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Review

Impact of climate change on agriculture and food security in Nigeria: challenges and adaptation

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Climate change is perhaps the most serious environmental threat to agricultural production in Nigeria. The patterns of the effects of climate change are dependent on latitude, altitude, type of crop grown and livestock reared. The direct impact of climate change on agricultural systems are: changes in rainfall and temperatures which could impact on agro-climatic conditions, altering growing seasons, planting and harvesting calendars, water availability, pest, weed and disease populations. Climate change would also impact on alteration in evapotranspiration, photosynthesis and biomass production and land suitability for agricultural production. Analysis of climatic data from 1914-1970 and 1971-2000 had indicated that there were changes of the onset of rains and cessation. There was also increase in the intensity of the rains. Measures mitigating the impact of climate change and adaptation have been discussed to include: human capital development, increase funding of Research and Technology development, breeding short duration varieties, draining lowland rice fields to reduce emission of methane, nitrous oxide and carbon dioxide (greenhouse gases), agroforestry, soil and water conservation and trade.

Keywords: Climate change, challenges, adaptation, food security.

The Impacts of Climate Change

Climate change is the latest challenge to sustainable human development. The scientific evidence is clear, climate change is likely to have negative impacts on efforts to achieve Nigeria's development objectives, including the targets set out in Nigeria Vision 20:2020 and the Millennium Development Goals (MDGs). In particular, climate change will impede efforts to reduce the poverty experienced by the majority of Nigerians. It will retard the drive to ensure equity in the distribution of development benefits, particularly among women and men; and it will check the effort to promote sustainable livelihoods. In addition, climate change will likely lead to other changes such as ecosystem degradation and reduced availability of water and food. It is therefore likely to become a major driver of increased human conflict.

Climate change is already having an impact in Nigeria. Weather-related disasters have become more frequent in the past four decades and the trend continues. In 2010, the National Emergency Management Agency (NEMA) reported that over 250,000 Nigerians were displaced by flood disasters that ravaged many communities across the country (NEMA, 2010). Weather related disasters, especially flooding, are reported, almost daily in the country's news media at the peak of rainy season.

The Intergovernmental Panel on Climate Change, IPCC's Fourth Assessment Report summary for Africa describes a trend of warming at a rate faster than the global average, and increasing aridity in many countries. Climate change exerts multiple stresses on the biophysical as well as the social and institutional environments that underpin agricultural production (IPCC, 2007). That is, socio-economic factors, international

competition, technological development as well as policy choices will determine the pattern and impact that agro-climatic changes will have on agriculture (Brusell, 2009). In all, Khanal (2009) classified the patterns of impact of climate change on agriculture into biophysical and socio-economic impact.

The biophysical impacts include; physiological effects on crop and livestock, change in land, soil and water resources, increased weed and pest challenges, shifts in spatial and temporal distribution of impacts, sea level rise and changes to ocean salinity and sea temperature rise causing fish to inhabit in different ranges. The socio-economic impacts result in decline in yield and production, reduced marginal GDP from agriculture, fluctuation in world market price, changes in geographical distribution of trade regime, increased number of people at risk of hunger and food insecurity, migration and civil unrest.

According to Khanal (2009), the patterns of the effects of climatic change are however dependent on latitude, altitude, type of crop grown and livestock reared. Mark et al. (2008) highlighted some of the direct impacts of climate change on agricultural system as: (a) seasonal changes in rainfall and temperature, which could impact agro-climatic conditions, altering growing seasons, planting and harvesting calendars, water availability, pest, weed and disease populations; (b) alteration in evapotranspiration, photosynthesis and biomass production; and (c) alteration in land suitability for agricultural production. Some of the induced changes are expected to be abrupt, while others involve gradual shifts in temperature, vegetation cover and species distributions. However, when looking critically on plant production, the pattern of climate change has both positive and negative impacts. Rises in temperature for example helps to grow crops in high altitude areas and towards the poles. In these areas, 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. The warmer conditions support the process of natural decomposition of organic matter and contribute to the nutrient uptake mechanisms. 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.

But when temperatures exceed the optimal level for biological processes, crops often respond negatively with a steep drop in net growth and yield. Food and agricultural organization (2007) stated that heat stress might affect the whole physiological development, maturation and finally reduces the yield of cultivated crop. The negative effects on agricultural yields will be exacerbated by more frequent weather events. For example, FAO, (2007) stated that rising atmospheric CO_2 concentration, higher temperatures, changes in annual and seasonal precipitation patterns and in the frequency of extreme events will affect the volume, quality, quantity, stability of food production and the natural environment in which agriculture takes place. Climatic variations will have consequences for the availability of water resources, frequency of pest and diseases, and soil quality, leading to significant changes in the conditions for agriculture and livestock production. In extreme cases, according to FAO (2007), the degradation of agricultural ecosystems could mean desertification, resulting in a total loss of the productive capacity of the land in question. This is likely to increase the dependence on food importation and the number of people at risk of famine.

Climate Change in Nigeria

There are two dimensions to the issue of climate change in Nigeria. The first, already acknowledged by households and communities across Nigeria, and reported by the Nigerian Meteorological Agency (2008), is changes that have already been observed in climate parameters such as temperature, rainfall and extreme weather events. The second deals with changes that are to be expected in the future. These two dimensions are dealt with in the sub-sections that follow immediately.

A key contribution on observed climate change has come from BNRCC (Building Nigeria's Response to Climate Change) research and pilot projects spread throughout the ecological zones of the country. The results of these projects have been collated and synthesized, providing documentation of community level experience with climate hazards, impacts, vulnerabilities and adaptation measures. In addition, the Nigerian Meteorological Agency (NIMET, 2008) assessed the Nigerian climate over the period 1941 to 2000 and demonstrated the following changes.

Rainfall

Between 1914 and 1970, only patches of the country, around Sokoto and Maiduguri and in the southeast, experienced late onset of rains. However, from 1971 to 2000 late onset of rains had spread to most parts, leaving only a narrow band in the middle of the country with normal conditions. Figure 1 shows onset of rainfall in 1970 and Figure 2 shows onset departure days in 2011 (NIMET, 2011). Similarly, only a small patch of the country in the southwest recorded early cessation of rains between 1914 and 1970, while from 1971 to 2000 early cessation of rains had covered most of the country Figure 3 and Figure 4 show cessation departure days in 2011.

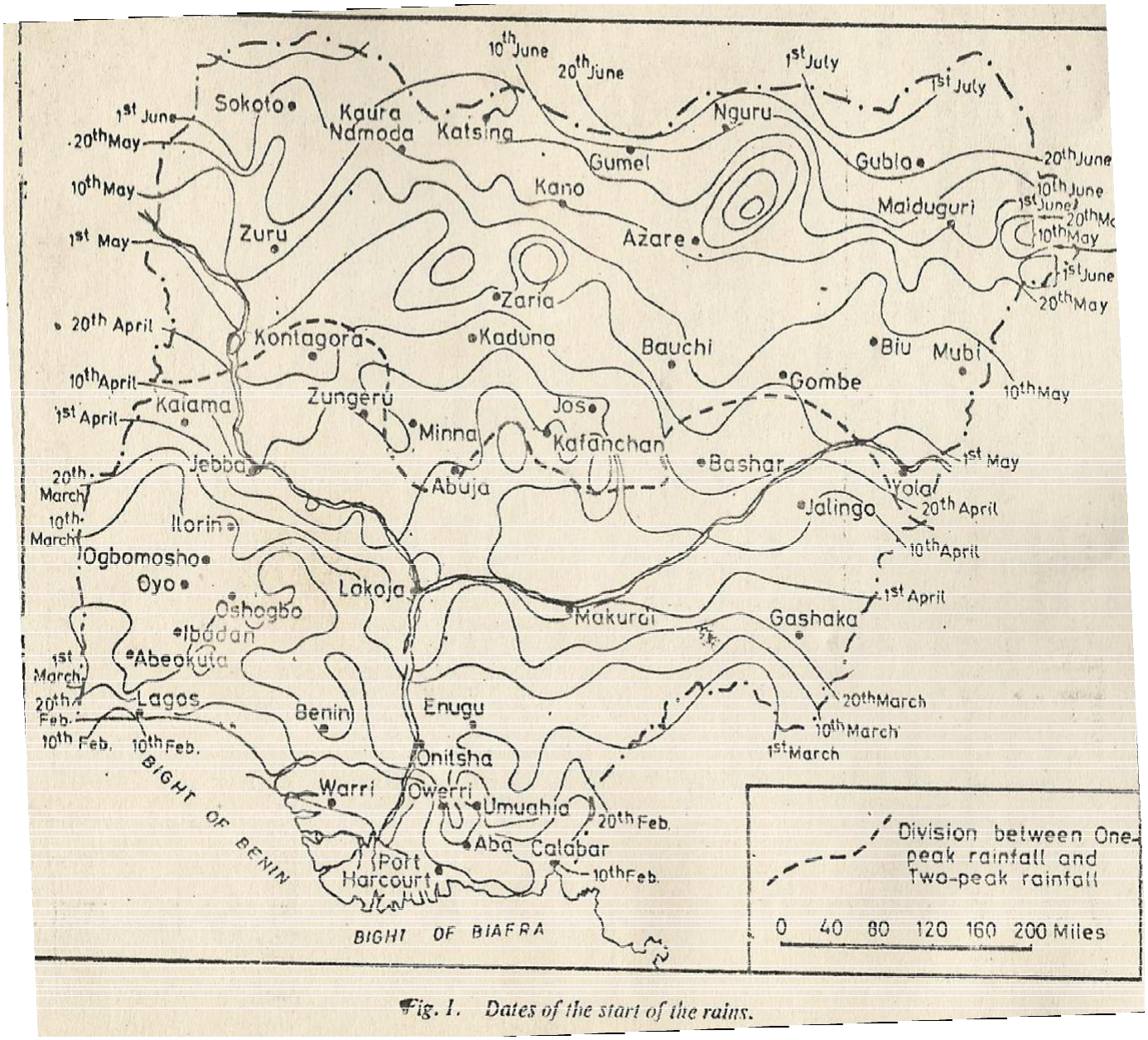

Figure 1. Dates of the onset of rains in 1914- 1970

The combination of late onset and early cessation of annual rainfall decreased by 2-8 mm across most of the country, but increased by 2-4 mm in a few places, most significantly around Port Harcourt. Nigerians are already feeling and adjusting to the impacts of climate variability and change.

Rainfall distribution in northern Nigeria is uni-modal; results of trend analyses of rainfall data have shown a tendency towards decreasing rainfall totals in all regions of Nigeria (Anyadike, 1992). However, significant decreases are recorded in northern Nigeria. The annual rainfall amount and rainy days decrease with increase latitudinal position (Table 1). For example, mean annual rainfall for Kano (latitude 12^0), Samaru (latitude 11^0) and Kaduna (latitude 10^0) are 850, 1050 and 1219 mm respectively; a negative correlation exist between year of measurement and annual rainfall totals. Regression equations revealed decrease of 3.18, 2.68, and 1.15mm per annum respectively, for Kano, Samaru and Kaduna [Oluwasemire, 1999). In Nigeria, as rainfall amount decrease northward; the number of rainy days decreases southwards. This shows an increase in the rainfall intensity for each event.

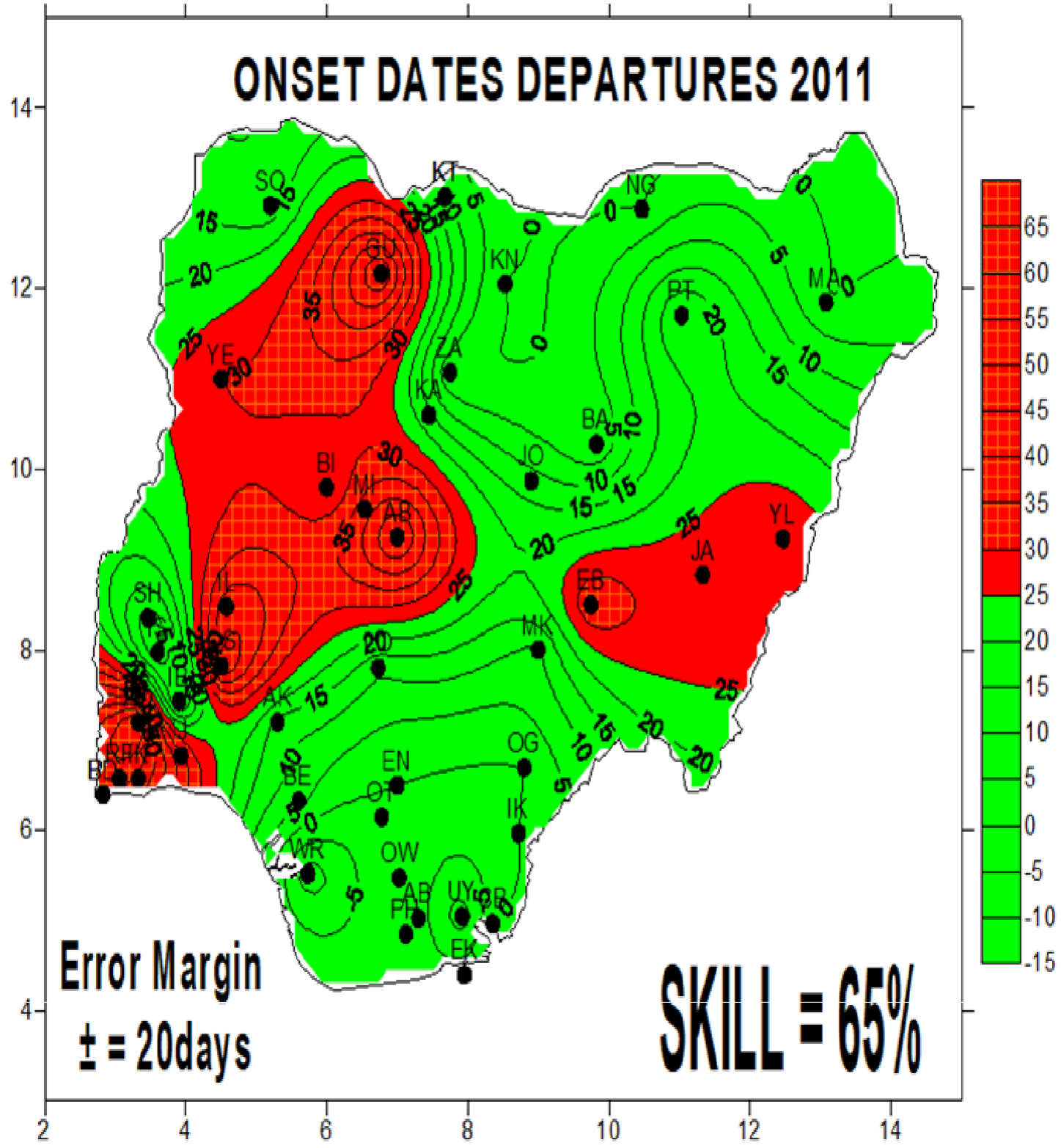

Figure 2. Map of Nigeria showing onset dates departures of rain in 2011 **Source:** NIMET (2011)

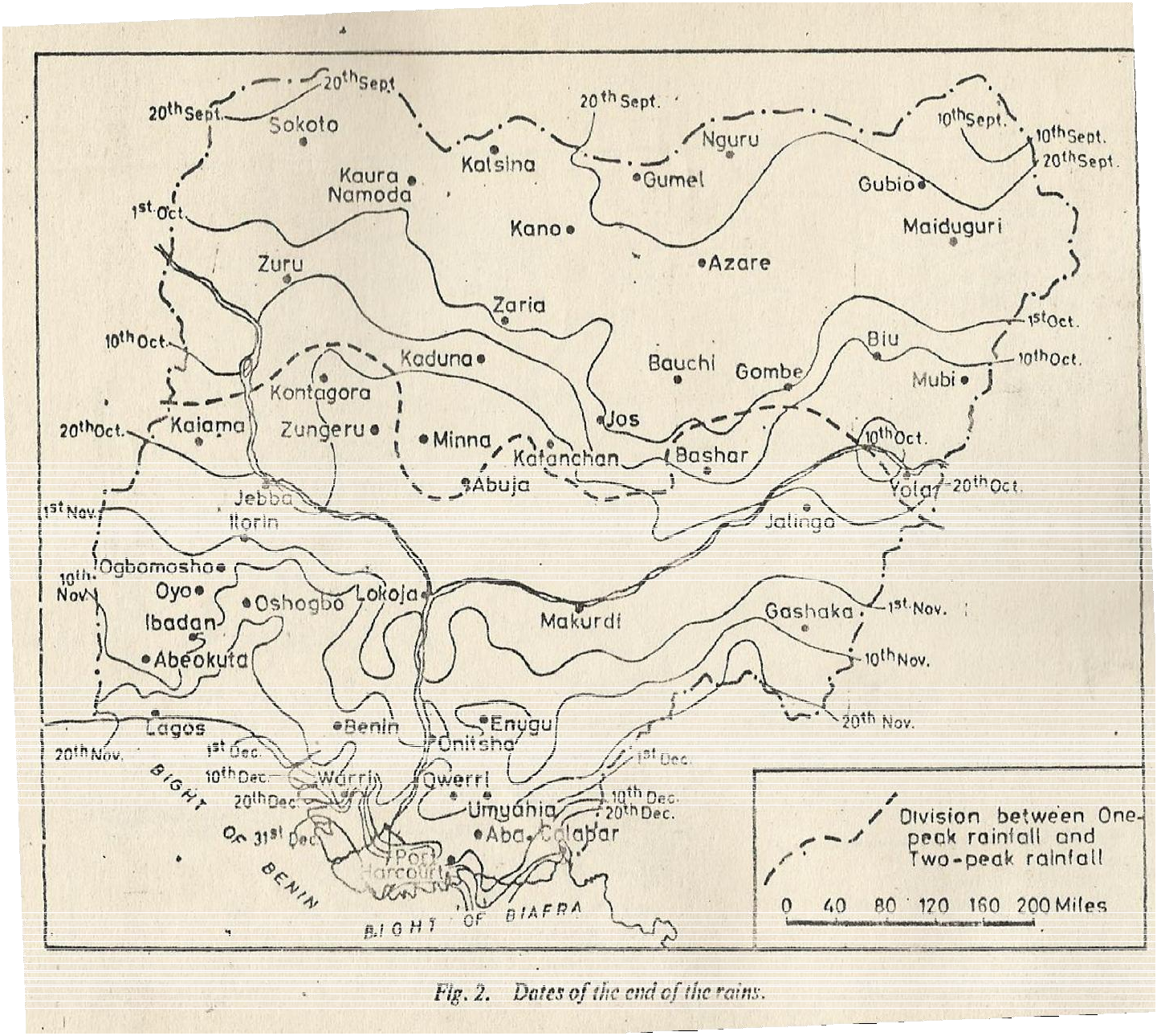

Fig. 2. Dates of the end of the rains.

Figure 3. Dates of cessation of the rains from 1914-1970.

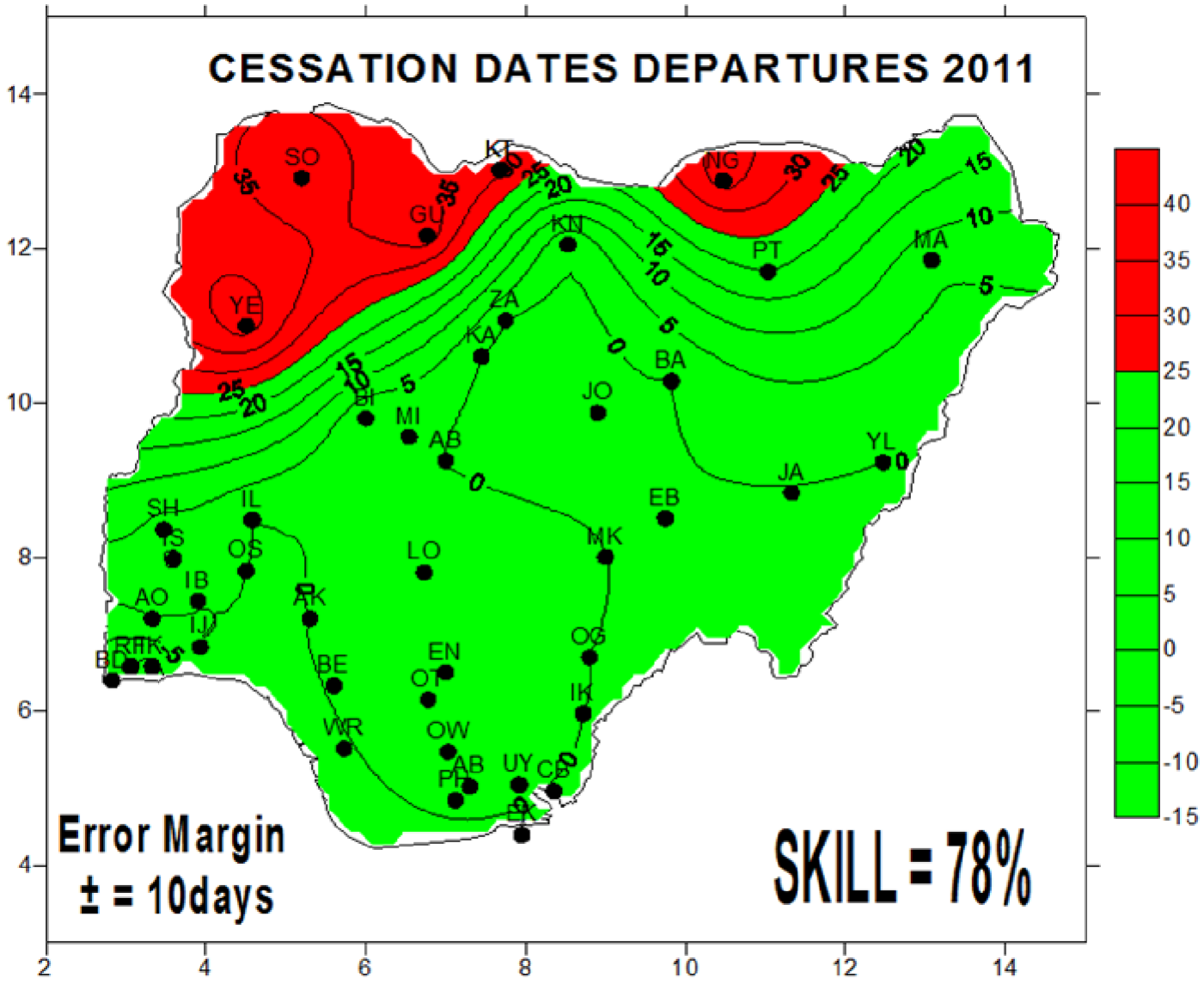

Figure 4. Map of Nigeria showing 2011cessation dates departures of rainfall.

Table 1. Spatial variability in long term monthly and annual rainfall in northern Nigeria.

Location	Latitude	Jan	Feb	mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Total
Minna	09^0	2.2	6.4	12.7	59.2	122.2	165.0	231.6	251.7	281.5	121.6	1175
Mokwa	09^0	2.0	4.4	18.1	69.8	141.2	170.2	163.6	168.2	228.7	89.0	1055
Bauchi	10^0	0,0	1.0	4.0	30.6	88.8	143.1	254.9	321.0	180.3	38.0	1062
Samaru	11^0	0.1	0.9	6.0	34.6	119.3	153.0	219.6	273.0	202.0	37.7	1046
Ngala	12^0	-	-	1.8	5.0	19.96	54.3	145.9	187.9	55.6	14.2	485

Source: Meteorological Unit (Institute for Agricultural Research Samaru, Nigeria)

Temperature

From 1941 to 2000 there was evidence of long-term temperature increase in most parts of the country.

The main exception was in the Jos area, where a slight cooling was recorded. The most significant increases were recorded in the extreme northeast, extreme northwest and extreme southwest, where average temperatures rose by 1.49 ^{0}C. Figure 5 showed temperature departures in 2011.

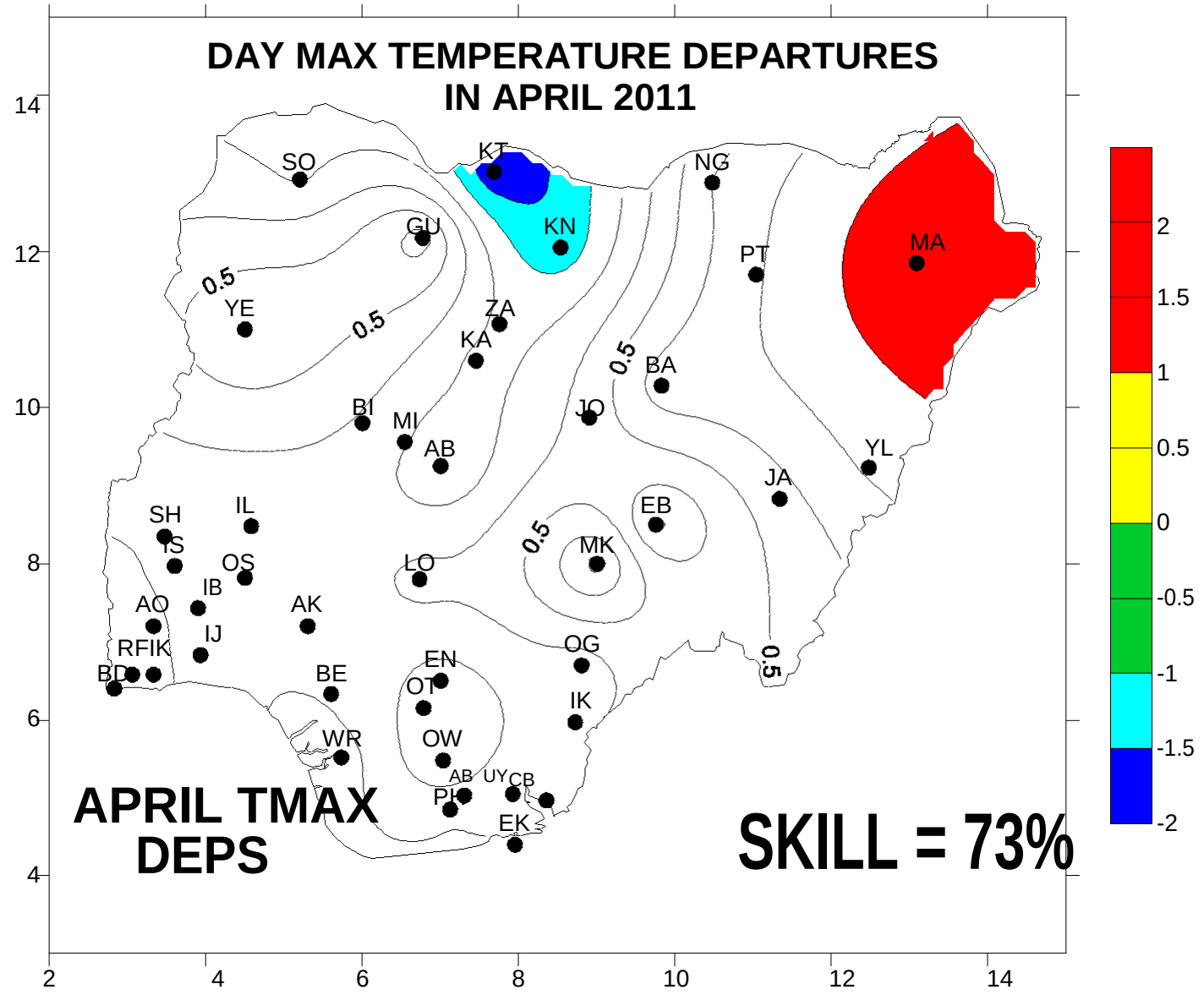

Figure 5. Maximum temperatures departures in April 2011.
Source NIMET

Climate Change and Food Production

Complex relationships between crops, atmospheric composition and temperature, combined with the complexities of world agricultural policies and trade, make it difficult to predict the future impacts of climate change on agriculture. Many studies indicate that the increased intensity and frequency of storms, drought and flooding certainly have implications on agricultural production, particularly food. Tobey (1992) indicated that climate change impacts on agriculture can be roughly divided into two groups: biophysical and socio-economic impacts. Recent research has focused on regional and national assessments of the potential effects of climate change on agriculture. Sensitivity studies of world agriculture to potential climate changes have indicated that the effect of moderate climate change on world and domestic economies may be small, as reduced production in some areas is balanced by gains in others (Tobey, 1992). However, there has to date been no integrated (combined biophysical and economic) assessment of the potential effects of climate change on world agriculture.

Fischer (2005) projected that global cereal production could continue to increase up to 3.7 - 4.8 billion tons by 2080 under the basic conditions i.e., without climate change. When it is factored in, global cereal production could be within 2% of reference scenarios, but with potentially large regional variations, with temperate regions on the northern hemisphere benefiting from

increased temperatures and longer growing periods for moderate degrees of warming; while tropical regions will lose agricultural production potential, reflecting both declining potential land available for crop cultivation and changes in productivity. A similar study, modeled the impacts of climate change on agricultural production and demonstrated that there will be negative effects on crop yields over the next century, particularly in developing countries where people are already at risk (Fisher, 2005). Despite technological advances such as improved crop varieties and irrigation systems, weather and climate are still key factors in determining agricultural productivity.

Food Production and Trade

Currently, fewer countries have the possibility to feed themselves and, hence, that there will be greater reliance on markets and trade. Some developing countries are particularly vulnerable to additional impacts of climate change on their ability to attain food security, due to their unfavorable positioning in international trade, compounded by poor development of domestic and regional markets. Being able to balance growing differences between food demand and on will mean paying greater attention to develop policies supporting trade, and putting in place the necessary infrastructure and institutions. With the increasing trend in the international food trade, the effects of climate change on agriculture in individual countries cannot be considered in isolation. Food trade has grown dramatically in recent decades and now provided significant increments of national food supplies to major importing nations and substantial income for major exporting nations (Fisher, 2005). This emphasizes the close links between agriculture and climate, the international nature of food trade and food security, and the need to consider the impacts of climate change in a global context. Climate Change, Food Production and Food Security: the Linkages change is real and its first effects are already here examined. The outcome was a redefinition of food security, which recognized that the behavior of potentially vulnerable and affected people was a critical aspect.

Currently, more frequent and more intense extreme weather events and droughts, rising sea levels, and increasing irregularities in rainy season patterns are already having immediate impacts on food production, food distribution infrastructure, incidence of food emergencies, livelihood assets and opportunities and human health, in both rural and urban areas. Food and agricultural organization (2002) reported that the impacts of gradual changes in mean temperatures and rainfall are likely to be disruptive, whether positive and negative.

According to Ludi (2007), about 768 million people are estimated to be undernourished in 2080. Africa and South Asia, where a large portion of the population will depend on agriculture, and where capacities (e.g. technologies, finances, investments, etc.), both at national and farm level to adapt to climate change, are lowest. Slater (2007) tried to trace the likely impacts of climate change through changes in the quality of the physical asset base, access to assets, and impacts on grain production and on agricultural growth. At moderate degrees of warming, impacts are likely to be negative in some regions, but positive in others, making it important to understand the possible implications for trade between the regions. The short term impacts of climate change, particularly changes in the frequency and severity of adverse weather events, remain uncertain, but their impacts on many developing countries are likely to be negative. However, there is likely to be time to make appropriate policy responses to some of the longer-term impacts.

Mitigation and Adaptation Strategies.

Mitigation measures have to do with limiting and controlling climate change. For example, measures that control the emissions of greenhouse gases which cause the atmosphere to warm .Existing and emergent technologies, ranging from renewable energy and nuclear power to carbon capture, storage and trade, would be needed to make the reductions in emissions essential if the world in particular Africa is to avoid the danger.

Adaptation measures to climate change have to do with living with climate change, for example agroforestry, conservation agriculture, inter-cropping, biodiversity and collection of rainwater for agricultural use referred to as rainwater harvesting. This process is particularly important in the arid and semi-arid Northern Nigeria. Efforts at improving local or indigenous practices of water harvesting and soil water conservation should be promoted. Reij (1991) defined soil water conservation technology as " sum of practices involved in managing soil and water in agricultural settings and they include agro-forestry, agronomic and tillage practices". Water saving techniques for rain-fed crops in Northern Nigeria are aimed essentially to: (i) trap, capture and increase rain water infiltration into the soil, (ii) facilitate plants to use water stored in the soil and, (iii) promote better conservation of water infiltrated in the soil.

The tie-ridge practice is the most popular cultivation practice in the arid and semi-arid Nigeria. This practice traps rain water and prevent surface runoff thus making more water available for plant use. The tie-ridge practice which involves construction of dykes at right angles to the ridges at intervals of one to two meters. The efficiency of this system depends on rainfall distribution with respect to date of tying the ridge. Ogunwale (2004) reported a 218% in seed cotton over the open ridge at Samaru. In degraded crusted soils, the planting pit techniques are commonly adopted to rehabilite the land; they concentrate rainfall and runoff to ensure that the crops

are less susceptible to water stress [Ouedraogo and Kabore, (1996).

Erosion control measures such as contour bunding, strip cropping, zero tillage and utilization of livestock waste could increase the rate of infiltration, thereby reducing runoff and erosion.

The submergence of soil promotes the production of methane by anaerobic decomposition of native and added organic matter. Lowland rice ecosystems have long been recognized as a source of methane – a greenhouse gas (Buresh et al. 2005). Temporary aeration or intermittent irrigation of lowland rice can effectively minimize methane emission and potentially save water (Buresh et al, 2005).

RECOMMENDATIONS

There should be an explicit national agricultural research policy framework to provide a conducive environment for continuity and effectiveness in agricultural programmers'/projects

There is a need to radically depart from reliance on rain-fed food production through heavy utilization of irrigation. There is therefore the need for adequate provision of irrigation and drainage infrastructure which could be regarded as crucial for climate change adaptation

The Nigerian government should take a bold step to establish better-equipped weather stations as against the scanty and ill-equipped ones. With this, accurate weather forecast and predictions will be possible and this will help to prevent weather-related disasters through early warning and effective response/adaptation system. In addition, efforts need to be made towards tackling the dilapidated infrastructure in the country.

With the increasing rate of erratic rainfall patterns, drought and desertification, drought resistant and short duration high yielding crops should be developed through research efforts and made available to farmers.

The high climate variability that characterizes the African continent presupposes that people have developed successful indigenous adaptation strategies. It is therefore advocated that indigenous knowledge and practices should be integrated into formal climate change mitigation and adaptation strategies.

There is need for effective capacity building to strengthen the most vulnerable group in agricultural production with requisite knowledge and information necessary for climate change mitigation and adaptation.

Desertification and other unhealthy environmental practices must definitely be curtailed if Nigeria must meet the 2015 target of the Millennium Development Goal (MDGs) of fighting hunger and poverty.

Strengthening of the nation's extension services perhaps by devolving the bulk of the services down to the local councils, which is closer to the farmers, and encouraging farmers to form farmer groups for enhanced capacity through group efforts.

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