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Climate Information for Development: An Integrated Dissemination Model

Aondover Augustine Tarhule

Abstract

This paper describes a new conceptual model of climate research and seasonal forecast dissemination for West Africa. The model was developed through a survey of 600 climate information end-users and 27 organisations in four West African countries – Burkina Faso, Mali, Niger and Nigeria. Despite significant advances in climate research and climate forecasting, the majority of African countries continue to suffer the full impacts of climate variability with serious adverse implications for economic growth and development. These countries are yet to experience the benefits of climate research for mitigating impacts. The major challenge is lack of access to, and ability to respond to, climate research information by both vulnerable groups and institutions and agencies charged with managing the impacts of climate variability. Additionally funding agencies outside the continent drive much of the research on African climate dynamics. Indeed few African countries have the resources, technical expertise and, in some cases, political commitment to give the necessary priority to climate and environmental research. Therefore, it is important to develop innovative strategies that allow them to take advantage of the results of climate research. The proposed model consists of a regional archive and database for all research related to West African climate variability. The goal is to improve access to emerging research findings and technologies and to avoid duplication of efforts. A second major component includes an institute dedicated to the testing, validation and adaptation of research for practical applications under local conditions. The model illustrates clearly the pathways of climate research information flow and linkages between the research community, policy makers, the media and end-users. Although based on research in West Africa, the model can easily be adapted for other parts of Africa.

* Department of Geography University of Oklahoma, Oklahoma, 73019 Oklahoma, USA. Email: atarhule@ou.edu

Résumé

L'auteur de cette étude décrit un nouveau modèle conceptuel de recherche climatologique et de diffusion des prévisions saisonnières pour l'Afrique de l'Ouest. Ce modèle a été élaboré à partir d'une enquête menée auprès de 600 utilisateurs d'informations météorologiques et de vingt-sept organisations dans quatre pays d'Afrique de l'Ouest, à savoir le Burkina Faso, le Mali, le Niger et le Nigeria. Malgré les énormes progrès réalisés dans le domaine de la recherche climatologique et des prévisions météorologiques, la majorité des pays africains continuent à souffrir de l'impact de fluctuations climatiques qui les frappent de plein fouet du entraînant de graves implications défavorables à la croissance économique et au développement. Ces pays n'ont encore jamais fait l'expérience des bienfaits de la recherche climatologique en matière d'atténuation d'un tel impact. Le gros défi à relever est le manque d'accès aux informations météorologiques et l'incapacité de réagir à ces informations des groupes et institutions vulnérables et des agences chargées de gérer les impacts des fluctuations climatiques. En outre, les agences de financement à l'extérieur du continent poussent la plus grande partie des travaux de recherche sur la dynamique du climat africain. De fait, peu de pays africains ont les ressources, l'expertise technique et, dans certains cas, l'engagement politique nécessaire pour donner la priorité requise à la recherche climatologique et environnementale. Il importe donc de développer des stratégies novatrices leur permettant de tirer profit des résultats de la recherche climatologique. Le modèle proposé comporte des archives et une base de données régionales pouvant servir à tous travaux de recherche sur les fluctuations climatiques en Afrique de l'Ouest. Il s'agit d'améliorer l'accès aux nouveaux résultats de la recherche et aux nouvelles technologies, et d'éviter les doubles emplois. Un second grand volet comporte un institut affecté aux essais, validations et adaptations requis par la recherche pour des applications pratiques dans des conditions locales. Ce modèle illustre clairement les routes des échanges d'informations sur la recherche climatologique et des liens à nouer entre chercheurs, décideurs, médiats et utilisateurs finaux. Bien que fondé sur la Recherche en Afrique de l'Ouest, ce modèle peut facilement être adapté à d'autres régions de l'Afrique.

Introduction

The impact of climate variability on the economies and development of African countries is well-documented (Berg 1975; Benson 1994; Benson and Clay 1986, 1998; Jury 2002; World Bank 1991). In 1984 the World Bank produced an index to compare trends in per capita food production from 1961 to 1983 for Africa, Latin America and Asia. The index revealed a persistent negative trend for Africa, in sharp contrast to upward trends in the other two regions. The decline appeared especially pronounced during the major drought episodes of 1968 to 1973 and 1981 to 1984, signifying the possible impacts of drought on food productivity.

Twenty years after the World Bank assessment, the situation has not changed appreciably despite significant advances in climate research and climate forecasting. The majority of African countries continue to suffer the full impacts of climate variability with serious adverse implications for economic growth and development. This paper describes a new conceptual model of climate research and seasonal forecast dissemination for West Africa. The overarching goal of the model is to fill a void that results from the absence of a formal climate information system in West Africa and the weakness and informality of the existing links among the disparate units that produce climate information.

The paper is divided into four sections. Section one provides examples of climate impacts on economic performance, section two looks at possible complicating factors that emerge in the climate development link, while section three briefly reviews the status of climate research and seasonal forecast information dissemination in West Africa. Finally, section four presents and discusses the features of the proposed integrated information dissemination model.

Examples of climate impacts on economic performance

Major floods that occurred in central and southern Mozambique in late 1999 and early 2000 clearly illustrate climate-economy dynamics. The floods displaced 500,000 people and caused major damage to key infrastructure, including houses, roads, water and communication facilities. The direct and indirect economic losses attributed to these floods were estimated at over US$600 million (more than double the country's annual export earnings). The magnitude of the disaster affected economic activity in such a profound way – with particular impact on agricultural and industrial production, and over such a large area – that the macroeconomic impacts in 2000 were enormous. Summarising the impacts of the floods, the Mozambican State Budget noted that the floods 'resulted in a sharp fall in GDP (Gross Domestic Product) from 7.5 per cent in 1999 to 1.6 per cent in 2000, inflation reached a high of 12.7 per cent in 2000 as compared with 2.9 per cent in 1999 and the exchange rate depreciated sharply at an annualised rate of 28.2 per cent in 2000 from a rate of 7.7 per cent in 1999' (Abt Associates 2002). This example illustrates that even low frequency or episodic climatic events can have profound economic impacts on a region or state.

Elsewhere, Benson (1994) showed that major drought in 1992 over much of southern Africa led directly to a decline of 9 per cent, 8 per cent and 3 per cent in the GDP of Zambia, Zimbabwe and South Africa respectively and significantly increased the unemployment rate in those countries. Jury (2002) showed that variations in the March to November rainfall in South Africa

explain nearly 50 per cent of GDP annual growth rate and suggested that swings of climate are manifested in South Africa's GDP fluctuations on the order of US$5 billion. Tarhule (2005) provides yet another example of the economic impact of climate hazards. On 20 July 1998, major flooding occurred in an important commercial market (Petite Marché) in Niamey, the administrative and commercial capital of Niger. The floods washed away an inestimable amount of trade goods and over 500,000,000 CFA (approximately US$830,000) in cash currency (Tidjani 1998). The loss from this one flood event exceeded the total annual budget for social welfare for all of Niger's 11 million inhabitants.

The reasons for the connection between African climate variability and economic impacts are obvious. First, human welfare and seasonal rainfall variability are strongly interlinked throughout most of Africa, arguably more so than in most other regions of the world. Whereas drought might lead to higher food prices elsewhere, in many parts of Africa it frequently leads to famine resulting in mass starvation of thousands of people and agricultural losses that disrupt the region's fragile economy. The reason for this is that agricultural production is at a near subsistence level, and the margin between normal food supply and starvation is extremely small even during normal years. As a result there usually is very little food to carry over from one year to the next, so that feast or famine cycles proceed in rhythm with the seasonal rains. Additionally, climate-induced food shortages reduce tax revenues while increasing expenditure on relief, social welfare and the logistical costs of food-related imports (Benson and Clay 1998).

Second, rain-fed agriculture is the single largest employer of labour in Africa. In West Africa, approximately 75 per cent of the labour force is engaged in one form of agriculture or another (up to 90 per cent in some countries, such as Niger and Burkina Faso). Moreover, it is important to point out that climate impacts generally permeate throughout the society and may affect even sectors not traditionally associated with or directly reliant on climate. In a study on climate information use in West Africa, Tarhule and Lamb (2003) found that 90 per cent of respondents, regardless of their primary occupation, expressed great concern about the impacts of climate variability and drought. This finding came as no surprise, because many so-called office workers in Africa also engage in some kind of agriculture to supplement their income. Furthermore, as noted above, adverse climatic conditions frequently translate directly to higher food prices impacting on everyone.

Finally agriculture (read, rain-fed agriculture) contributes a significant proportion of GDP in many African countries (on average about 40 per cent for West Africa as a whole, but up to 70 per cent in some countries, such as

Liberia). Thus, fluctuations in GDP frequently reflect major shocks in the agricultural sector.

Possible exacerbating factors

Owing to major regional changes in socio-economic activities, population growth and environmental degradation, some researchers fear that the economic impacts of climate variability may get worse rather than improve in the years ahead. In West Africa, as elsewhere in Africa, new socio-economic dynamics continue to superimpose upon and further complicate the climatic problem. Previously, nomadic livestock herders migrated out of the semi-arid Sahel zone during the dry season or periods of prolonged drought. This out-migration mitigated drought impacts by easing pressure on water and grazing resources. However, during the past few years nomadic herders have found their migratory routes increasingly blocked (due to increased urbanisation and expanded agricultural activities), forcing them to spend longer periods (sometimes the entire year) in the Sahel.

Rapid population growth also portends serious problems for climate impacts. West Africa's current population growth rate is estimated at 2.45 per cent, noticeably smaller than the 3 per cent growth rate prevalent during the 1980s and 1990s but still among the highest rates in the world. Major urban centres are growing even faster with growth rates of between two to three times those of the national population. To feed the burgeoning population, agriculture and livestock grazing have expanded correspondingly, often extending into marginal areas ecologically unsuited to such activities (Glantz 1994). Expansion in cultivated acreage has been especially large, because production tonnage has remained static during the past three decades. In other words increased crop output has been achieved primarily through expansion of cultivated area, with serious consequences for ecological sustainability. Demand for firewood in the urban centres has contributed further to massive deforestation in the surrounding areas. Around major cities like Niamey, tree cover has been so reduced that from the air the city itself appears as the most heavily wooded area within a radius of 30 to 40 km (Foley et al. 1997). With the runoff-moderating vegetation cover removed, increased erosion and sediment production from the exposed surfaces clog already limited urban storm drainage systems (Späth 1997), increasing flood risk (Tarhule 2005). This particular example qualifies primarily as environmental abuse, but the role of such degradation in amplifying climate hazards makes it relevant to the present discussion.

The Status of climate research and information dissemination in West Africa

The above analysis suggests that for many African countries, development, however defined, depends critically on the ability to mitigate the impacts of climate variability and hazards, especially floods and droughts. As with most natural hazards the capacity for dealing with climatic hazards depends principally on the extent to which (see van Appeldoorn 1981:7):

- the problem is understood,
- such knowledge is accessible to potential victims, and
- society and vulnerable groups have the ability to act upon the information provided.

If we understand this three-point criteria as proceeding sequentially, then West Africa as a whole could be said to be somewhere between the first and second criterion. 'Beginning in response to the disastrous drought of 1968 to 1973, considerable research and monitoring effort has been directed at trying to understand the physical causes, dynamics and socio-ecological impacts of Sudano-Sahelian drought' (Tarhule and Lamb 2003: 1741). This effort is still ongoing, with new initiatives like the African Monsoon Multidisciplinary Analysis (AMMA), an international project to improve the scientific knowledge of the West African Monsoon (WAM) and its variability with an emphasis on daily to interannual scales. The project held its first international conference in November and December 2005 in Dakar, Senegal. AMMA builds substantially on a previous long-run study, the Sahel-HAPEX initiative, which investigated the links between hydrologic and atmospheric processes and their role in Sahel droughts (Le Barbé and Lebel 1997).

In contrast to the concerted efforts of more than three decades to understand the causes of droughts, only during the past 10 years or so have there been any attempts to systematically evaluate how, or even if, the results of such research are accessible to communities and activities at risk (second criterion above). To a degree this delay reflects difficulties with understanding the causes of droughts, which must necessarily precede any programme of information dissemination. Even so, substantial progress has been made. Recent advances concerning the causal mechanisms have now led to reasonably skilful season-ahead climate forecasts (up to several weeks in advance). Such information can now be applied to benefit society including 'the reduction of weather/climate related risks and vulnerability, increased economic opportunities, enhanced food security, mitigation of adverse climate impacts, protection of environmental quality, and so forth' (Garbrecht et al. 2005:

227). For West Africa this new knowledge has provided the foundation for the annual West Africa Climate Outlook Forums, which have issued seasonal rainfall predictions since 1998 (Regional Climate Outlook Forums Review Organising Committee 2001). Similar developments have occurred elsewhere in SSA. Major regional organisations, notably the African Centre of Meteorological Applications for Development (ACMAD), the National Hydrological and Meterorological Services (NHMS) and the Centre Regional de Formation et d'Application en Agrométéorologie et Hydrologie Opérationelle (AGRHYMET) have taken the lead in disseminating climate forecast information. Additionally Famine Early Warning Systems (FEWS), established by the United States Agency for International Development (USAID), provides assessments of vulnerability to drought and famine for up to six months in advance, based on consideration of rainfall, vegetation and crop yield data and, increasingly, social information (Stern and Easterling 1999; USAID 1999, 2000). In many countries multi-disciplinary forecast monitoring groups comprised of analysts from ACMAD and the national hydrological and meteorological services have been established to develop consensus regarding each season's rainfall forecast and to disseminate and monitor the response to that forecast. Tarhule and Lamb (2003) provide further discussion on the pathways of information flow.

The above developments relate primarily to procedures and structures within government agencies charged with managing the impacts of climate variability. Other efforts have focused on the village level and the ultimate consumers of climate forecast information. For example the Office of Global Programmes (OGP) in the US National Oceanic and Atmospheric Agency (NOAA) has been especially active in sponsoring pilot studies to evaluate constraints and opportunities in utilising climate forecast information as well as the best practices, structures, and mechanisms for delivering such information to vulnerable groups. One example is Climate Forecasting for Agricultural Resources (CFAR), which investigates incentives and constraints to implementing seasonal forecasts in Burkina Faso (Kirshen and Flitcroft 2000; Roncoli et al. 2001, 2002; Ingram et al. 2002). A second NOAA-funded project based in Ghana within the sub-humid zone is currently developing a decision support system for agricultural applications of climate forecasts, while the CLIMAG (Climate Prediction and Agriculture) initiative, based in Mali and funded by the US National Science Foundation, is also focused on reducing food insecurity and vulnerability of agro-ecosystems caused by the interactive effects of global climate change, resource degradation and seasonal climate fluctuations in Sudano-Sahelian West Africa.

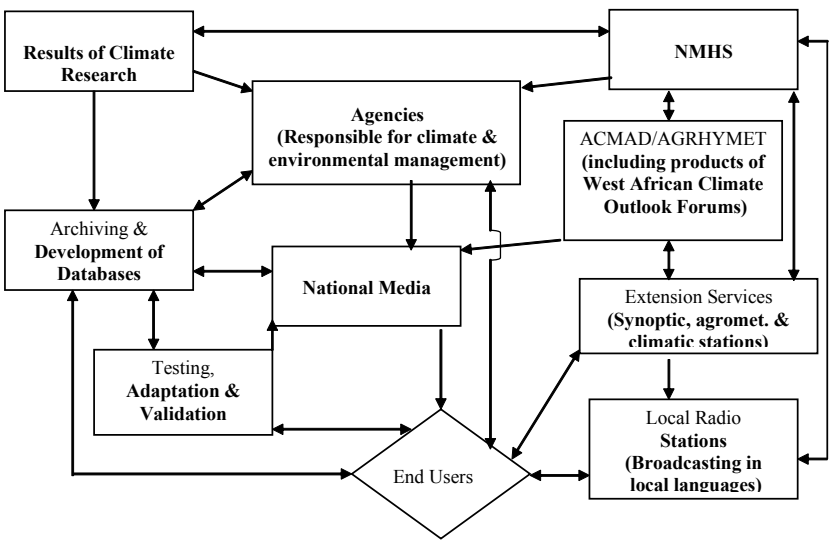
A number of experiments in the most appropriate technologies for disseminating climate information are also being carried out. One of these is

the USAID-funded project RANET, whose goal is to bring NMHS and related information to the village level in Africa by pioneering the use of new communication technologies (from satellite and internet reception by local radio stations, to FM radio transmission, to wind-up radio listening in villages).

An integrated approach to information dissemination

The developments and initiatives discussed above can potentially allow Africa to simultaneously mitigate risks and take advantage of favourable climatic conditions to secure positive social and economic outcomes (see Stern and Easterling 1999). However, to reach that objective, there is a need for greater synergy and systematic links between policy, the various research programmes and stakeholders. The conceptual model presented here provides a framework for achieving those objectives. The model was developed based on the findings of a survey of 600 climate information end-users and twenty-seven organisations in Burkina Faso, Mali, Niger and Nigeria. Tarhule and Lamb (2003) present detailed discussion of the results of this survey. The proposed model (see Figure 1) builds upon climate forecast dissemination concepts at ACMAD, as well as gaps and shortcomings identified in existing dissemination structures.

Figure 1: Conceptual model of climate research seasonal forecast information dissemination for West Africa*



* After Tarhule and Lamb (2003: 1755).

- The extreme right hand column in Figure 1 is based on information dissemination ideas developed at ACMAD (From Tarhule and Lamb 2003). The model is premised on the idea that institutional structures for monitoring, archiving and adapting potentially beneficial research findings must be strengthened or established where none exist currently. This is important because few African countries currently have the resources or technical capacity to fund major climate and environmental research programmes. The model recognises that scattered in the pages of various academic journals and technical reports are the results of climate studies and experiments that could potentially benefit many vulnerable groups and planning agencies. However, these results often remain unutilised because of low literacy levels, lack of access, and the absence of structures that can facilitate their translation into practice. It calls for the establishment of a new agency charged with monitoring emerging research findings that might have relevance or applications to African situations. This agency would maintain an archive and database of such results that could be assessed and queried by researchers, policy makers, media organisations and funding agencies. This would facilitate more rapid propagation of best practices and minimise duplication of efforts. In lieu of entirely new agencies, existing organisations such as ACMAD could take on this additional responsibility. It must be stressed that the approach suggested here is a "backdoor" way for African countries to utilise research findings that they cannot produce themselves. Ultimately, however, Africa must take control of its own research. A society cannot develop by being dependent on external science and technology. Africa must produce and retain indigenous scientists and research facilities with sufficient technical expertise to solve its own problems.
- In any case, the results of research culled from journal articles would seldom be directly applicable to specific local conditions. For this reason, there will be a need to test and validate such results using local data and circumstances and to develop the best adaptation strategy. This role is recognised in the model (see the third box of the first column in Figure 1 above). Information flow is a two-way process, but many existing arrangements for climate information dissemination appear to be linear and unidirectional. While much effort is devoted to getting information to stakeholders and user groups, far less priority is attached to receiving feedback that might improve both the quality of the information as well as the dissemination process. The proposed framework remedies this deficiency by linking climate research and forecast dissemination pathways with agencies responsible for managing the effects of climate variability, the news media and end users in a coherent, logical structure. To appreciate

this expanded scope, it is worth considering that the extreme right column of Figure 1 above is the forecast dissemination structure that was proposed at ACMAD. The framework can accommodate nested, finer-scale information flow pathways without a need for major reconfiguration. For example, information does not get dumped in a vacuum within the end-user node: contacts receive information and then transmit it through appropriate channels in the village information flow network. Notice that this level of detail does not affect the overall structure of the proposed framework.

Conclusions

Societal welfare in many parts of Africa is linked strongly to cycles of climatic variability and hazards, because a majority of the population depends directly on rain-fed agriculture. The link between climatic variability and agriculture has implications for the GDP of African countries, because the agricultural sector comprises about 40 per cent of GDP for many of these countries. It is imperative therefore to mitigate climate effects if meaningful development is to take hold. Some social thinkers have argued that true development is akin to an ecological process in which a society increases its capacity for dealing with the environment, including extreme environmental conditions that produce disasters (Apeldoorn 1981). This process involves three stages – understanding the problem, disseminating information about the problem and having the ability to act on the information. A review of the situation for West Africa suggests the region is probably between stages one and two. While much effort has been made to understand the major climatic hazard (drought), only now is concerted effort being made to disseminate information on drought to vulnerable groups. This paper has proposed a new conceptual framework of information structure and flow pathways as a contribution towards that dissemination effort. The proposed structure integrates the disparate components presently involved in information dissemination. It represents the first systematic structure of information flow that can be applied at a national or regional scale. Successful implementation will contribute significantly to improved dissemination and use of climate forecast information for precautionary planning and risk management.

References

Abt Associates, 2002, *Mozambique 1999-2000 Floods Impact Evaluation*, Washington, DC: USAID. Available online at http://www.sarpn.org.za/documents/d0000811/index.php.

Benson, C., 1994, *Drought and Macroeconomic Performance: A Comparative Analysis of Six Sub-Saharan African Economies*, Mimeo. London: Overseas Development Institute.

Benson, C. and Clay, E., 1986, 'Food Aid and Food Crisis in Sub-Saharan Africa: Statistical Trends and Implications', *Disasters* Vol. 10, pp. 303-316.

Benson, C. and Clay, E., 1998, *The Impact of Drought on Sub-Saharan African Economics: A Preliminary Examination*. World Bank Technical Paper No. 401, Washington DC: World Bank.

Berg, E., 1975, *The Economic Impact of Drought and Inflation in the Sahel Based on the Recent Economic Evolution of the Sahel*. Prepared by the University of Michigan for the U.S. Agency for International Development. Ann Arbor: University of Michigan.

Foley, G., Floor, W., Madon, G., Lawali, E. M., Montagne, P., and Tounao, K., 1997, *The Niger Household Project: Promoting Rural Fuelwood Markets and Village Management of Natural Woodlands*, World Bank Technical Paper No. 362, Washington, DC: World Bank.

Garbrecht, J., Meinke, H., Sivakumar, M. V., Motha, R. P., and Salinger, M.J., 2005, 'Seasonal Climate Forecast and Adoption by Agriculture', *EOS*, Vol. 86, No. 24.

Glantz, M., 1994, 'The West African Sahel', in M. Glantz, ed., *Drought Follows the Plow*, Cambridge: Cambridge University Press, pp. 33-43.

Ingram, K. T., Roncoli, M. C., and Kirshen, P. H., 2002, 'Opportunities and Constraints for Farmers of West Africa to Use Seasonal Precipitation Forecasts, with Burkina Faso as a Case Study, *Agric. Syst.,* Vol. 74, pp. 331-339.

Jury, M. R., 2002, 'Economic Impacts of Climate Variability in South Africa and Development of Resource Prediction Models, *Journal of Applied Meteorology*, Vol. 41, pp. 46-55.

Kirshen, P. H., and Flitcroft, I. D., 2000, 'Use of Seasonal Forecasting to Improve Agricultural Production in West Africa: An Institutional Analysis of Burkina Faso', *Natural Resources Forum,* Vol. 24, pp. 184-195.

Lamb, P. J., 1978, 'Large-scale Tropical Atlantic Surface Circulation Patterns Associated with Subsaharan Weather Anomalies', *Tellus*, Vol. 30, pp. 240-251.

Le Barbé L., and Lebel, T., 1997, 'Rainfall Climatology of the HAPEX-Sahel Region during the Years 1950-1990', *Journal of Hydrology,* Vol. 188-189, pp. 43-73.

Nicholson, S. E., 2000, 'Land Surface Processes and Sahel Climate', *Rev. Geophys*., Vol. 38, pp. 117–139.

O'Brien, K., Sygna, L., Naess, L. O., Kingamkono, R., and Hochobeb, B., 2000, *Is Information Enough? User Responses to Climate Forecasts in Southern Africa*. Centre for International Climate and Environmental Research Technical Report 3:2000. Available online at www.cicero.uio.no/media/22.pdf.

O'Keefe, P., and Wisner, B., 1975, 'African Drought: The State of the Game', *Afr. Environ. Probl. Perspect,* Vol. 1, pp. 31–39.

Regional Climate Outlook Forums Review Organising Committee, 2001, *Coping with Climate: A Way Forward*, International Research Institute for Climate Prediction Publication IRI-CW/01/1,

Roncoli, C., Ingram, K. and Kirshen, P., 2001, 'The Costs and Risks of Coping with Drought: Livelihood Impacts and Farmers' Responses in Burkina Faso', *Climate Res*., Vol. 19, pp. 119-132.

Roncoli, C., Ingram, K. and Kirshen, P., 2002, 'Reading the Rains: Local Knowledge and Rainfall Forecasting in Burkina Faso', *Soc. Nat. Resour*, Vol. 15, pp. 409-424.

Späth, H-J., 1997, 'Fuelwood Crisis of Niamey: Vanishing Forests and Development of an Arid Island in the Sahel of Niger', in H-J. Späth, ed., *Land Use and Desertification in North and West Africa*, Paderborner Geographische Studien, Band 6, pp. 55-88.

Stern, P. C., and Easterling, W. E., eds., 1999, *Making Climate Forecasts Matter,* Washington, DC: National Academy Press.

Tarhule, A., 2005, 'Damaging Rainfall and Flooding: The Other Sahel Hazards', *Climatic Change*, Vol. 72, pp. 355-377.

Tarhule, A., and Lamb, P. J., 2003, Climate Research and Seasonal Forecasting for West Africans: Perceptions, Dissemination and Use?', *Bull. Am. Meteor. Soc*., Vol. 84, No. 12, pp. 1741-1759.

Tidjani, A. A., 1998, 'Naufrage à la Vallée aux chauve souris', *Le Sahel*, No. 5591, 23 July, 5.

USAID, 1999, FEWS Current Vulnerability Assessment Guidance Mannual, Washington DC: USAID. Available online at http:/fews.org/va/vahome.html.

USAID, 2000, FEWS Sahel 1999/2000 Current Vulnerability Assessment, Washington DC: USAID. Available online at http://fews.org/va/vahome.html.

Van Apeldoorn, J. G., 1981, *Perspectives on Drought and Famine in Nigeria.* New York: Allen and Unwin.

World Bank, 1991, *Food Security and Disasters in Africa: A Framework for Action.* Africa Technical Department, Washington, DC: World Bank.