AIACC Notes

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Report from the Secretariat

Neil Leary and Sara Beresford

As the year 2003 comes to a close, the 24 AIACC regional assessment teams are completing the second year of their three-year studies. Progress reports from each regional study can now be viewed at http://sedac.ciesin.columbia.edu/aiacc. AIACC investigators continue with their research while gearing up for the second round of regional workshops slated for 2004. AIACC investigators have also represented AIACC by presenting their research and participating in numerous international scientific meetings. The participation of AIACC investigators at international meetings, which is described in more detail below, is an important step in achieving a critical objective of AIACC, which is to enable more developing country scientists to participate in international science and policy dialogues on climate change.

In this issue of AIACC Notes, articles from four of the AIACC regional studies highlight work that is completed and underway. An article on AIACC participation in the Energy Modeling Forum (Snowmass) Workshop on Climate Change Impacts and Integrated Assessment highlights an important contribution that AIACC investigators are making to the international dialogue on adaptation to climate change.

Planning for 2004 Regional Workshops

AIACC is currently preparing for the second round of AIACC regional workshops to be held in 2004. The workshops will be hosted by AIACC regional study teams based in Senegal (March 2004), Argentina (August 2004), and Philippines (October 2004). The regional workshops will bring together AIACC investigators to present and discuss their research, and will provide opportunities to make a wider community of stakeholders aware of the work and outputs from the regional studies. Participants at the workshop will include four members from each AIACC regional study team, one stakeholder relevant to each regional study, and a group of international stakeholders, AIACC committee members, mentors, and staff. The 2004 workshops will emphasize linkages between research and end-users (e.g. IPCC, national communications and adaptation planning activities), and will lay the groundwork for synthesis of AIACC results and lessons in 2005.

AIACC Participation in the IPCC 4th Assessment Report Planning

Several investigators from AIACC regional studies have been participating in meetings that are laying the groundwork for the next major assessment report of the Intergovernmental Panel on Climate Change (IPCC). AIACC investigators have participated in the First and Second Scoping Meetings held in Morocco and Germany, which brought together researchers from around the world to plan the IPCC report. AIACC investigators have also participated in a number of IPCC expert meetings that have been convened to explore selected topics that are expected to be highlighted in the Fourth Assessment Report. These meetings include: TGCIA Experts Meeting on Scenarios (Netherlands), Expert Meeting on Climate Change and Sustainable Development (Sri Lanka), Workshop on the Theory and Use of Regional Climate Models (Italy), Working Group II Expert Meeting on Detection and Attribution of Effects (USA), and Terrestrial Carbon Stocks Experts Meeting (Switzerland). The participation of AIACC-affiliated scientists

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AIACC at the Stanford Energy Modeling Forum, Snowmass, Colorado

Rex Victor Cruz (AS21), Anthony Nyong (AF92), Balgis Osman (AF14), Monica Wehbe (LA29)

AIACC research on adaptation was highlighted at the Stanford University Energy Modeling Forum's workshop on Climate Change Impacts and Integrated Assessment. The annual 2-week workshop, held each summer in Snowmass, Colorado USA, has for several years brought together leading researchers in the areas of integrated assessment modeling and climate change impacts. The purpose of these gatherings is to advance integration across the many research areas related to climate change, such as social and economic drivers of greenhouse gas emissions,

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Report from the Secretariat (cont.)

in these meetings is an important step toward reaching one of the objectives of the AIACC project, which is to foster greater participation of scientists from the developing world in the assessment reports of the Intergovernmental Panel on Climate Change (IPCC). AIACC will continue to work to bring its scientists and their work to the attention of the IPCC Bureau, and has recently nominated 43 AIACC-affiliated scientists to participate as authors in the IPCC Fourth Assessment Report.

Introduction of the AIACC Working Paper Series

This month, AIACC will initiate the AIACC Working Papers. The aim of the Working Papers is to encourage AIACC investigators to publish their findings, and to provide a forum – the AIACC website – for electronic distribution of their preliminary papers. In order to ensure quality of the papers, the initial working paper submissions will be peer-reviewed by 2-3 experts prior to their electronic distribution on the website. Once on the website, the Working Papers will provide a further opportunity for a general audience to learn about AIACC regional study results prior to the end of the project in 2005. Comments on the papers from a wider audience will be encouraged. Thus the Working Papers provides an important opportunity for AIACC investigators to receive feedback on research that is in progress. It is the aim of AIACC that these papers be an important step in the process of producing papers for publication. The Working Papers will be available on the AIACC website (www.aiaccproject.org) by clicking on the link "AIACC Reports and Publications."

AIACC Participation in the Human Dimensions Open Meeting

The 2003 Open Meeting of the Human Dimensions of Global Environmental Change Research Community took place on 16-18 October 2003 in Montreal, Canada. Several sessions at the meeting highlighted vulnerability and adaptation to climate change, which underscored the importance and attention being devoted to these issues in the global change research community and beyond.

Papers presented by AIACC researchers at the Open Meeting:

- Vulnerability and Adaptation of Watershed Communities, Juan M. Pulhin, Philippines (AS21)
- Assessing Agricultural Producers' Vulnerability to Climate Variability and Extremes: an Analytical Methodological Framework based on the Notion of Sustainability, Mónica B. Wehbe, Argentina (LA29)
- Stakeholder Engagement in Community-Based Management of Conservation Areas: An Example from Northern Mozambique, Patrick Mushove, Zimbabwe (AF38)
- Does Climate Risk Matter? Agricultural Adaptation in A "Multi-Stressor" Context: Three Cases from Mexico, Hallie Eakin, Mexico (LA29)
- Human Dimension of Climate Change Activities in Jamaica and the Caribbean, A. Anthony Chen, Jamaica (SIS06)

Posters presented by AIACC researchers at the Open Meeting:

- Perceptions of Climate Change Among Different Sectors in the Mexican Population, Cecilia Conde, Mexico (LA29)
- Overall Vulnerability of the Uruguayan Coastal Fishery System to Global Change in the Estuarine Front of the Rio de la Plata, Gustavo Nagy, Uruguay (LA32)
- Assessing the Role of Wood Products in Mitigating Climate Change, Florencia Pulhin, Philippines (AS21)
- An Integrated Assessment of Climate Change Impacts, Vulnerability and Adaptation in Watershed Areas and Communities in Southeast Asia, Sheila Sophia N. Roy, Philippines (AS21)
- Evaluating Adaptation Options To Reduce Water Use Vulnerability In The Heihe Basin Of China, Yongyuan Yin, China (AS25)

AIACC at the Stanford Energy Modeling Forum, Snowmass, Colorado(cont.)

atmospheric chemistry and radiative forcing, climate system behavior, biophysical and social impacts of climate change, adaptation, and mitigation. These productive exchanges are conducted in a scenic, informal setting under a tent at 3000m in the Rocky Mountains, with many of the participants accompanied by their families and taking opportunities in the evenings and weekend to enjoy a mountain hike, attend a rodeo, eat some barbecue, and dance to country western music under the stars.

John Weyant, Director of the Stanford Energy Modeling Forum, invited Neil Leary of AIACC, Bo Lim of the United Nations Development Program (UNDP), and Kris Ebi of the Electric Power Research Institute (EPRI) to organize sessions on adaptation for the workshop. The sessions included methods papers from UNDP's Adaptation Policy Framework (see adjacent figure), case study research from AIACC, and recent research on insurance mechanisms and frameworks for integrating analyses of adaptation and mitigation policies. Investigators from five of the AIACC regional studies attended the workshop to give presentations on their research. These included Rex Victor Cruz of the Philippines, Balgis Elasha Osman of Sudan, Anthony Nyong of Nigeria, Monica Wehbe of Argentina, and Molly Hellmuth of USA. Also participating in the adaptation sessions were several other members of AIACC's extended family of mentors and advisors: Ian Burton, Roger Jones, Anand Patwardhan, Gary Yohe, Tom Wilbanks and Gina Ziervogel.

Rex Victor Cruz spoke about the approach being taken in AIACC Project No. AS21 to engage key stakeholders in the assessment of climatic vulnerabilities and possible adaptation responses in Philippine watersheds. Representatives from study site communities, the Department of Environment and Natural Resources, the National Power Corporation, and National Irrigation Administration have been consulted, interviewed and invited to workshops. These activities have provided opportunities for key stakeholders to articulate their views of climate change and variability and appropriate responses. The researchers are using these discussions to better understand the risks faced by different groups of stakeholders, feasible options for adaptation by each group, and the human and institutional consequences of different options.

Balgis Elasha Osman reported on AIACC Project No. AF14's assessment of sustainable

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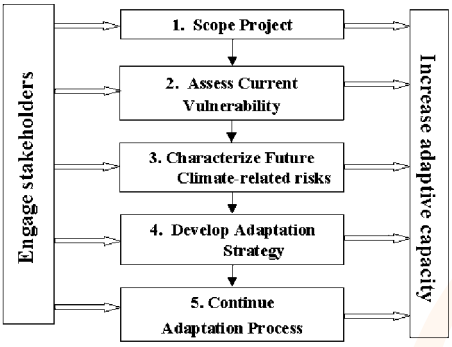

The five major steps in an adaptation policy framework.

livelihood strategies for building resilience to drought and the potential application of these strategies for reducing vulnerability to longer-term climate change. Selected communities in rural Sudan that have implemented sustainable livelihood and natural resource management projects are being studied using a participatory research approach to evaluate the effectiveness of the projects and identify the factors that contribute to or inhibit their effectiveness. The factors include a mixture of local characteristics of the communities as well as the broader policy, economic and social context in which the communities are attempting to cope with climatic and other stresses. Initial results suggest that sustainable livelihood strategies have been an effective means for increasing resilience to climatic stresses.

Tony Nyong presented a methodology being employed by AIACC Project No. AF92 to classify households by current vulnerability using indicators that were identified through participatory processes. Preliminary results showed that of the three major livelihood systems identified in the Sahel, fishing was the least vulnerable to drought, followed by farming and livestock. Economic assets and conditions of the household serve as major determinants of adaptive capacity. The paper concluded that productive labor plays a crucial role as the most important asset in a poor rural household, and perhaps the only one that poor households have abundantly to cope with vulnerability to climate change.

Monica Wehbe described a conceptual approach being pursued by AIACC Project No. LA29 to assess the vulnerability and adaptive capacity of agricultural systems in Argentina within a context of changing political, institutional, economic and climatic conditions. The approach has been applied to a study of vulnerabilities of peanut farmers of varying scales to climate variability and other forces. The study concluded that climate variability and market changes resulted in unstable incomes from peanut production and a shift of medium sized farms from peanut production to soybean production as an adaptive strategy to reduce income variability. Ongoing work is evaluating the sustainability of this strategy at the individual farm scale and at the regional scale.

Molly Hellmuth provided an overview of a benefit-cost framework that is being developed by AIACC Project No. AF47 to evaluate adaptation measures. The framework will be demonstrated by applications in South Africa that will focus on a dam project near Cape Town and in the Gambia that will focus on agricultural system responses. It is expected that the framework will be widely applicable to the evaluation of adaptation measures.

At the conclusion of the adaptation sessions, John Weyant stated that he had high expectations for the contributions that AIACC participants would make to the workshop and congratulated the speakers for having surpassed his expectations.

Estimating and Comparing the Benefits and Costs of Avoiding Climate Change Damages

J.M. Callaway[1], M.E. Hellmuth[1], J.C. Nkomo[2], D.A. Sparks[2] and D.B. Louw[3]

Project Objectives

The broad objective of AIACC regional study AF47 is to develop the capacity to estimate and compare the benefits and costs of projects in natural resource sectors that reduce the expected damages from climate change in Southern and West Africa. There are two parts to this project. The first consists of using well-established principles from economic benefit-cost analysis to develop a framework to estimate the economic benefits and costs associated with the expected climate change damages avoided by a development project that does not take climate change into account. Then, these benefits and costs can be compared to the case where planners incorporate expected climate change into the project assessment. This framework is reported in Callaway (2003). The second part consists of demonstrating this methodology in two project case studies, one in The Gambia and the other in South Africa. This paper reports on the South African case study, which is examining the benefits and costs of avoiding climate change damages through structural and institutional options for increasing water supply in the Berg River Basin in the Western Cape Province.

View of the study area: Franshhoek Valley of the Berg River Basin in South Africa.

The Berg River Case Study

The upper Berg River is an economically important water supply system in the Western Cape that provides the bulk of the water for household, commercial and industrial use in the Cape Town metropolitan region. It also provides irrigation water to cultivate roughly 15,000 hectares of high-value crops, primarily deciduous fruits, table and wine grapes and vegetables both for domestic and export use with strong multiplier effects in the domestic and national economy. As the population of the Metropolitan Cape Town region grows, the competition for water in the basin has become even more intense as farmers have shifted production toward highly valued export crops and the government searches for solutions to make good on its promise to provide a minimum amount of "free" water to all households to meet minimum daily requirements.

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Estimating and Comparing the Benefits and Costs of Avoiding Climate Change Damages (cont.)

Recently, the government of South Africa commissioned a new dam in the Berg River basin in an effort to alleviate the problem of increasingly scarce water supply for the Cape Metro Region. The commissioning of the new Berg Dam was a controversial and lengthy process. The government is also moving towards the creation of competitive markets for water in the basin (and elsewhere) under the new National Water Act (1998). Planning for both options has, up until this point, failed to take into account the possibility that the build-up of greenhouse gases in the global atmosphere is affecting and will continue to affect the regional climate, potentially reducing existing runoff in the Basin.

The AIACC AF47 group is collaborating with regional grower's associations in the Berg River, as well as with the Department of Water Affairs and Forestry (DWAF). Both groups have shown considerable interest in the project as the explicit costs and benefits of adjustment measures to climate change have not been previously examined in the region.

In that general context, the objectives of this study are to develop and implement the necessary analytical tools to:

- Estimate the potential impacts of alternative climate change scenarios on water supply and demand in the basin through changes in runoff, evapotranspiration and surface evaporation
- Translate these physical impacts into monetary losses (or gains) for different groups of farmers and urban water users, and
- Estimate and compare the benefits costs of the storage and water market options of avoiding climate change damages, with and without accounting for expected climate change in the ex ante planning for these options.

Methods

The study team is currently modifying an existing spatial equilibrium model of the Berg River Basin (Louw, 2002) for use in an integrated environmental-economic assessment of climate change. The current model includes all of the major water supply sources in the basin, as well as detailed farm-level irrigation water uses for important crops and livestock, and urban water demand in the Cape Town Metropolitan region. The most important modifications to the model consist of:

- Incorporating the inter-temporal features of reservoir storage for both major storage reservoirs and on-farm water storage, so that the model can be used to assess climate change impacts over time
- Creating a hydrologically realistic, but simplified, spatial representation of the physical and man-made water-supply system in the basin
- Improving the hydrologic aspects of the model to allow:
  - Incorporation of stochastic streamflow ensembles from the WatBal rainfall-runoff model (Yates, 1996) and
  - Calculation of return flows, reservoir evaporation and conveyance losses;
- Addition of investment functions for new reservoir capacity
- Development of on-farm water-use intensity estimates for different temperature regimes, and
- Development of scenarios to reflect changes in water demand over time due to population and agricultural commodity market developments.

Implementation

Once modified and verified, the model will be used to assess the physical and economic effects of a number of alternative runoff scenarios, associated both with the historical climate, recent climate anomalies, and equally plausible changes in climate for the Basin. Each of these scenarios will be run for the following options:

- No water markets, no additional storage
- Water markets, plus additional storage (both planned and optimal)
- Additional storage (both planned and optimal), no water markets, and
- Both water markets and additional storage (both planned and optimal).

The results from these sets of simulations will make it possible to estimate both the monetary value of the climate change damages without the various options and the monetary value of the benefits and costs of avoiding these damages through the various alternatives. This information can then be used to isolate the benefits and costs of planning for expected climate change, versus not planning for it, over a range of subjective probabilities for each climate change scenario. One can also extend this approach (as shown in Callaway, 2003) to analyze the variation in optimal reservoir storage capacity over the same range of probabilities and then find the ex ante reservoir capacity that leads to the minimum level of regret, both in terms of planning for climate change that does not happen ex post and not planning for climate change that does occur ex post.

Conclusion

The methodology being used in this study – ex ante, ex post planning – is not new. It has been used in one form or another to evaluate natural resource development projects under risk and uncertainty associated with historical climate variability. Nevertheless, planners in natural resource sectors often seem mystified about how to incorporate the uncertainty associated with climate change into their current projects. One of the most important benefits of this project hopefully will be to de-mystify the problem by demonstrating how existing tools and approaches can be modified slightly to integrate climate change into the assessment of natural resource development investments in South Africa and The Gambia. While the South African case study will consider a relatively developed watershed with competing urban and agricultural users, the Gambian case study focuses primarily on evaluating the effectiveness of a variety of agricultural adaptation options in reducing the vulnerability of a spectrum of rural farmers to climate changes.

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Rainfall Patterns for Mainland Southeast Asia under Different Atmospheric CO_2 Levels

Anond Snidvongs[1,2], John L. McGregor[3], Kim Chi Nguyen[3], Weerasak Weerakant[2]

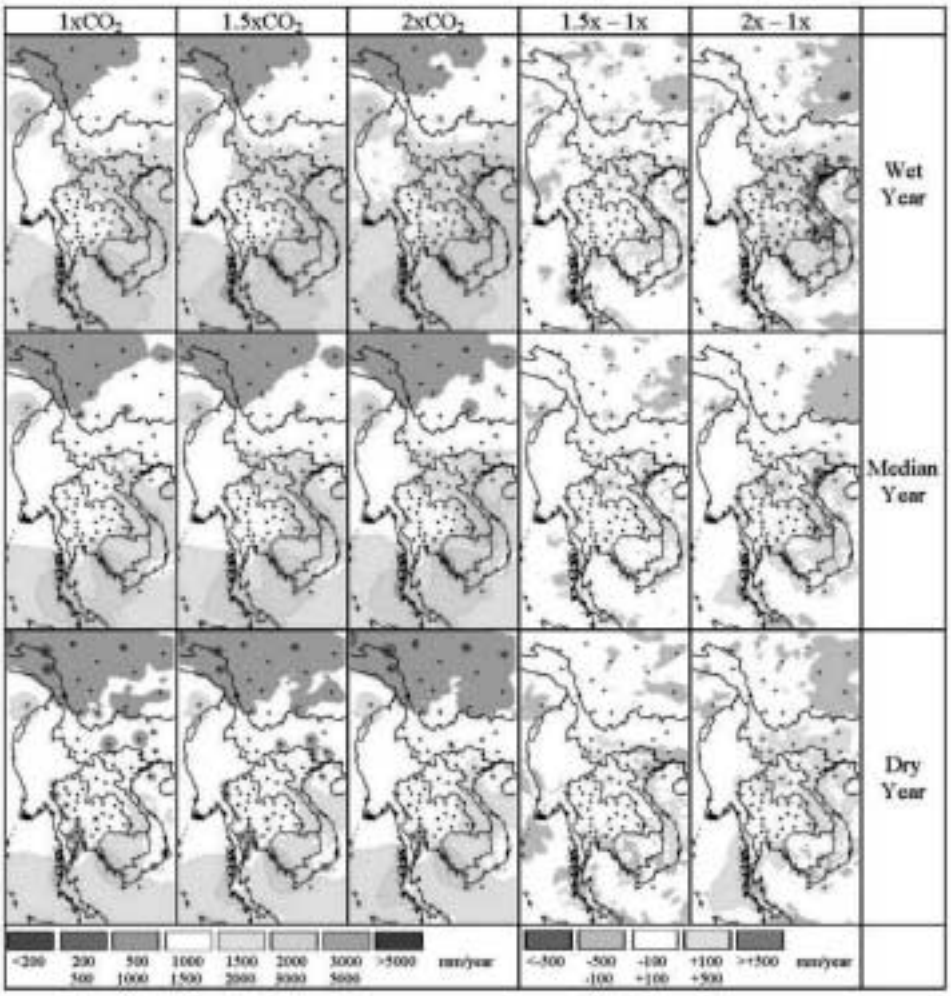
Introduction and Methods

Mainland Southeast Asia is comprised largely of agricultural-based countries such as Cambodia, Lao PDR, Thailand and Viet Nam. Food and grain, especially rice, produced from this region are not only for local consumption but are also exported to other parts of the world. The region also has extensive and highly-populated coastal lowland areas and river deltas, which are vulnerable to flood, salt intrusions and other water quality and quality-related problems. Any changes in the hydrological cycle, as induced by climatic change, would have impacts on human livelihood and well-being in the region.

In this AIACC regional study AS07, the Southeast Asia regional climate was simulated over three separate decades using the Conformal-Cubic Atmospheric Model (CCAM) developed by CSIRO Atmospheric Research, Australia. The decade between 1980-1989, with an atmospheric CO2 about 360 ppm, was taken as the baseline. Two other decades were simulated with elevated CO2 levels of 540 ppm and 720 ppm, which correspond respectively to 1.5 and 2 times the concentration of the baseline.

CCAM was run in stretched grid mode to provide high resolution over the region of interest. The average resolution in this study was about 0.1 degree, or about 10 km. Each CCAM run produced arrays of climatic variables, including daily maximum and minimum temperature, wind speed and direction, cloud cover and solar radiation. However, only rainfall, which is probably most relevant to human livelihood in the region, will be covered in this article. In this article the daily climate for each of the 54,480 grid cells over 10 years from each CCAM run were aggregated for each year to derive contour maps for visualization of the general trend of the annual rainfall for the region.

The annual rainfall for the baseline decade (1980-89) was compared with the observed



Rainfall scenarios for mainland Southeast Asia from CCAM. Columns 1-3 are for 360, 540 and 720 ppm CO2, and columns 4-5 are for rainfall anomaly for 540 and 720 ppm CO2 relative to that for 360 ppm CO2 baseline, respectively. Rows 1-3 are for wet year, median year and dry year of each decade, respectively. Points shown are location of meteorological stations that observed data were used for CCAM result calibration.

data from over 100 meteorological stations distributed throughout the study area. Before the data were compared, both observed and CCAM simulated annual rainfall were sorted into wet, dry and median years. CCAM annual rainfall was subsequently log-transformed to best-fit the observed data at each location. The same empirical forcing functions were used for the projected climate simulations.

Results

The general rainfall pattern for mainland Southeast Asia is characterized by high rainfall at low latitudes and less rainfall at higher latitudes. The wettest spots in the region are found along the Andaman Sea coast of the Thai-Malay Peninsular and along the eastern coast of the Gulf of Thailand, where annual rainfall in these areas can well exceed 5,000 mm/year due to the landfall of the southwest monsoon. Along the mid-latitude zone of the region, there is generally more rain along the eastern side toward the South China Sea than along the western side toward the Bay of Bengal. Comparison between wet and dry years of the same decade indicates that during the dry years the dry wedge from the north extends southeastward from the Tibet Plateau toward the South China Sea, while the rain belts to the east and to the south of the region are generally weakened. Also during the dry years, the rainfall shadow zone in west central Thailand can be clearly recognized.

Elevated atmospheric CO2 levels from 360 ppm to 540 ppm and to 720 ppm, or about 1.5 and 2 times, respectively, do have several visible impacts on the simulated annual rainfall pattern of the region. The area that appears most sensitive to this is the South China Sea

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Rainfall Patterns for Mainland Southeast Asia under Different Atmospheric CO_2 Levels (cont.)

coast of Viet Nam, where a uniform increase in annual rainfall can be observed even during the driest year of the decade when the atmospheric CO2 is increased to only about 540 ppm or by about 50% above the baseline. When the atmospheric CO2 is further increased to 720 ppm, this intensified coastal rain belt may further expand to cover most parts of all three Indochina countries, namely Cambodia, Lao PDR and Viet Nam, especially during the wet years of the decade. The total annual rainfall is also substantially increased in all years of the decade. For example, some locations in the Red River delta, where annual flooding has already been a serious problem during wet years, are expected to receive increased annual rainfall to be more than 5,000 mm/year, up from about 2,500 mm/year for the wet years during the baseline decade, to make those locations among the wettest spots in the region. The southern part of Lao PDR, which is the rice bowl of that country, is also expected to receive increased rain up to around 2,000 mm/year during the wet years compare with about 2,500 mm/year for wet years during the baseline decade.

The Thai-Malay Peninsular is another area where the rainfall is sensitive to the atmospheric CO2 increase. However, the impacts on the rainfall pattern are quite different between wet and dry years of the decade. During the wet years, certain spots in this area may receive increased rain from about 4-5,000 mm/year during the baseline decade to around 2,000 mm/year, even when the atmospheric CO2 for the decade is increased only 1.5 times. However, during the dry years of the decade, there may be less annual rainfall in the area by about around 1,000 mm/year compare to the baseline for both 1.5 and 2 times atmospheric CO2. These same patterns of annual rainfall during the wet and dry years due to atmospheric CO2 forcing can also be seen in the Mekong River delta area, but the indicated magnitude is slightly less extreme.

The parts of mainland Southeast Asia that are expected to experience only minor or no changes in rainfall pattern due to an increase in atmospheric CO2 would be most parts of Myanmar and Thailand as well as Yunnan Province of China. However, these areas may be subjected to the changes in other climatic variables as well as some shifts in seasonality within the year that need to be further studied in more detail.

Future Work

During the next phases of the project, the impacts of climate change on regional and local water resource and rice production will be studied. Vulnerability of human society and economy, as well as adaptation strategy and policy options, will be formulated and analyzed. With additional funding from Asia Pacific Network for Global Change Research (APN), SEA START RC will be able to carry out a regional capacity building initiative for members of academic and line agencies in the region on the methodology and techniques to study and assess climate change impacts, social and economic vulnerability, adaptation strategy and policy formulation. This new program is expected to begin in early 2004 and will continue through 2005.

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Vulnerability of Rural Households to Drought in Northern Nigeria

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Drought is a recurrent feature in the Sahel region. The magnitude and intensity of these droughts, and consequently the destruction caused by these droughts, have been on the increase over the last 100 years. The rural and marginalized poor are most affected by drought, as they have the least resources to adapt. Within this group are those who depend on traditional livelihood systems (farming, pastoralism and fishing). Any meaningful attempt at developing policy initiatives to facilitate or promote adaptation at the local level where vulnerability should be situated should begin by assessing and enhancing the adaptive capacity of vulnerable groups. This article explores household factors that can influence adaptive capacities among rural households in semi-arid northern Nigeria. It is based on ongoing research carried out at the University of Jos and funded by AIACC.

Climate and Rural Livelihood Systems in Northern Nigeria

The basic livelihood systems in northern Nigeria are agriculture – crop farming, pastoralism and inland fishing. Crop yields are not only determined by climatic conditions, but by many other variables, including soil fertility, farming methods, level of technology, farm inputs, and pest incidence. Most of these variables do not vary from year to year as much as climatic conditions, particularly rainfall. In the northern fringes, pastoralism is the dominant livelihood system. The Sahel of Nigeria is estimated to support about 15 million cattle, 10 million sheep, 18 million goats, and all the donkeys. Here, nomadic herdsmen graze their livestock and are constantly in search of suitable pasture. Three million hectares of wetlands dot this pastoral landscape, with an average livestock density of 13 animals/ha, well above the carrying capacity. These wetlands and a few seasonal rivers provide the bulk of the fish that is consumed in northern Nigeria. If the

A typical wetland in Sahelian Northern Nigeria.

present trend of increased droughts occurs, how vulnerable will the livelihood systems be? Can the rural populations adapt to the situation? To be able to plan for adaptation within this region, it is important that we explore the adaptive capacities of the people for whom the adaptation would be planned.

Vulnerability and Adaptive Capacities of Rural Households

For this study, we developed a methodology for classifying households based on their levels of current vulnerability using the vulnerability indicator approach. We chose 3 villages for this pilot study, each representing one major livelihood system, and administered questionnaires to 90 households. Using participatory vulnerability ranking, akin to wealth ranking, households were grouped into three classes of vulnerability: highly vulnerable, vulnerable and not vulnerable. Based on this ranking, households within the farming systems were most vulnerable, followed by the pastoralists. The least vulnerable group was those from the predominantly fishing community.

Among the determinants of adaptive capacity the economic condition of the household serves as the most significant determinant, since economic resources facilitate preparation and recovery. Households make use of their assets/resources to undertake a wide range of income-generating activities. Four broad categories of assets are generally available to rural households regarding income-generating activities: human capabilities, natural resources, social and institutional networks and human-made capital.

Household income is traditionally seen as a strong indicator of household vulnerability. Wealthy households in general are in a better position to adapt to climate change than poor ones. Income serves as a proxy for access to resources for adaptive capacity at the household level. Our results found that average income per consumer unit rather than total income served as a better index of adaptive capacity. The higher the income per consumer unit, the better positioned is that household to adapt to climate change impacts.

Livelihood diversification has become a well-accepted adaptation strategy in the Sahel. Households are less vulnerable to climatic stress if they have other sources of livelihood to fall back on in times of scarcity. Our study

A participatory vulnerability ranking session.

confirms that the more the number of non-agricultural income-generating activities a household engages in, the less vulnerable it was. These income-generating activities directly relate to the number of people who engage in them, that is, the quantity of available labour. Family and social networks are crucial social assets as they are based on systems of mutual help and reciprocity as mechanisms that increase and protect household resources. Most people in our study sites belong to community, social and age-grade organizations that serve as social nets in times of disaster. Also, households who have families outside of their area and receive either cash, food or labour from them are less vulnerable than those who don't.

There is a strong relationship between the health of a household and the vulnerability of that household. Households that have more disabled and ill members are considered more vulnerable than those with healthy members. The number of healthy household members directly translates to the number of people available for productive labour in the household. In addition to the fact that ill-health and disability does not allow every member of the household to be economically productive, it also puts a strain on household finances.

While there is no convergence in research regarding the place of large household sizes in enhancing adaptive capacity, preliminary results reveal that higher vulnerability lurked in both very small and very large household sizes, but more in larger households. Regarding the sex of the household head, there also exist divergent views among researchers regarding the vulnerability of female-headed households. While some support that female-headed households are more vulnerable, others argue that female-headed households are as economically and socially viable as male-headed. However, our study supports the idea of greater vulnerability of female-headed households. This, acting in combination with the age of the household head, is a stronger influence on the probability of being vulnerable.

Conclusion

Within the range of multiple resources available to a household to reduce its vulnerability to droughts, labour plays a crucial role as the most important asset in a poor household, and perhaps the only one that poor households have abundantly to cope with vulnerability to climate change. It is therefore pertinent that policies aimed at reducing vulnerability and hence increase adaptive capacity should include programs that could impact the local population even at the household level.

Climate Variability and Patterns of Dengue in the Caribbean

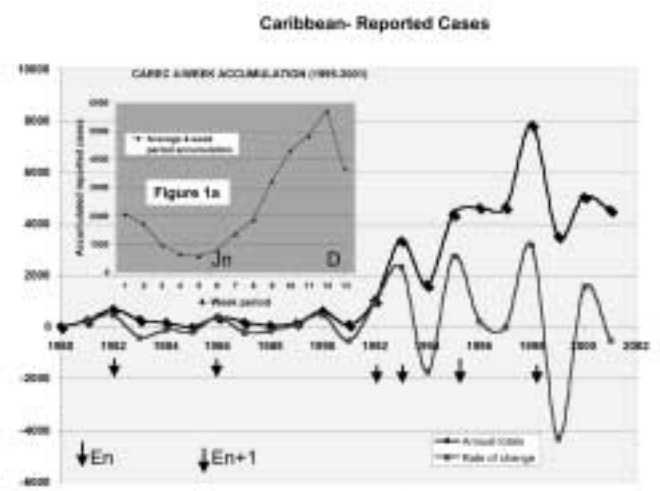
Dharmaratne Amarakoon[1], Anthony Chen[1], Samuel Rawlins[2], Michael Taylor[1]

It is a known fact that millions of people are under the threat of dengue fever in the tropics and sub-tropics. Despite the fact that vector-borne diseases such as malaria have been eradicated from the Caribbean, 43,000 cases of dengue have been reported over the last 22 years (1980-2001).The incidence has been very high in the last decade.About 41,000 cases have been reported in the last decade, and indications are that the frequency and intensity of outbreaks of the epidemic are on the rise. Studies done in other regions of the globe have inferred association of upsurges of dengue with ENSO events through temperature increases and availability of stored water during droughts as well as stagnant water after rains.

These conditions enhance mosquito breeding and dengue transmission rate. Recently published studies (Chen and Taylor, 2002; Peterson and Taylor et al, 2002) indicate drier than normal conditions with warmer temperatures in the latter half of El Niño years, increase in precipitation in the early part of the following year as well as a warming trend in the Caribbean.Thus, it appears that we can expect a higher probability of dengue outbreaks in the Caribbean in El Niño or El Niño+1 years, as more favorable conditions may exist for vector breeding and disease transmission.The work summarized in this article presents the pattern of dengue, its seasonality, and the level of association of the epidemic with ENSO events in the Caribbean.The work encompasses the preliminary findings in the retrospective component of the AIACC project SIS06: The Threat of Dengue Fever - Assessment of Impacts and Adaptation to Climate Change in the Caribbean.

Methods and Results

The study period was 1980 to 2001.The climate data analyzed were daily and monthly values of maximum and minimum temperatures, and precipitation.The climate data were available from the Climate Studies Group Mona repository, while the Caribbean Epidemiology Centre provided dengue and vector data. Data analysis consisted of: time series analysis of annual reported dengue cases and their rates of change, time series analysis of temperature, precipitation, and anomalies of temperature and precipitation, study of climatology of temperature and precipitation, monthly average variation of reported cases; and performance of statistical significance tests for observed correlations, where applicable. ENSO-year classification was according to NOAA-CDC MEI index. El Niño years considered were: 1982/83, 1986/87, 1992/93, 1994/95 (weak), and 1997/98. La Niña years considered were: 1988/89, and 1998+/00.



Time series of Caribbean reported dengue cases and the rate of increase: 1980 to 2001.The inset figure shows the variation of the 4-week average accumulation of the reported cases during 1995 to 2001to illustrate the seasonality of the epidemic.

In the adjacent figure, the rate of change represents the change in the reported cases over one year. It is assumed that the population has not increased significantly over the last two decades.

Discussion and Conclusion

In general, across the Caribbean region, the last decade is observed to be more prone to the epidemic than the previous decade. There is a periodicity of about 4 to 3 years in the previous decade compared to 3 to 2 years in the last decade.The intensity and the frequency of the outbursts in the last decade is more than that had been in the previous decade.These features may be due to the fact that, in the last decade, temperatures were warmer and rainfall was less abundant, for example, as indicated by the behavior of temperature and precipitation anomalies for Trinidad and Tobago.These are favorable conditions for reducing the vector incubation period and increasing the disease transmission rate. Out of the 8 outbreaks observed, three have occurred in El Niño years and three in El Niño+1 years, including 1995.Thus, the probability of an epidemic in an El Niño or El Niño+1 year is high compared to that in a La Niña or a neutral year. Further, the epidemic shows a well defined seasonality as seen the inset figure. It occurs in the latter half of the year, during which the temperatures are warmer and rainfall less abundant, especially under El Niño conditions. It is worth mentioning that, even though details are not presented in this article, onset of the epidemic in an El Niño+1 year appears to occur about 2 months earlier than the occurrence in an El Niño year. Higher early season rainfall, which leaves stagnant water in discarded objects, may be providing suitable habitats for enhanced mosquito breeding and hence triggering the epidemic with the onset of the Caribbean warm summer in an El Niño+1 year.

It is clear from the results that an association between dengue epidemics and ENSO events exists in the Caribbean. Seasonality, the predictability of ENSO events and a thorough understanding of socio-economic factors that influence the triggering of an epidemic, could provide useful tools in designing early warning systems.

References

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