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REGIONAL CONFERENCE ON CLIMATE CHANGE AND FOOD SUSTAINABILITY IN THE 21ST CENTURY

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(Lagos, Nigeria, 11 November 2003)

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1. INTRODUCTION

The theme of this Conference is indeed of paramount importance to the sustainable socio-economic development of Africa, a continent that is rich in natural resources and yet, has not been able to effectively harness this potential in the past. According to estimates, ninety per cent of Africa's poor live in rural areas, and seventy per cent of Africa's population depend on agriculture as a primary source of employment and livelihood. Raising agricultural productivity is therefore a key factor in reducing food insecurity. Agricultural development is therefore a necessity, not an option, for food sustainability in the 21st century.

Available and emerging evidence suggests that the deterioration of the environment and natural resources is seriously undermining the development prospects of African countries. Land degradation is widespread throughout the continent, mainly due to soil erosion and impoverishment, and this is directly, or indirectly, leading to desertification. There is increasing concern over the rapid depletion of the natural resources base through deforestation, loss of biological diversity and the unsustainable utilization of fresh water. The most recent evidence on global climate change indicates that African countries may yet face another major emerging environmental and development challenge. Reduced and uncertain levels of rainfall, extreme climatic events, armed conflicts and civil strife, inappropriate land tenure and land use and the uses of

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technologies further exacerbate the problems. These issues are even more critical when viewed in the light of the need for countries to achieve their overall food security and sustainable development goals. Thus, the challenge for Africa is to halt and reverse the current trend in environmental degradation, so as to maintain a productive natural resource base as the foundation for sustainable agriculture and industry, which are essential for sustained economic growth.

According to the latest estimate, there were 815 million undernourished people in the world in 1997-99, and 777 million of these people live in developing countries. In terms of the percentage of undernourished people in the total population, the highest incidence is found in sub-Saharan Africa, where it was estimated that one-third of the population (34 per cent) were undernourished in 1997-99. Over the past decade, the incidence of undernourishment in sub-Saharan Africa has declined only marginally. Considering the rapid population growth in this region, this means that the total number of undernourished people in sub-Saharan Africa has increased significantly.

Food shortages and food insecurity in sub-Saharan Africa are linked to the results of poor agricultural performance, which weakened substantially in 2000. The poor performance of the African agricultural sector over the last 15 years was a result of both policy and structural factors as well as natural and human-made disasters. The policies followed by most African countries were inadequate as a result of chronic civil and social unrest, displacement of populations, inappropriate management of resources, including natural resources, and inability to build capacity and strengthen local institutions. Moreover, the terms of trade of most African agricultural commodities, which account for 40 per cent of export trade, were very unfavourable during most of the 1980s, resulting in a loss of income of 60 per cent and thus jeopardizing further economic development.

For example, in 2000, the overall agricultural production decreased by 0.3 per cent after increasing by 3.7 and 1.9 per cent in 1998 and 1999, respectively. The estimates for 2001 point to another year of disappointing agricultural performance in the region, with agricultural output expanding by less than 1 per cent, and with crop and livestock production rising by only 0.9 and 0.5 per cent, respectively. Millions of people in Africa are in need of emergency food assistance as a result of poor performance in agricultural production. For example, in eastern Africa, food supply

difficulties persist in some parts as a consequence of poor rainy seasons and/or civil conflict. In West Africa, several countries continue to face food supply difficulties as a result of localized unfavourable weather (Chad, Ghana), or past or ongoing civil strife or population displacements (Guinea, Liberia, Sierra Leone). Approximately 5.2 million people in Ethiopia, 1.5 million in Kenya, 2 million in the Sudan and 300 000 in Uganda depended on food aid in 2002. The reduced 2001 maize harvest, caused by adverse weather in several parts of southern Africa, has led to food shortages. In conjunction with other physical, social and political-economic factors, climate variability and change contribute to vulnerability, economic loss, hunger, famine and displacement.

Over the years however, it has become clearer that any meaningful plan of action to address food security issues should focus primarily on the socio-economic factors that most contribute to food insecurity, as well as on the important linkage with weather, climate and water, and in particular extreme weather events such as droughts and floods (Obasi, 1997). One will recall, for example, the droughts in the Sahel region which caused considerable damage to food production systems during the late sixties and early seventies. As an African economic planning minister once put it, "*the economic case of most African countries is agriculture. Agricultural production and weather are so highly interrelated that a good rainy season means a healthy economy, and failure of the rains ..... means famine and death.*" If one were able to reliably predict the gross features of rainfall and temperature anomalies at least a few months ahead, decision-making and planning by farmers and governments could be facilitated and major famine disasters averted.

2. INFLUENCE OF CLIMATE VARIABILITY AND CLIMATE CHANGE

Although significant advances have been made in our understanding of the influence of climate on agricultural production, climate variability has been, and continues to be, the principal source of fluctuations in global food production, particularly in the arid and semi-arid tropical countries of the developing world. Throughout history, temperature extremes, droughts and floods, tropical cyclones and various forms of violent weather have wreaked havoc on the agricultural systems in these regions. Rainfall is one of the most important natural resources for many African nations (Hulme, 1992). Inter- and intra-annual variability in rainfall is perhaps the key climatic

element that determines the success of agriculture in these regions where the climatic control of soil water availability through rainfall and evaporation is most prominent. In low-rainfall years, there may be droughts; in high-rainfall years, or even for short periods in low-rainfall years, there may be floods. Extensive droughts have afflicted Africa, with serious episodes in 1965–1966, 1972–1974, 1981–1984, 1986–1987, 1991–1992, and 1994–1995. The aggregate impact of drought on the economies of Africa can be large: 8–9 per cent of GDP in Zimbabwe and Zambia in 1992, 4–6 per cent of GDP in Nigeria and Niger in 1984. In Mozambique, the 2000 flood impact accounted for nearly 12 per cent of the GDP.

African rainfall has changed substantially over the last 60 years. Over tropical North Africa this change has been notable as rainfall during 1961-1990 declined by up to 30 per cent compared with 1931-1960. From an analysis of recent rainfall conditions in West Africa, Nicholson *et al.* (2000) concluded that a long-term change in rainfall has occurred in the semi-arid and sub-humid zones of West Africa. Rainfall during the last 30 years (1968-97) has been on average some 15 to 40 per cent lower than during the 1931-60 period. A similar but smaller change has occurred in semi-arid and sub-humid regions of southern Africa. The possible causes of rainfall changes can be categorized into three broad areas: those related to land cover changes within the continent; those related to changes in the global ocean circulation and associated with patterns of sea-surface temperature (SST); and those related to the changing composition of the global atmosphere.

A number of theoretical, modelling and empirical analyses have suggested that noticeable changes in the frequency and intensity of extreme events, including floods, may occur when there are only small changes in climate. For example, significant increases in the intensity of extreme rainfall events were identified over about 70 per cent of the country in South Africa between 1931-60 and 1961-90 (Mason *et al.*, 1999). Hence, it is imperative that these aspects are well understood in order to formulate more sustainable policies and strategies to promote food production in the arid and semi-arid tropics.

3. PROJECTED CHANGES IN CLIMATE IN THE 21ST CENTURY

Today, there is growing understanding that increases in greenhouse gas accumulation in the global atmosphere and in regional concentrations of

aerosol particulates are having detectable effects on the global climate system. According to the WMO/United Nations Environment Programme (UNEP) Intergovernmental Panel on Climate Change (IPCC), the global average surface temperature has increased over the 20th century by about 0.6°C, and temperatures have risen in the past four decades in the lowest eight kilometres of the atmosphere (Obasi, 2001). New analyses of data for the Northern Hemisphere indicate that the increase in temperature in the 20th century is likely to have been the largest during any century since 1000 AD.

In the future, annual warming across Africa is projected to range from 0.2°C to more than 0.5°C per decade (Hulme *et al.*, 2001). This warming is greatest over the interior of the semi-arid margins of the Sahara and central southern Africa. Land areas may warm by 2050 by as much as 1.6°C over the Sahara and semi-arid parts of southern Africa. Equatorial countries (Cameroon, Uganda, and Kenya) might be about 1.4°C warmer. Sea-surface temperatures in the open tropical oceans surrounding Africa will rise by less than the global average (i.e., only about 0.6–0.8°C); the coastal regions of the continent therefore will warm more slowly than the continental interior.

Future changes in mean seasonal rainfall in Africa are less well defined. Rainfall changes projected by most general circulation models (GCMs) are relatively modest, at least in relation to present-day rainfall variability. Under the two intermediate warming scenarios, significant decreases (10 to 20 per cent) in rainfall during March to November are apparent in North Africa in almost all models by 2050. In southern Africa, decreases of 5 to 15 per cent in rainfall in the growing season during November to May are projected. Seasonal changes in rainfall are not expected to be large. Great uncertainty exists, however, in relation to regional-scale rainfall changes simulated by GCMs (Joubert and Hewitson, 1997). Under the most rapid global warming scenario, increasing areas of Africa experience changes in rainfall that exceed over 65 per cent of natural variability. Parts of the Sahel could experience rainfall increases of as much as 15 per cent over the 1961–90 average. Equatorial Africa could experience a small (5 per cent) increase in rainfall. These rainfall results are not consistent: different climate models, or different simulations with the same model, yield different patterns. The problem involves determining the character of the climate change signal on African rainfall against a background of large natural variability compounded by the use of imperfect climate models.

Little can be said as yet about changes in climate variability or extreme events in Africa. Rainfall may well become more intense, but whether there will be more tropical cyclones or a changed frequency of El Niño events is the subject of intensive studies. The combination of higher evapotranspiration and even a small decrease in precipitation could lead to significantly greater drought risks. An increase in precipitation variability would compound temperature effects.

Changes in sea level and climate in Africa might be expected by the year 2050. A sea-level rise of about 25 cm is projected, and there will be subregional and local differences around the coast of Africa in this average sea-level rise—depending on ocean currents, atmospheric pressure, and natural land movements—but 25 cm by 2050 is a generally accepted figure.

The temperature-precipitation-CO_2 forcing of seasonal drought probably is less significant than the prospect of large-scale circulation changes that drive continental droughts that occur over several years. A change in the frequency and duration of atmosphere-ocean anomalies, such as the ENSO phenomenon, could force such large-scale changes in Africa's rainfall climatology. However, such scenarios of climate change are not well developed at the global level, much less for Africa.

4. IMPACT OF CLIMATE CHANGE ON AGRICULTURE AND FOOD SUSTAINABILITY

The 1996 World Food Summit in Rome took these facts into account when drawing up its Action Plan aimed at reducing the number of undernourished people in the world by half by the year 2015. Presently, there is wide consensus that climate change, through increased extremes, will worsen food security in Africa. Evidence has shown that certain arid, semi-arid and dry sub-humid areas have experienced declines in rainfall, resulting in decreases in soil fertility and agricultural, livestock, forest and rangeland production. The projected climate change could have more negative socio-economic consequences in countries in the arid and semi-arid regions, with West Africa being the most vulnerable. Recently, IPCC reinforced the concern that climate change resulting in increased frequencies of drought poses the greatest risk to agriculture. Consequently, the arid and semi-arid tropics, which are already having difficulty coping with environmental stress, are likely to be most vulnerable to climate

change. Agriculture in the semi-arid tropics of Africa, which is predominantly rain-fed, is finely tuned to climate since it relies on the timely onset of rainfall and its regular distribution throughout the rainy season. Hence, even a slow, small change towards a worsening climate can increase climatic risks. The impacts in these regions can be described as those related to projected temperature increases, the possible consequences to water balance due to the combination of enhanced temperatures and changes in precipitation, and the sensitivity of different crops/cropping systems to projected changes. Some of these impacts on agricultural production can be summarized as follows:

- Warmer climates will alter the distribution of agroecological zones. Highlands may become more suitable for annual cropping as a result of increased temperatures (and radiation) and reduced frost hazards. Although certain crops exhibit a positive response to increased CO_2 (as much as 30 per cent with $2 \times CO_2$), the optimal productive temperature range is quite narrow. Some regions could experience temperature stress at certain growing periods—necessitating shifting of planting dates to minimize this risk.
- Expansion of agriculture is important in the east African highlands. For example, agroecological suitability in the highlands of Kenya would increase by perhaps 20 per cent with warming of 2.5°C based on an index of potential food production. In contrast, semi-arid areas are likely to be worse off. In eastern Kenya, 2.5°C of warming results in a 20 per cent decrease in calorie production. In some lowlands, high-temperature events may affect some key crops such as wheat, rice, maize and potatoes. In certain agroecological zones, such as the Southern Sahelian zone of West Africa, under higher temperatures, enzyme degradation will limit photosynthesis and growth. In the long term, the very establishment and survival of species in both the managed and unmanaged ecosystems in this region may be threatened, resulting in a change in the community structure. Furthermore, numerous cases of the devastating effects of interannual variability of rainfall on crop yields and national economies have been observed in the past five decades, but none more dramatic than the Sahelian droughts in the early 1970s. Average yields of groundnut in Niger decreased from 850 kg/ha in 1966-67 to 440 kg/ha by 1981 due mainly to drought and diseases.
- Most livestock in Africa are herded in nomadic areas, although significant numbers are kept in paddocks on farms. Domestic animals,

especially cattle, also will be affected by climate change. In the cold highlands of Lesotho, for example, animals would benefit from warmer winters, but could be negatively affected by a lowering of the already low nutritional quality of grazing. The direct impact of changes in the frequency, quantity and intensity of precipitation and water availability on domestic animals is uncertain. However, increased droughts could seriously impact the availability of food and water—as in southern Africa during the droughts of the 1980s and 1990s.

- Agricultural pests, diseases and weeds also will be affected by climate change. Little quantitative research on these topics has been undertaken in Africa, however. Perhaps the most significant shifts could occur in tsetse fly distributions and human disease vectors (such as mosquito-borne malaria). Tsetse fly infestation often limits where livestock can be kept or the expansion of extensive agriculture. Declining human health would affect labour productivity in agriculture.
- The prospect of global climate change has serious implications for water resources and regional development. Projected temperature increases are likely to lead to increased open water and soil/plant evaporation. As a rough estimate, potential evapotranspiration over Africa is projected to increase by 5 to 10 per cent by 2050. Since Africa is the continent with the lowest conversion factor of precipitation to runoff (averaging 15 per cent), the dominant impact of global warming is predicted to be a reduction in soil moisture in sub-humid zones and a reduction in runoff.
- The widespread deterioration of large areas of savannah in the semi-arid regions of Africa is believed to be associated with the overexploitation of marginal land through the removal of wood and overgrazing. The net change of forest area in Africa is the highest among the world's regions, with an annual net loss based on country reports estimated at 5.3 million ha, which contributes to 56 per cent of the total destruction of forests worldwide. Because open forests are mainly an unmanaged ecosystem, their regeneration may pose problems.
- In Africa, most mid-elevation ranges, plateaus and high-mountain slopes are under considerable pressure from commercial and subsistence farming activities. Mountain environments are potentially vulnerable to the impacts of global warming. This vulnerability has important ramifications for a wide variety of human uses such as nature conservation, mountain streams, water management, agriculture and tourism.

- Nigeria has had its own share of weather- and climate-related problems in relation to food sustainability. The extent of the problem could be seen in better perspective when we consider the fact that the United Nations estimates that the population of Nigeria was about 106 million in 1998 and will reach approximately 244 million in 2050. Such a growth in population will call for an increase in the supply of basic needs such as food, energy, shelter, and clean air and water. As regards food security, therefore, it is necessary to work more closely with other experts, especially those in agriculture and rural sociology, in ensuring adequate policy framework and also to ensure that farmers get the right information at the right time.
- A few studies indicate that in Nigeria, a 1-m rise in sea level would lead to a loss of 2 600 km^2 of land due to flooding, and up to 3.7 million inhabitants may be displaced. Any sustainable integrated coastal management strategy should therefore take into account, among others, salinization of fresh water; aggravation of existing coastal ecological problems; loss of wetlands; and coastal flooding and erosion, together with the potential availability of cheaper technology for sea water desalinization in the new millennium (Obasi, 1999*a*).

In view of these problems, an important workshop on Climate Prediction and Agriculture (CLIMAG) was held in September 1999 in Geneva, Switzerland, with the aim of contributing to the provision of relief from food insecurity and, in so doing, reducing conflicts. The CLIMAG Project was instituted on the awareness that agricultural production is highly dependent on weather, climate and water availability, and is adversely affected by weather- and climate-related disasters (Obasi, 1999*b*).

5. ACTION DESPITE UNCERTAINTY

While there is universal agreement that the direction of climate change, especially at the regional scale, is somewhat uncertain, it should not lead us to a degree of complacency or to believe that adaptation to climate change will be easy. The importance of the rate of climate change must be assessed by comparing the rate at which the systems that might be affected change and adapt. Adaptations are expensive, and the level of technological and economic development of a country determines the extent to which countries can cope with climatic changes. The sensitivity of a crop to climate change depends not only on its physiological

response to temperature or moisture stress, but also on other components of the system. The poor soils in the arid and semi-arid regions of Africa with low native soil fertility are a major component affecting this sensitivity. With the reduced ratio of the length of fallows to cropping years, soil fertility has been declining. In the absence of added manure or fertilizers on these poor soils, the nutrient reservoir of soil under continuous cropping is dropping to levels that can no longer sustain the desired yield levels.

Whether or not there will be a significant climatic change, the inherent climatic variability in the arid and semi-arid regions of Africa makes adaptation unavoidable. Environmental problems facing this zone are serious and certain. The need for development and implementation of sustainable agricultural strategies on a regional scale is crucial in this marginal region that is already threatened by environmental degradation. The approaches we need should be prescriptive and dynamic, rather than descriptive and static.

6. THE ROLE OF WMO

WMO has been playing a leading role in addressing the issues relating to climate variability and change, and the possible impacts on food security, in particular, through its Agricultural Meteorology Programme and other related activities. It is now increasingly recognized that enhanced applications of science and technology, including prediction and early warning with good lead time about impending weather and climate hazards, provide some of the best solutions to minimizing loss of life, suffering and crop damages by weather and climate events. An improved lead-time of prediction and early detection of extreme meteorological and hydrological events along with climate variability and change are vital in enhancing food and agricultural production, as well as in the utilization and management of fresh water, energy and other natural resources that support agriculture.

WMO has been spearheading several international efforts to enhance agricultural production and food security, giving special attention to the latest assessments of the science and the likely impacts of climate variability and climate change on agriculture and forestry in different agroecological regions. Among other things being addressed is the range of

adaptation options for agriculture and forestry, including the use of technological advances, for reducing the vulnerability of different ecosystems to climate variability and climate change, particularly for developing countries with limited access to these technologies and appropriate information. The ways and means to promote a more active use of climate forecasts and climate bulletins in agricultural planning and operations to decrease vulnerability to climate variability and climate change are also given special attention.

Seasonal prediction

In order to translate the advances in climate research and seasonal prediction, where appropriate, into information and advice that will increase the socio-economic well-being of humanity, WMO has continued to implement the Climate Information Prediction Services (CLIPS) project. Through the CLIPS project, WMO, in collaboration with partner institutions, has organized regional climate outlook fora in several parts of Africa. These fora are being used to enhance regional climate outlooks and associated impact projections during El Niño events. Such predictions continue to have a tremendous impact on the contribution of National Meteorological and Hydrological Services (NMHSs) to agricultural planning and production.

Role of National Meteorological and Hydrological Services

As the demand for food continues to grow with the increasing world population, agrometeorologists, agronomists and related scientists are confronted with the challenge to more effectively integrate and deploy the skills developed in operational, experimental and theoretical aspects of agricultural meteorology, so as to make production in systems of agriculture and forestry more reliable, more efficient and, above all, more equitable in the world at large. The National Meteorological and Hydrological Services (NMHSs) can contribute to the national economy and best obtain recognition and remuneration for the investments made in agricultural meteorology by making the best use of the current advances in weather observations, data processing and management as well as communications technology. The need for the reorienting and recasting of meteorological information, the fine-tuning of climatic analysis and presentation in forms suitable for agricultural

decision-making and the protection of marginal farmers with smallholdings from the adverse impacts of weather vagaries has become more pressing.

Use of Climate information

There is a need to work towards a better application of climate information in agriculture. For example, it has been demonstrated in Brazil that enhanced agricultural production was obtained when El Niño information was used in making specific agriculture-related decisions. Grain production increased to about 80 per cent of the mean compared to the year when such information was not used. In the latter case, grain production was only about 20 per cent of the mean. Also, climate information could be used to improve irrigation systems by undertaking research on water availability, in terms of quality and quantity, distribution and cost-effective utilization.

Use of information and communication technology

Developments in communications and electronic media, in particular the ever-expanding cyberspace linkages through the Internet and the World Wide Web, are changing the way people view information dissemination and exchange. The potential to enhance the international exchange of ideas, concepts, data and information at the global level is expanding rapidly. The enhanced computing power that is available today is making data manipulation much easier than ever before, and revolutionary changes in audio-video media make it easy to take the information to users. Geographical Information Systems, remote sensing and other spatial modelling tools make it possible to integrate biological, physical and socio-economic factors in a holistic manner. Hence, the opportunity exists, more than ever before, to obtain and provide information to users through a variety of sources. It is also possible now to reach a larger audience using cost-effective means that were just not available even a few years ago.

Capacity building

In order to extend these opportunities to Members, and to assist in improving their capabilities on these new developments, WMO has organized several training events and workshops organized during the past intersessional period. These training events addressed several issues, such as crop-yield weather modelling, data management for agriculture, instrumentation and operations of automatic weather stations for

applications to agriculture, drought preparedness and management, and geographic information systems and agroecological zoning, which are crucial to sustainable agricultural production. The importance of the timely provision of agrometeorological information in a user-friendly format and how to improve agrometeorological bulletins that are routinely supplied to the users was also the subject of intense discussion at an inter-regional workshop on improving agrometeorological bulletins. The outcome of these training events can help Members significantly in improving service delivery.

International cooperation

Indeed, WMO continues to enhance its cooperation in agrometeorology with various international and regional organizations in the promotion of increased agricultural production, food security and poverty eradication. I would, in particular, like to mention the fruitful cooperation that exists between WMO and FAO, the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP), International Agricultural Research Centres (IARCs) under the Consultative Group on International Agricultural Research (CGIAR), the System for Analysis, Research and Training in global change science (START), the African Centre of Meteorological Applications for Development (ACMAD), AGRHYMET Centre in Niger and the Drought Monitoring Centres (DMCs) in Nairobi and Harare.

Some other priority actions

In order to address the challenges posed by climate change to food sustainability in the 21st century, African countries must consider all options at their disposal to enhance their socio-economic development, in order to be more competitive in the global economy. Improved physical and natural resources infrastructure, such as transport, communications, information technology, health and environment facilities, together with a conducive macro-economic environment are all essential in raising the standard of living of millions of Africans. To this effect, I would like to suggest the following priority actions for the consideration of the conference:

Improve monitoring - In order to assess carefully the impact of future climate change on the managed and unmanaged ecosystems, it is crucial

to monitor local climate and natural changes in species adaptation, if any. It will be necessary to install improved methods of climate monitoring by taking advantage of recent developments in automatic weather stations, which make it easy to record the occurrence of extreme events on a routine basis. For species adaptation, it will be useful to set up phenological gardens at benchmark sites to carefully assess the changes in their adaptation and in the duration of the developmental stages.

Apply strategies for efficient natural resource use - Increasing the promotion and strengthening of resource conservation is the first step in coping with climate change. These strategies will include, for example: soil and moisture conservation, better moisture use efficiency, collection and recycling of runoff, reducing deforestation, increasing reforestation, and reducing biomass burning. Strategies that can increase water use efficiency, such as relay cropping during years with the early onset of rains, are now available and should be transferred to the farm level.

Implement sustainable agricultural practice - It is important to increase the emphasis on the development and adoption of technologies that may increase the productivity or efficiency of crops, consistent with the principles of sustainable development. These include techniques such as minimum/no till systems, traditional agro-silvi-pastoral systems, choice of appropriate crop varieties, intercropping/relay cropping of cereals with legumes, Faidherbia albida systems, mixed tree/grass/crop systems, rotations, use of manures with a limited quantity of fertilizer, and use of crop residues.

Enforce effective intervention policies - One of the adaptation strategies recommended is intervention by governments to influence the circumstances of choices. The criteria laid down for government action are that the:

(*a*) Amount of time needed to carry out the adaption is so long that we must act now.
(*b*) Action is profitable even when climate does not change.
(*c*) Penalty for waiting a decade or two is great.

The need for good, timely climate information in the drought-prone regions is too well known to be stressed further. Recent developments in information technology now make it possible to quickly acquire and sort the enormous amount of information into items relevant to the end user. The implementation of policies to provide timely information, improved weather

and climate forecasts and good markets should help farmers adapt quickly.

Strengthen human capacity building - Human resources development is essential for natural resources development and management. There is a need to develop a supply of skilled labour and to invest in people's education and training.

Improve supporting infrastructure - To improve the quality and availability of agricultural products and utilisation in Africa, particular attention should be given to enhancing infrastructure, notably in transport, communications and public utilities.

Improve science and technology acquisition and development - In order for Africa not to lag further behind in the area of science and technology, there is a need for a deliberate programme to enhance capacity and to internalize modern techniques and methods in the development and utilization of natural resources. Such a programme should have as its core, enhancing the capacity of learning and training institutions. Research and development assumes particular importance in this regard. For example, an issue to consider is the application of biotechnology in developing new crop varieties such as the development of New Rice for Africa (NERICA) varieties by the West African Rice Development Authority (WARDA) with the support of its partners. These rice varieties can support 50 per cent more grain than current varieties when cultivated with traditional rain-fed systems without fertilizer.

7. CONCLUSION

The various important issues regarding the link between climate and food security in this region have been highlighted. This relationship is evident in the relationship between drought occurrences in the region and dealing with food shortages resulting in famine. Given the need to increase food production in Africa, therefore, meteorologists and hydrologists have the challenge of working hand in hand with other experts and policy makers alike in ensuring food security for the growing population, more so in view of climate change. While working towards a better understanding of the situation through research, experts have the responsibility to increase the communication of existing findings to policy makers for effective implementation.

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