Climate Variability, Climate Change and the Development Process
in Sub-Saharan Africa

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Introduction

Climate variability seems to be replacing other aspects of climate (e.g., climate as a boundary condition) as the major concern of those involved in the practical aspects of economic development around the globe. In fact, all countries, regardless of the types of ecosystems they have, have been plagued by some aspect of climate variability; for some the problem occurs with variability in rainfall, for others with temperature, and still others with snowpack, evaporation rate, and so forth. These changes can occur slowly over time or they can occur abruptly. They can be prolonged in time or they can be of short duration.

Each country’s or region’s historical records are filled with stories about the impacts of climatic events; prolonged severe droughts have at various times plagued China, India, the USSR, Africa, South America, North America, Australia, Indonesia, among others. Floods, too, have caused great damage in such countries as Brazil, Peru, Ecuador, China, Kenya, and India. It appears that in many instances societies tend to accept these climate-related anomalous events and their impacts as acts of nature against which little meaningful defense could be mustered. The leaders of these countries often resign themselves and their citizens to remain as passive victims of the vagaries of atmospheric processes. Today, however, climate impacts research shows that there is no reason for societies to remain passive. Information about climate and climate variability can be used to mitigate their impacts on society. An improved understanding of climate variability and its environmental and societal impacts is important for an improved understanding of economic development processes. While a drought may last for a few years, its
socio-economic impacts could be felt for the remainder of a decade, as debt incurred as a result of drought must be repaid once that drought has ended and the “rains return to normal.”

This paper briefly discusses the historical evolution of views about climate and economic development. In addition, it shows how drought can affect the development prospects of a country, and how the natural progression of the seasons (an aspect of climate that has frequently been overlooked in the development literature) can increase the vulnerability of some sectors of society as well as some segments of the population to climate anomalies. It also discusses global phenomena such as El Niño-Southern Oscillation events that have been associated with some of the droughts that have occurred in Africa. Finally, the paper discusses recent scientific findings related to the carbon dioxide/trace gases-induced global warming issue and its potential effects on African climate and on development processes.

Climate and development

As an aspect of the search by ethnologists (as well as geographers and political scientists) for clues to the processes behind cultural development (as well as political and military strategy), the influence of climate on economic development prospects was an important topic of discussion at the turn of the century. Why were some cultures seemingly more advanced than others? Why had some remained in the dark ages with respect to technological developments while others had industrialized?
Climate was viewed at the time as a boundary constraint for the development prospects of a society. One of the leading proponents of this view was Ellsworth Huntington, a political science professor at Yale. Huntington’s work (1915) identified the hot, sultry climate of the tropics as a constraint to development in that region. In his view inhabitants of the tropics were doomed to lower levels of development because the climatic conditions were not conducive to lively activity and to an aggressive work ethic. Climate, according to Huntington, was the main culprit that made people in the tropics less productive than those in temperate regions.

The temperate climates, Huntington suggested, had just the opposite effect on populations. The cool, seasonal temperate climate was more conducive to hard work and, therefore, to economic and technological development. Unlike in the tropics, in the temperate zones seasonal temperature changes served to re-invigorate a population on an annual basis.

Huntington’s work and that of his “followers” was seen as having racial overtones and was mostly discredited and discarded. Aside from the racial implications of Huntington’s works, others after him continued to view tropical climate as a constraint on the ability of certain cultures to develop. A book by Markham in the 1940s referred at length to the “air-conditioning revolution,” a revolution that would bring islands of temperate zone climate to the tropics (Markham, 1944). By implication, therefore, there could be islands of development in the tropics.

In the mid-1950s the Council on Foreign Relations focused on the issue of climate and economic development in the tropics. It, too, treated climate as a boundary con-
straint on development; temperature, rainfall, and humidity, among other factors, each provided its own limits to development. Their report (Lee, 1957) was written in the 1950s which happened to have been a period of generally favorable rainfall for sub-Saharan Africa.

This view of climate still persists and is subscribed to, not only by observers from the temperate zones but by those in the tropics as well. For example, in a recent book by Indian scientist J. Bandyapatthay (1983), the author noted that he felt more energetic and willing to work in the climate of London than in the climate of Delhi. Thus, even today the idea of climate as a boundary constraint on development in the tropics (and climate as a boon to development in the temperate regions) persists. When raised explicitly, however, it still seems to carry with it pejorative racial connotations. However, to disregard considerations of climate would be to provide an incomplete picture of existing constraints on economic development. Thus, it is necessary to discuss aspects of climate that can be shown to specifically inhibit (or abet) development prospects. Drought is one such aspect.

In the mid 1970s a World Bank report on economic prospects for developing countries (Kamarck, 1976) drew attention to the problem of climate variability. Kamarck suggested that recurrent droughts in Northeast Brazil had plagued its prospects for economic development. This implicit reference to variability was only briefly mentioned and hardly elaborated.

Clearly, climate variability affects the development process in many ways. Focusing on such elements of climate as droughts and seasons can improve our understanding of
how atmospheric processes can positively or adversely affect human activities. There is a need to understand these and other elements of climate that can be shown in specific ways to affect various aspects of the process of economic development in tropical countries.

A close look at climate variability (which is in fact, a statistical construct) immediately identifies drought as an important aspect with which almost all countries are concerned. It is also an aspect of climate that does not carry with it racial overtones, thereby allowing it to become part of a reasonable discussion of constraints on development in sub-Saharan Africa. Drought is the central focus of this paper.

Drought as a constraint to development

Rainfall and temperature are important aspects of climate for food production and for water resources. As most of the populations in the Third World are dependent on rainfed agriculture and on the exploitation of rangelands by their livestock, any variations in the timing or amount of rainfall can cause problems for crop production and for livestock well being. Thus, insights into the frequency, timing, location and intensity of droughts can be used by development planners to prepare for and possible mitigate the environmental and societal impacts of droughts.

1972 has been referred to as the year of the climate anomalies. In that year devastating droughts occurred around the globe; in Brazil, the USSR, China, Australia, Central America and in various parts of sub-Saharan Africa. The simultaneous occurrence of these droughts sparked widespread concern about the rapid deterioration of the global food situation. Grain reserves of major grain producers were greatly reduced causing
prices for the remaining grain supplies to increase sharply. It was perhaps the droughts and famines in the West African Sahel and in Ethiopia that drew attention to the devastating impacts of climate variability in developing areas. These events, coupled with a growing concern about the ability of the world’s population to feed itself in the face of a seemingly changing climate, generated a call for a World Food Conference in 1974.

Each recurrence of prolonged drought in a specific region seems to be greeted with surprise and shock. Yet, once it appears to have ended there is a belief that “now we can get back to normal.” In many areas, including the West African Sahel, drought is a part of the climate, and therefore those societies could in some general way at the least prepare themselves for recurring droughts treating this knowledge as a factor in development planning.

Until recently there had been few, if any, meaningful discussions in the development literature about the impacts of drought on economic development prospects. Now, as a result of African droughts in the early 1980s, there are now more references to drought in the literature. Discussions about it, however, still do not focus on its impacts on a region’s long-term development prospects.

While individual drought episodes, or even runs of drought years, do come and go in relatively short periods of time, their impacts on the environment and on society often linger for years. For example, drawing down grain reserves during a few years of drought can cause a government to borrow funds to purchase grain in the international marketplace. Even when the drought ends and grain stocks are rebuilt, that government (and
individuals) will still have to pay back its (their) drought-related loans. This is yet another reason why more attention should be paid by those involved in theories of economic development to drought as a recurring phenomenon and to its societal and environmental implications. Drought will not necessarily always be a major problem to a drought-prone society. However, it must be included in the list of factors that needs to be taken into consideration and assessed for its relative importance as a constraint to economic development.

Not every drought by itself generates problems for policymakers or inhibits economic development. In fact, in most cases drought combines with other existing societal or environmental problems to exacerbate (or accelerate) the impacts that those existing problems might have alone. Thus, one can find in the US Department of Agriculture’s “Situation Outlook” reports prepared for various areas of the world comments like the following: “drought and rising cost of fertilizers led to a reduction in production”; “drought and aging cacao trees led to sharp decline in cocoa output”; “the continuing economic crisis in the region was worsened by drought”; “drought and continued weak finances among farmers adversely affected crop yields by reducing the need for, and use of, fertilizers”; “drought and import restrictions caused severe distortions in the corn price”; “the combination of guerilla disruption and drought has had a disastrous impact on food production in Mozambique.” Drought episodes, especially when combined with other factors specific to a country at a given time, can make a bad situation worse and can constrain if not derail the economic development process.
Each drought leaves its own imprint with regard to societal and environmental impacts, even if two of them have the same intensity and strike in the same location but occur at different times. The severity of these impacts will vary in the two situations as a result of different underlying social or environmental conditions that may exist at the different times.

Several other major difficulties in dealing with drought should also be mentioned. One difficulty is the nature of drought; it is a creeping phenomenon. Its onset as well as its end are often difficult to identify, because of the lack of a clear distinction between drought and non-drought dry spells. As Tannehil suggested, “The first rainless day in a spell of fine weather contributes as much to the drought as the last day, but no one knows precisely how serious it will be until the last dry day has gone and the rains have come again” (1947, p. 2).

Another difficulty is that drought is usually perceived to be a transient phenomenon. As a result, it is often not taken seriously once the rains return. There is pressure on decisionmakers to deal with more pressing and immediate problems, putting considerations about dealing with drought on the back burner once it has passed. Compounding this situation is the fact that tenure in office of policymakers may be on the order of years whereas the return period for droughts in a given area may be on the order of decades. Thus, the consequences of postponing the development and enactment of policies to mitigate the societal and environmental impacts of future droughts are not borne by the current generation of decisionmakers but are usually borne by their successors. Related to this difficulty is the fact that policymakers in the past have viewed
drought as being apart from the normal climate regime of a given area instead of an in-
tegral part of it. As a result, they have less incentive to enact regular policies to miti-
gate its effects.

Yet another difficulty in dealing with drought is the fact that its impacts on soci-
ety are pervasive. While some aspects of drought are obvious (e.g., a large reduction in
rainfall, the wilting of crops in the fields or the drying out of watering points), others are
less so, making them more difficult to attribute to drought. Such second and third order
effects might include price increases, increases in food imports, and surges in population
movements from rural to urban areas.

The following chart (Figure 1), used in a 1981 report entitled Food Prospects for
Sub-Saharan Africa, was prepared by the US Department of Agriculture for the US
Agency for International Development. It provides an example of how officials perceive
the relationship between weather and society.

A close look at this chart suggests that weather affects only crop yields. However,
if one were to replace the box on the diagram labeled “weather” (used here as a bound-
ary condition) by a box labeled “drought,” as an aspect of weather, one could identify
several other activities on the chart that are adversely affected by drought; for exam-
ple, migration, labor supply, on-farm storage, acres planted, home grain consumption,
food imports, export crop acreage, land quality, and so on. Charts like these can be very
misleading and can serve to reduce the perceived importance of climatic factors to the
development process. They also convey a false sense of expertise and understanding of
how climatic factors interact with societal activities. Based on information in this chart,
a logical response to cope with anomalous weather might be for a society to focus its resources primarily on the development of drought-tolerant seed varieties. However, such an approach could be more detrimental than helpful in the long run.

Yet another difficulty in dealing with drought is the fact that it means different things to different people, with one's definition of drought often reflecting one's interest
in, or need for, rainfall. For example, there are meteorological, agricultural and hydrologic droughts. Meteorological droughts can be defined as a specified (e.g., 25 or 50%) reduction in average rainfall for a given period of time (week, month, season).

Agricultural drought can be defined as occurring when there is insufficient moisture available at the appropriate time for crop growth and development. The timing of precipitation throughout the growing season is as important as the absolute amount of annual, seasonal and monthly precipitation. Thus, not every meteorological drought turns into an agricultural one. If, for example, during a meteorological drought an adequate amount of rainfall happens to fall during key stages of a crop's growth and development, there will be no agricultural drought.

Hydrologic drought has been defined as taking place when streamflow falls below some predetermined level (Dracup et al., 1980). Most often that level is determined in terms of a reduction in streamflow that interrupts the successful undertaking of particular human activities of importance to society. In many countries where flood recession farming is practiced, hydrologic drought can be very devastating to local food production efforts.

Thus, it is important to keep in mind that there are now scores of definitions of drought (Wilhite and Glantz, 1985). These differences in meaning must be made explicit for the sake of clarity in communication. This paper focuses mainly on meteorological and agricultural drought. As a result of the persistence of meteorological and agricultural droughts in various parts of sub-Saharan Africa in the 1970s and 1980s, much more
attention is now being paid to the impacts of drought on various populations, economic sectors, and ecosystems.

Development and the seasons

In recent decades the focus of attention on climate in sub-Saharan Africa has centered around the environmental and societal impacts of recurrent droughts. The impacts of droughts are often spectacular. Mention of specific droughts conjures up vivid memories. For example, the drought in the US Great Plains in the 1930s sparks memories of recurrent dust storms; the droughts in the West African Sahel and in Ethiopia in the early 1970s and the early 1980s generate images of refugee camps and famines. In fact, Africans often refer to specific droughts by their impacts. In interviews with farmers and livestock owners, for example, Laya (1975, p. 62) noted that refugees from the Sahelian drought in the early 1970s identified earlier droughts by name; Grande Brasse, Goat Pool, Dismissal of the Wife, Pressure on the Shoulder, Tergiversation, Carry Off and Throw Away (this referred to the fact that the farmers had no time to bury their dead and had to carry them off and “throw them away”), with each name or phrase signifying a social hardship. One farmer being interviewed suggested that “We could not count the famines which took place [recently] because they [were] too numerous, they did not even leave us time to name them!”

Some societies are clearly less vulnerable to climate anomalies than others for a variety of reasons (e.g., different agricultural practices, different technological factors). A drought in the US Great Plains, for example, no longer leads to malnutrition, migration
and food shortages in the region as was the case in the 1930s. A different situation prevails, however, in drought-prone countries with scarce food resources such as Ethiopia and Mozambique.

Although occurring regularly (but less spectacularly), the normal flow of the seasons also has an effect on human activities, on social and economic relationships and on the physical well-being of human and livestock populations. A relatively small group of researchers have concerned themselves with the effect of the seasons on human nutrition and health (e.g., Huss-Ashmore, 1982). Another small group has focused their research on the way the seasons affect economic interactions among various groups (Chambers et al., 1979, 1981).

It is generally recognized that there is a “hunger season” every year. This is the season when crops are being grown but have not yet been harvested and the grain reserves held by families have been drawn down to critical levels. The populations that work in the fields are in their worst nutritional condition at the time when they are most in need of their strength to work fields and harvest crops. Women suffer more than men and children and the elderly suffer more than women.

Often the poorer farmers must borrow seeds for planting from the richer peasants. In return they must pay back their loans (with interest) in kind and with services in the fields of the richer peasants. The sequence of events may be generalized as follows: After a normal harvest, debts are repaid, marriages take place, grains are stored for use throughout the rest of the dry season until the next harvest. At the end of the dry season, grain reserves have been depleted and seed is needed for planting. Seed is then bor-
rowed and planted. If the rains fail to materialize within a certain number of days, the farmers must replant. This can happen for several replantings; each time the supply of grain becomes further reduced. Food may be rationed until the harvest, when supplies can hopefully be replenished.

The natural progression of the seasons distorts economic relationships among groups in society with a small number benefiting from seasonal change and a much larger number suffering from it. Droughts tend to further distort those existing economic relationships, often enabling the rich either to get richer or to at least survive in place, while the poor get poorer and, as is often the case, have to abandon their villages in search of food. Thus, to understand the impacts of climate anomalies such as drought on human activities and well-being, it is imperative to identify and to understand the role of the seasons in rural poverty. Only then can one identify the actual role of climate anomalies in the persistence of rural poverty.

The following chart (Figure 2) represents a generalized situation of the effects of seasonality on an agricultural community in West Africa. It does not necessarily apply to any particular community. The first column of the chart is based on a scenario presented in Chambers et al. (1979). It is presented to suggest to the reader how the “usual” rhythm of the progression of the seasons might affect rural populations in a community faced with a wet season and a dry season. The second column of the chart suggests how drought might adversely affect the seasonal rhythm of agricultural activities.
<table>
<thead>
<tr>
<th>(Usual) Seasonal Impact</th>
<th>Prolonged Drought Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Post-Harvest (early dry season)</strong></td>
<td><strong>food availability declines</strong></td>
</tr>
<tr>
<td>• food available</td>
<td>• food prices continue to rise</td>
</tr>
<tr>
<td>• food prices decline</td>
<td>• domestic food self-sufficiency jeopardized</td>
</tr>
<tr>
<td>• migrant laborers return to villages</td>
<td>• families borrow from kin/friends</td>
</tr>
<tr>
<td>• morbidity declines</td>
<td>• disposal of assets for money</td>
</tr>
<tr>
<td>• mortality declines</td>
<td>• migrants do not return</td>
</tr>
<tr>
<td>• nutritional status improves</td>
<td>• additional family members migrate</td>
</tr>
<tr>
<td>&quot;Post-harvest food availability largely determines the size and</td>
<td>• nutritional intake deteriorates</td>
</tr>
<tr>
<td>distribution of village calorie supplies, not just at the time</td>
<td>• morbidity stays high or increases</td>
</tr>
<tr>
<td>but until the next harvest&quot; (Schofield, 1974, p. 23).</td>
<td></td>
</tr>
<tr>
<td><strong>Dry Season (late dry season)</strong></td>
<td></td>
</tr>
<tr>
<td>• food becomes less available</td>
<td></td>
</tr>
<tr>
<td>• food prices increase</td>
<td></td>
</tr>
<tr>
<td>• nutritional status (especially women, children declines)</td>
<td></td>
</tr>
<tr>
<td>• drinking water becomes scarce</td>
<td></td>
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<tr>
<td>• dry season irrigation becomes more important</td>
<td></td>
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<tr>
<td><strong>Wet Season (early wet season)</strong></td>
<td></td>
</tr>
<tr>
<td>• &quot;hunger season&quot; begins</td>
<td></td>
</tr>
<tr>
<td>• wild food use begins</td>
<td></td>
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<tr>
<td>• gathering added to agricultural labor</td>
<td></td>
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<tr>
<td>• high food prices</td>
<td></td>
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<tr>
<td>• poor families borrow agricultural inputs</td>
<td></td>
</tr>
<tr>
<td>• distress borrowing/distress sales</td>
<td></td>
</tr>
<tr>
<td>• draft animals in relatively weak condition</td>
<td></td>
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<tr>
<td>• diseases more prevalent</td>
<td></td>
</tr>
<tr>
<td>• morbidity increases</td>
<td></td>
</tr>
<tr>
<td>&quot;During the wet season itself when seasonal food shortages peaked, hardship could be</td>
<td></td>
</tr>
<tr>
<td>partially alleviated by participation in communal work parties and short-distance</td>
<td></td>
</tr>
<tr>
<td>migration making use of the variation in the onset of the rains (and hence in the</td>
<td></td>
</tr>
<tr>
<td>timing of planting, weeding, and harvest&quot; (Watts, 1983, p. 49).</td>
<td></td>
</tr>
<tr>
<td><strong>Pre-Harvest (late wet season)</strong></td>
<td></td>
</tr>
<tr>
<td>• food prices are at seasonal high</td>
<td></td>
</tr>
<tr>
<td>• food intake is lowest (especially women and children)</td>
<td></td>
</tr>
<tr>
<td>• body weights decline</td>
<td></td>
</tr>
<tr>
<td>• &quot;hunger season&quot; peaks</td>
<td></td>
</tr>
<tr>
<td>&quot;Peak-season labour inputs often coincide with seasonal food shortages, as on-farm</td>
<td></td>
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<tr>
<td>grain stocks are running low before prices begin to be pulled down by the impending</td>
<td></td>
</tr>
<tr>
<td>harvest &quot;(Schofield, 1974, p. 23).</td>
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</tbody>
</table>
The impact of drought on society's seasonal stress will vary in part according to its timing. If drought occurs at the onset of the growing season, for example, those farmers in a position to do so might replant several times thereby using up their seed reserves. If drought were to occur in midseason, the number of options available to farmers, such as the planting of varieties that require a somewhat shorter growing season, would be greatly reduced. Drought also tends to intensify seasonal hunger and to spread it across other seasons. For example, grain prices often rise sharply as a result of drought and can remain high for several seasons, making it extremely difficult for the poorer segments of society to purchase grain.

Clearly, the natural progression of the seasons tends to keep certain elements of society in economically and socially inferior positions while others use that seasonal progression to their economic and social advantage. The occurrence of drought can be shown to upset the already precarious balance of food production and food availability and to exacerbate even further the existing economic and social disparity between these groups. The poorer elements of society become more dependent on borrowed seed for planting and for consumption. Thus, droughts exacerbate existing unequal economic relationships; they do not necessarily create them.

**Atmospheric-oceanic teleconnections and economic development**

There is considerable excitement in the scientific community about the linkages that are being identified between sea surface temperature (SST) anomalies in the Pacific, Atlantic and Indian Oceans and droughts in various parts of the world. These linkages have been referred to as "teleconnections" or the connections between SST
anomalies and particular climate anomalies which occur at some distance from the geophysical location of the SST anomalies. The identification of these connections can be based on statistical assessments, geophysical processes or "wishful thinking" on the part of the observer. Not all of the teleconnections suggested will prove to have been well founded. Those that are found valid, however, may eventually be used to predict droughts, thereby giving societies some lead time to prepare for and mitigate the impacts of the drought. This kind of information can prove useful for those involved in development planning.

Much of the current speculation about teleconnections was sparked by recent El Niño events in the eastern and central Equatorial Pacific. El Niño is the warming of surface waters in the eastern Equatorial Pacific off the western coast of South America. Droughts and floods that occurred in various parts of the world in 1972-73, were blamed on a major El Niño event. These associations generated increased scientific interest in identifying possible linkages and increased societal interest in their potential for long-range forecasting purposes. Since that time, scientific understanding of the phenomenon has grown and current wisdom suggests that El Niño events are really a local manifestation of a hemispheric and global phenomenon called El Niño-Southern Oscillation (ENSO).

Walker and Bliss (1932) described the Southern Oscillation as follows: "When [sea level] pressure is high in the Pacific Ocean it tends to be low in the Indian Ocean from Africa to Australia; these conditions are associated with low [sea surface] temperatures in both these areas and rainfall varies in the opposite direction to pressure" (p. 60).
Thus, the ENSO phenomenon is the result of the interaction between the Pacific tropical ocean, the atmosphere and the annual cycle of the seasons (Nicholls, 1987, p. 7).

ENSO events occur aperiodically, every 2 to 10 years, when there is a build up of warm water in the central or eastern Equatorial Pacific. According to Nicholls (1987), the anomalies last for about 12 months, commencing around the start of one calendar year and collapsing just into the next year. The mass of warm water heats the atmosphere above it which in turn leads to major increases in rainfall in areas that are usually dry and leads to a reduction in rainfall in areas that are usually wet. The arid coast of western South America during major ENSO events is often ravaged by torrential rains and floods. For example, in 1982-83, during one of the biggest ENSO events in a hundred years, damage to infrastructure in Peru and Ecuador was in the tens of millions of dollars. In the normally wet western part of the Pacific basin, southeastern Australia, Indonesia and the Philippines, droughts often occur (Figure 3).

For example, during the 1982-83 ENSO event, Australia recorded its worst drought in a hundred years. As another example, scientists have attempted to associate droughts in Indonesia with ENSO events during the past 200 years or so (Quinn et al., 1978; Quinn et al., 1987).

Recent research reports (e.g., WMO, 1985) have suggested that teleconnections exist between droughts in various parts of sub-Saharan Africa and ENSO events. Rasmusson (1987), for example, has suggested that a strong statistical correlation exists between ENSO events and rainfall in southeastern Africa, noting that of the 28 ENSO events in the past 110 years or so 22 were accompanied by below average rainfall in the region.
Rasmusson found, however, that the correlations between ENSO events and rainfall in the West African Sahel, Ethiopia and East Africa are much weaker.

Other scientists have suggested that a statistical relationship between ENSO and rainfall in Ethiopia does exist (Degefu, 1988). Today, the Ethiopian government is aware of ENSO and has instructed its National Meteorological Service Agency (NMSA) to keep it informed about SSTs in the Pacific. In fact, the NMSA used ENSO information in its formulation of a seasonal climate forecast for the two rainy seasons of 1987 and again for 1988. With this additional information the Ethiopian government was apparently able to mitigate to some extent the impact of drought on food production in 1987.

In the late 1970s and early 1980s attention focused on using ENSO information to forecast drought in the West African Sahel, a region of Africa that had been plagued by relatively persistent drought between 1968 and 1985. The hope was that linking the occurrence of droughts to ENSO events might build in some lead time for drought forecasting for the Sahel. Research has expanded the focus of attention from SST anomalies in the Pacific to SST anomalies in the Atlantic and Indian Oceans as well. According to a series of papers by Parker, Folland and Palmer (Folland et al., 1986; Parker et al., 1985; Palmer, 1986), some success has been achieved in using Atlantic (and later all oceans) SST anomalies to forecast seasonal precipitation deficits in the West African Sahel. According to Palmer, studies show strong connections between Sahel rainfall and simultaneous anomalous patterns of SSTs on a global scale. It was found that “over the western Sahel the Atlantic and Pacific fields have a comparable effect in reducing rainfall...over the eastern Sahel, however, the Indian Ocean has the dominant role in reducing rainfall”
(1986, p. 251). Thus, the implications of an improved understanding of anomalous SSTs for forecasting droughts in Africa remain an intriguing as well as promising area of scientific research.

As research continues on SSTs and their teleconnections to droughts in various parts of the tropics, the geophysical and statistical relationships on which they are based will become more clearly defined. In time they may be used operationally for forecasting droughts and for avoiding the development of famines.

**CO₂/trace gases, global warming and economic development**

Many scientists (if not policymakers) consider the droughts that have plagued various parts of sub-Saharan Africa for the past two decades to be a part of the region’s climate. In arid and semiarid areas the climate is skewed toward dryness with a small number of high rainfall years balanced out by a larger number of low rainfall years. If the climate is stable and if we were to have a “long enough” time series of relevant climatic data (e.g., precipitation), then eventually we should be able to develop some forecasting skills based on the use of climatological probabilities on a seasonal and interannual basis. The more that we know about the characteristics of climate in a given region, the better prepared we will be to develop, for example, agricultural and rangeland production schemes. A failure to take into account what we already know about climate can be extremely costly.

The most cited example of this failure is the Tanganyikan groundnut scheme. This scheme was developed in the late 1940s to produce groundnuts that would be processed into peanut oil for European markets. It failed in the early 1950s at a cost of tens of
millions of British pounds because the planners of that scheme failed to consider the
certainty of droughts in the region. A few good rainfall years gave the planners a false
picture of the climatology of the region (Voll, 1980). Other similar examples also exist in
recent decades (e.g., Glantz, 1976; Franke and Chasin, 1980). Clearly, better information
about climate and climate variability can provide useful information for development
planning and can help to reduce the possibility of inappropriate development activities.

The assumption that the global climate is stable, however, has been challenged. In-
creasingly, physical scientists are joining together to suggest that a global warming could
possibly occur, primarily caused by increased concentrations in the atmosphere of carbon
dioxide and other radiatively active trace gases and by deforestation and other land use
practices. Theory as well as observation seem to support the contention that the global
atmosphere is heating up at unprecedented rates.

As global average temperature changes, one must ask what the regional impact will
be on the timing, spatial distribution, duration and intensity of rainfall and runoff as
well as on the frequency of extreme meteorological events such as droughts in the trop-
ics. Will droughts become more frequent, more persistent, more widespread? Some sci-
entists have suggested that the CO₂/trace gases induced global warming is behind the
recent droughts in Africa. Wigley and Farmer (1985) noted that

Past rainfall records [in sub-Saharan Africa] show that drought is not uncom-
mon, but the long duration of the present drought, its unusual seasonal struc-
ture and the changes in the geographical patterns of rainfall deficits, all sug-
gest that some new mechanisms may be operating...[However], a statistically-
convincing demonstration of the role of CO₂ is impossible because of the exis-
tence of natural long term rainfall variations, and because we cannot yet define
the regional character of any CO₂ signal (p. 99).
Such changes in climate, if real, will make forecasting climate anomalies increasingly more difficult in the future. Much of the meteorological information gathered to date (under what might be viewed as a somewhat stable climate regime, i.e., a stationary process) may become less indicative of future meteorological conditions throughout the continent. One can only wonder at this stage of our scientific knowledge regarding the impacts of a global warming how regional rainfall regimes will change and what the impacts of those changes will be on governments, societies, and cultural groups as well as on the development process.

It is important for development specialists to be aware of the discussions about the probability of climate change (in addition to assessments of climate variability) because such changes could have profound regional impacts, for example in various parts of sub-Saharan Africa. As scientists improve their tools for identifying regional impacts of a global change, this information should be taken into consideration for the development of long-lived projects such as dams. These structures are expected to remain in service for decades. If rainfall amounts and intensities change, there could be an increase in the rates of soil erosion as well as of desertification. At this time, however, despite some speculation (e.g., Kellogg and Schware, 1982), it is not at all clear how the regions throughout sub-Saharan Africa would be affected by global warming, whether the change proves to be gradual or step-like.
Conclusion

This paper illustrates how climate can and does affect the development process. Although drought, for example, may not prove to have been the most important factor in determining a country's ability to develop economically, it clearly merits serious consideration. Droughts can thwart development prospects but if we understand how they do impinge on development then we may be better able to incorporate this knowledge in the planning process. As noted, drought distorts economic relationships that have been established by the natural flow of the seasons. It is therefore important to understand the role that the natural progression of the seasons plays in maintaining the status quo with respect to economic and social relationships in various regions. Understanding these relationships can help governments and societies to better cope with the impacts of recurring droughts.

Understanding atmospheric and oceanic processes might seem to be a long way removed from considerations of drought (and climate variability) and its impacts on economic development. Yet, recent research has indeed uncovered new avenues for improving our understanding of drought characteristics such as timing, location, intensity and duration. Understanding the changes in sea surface temperatures around the globe presents us with one of the most promising areas of research today in understanding and predicting drought.

As if sub-Saharan African countries have not been faced with enough climate-related problems in the past few decades, the climate change issue represents yet another factor that could affect development plans for the region. While it may appear that a
climate change of some degree is in the offing we can not yet say what that will mean for the continent's regional and local climates. There are some scientists who suggest that northern and eastern Africa will become wetter than the present (Kellogg and Schware, 1982). Yet, one cannot count on speculation to be a reliable guide to future climate and therefore to future climate impacts and policy responses to those impacts. This issue clearly bears watching by government leaders as well as by those concerned with creating self-sustaining development processes in sub-Saharan Africa.

In addition, the changes in climate that are expected are primarily the result of human activities. Thus, a dependence on the use of fossil fuels for development, or the cutting down of forests for export and foreign exchange can abet the changing of the climate. Perhaps the impacts of development schemes on the environment (especially on the atmosphere) should also be taken into account.

While the focus of this paper has been on sub-Saharan Africa, the issues raised also apply to other countries and regions regardless of level of industrial development. No country is immune from the impacts of climate variability or climate change.

Furthermore, there are examples of countries that have already benefited from the use and understanding of information about climate variability and its societal and economic impacts, but they are mostly not in sub-Saharan Africa. Two examples from Brazil come to mind, where Brazil used information regarding climate impacts elsewhere to its own developmental advantage. During the 1972–73 El Niño event, the Peruvian anchoveta fishery collapsed as a result of the combined effects of the pressure of this major environmental perturbation and overfishing. With the collapse of the anchoveta
fishery, Peru's exports of fishmeal as a livestock feed supplement declined and the price for fishmeal in the international marketplace rose sharply. The El Niño-related decline in fishmeal exports prompted Brazilian entrepreneurs to engage in soymeal production, which is a preferred feed grain in the absence of fishmeal. Today, Brazil is one of the world's leading exporters of soymeal.

A second example relates to citrus processing industries. Florida has been the major producer of frozen concentrate of orange juice (FCOJ). Florida citrus producing areas are subject to freeze events in wintertime. In the past, when a freeze hit the citrus region, the prices of the remaining undamaged citrus crop would increase sharply. This happened after the major freeze of 1962. This freeze event has been acknowledged by the Americans as well as the Brazilians as having catalyzed Brazilian entrepreneurs to engage in the development of a Brazilian citrus processing industry. Today, Brazil is one of the leading producers and exporters of FCOJ as well as other forms of orange juice to both North American and European markets.

These examples suggest that it is not only important to know how climate variability affects one's own country but how it affects the rest of the world as well.
References


