristics or behavior to cope better with changes in external conditions observed Anselm and Taofeeq (2010).

Introduction

Most economies in Africa are driven by agriculture which in Africa, particularly is climate dependent. In addition, African agriculture is basically subsistence, with family survival rather than profit (market) as the main focus. Thus capital and technology deployment are relatively low. These factors affect their responses to change and their ability to cope with production stresses. This is further compounded by the fact that African subsistence farmers are mostly poor, which has negative implications on innovation, coping and response to climate change.

For centuries these farmers have however, mitigated against unfavorable environmental outcomes by adopting various survival strategies, which include multiple cropping systems, cropping drought resistant or drought tolerant crops, or simply avoidance of bank credits (to forestall possibility of foreclosure) in the face of often threatened crops, since they may not be able to pay back loans taken on farms or employing other strategies that are meant to cushion effects of unfavorable environmental factors. But of recent climate change is posing new challenges for these low input farmers who have before now provided the nation's food requirements; in some cases accounting for the production of over 80 per cent crop and animal produce and products. Their ability to meet the nation's food requirements is based on farmers' population (over 65 per cent of the country) and not on yield per unit area, which is often low. That agriculture had provided employment for over 65 per cent of the population and that this means of livelihood is threatened by climate change further underpin the grave implication of this process on African population.

Drastic changes in weather always do have reciprocal effects on agricultural activities, particularly in places where agricultural operations are weather dependent, and these effects may be detrimental if not catastrophic in some cases. However, as communities try to adjust to the challenges of recent climate events: tornadoes, frequent droughts and floods, as well as forest fires, snows, *etcetera* the world is becoming more aware of local peculiarities in these observed climatic events, thus this call for specific and localized interventions as against generalized outlook. An intervention which takes cognizance of the farmer's socio-economic environment, as it affects the ability of the farmer to respond to stresses, changes, to adopt and adapt recommended mitigation processes.

There has been a lot of harping on expected consequences of climate change (IPCC, 2007; BNRCC, 2008; Deressa *et al*, 2008; Anselm and Taofeeq, 2010; Okhakhu, 2014). Though this event may be global, its outcomes may not be easily generalized. However, in some cases there could be spillover effect as observed in recent flooding in Nigeria (Benue, Edo, Kogi, Anambra, Delta, Bayelsa and Rivers States) owing to torrential rainfall and the sudden release of water from the dams in Cameroun; compounded by the fact that Nigeria is of higher elevations in the north than in the south (Iloeje, 1982; Ayoade, 2004; Okhakhu, 2014). This makes the country a sloping geomorphic entity with most of her hydrological resources trickling down towards the south from the north (Ayoade, 2004; Okhakhu, 2014). This orientation should be expected to affect how climate change events impact on the country, particularly heavy rain fall and flooding in the north which may find their ways into the river Niger and Benue, with possible spillover effects on surrounding lands bordering the two rivers. This horror was seen in the 2012 flooding of over 19 states in Nigeria, with the destruction of properties, cutting off roads, wiping out farm lands.

There have been calls for reduction in Carbon emission as a mean to steaming effects of climate change, however there have not been political will to follow through on pledges made over the decades. This article intend to draw attention to some of the underlying role of energy utilization in any issue regarding Carbon emission, as well as draw attention to timing in the revisal process, thus the need for cushioning effects of climate change on agricultural system; as this is heavily dependent on climate. It also spelt out some of the difficulties in arriving at a unified mitigation process, drawing attention to climate variability.

The statement of the problem

In Africa, climate change is expected to, and in some parts, it has already begun to, alter the dynamics of drought (see Appendices I to VI), rainfall and heat waves, and trigger secondary stresses such as the

spread of pests, increased competition for resources, and attendant biodiversity losses. In many parts of Africa it seems that warmer climates and changes in precipitation may destabilize agricultural production, mainly because African agriculture has not taken cognizance of the change in statuesque. As a credit to African agriculture, the farming systems found in African is more resilient to environmental hazards. That the family survival is central to African agriculture, there exist within the system a mechanism to survive, and thus there are multiple complexes of crop combinations, varietal selections, risk avoidance mechanisms, *etcetera*, which are based on years of slaving to survive. A basic question is, will this system hold under climate change?

Limitation of the study

The focus of this paper is on agriculture that is dependent on natural environment, not on those raised on artificial or controlled environment, such as those provided irrigation, or in green house husbandry, or raised aeroponically, or via hydroponics. Decision are based on critical reviews, secondary data as against primary or empherical observations, thus they are only as accurate as available information.

Climate and Agriculture:

Why should we be bothered about climate change?

Climate influences plant and animal life; as adequate functioning of plant and animal is partly a product of factors which include certain elements of weather/climate, such as temperature, relative humidity, solar radiation, rainfall, wind etc. These factors may directly or indirectly impact on animal and plant life within an ecosystem. Thus climate/weather influences what the farmer can plant, when he can plant that, incidences of pests and diseases, pollination, length of growing season, and eventual crop yield. Soil and soil factors which are basic to agriculture are also influenced to a large extent by elements of weather/climate, observing that water and wind are both involved in soil formation and soil erosion and both processes expected to occur in the presence of these elements. However with heavy rainfall and flooding erosion should be expected to be faster that soil creation.

Animal lives also do respond to elements of weather, such as physiological responses to temperature, relative humidity, requirement for water intake, etc. The consequences of these relationships are that variations in these impacting factors, may negatively or positively affect plant and animal lives. Thus it was observed that climate change is perhaps the most serious environmental threat to the fight against hunger, malnutrition, disease and poverty in Africa, mainly through its impact on agricultural productivity.

Already crippled by burdens of food insecurity, climate change may aggravate the already delicate situation in African states observed Jagtap (2007); Nwafor (2007); Khanal (2009). Farmers (who constitute the bulk of the poor in Africa), may face prospects of tragic crop failures, reduced agricultural productivity (Zoellick, 2009), with reciprocate effect on prices of agricultural produce which would subsequently impact on all citizenry, resulting in increased competition for fewer food, hunger, malnutrition and diseases and possible death (Zoellick, 2009).

It is predicted that as the planet warms, rainfall patterns should shift (see Appendices I to VI an indication of delayed rainfall), becoming less predictable, and extreme events such as droughts, floods, and forest fires should become more frequent (UNFCCC, 2007; Zoellick, 2009) resulting in poor and unpredictable yields in some areas thereby making such farmers more vulnerable - particularly in Africa. The observations would not be this straight forward, as experiences will vary among locations. Thus the need for definite responses that is localized, specific and targeted at locations. Predicting the impact of climate change on complex biophysical and socio-economic systems that constitute agricultural sectors is difficult; as interactions between climate elements and crop responses are complex and at times unpredictable. While farmers may be in the front line of the recipients of climate change as their means of livelihood come under attack, its effect will eventually trickle down, affecting everyone, as food insecurity hits.

It is projected that crop yield in Africa may fall by 10 – 20 percent by 2050 or even up to 50 percent due to climate change (Jones and Thornton, 2003), particularly because African agriculture is predominantly rain-fed and hence fundamentally dependent on the vagaries of weather (Jones and Thornton, 2003). It should however be observe that vulnerability of Africa's agriculture to climate change is not determined by the nature and magnitude of environmental stress like climate change per se, but by the combination of the societal capacity to cope with and / or recover from this environmental change (Anselm and Taofeeq, 2010). That the ability to cope with and / or recover from the predicted environmental change may be lacking in most African country's set-up would make their agricultural system more vulnerable to the devastating effects of weather observed Anselm and Taofeeq (2010). While Africans may be hit the most because of their low level development, advanced

economies may not be spared the spillover effects of such outcomes. They may have to take up the responsibility of feeding the continent, or allow them to die of hunger and lose the source of the raw materials, and a huge junk of the market to climate change.

How would this affect Nigeria specifically?

As in tropical environments rainfall as against temperature determines the length of the growing season in Nigeria. Thus, any form of variation in rainfall pattern, duration or length will have definite implications for agricultural production in Nigeria. Seasonal northward and southward oscillatory movement of the Inter-Tropical Discontinuity (ITD) largely dictates the weather pattern in Nigeria (Ayoade, 2004; Nigeria Climate Review Bulletin, 2010). The moist southwesterly winds from the South Atlantic Ocean, which is the source of moisture needed for rainfall and thunderstorms to occur, prevail over the country during the rainy season (April – October). Thus most agricultural activities are conducted during this period.

In most parts of the country, the rainy season is interlude by a short dry spell in August, usually referred to as August break. As one heads towards the coastal regions of the country (down river Niger and Benue), the rainy season is long enough to accommodate two cropping periods: a main and a minor, often separated by the August break. The dry spell in August allows farmers to bring in dry maize which matures on the field. Arable crops such as maize, cassava and yam are usually accommodated within the main cropping period for those areas that can accommodate two crops, while the legumes (Bambara, groundnut and soy bean) form the major focus for the minor cropping period in most places. As one moves deeper hinterland towards the coastal regions, crops such as plantain, banana, pineapple, and tree crops (cacao, kola, robber, oil palm etc) are prevalent in the cropping systems.

However, within the country, there are complex cropping systems, often dictated by farming family needs, goals, culture, environment and market policies. Whatever these complexes, a common baseline is rain fed agriculture in most areas, thus the commencement and cessation of rain marks the beginning and end of cropping for most farmers engage in arable crop production. Also, available rainfall is the basic tool for determining crop types found on most farmers' fields. Even multiple cropping systems take cognizance of rainfall regimes in the selection of associating crops. Implication of this is that if climate change should impact negatively on available rainfall, this will heavily affect farmers' fields, except where farmers are ready to change to other crops that can be accommodated within the new rainfall regime. Such sudden change may however be difficult to achieve as such shifts do require time, technical know-how and assurance of readily available markets. This change may be compounded by the fact that farmers' cropping systems are a product of decades of knowledge acquisition, acceptance of certain way of life, or the inclusion of a farm produce in the culture and beliefs of the people.

For those regions where rainfall comes in later than April or May, millet and sorghum which are more tolerable to drought form the back bone of the cropping system and in most cases, legumes: cowpea and groundnut are incorporated concurrently, as the rainy season is not long enough to allow for two cropping periods. In most of these areas rainy season cropping is complemented often by irrigated farming in the fadama.

In reverse, northeasterly winds which raise and transport dust particles from the Sahara prevail all over the country during the harmattan period (November – March). These overall changes in temperature, rainfall and other meteorological parameters determine the changes in climate in the country each year. These changes are felt differently in the country. These weather variations have dictated crop and livestock types kept in the different ecological zones of Nigeria for decades. With the seemingly consistent weather pattern for decades farmers have acquired adequate understanding and ease of prediction of weather elements in guiding their farming activities (Nigeria Climate Review Bulletin 2010). Contrary to previous weather observations the 2010 Climate Review Bulletin (Nigeria Climate Review Bulletin 2010) which presented scientific information on the magnitude, departures from long term conditions and trends in maximum and minimum temperatures, incident solar radiation, dust haze, rainfall amount and distribution gave insight into some abnormal and extreme weather occurrences in the country. With a good number of places in the country, especially in the north, experiencing record flooding and the August Break was less pronounced in the southwest. Both outcomes have implications for cropping systems. While flooding is likely to cause crop destructions, absence of August break will affect availability of dry maize, thus shooting up prices of dry maize where available. There is also possibility of weevil and mould infestations and as early maize and groundnut dry up in the field amid rain. Observing that most African farmers are poor, and depend on natural crop drying, ensuring that early maize or groundnut comes in dry would be difficult.

The temperature analysis (Nigeria Climate Review Bulletin 2010) also revealed that almost the entire country was warmer than normal. Mean maximum temperatures across the country ranged between 31.1 – 42.6 °C during the hot season. The highest temperature range of 40.0 – 45.0 °C was recorded over the northeast and northwest zones of the country. Almost all parts of the country had mean temperatures higher than the 1971 - 2000 normal (Nigeria Climate Review Bulletin 2010); showing the effects of global warming on the country. However, Anselm and Taofeeq (2010) had observed that rise in temperature helps to grow crops in high altitude areas and towards the poles. While Khanal (2009) reported that increases in temperature extend the length of the potential growing season, allowing earlier planting, early harvesting and opening the possibility of completing two crop cycles in the same season. This author added that warmer conditions support the process of natural decomposition of organic matter and contribute to the nutrient uptake mechanisms (Khanal, 2009). The process of nitrogen fixation, associated with greater root development is also predicted to increase in warmer conditions and with higher CO_2, if soil moisture is not limiting (FAO, 2007). The increased CO_2 levels lead to a positive growth response for a number of staples under controlled conditions also known as the carbon fertilizations effect (Mark *et al.*, 2008).

These positive implications observed above of temperatures on crop growth and development must be taken with caution, as when temperatures exceed the optimal level for biological processes, crops often respond negatively with a steep drop in net growth and yield. All crops have their minimum and maximum requirements for temperatures, outside which they experience stress. Khanal (2009) stated that heat stress might affect the whole physiological development, crop maturation and finally reduces the yield of cultivated crops. If the country is taken down by climate change, the world would not be better for it, considering the market provided by its huge population, besides its crude oil and agricultural produce that feeds large industries in advanced economies.

Mitigating Effects of Climate Change

Available evidence (Nwafor 2007; Jagtap 2007) shows that climate change is global, likewise its impacts; but the most devastating adverse effects will be felt mostly by developing countries, especially those in Africa, due to their low level of coping capabilities. Nigeria is one of such developing countries (Odjugo, 2010) where a huge percentage of its population lives on less than one dollar a day.

While it may be difficult if not impossible to completely halt certain events leading to climate change, due to energy consumption in manufacturing and developmental processes, it is however necessary to develop coping strategies to cushion the effects these changes if we are to ensure food security in the face of changing weather elements.

Why mitigation? Effects of climate change are already with us and for decades there have been lack of political will to address issues leading to global warming. In the face of this lack of commitment to cut down Carbon emission and green house gasses, it becomes imperative to map out coping strategies against climate change; knowing as we do that global warming or climate change will pose greater risk to crop production in coming decades. A discuss on mitigation processes against global warming that encompasses all areas would not be a straight forward process, due to perceived climatic element variability from place to place. While some areas may become hotter, others are expected to grow cooler. While some are experiencing drought, others flooding, etc, thus the need to have a proper understanding of the local environment in chatting mitigation processes. How do we surmount this?

The hurdles

The first measure to consider in drawing up mitigations against effects of climate change on agricultural production is to evolve sustainable farming systems that are flexible, acceptable, and easy to apply, cheap and farmers friendly. This requires adequate understanding of the likely effects of climate change on the farming environment and community, noting that environments and communities may be peculiar and specific in their outcomes and reactions as it pertains to climatic events. There is the need for an adequate understanding of likely effects that may be peculiar to the environment or community of interest. There after effects of such climate changes should be simulated for every community as against having a generalized view. Based on the outcome of such simulation, sustainable farming/cropping systems can then be mapped out.

However for such systems to be sustainable, it must put into consideration the socio-economic environment of the target farmers. This will require community study, covering farming family needs, beliefs, diets, aspirations, etc – complex interactions of issues and needs, which will rightly address the farmer's situation. If the farming/cropping systems fail to address these goals, getting farmers to adopt them may be difficult, as family survival is central to African agriculture.

In addition the farming/cropping systems evolved must be within the farmer's ability and means. Observing that most African farmers are poor, such proposed innovations must not be expensive unless governments are ready to bear the cost.

The systems evolved must also be easy to deploy, not too foreign to the farmer or target areas. Noting that subsistence farming focuses first on the family food needs, thus crops and animals are raised first to meet the food needs of the family before sales. Therefore an introduction of crops/animals into the farming systems that does not form part or whole of the dietary intake of the farming family may be unacceptable.

Chatting the way forward: Dealing with drought related issues

Weather forecasting

A critical component of the mitigation process is the need for adequate provision for weather forecasting and other agricultural technological infrastructure that allows for weather prediction; providing guide to farmers on expected agricultural related weather elements. This information should guide farmers on choice of crops to plant.

Education

There should be an incentive for training in agriculture, participatory and on-going capacity building for farmers on climate change, strengthening of the extension services, and encouragement of formation of farmer groups (IPCC, 2007; Deressa *et al.*, 2008; BNRCC, 2008; Anselm and Taofeeq, 2010).

Explicit national agricultural policy framework

There should be an explicit national agricultural policy framework as it relates to climate change, its effects on agricultural production and mitigation processes. This policy framework should be holistic and in depth, addressing all salient areas of climate change and agricultural productivity as it affects Nigeria.

Reconsidering planting dates

In the face of unpredicted rainfall (where such may occur): commencement, duration, frequencies and intensity, there is the need to re-address planting date experiments; reassessing the effects of delayed sowing on crop components in the local cropping systems - to get the most suitable date, or introduce a more adjusted crop(s) to accommodate the change in *statuesque*. Where reduction in length of cropping season is anticipated, planting of shorter duration crops/varieties could greatly help in the mitigation process.

Planting drought resistant/drought tolerant varieties

Planting drought resistant / tolerant varieties may mitigate low rainfall, address unpredictability of rainfall or sudden breaks in rainfall. Where drought may not be intense or persistent, long duration crops like cassava and pigeon pea may form an important component of the cropping systems; as these crops, based on their life span may be able to recover from temporary droughts.

Varietal selections for diseases and temperature

Varietal selections for diseases and temperature (high and low) may also be necessary.

Investment on dams and irrigation facilities

The possibility of drought in areas prone to this phenomenon, underpins the need to heavily invest on dams and irrigation facilities. As global warming accelerates and its impact on agriculture becomes more pronounced, it is expected that agricultural adaptation to climate change can only be meaningful and sustainable, if irrigated agriculture (in those areas prone to drought) or any other form of creation of artificial environment for crop husbandry gains prominence among African farmers (Anselm and Taofeeq, 2010) though this measure would entail additional cost of production and may push up cost price of food items. At this moment, crop production in Nigeria is still predominantly rain-fed and therefore particularly vulnerable to the impacts of climate change.

Chatting the way forward: Dealing with flood related issues

Coping with floods

Climate change may not only bring with it, drought, but flooding as well, besides temperature increases or lowering (IPCC, 2007; BNRCC, 2008; Anselm and Taofeeq, 2010). For those areas that may be prone to flooding, there may be need for adequate drainage systems, water control mechanisms, selection of crops suitable for such environments, if agricultural production is to be sustained. There is the need for:

- **Adequate weather forecasting for possibility of flood**
- **Adequate education to handle flood related issues**
- **Reconsidering planting dates to accommodate flooding periods**
- **Varietal selections for diseases and pests**

Conclusion

Droughts and floods are not new to the existing world; these, pre dates Biblical times. However, that these events have hunted mankind for centuries; determining civilizations, changing history and

human survival through the course of history have not made man a master of these events. Their coming have remain as potent as they were centuries ago.

Warnings of impending dooms that climate change could unleash on the world have sounded for decades, yet for those experiencing these realities in Africa, they are often caught unprepared. This fact is evident in the low level response as it pertains to mitigation, or coping strategies often available when weather related disasters strike. Consequently droughts were usually accompanied by hunger, diseases and even death, where foreign interventions delay; as expectations of this phenomenon had not prompted food storage in most cases, or adopting cropping strategies that may cushion effects of drought. Expectations of floods were not handled differently; these are usually greeted with despair, as homes are destroyed, crops swept away, and lives lost. Anticipation of impending catastrophe that may accompanied climate change, has not made the world more prepared, probably because of doubts, or the lack of political will to change the way of life. Catastrophic consequences of weather related natural phenomenon are more prevalent in Third World countries as seen in Africa and Asia, due to low level coping strategies, resulting from poverty. In view of climate change expectations, experiments addressing various expected outcomes should have commenced in earnest with principal goals in mind. For experimental recommendations to be sustainable, it must incorporate economic and social environment of the farming family.

African farmers have often being viewed as conservative; often adhering to principles and practices that are decades or even centuries in operation, but in a changing climate, this single character may be the undoing of Africa's agriculture. As climate change catches up with most places in Africa, weather elements, particularly rainfall (commencement, duration, intensity, reliability, etc.), and temperatures have become less predictable. In a world where a great percentage of foods consumed are grown under natural environment, such unpredictability will definitely affect Africa's food security. Conservative character of most African farmers, which may not allow for prompt adjustment to cropping systems, should be expected to negatively compound mitigation processes. In the face of predicted climate change (Ziervogel *et al*., 2006; IPCC, 2007; BNRCC, 2008) farmers' response to mitigation process should be expected to be depended on:

- Economic factors: Cost of new innovation, farmers' finance, available financial assistance, access to finance, cost of finance etc.
- Available options/technology: Cost of new innovation, speed of deployment, accessibility to new technology, technical-know-how, and farmer's educational level.
- Available information: Cost of new information, accessibility to information.
- Farmer's response to information.

For some climate change is expected to undermine the systems that provide food security. Whilst farmers in some regions may benefit from longer growing seasons and higher yields, the general consequences for Africa are expected to be adverse, and particularly so for the poor and the marginalized, who do not have the means to withstand drastic changes.

Evolving new cropping systems that may adequately mitigate climate change effects require simulating various expected scenarios (short and long term scenarios) with its mitigation. This process would not be easy, as climate elements should become irrational and less predictable, thus postulated solutions may not serve for long, as weather elements may tend to change without much notice. An option is to choose crops that can adapt to varying environmental changes and that transcend ecological barriers as basis for the cropping systems; a crop with wide adaptability, able to adjust to drought and cope with flood and well as variations in temperatures. Typically, soybean a subtropical crop; able to survive in temperate and tropical environment is tolerant to drought while it is able to tolerate brief flooding. Such crop and the likes could find prominent position in cropping systems in a changing climate. Areas prone to flooding may adopt crops such rice, while those prone to drought can focus on millet and sorghum as basis of the cropping systems. However, to adequately address the issues of evolving cropping systems that are sustainable demand the bringing together of all fields of agronomy to chat new course.

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Appendices

Figure 1: May 10, 2015: Yam-maize intercrop showing effect of low rain on maize crop grown in February in Anyigba, Kogi State, Nigeria

Figure 2 May 10, 2015: Yam-maize intercrop showing effect of low rain on yam sown in January and maize cropped in February in Anyigba, Kogi State, Nigeria

Figure 3 May 21, 2015: Yet to be cropped land due to late establishment of rains in Anyigba, Kogi State, Nigeria. This land should have been cropped in March

Figure 4:May21, 2015: Yam-maize intercrop showing effect of low rain on yam sown in January and maize cropped in February in Anyigba, Kogi State, Nigeria

Figure 5: May 10, 2015: Pigeon pea-maize intercrop showing effect of low crop component sown in February in Anyigba, Kogi State, Nigeria

Figure 6: May 10, 2015: Yam-maize intercrop showing effect of low rain on maize cropped in February in Anyigba, Kogi State, Nigeria