Annual Report for Period: 09/2003 - 09/2004

Submitted on: 10/13/2004

Principal Investigator: Campbell, David J.

Award ID: 0308420

Organization: Michigan State University

Title:

BE/CNH: An Integrated Analysis of Regional Land-Climate Interactions

Project Participants

Senior Personnel

Name: Campbell, David

Worked for more than 160 Hours: Yes

Contribution to Project:

Campbell has been involved in 1) administering the grant at the university level. This has involved hiring of post-doctoral staff, negotiating space and equipment issues, and overseeing the budget. 2) The land use component of the project. He designed the Role Play Simulation exercise and implemented it in Kenya. The 'roles' of herders, farmers, and administrators were played by senior personnel in a variety of Kenyan government agencies invited by Dr Mwangi of the National Environment Management Authority. He conducted a fieldwork in Kenya to update information on changes in land use patterns and dynamics.

Name: Pijanowski, Bryan

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Pijanowski is leading the land use/cover change modeling activities which are being coordinated with other PIs on the land use/cover change group (principally Drs. Campbell and Olson).

Name: Olson, Jennifer

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Olson has led the land use component of the research. This has included 1) collecting and preparing a variety of data and information concerning land use change, and socioeconomic and environmental variables at the case study and the East Africa regional level; 2) designing the approach and conducting land use expert systems workshops in Kenya, Uganda and Tanzania, 3) designing and supervising specific studies affecting future land use (urbanization, deforestation related to fuelwood harvesting), and 4) coordinating particularly with the remote sensing and the land use modeling component of the project on, for example, issues of temporal & spatial data comparability. She has also acted as a project manager for much of the project activities, such as coordinating people and research components in the US, UK and East Africa, organizing meetings, hiring personnel, purchasing equipment, etc.

Name: Qi, Jiaguo

Worked for more than 160 Hours: Yes

Contribution to Project:

This past year, Dr. Qi focused on the land cover dynamics analysis over East Africa. He and his students analyzed three currently available land covers (IGBP, Africover, and GLC200)to study which land cover product is best fit for the regional climate model (RAMS). He also worked on the comparison of these three classification systems and tried to merge classes that make sense to the RAMS model.

In addition to these analysis, he worked with his students to derive other surface parameters that RAMS model requires. They include albedo, LAI, fPAR, and surface temperature derived from current satellite images. These data have been organized and transformed to the format that is ready to use for RAMS model. Working with Lijian Yang and his students, Dr. Qi also analyzed the phenological characterisitcs of the LAI and fPAR variables required by the RAMS model. The results from this activity should be a better phenological parameterization derived from the data, to replace assumed parameterization by the current RAMS model. Also, Dr. Qi worked with his students Jianjun Ge, on RAMS model re-paramerization and tested which biophysical parametes (LAI, fPAR, albedo, and geospatial changes of land cover types) are RAMS model most sensitive to. The results from this analysis will help prioretize the tasks when parameterizing the RAMS model.

Name: Andresen, Jeffrey

Worked for more than 160 Hours: Yes

Contribution to Project:

Andresen has been involved with 1) The agroclimatic modeling portion of the project. He participated in the design and set up of two cropping system simulations considered in the project, maize and natural vegetation/rangeland pasture. Major activities thus far have included selection of the simulation models to be used in the project, collection of daily climate, soil profile, and agronomic data from East Africa, early validation of the selected models, and preparation of software needed to stochastically generate sequences of representative daily climate data for use in the models. 2) The regional climate modeling portion of the project. He assisted with the set up new parallel processor computational facilities at MSU and in initial validation of the regional climate models (surface parameterization). 3) The recruitment and hire of two post doctoral (research associate) positions associated with the regional climate modeling and the agroclimatic simulation portions of the project

Name: Huebner, Marianne

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Huebner (Department of Statistics) produced estimates for the temporal dynamics of the medians of LAI using different algorithms (Monte Carlo, robust, Levenberg-Marquardt) and assessed the goodness of fit. She led regular discussions about research design and also on the functions for land cover variables used by RAMS, the study area and land cover types to be considered, and the available data and statistical methods that can be used to analyze these data. She also worked with graduate students to produce exploratory statistical analysis to study the temporal and spatial distribution of LAI for various land cover types.

Name: Lusch, David

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Lusch has worked on the land cover analyses. A major task has been the selection and quality assessment of different land cover schemes, such as Africover. Dr. Lusch conducted an aerial survey in Kenya over two study sites taking digital video images that permit comparison between land covers on the ground and those reported in the classification schemes.

Name: Yang, Lijian

Worked for more than 160 Hours: No

Contribution to Project:

Dr. Yang supervised the graduate students in Statistics in the production of confidence bands for preliminary data to evaluate the fit of the trigonometric curve for LAI in one land cover type used by RAMS. These procedures will now be available for assessment of the structure of a variety of land cover variables.

Name: Wilson, Sigismond

Worked for more than 160 Hours: No

Contribution to Project:

Mr. Wilson (new PhD student in Geography, MSU) has started a study on migration trends and the political ecology of those trends in East Africa.

Name: Lofgren, Brent

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Lofgren, NOAA GLERL Labs, Ann Arbor, has been involved in coordinating the efforts of those involved in the climate work for CLIP. He played a primary role in setting up the 8-node cluster and setting up RAMS to run on that system, and has supervised and done extensive consulting with Nathan Moore in running and testing RAMS in the African domain, and helped to provide guidance in coordinating the input and feedback of land cover data for RAMS.

Name: Conway, Declan

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Declan Conway, Climatic Research Unit, University of East Anglia. Drs. Conway and Hansen (below)have collected and disseminated to team members historical rainfall and temperature data for East Africa. They have conducted trend analysis of monthly rainfall examining inter-annual and seasonal variability.

Name: Misana, Salome

Worked for more than 160 Hours: No

Contribution to Project:

Dr.Misana (Assoc Professor, University of Dar es Salaam): completed a case study of land use change and driving forces in Tanzania and participated in a cross-site regional comparison of land use change in East Africa (funded mostly under another project). She also assisted with and participated as an expert in the Tanzanian land use expert systems workshop.

Name: Yanda, Pius

Worked for more than 160 Hours: No

Contribution to Project:

Dr. Pius Yanda (Assoc Professor, University of Dar es Salaam): has collected and made available data and information from Tanzania, including meteorological and GIS data (land cover, etc.). He also prepared and coordinated the Tanzanian land use expert systems workshop (identified and invited the experts, etc.) and wrote a report of workshop results.

Name: Mugisha, Samuel

Worked for more than 160 Hours: No

Contribution to Project:

Samuel Mugisha (Geographer, Makerere University): completed three case studies of land use change and driving forces in Uganda and participated in a cross-site regional comparison of land use change in East Africa (funded mostly under another project). He also prepared and coordinated the Ugandan land use expert systems workshop (identified and invited the experts, etc.) and digitized the resultant land use change 'zones'.

Name: Thornton, Philip

Worked for more than 160 Hours: No

Contribution to Project:

Dr. Thornton of ILRI has organized the establishment of the soils and meteorological database for paramaterizing the crop- and rangeland-climate models for East Africa, and has been conducting initial runs of the models. The research associate in this area who has been hired and will begin work in the next year will build this on.

Post-doc

Name: Moore, Nathan

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Moore has been engaged in calibration and validation of the atmospheric model The code has been modified to permit the use of an alternative, more accuate land cover database (Africover). The model has been calibrated via several numerical parameterizations to produce atmospheric conditions in close agreement with observed measurements-- temperature, relative humidity, and so on. At this point the validation is heavily dependent on quality and availability of observations. We have found that observations are extremely sparse in both space and time, and that some gridded datasets offer significantly different respresentations of some variables (see attached figure; scales are different, but maxima/minima are not consistent). Time series of domain-averaged quantities should improve model-to-observation correspondence, at the expense of higher spatial resolution.

Name: Hansen, Clair

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr Hansen, Climatic Research Unit, University of East Anglia. Drs. Hansen and Conway (above) have collected and disseminated to team members historical rainfall and temperature data for East Africa. They have conducted trend analysis of monthly rainfall examining inter-annual and seasonal variability.

Graduate Student

Name: Goodwin, Michael

Worked for more than 160 Hours: Yes

Contribution to Project:

Mr. Goodwin (M.A. student, Geography Department, MSU) has conducted a study of urbanization trends in East Africa. He has collected and collated census and other demographic data for Kenya, Uganda and Tanzania, and has written a report summarizing trends and their driving forces. He has also started a report on tree cutting due to fuelwood collection in the region. Supported with funds from NSF and from FLAS Language Fellowship.

Name: Wang, Jing

Worked for more than 160 Hours: Yes

Contribution to Project:

From the Department of Statistics (MSU),with Lan Xue examined relationships between a number of variables that represent land surface characteristics. These include procedures to analyze the dependence structure of one variable (e.g., LAI - leaf area index) on a large number of other variables, and formulated procedures for the construction of confidence band (error bar) around the regression curve that relates one variable to another.

Name: Xue, Lan

Worked for more than 160 Hours: Yes

Contribution to Project:

From the Department of Statistics (MSU),with Jing Wang examined relationships between a number of variables that represent land surface characteristics. These include procedures to analyze the dependence structure of one variable (e.g., LAI - leaf area index) on a large number of other variables, and formulated procedures for the construction of confidence band (error bar) around the regression curve that relates one variable to another.

Name: Mitchell, Marian

Worked for more than 160 Hours: No

Contribution to Project:

(PhD student, Geography Department, MSU): Ms. Mitchell has conducted several tasks, including a broad literature review and complication of knowledge elicitation methods (for the expert systems workshops), and some GIS data preparation.

Name: Alexandridis, Konstantinos

Worked for more than 160 Hours: Yes

Contribution to Project:

Mr. Alexandridis (PhD student, Purdue University) is coordinating the agent-based model development with Mr. Pithadia and Dr. Pijanowski. He is also leading the development of three peer-reviewed papers on the agent based simulation model. He is also conducting research on how role playing simulation and agent based models can be interfaced.

Undergraduate Student

Technician, Programmer

Name: Pithadia, Snehal

Worked for more than 160 Hours: Yes

Contribution to Project:

Mr. Pithadia (Research Technician, Purdue University)) is working on developing GIS layers for input to the neural network model as well as recoding the model so that it can be used with a mid-scale multi-criteria evaluation component. Male, East Indian, citizen of India.

Name: Ford, Tavares

Worked for more than 160 Hours: Yes

Contribution to Project:

Tavares Ford is working with Brent Lofgren at GLERL Labs on the RAMS simulations. He is an expert in RAMS programming and applications, and in hardware management.

Other Participant

Research Experience for Undergraduates

Organizational Partners

NOAA Great Lakes Environmental Research Lab

glerl IS providing one-quarter of Brent Lofgren's time, and a portion of Tavares Ford's time, to conduct research on this project.

FAO

Provided land cover data - Africover

USGS EROS Data Center
Provided SRTM data

NASA
Provided MODIS data

Various
Participants in the Land Use Expert Systems Workshops came from a variety of ministries and government agencies in Kenya, Uganda and Tanzania, and from the University of Nairobi, Makerere University, the University of Dar es Salaam, the Global Environment Facility, and the U.S. National Science Foundation.

University of Dar Es Salaam
Institute for Resource Assessment (IRA) provided meteorological data

Makerere University, Uganda
MUIENR provided meteorological data

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities:

Land Use
1) Data and information collection and preparation on land use, land cover and many other socioeconomic, environmental and climatic variables for East Africa. This has included information from case studies, Africa-wide and national levels. This data and information is being used as the basis for the land use/ cover modeling, to provide a context to review modeling results, and the land cover data will be linked to the regional climate model.

2) Information collection and analysis of land use change patterns and their driving forces was completed for six case studies in Kenya, Tanzania and Uganda (mostly conducted under the prior LUCID UNEP-GEF project). This included interpretation of aerial photographs and satellite images from the 1950s to the present, and analysis of a variety of data and information within a LULCC and political ecology framework. A cross-site comparison of patterns, drivers and environmental impacts has been completed at the regional level, and numerous reports prepared. The case study and cross-site comparison research will directly inform the land use modeling in several ways: the relationship between drivers and spatial patterns of land use change, the environmental (agroclimatic) context within which land use change occurs, and how people respond to various shocks to their system such as droughts and soil degradation.

3) A methodological approach to conduct the 'expert systems' input into the land use modeling was designed, and land use expert systems workshops were conducted in Kenya, Tanzania and Uganda. They consisted of inviting 8 to 10 people to each workshop with expertise and experience in a variety of fields (e.g., government finance and planning, an agency working with pastoralists, various facets of agriculture and of the environment (wetlands, agricultural research, forestry, conservation, land use planning), and academe (e.g., geography, botany). The purpose of the workshops was to arrive at a consensus of how land use could be expected to change in the next 20 to 30 years in the whole country, and how the driving forces of those changes would vary over time and space (and identify levels of uncertainty of the changes). The participants worked in small groups and in plenary with maps and other aids, and arrived at an agreed upon 'land use change zone' designation for their country, and tables with information on the changes expected and their driving forces for each zone. This combination of spatial zonation and variables on the drivers of change and how they will vary will parameterize the land use model LTM. A similar approach will be used to critique model outputs, providing a 'reality check' to the modeling. This use of experts systems combined with modeling is especially important due to the lack of spatial economic or other data for Africa.

4) A study of urbanization trends in East Africa was conducted. This consisted of collating census and other demographic data for Kenya,

Uganda and Tanzania (GIS and tables), and writing a report summarizing past and current trends and their driving forces. This will be supplemented with information from collected from demographers and others in East Africa on what they foresee as future trends in their country (collected with a similar table as for the expert systems workshops). This information will be used to prepare an urbanization model as a component of the land use model.

5) Two other studies have been startedùone examining tree cutting due to fuelwood collection in the region (around 90% of urban populations use charcoal made from native tree species for all their cooking), and one on migration trends and the political ecology of those trends in East Africa.

6) Role Play Simulation (RPS) was designed and implemented in Kenya. The RPS allows examination of different scenarios of land use change from the perspective of a variety of land user groups. These user groups (farmers, herders, administrators) were represented by senior personnel in Kenyan government agencies. These individuals have extensive professional experience as decision makers in agencies whose policies directly affect land use change. They are also all landowners, farmers and herders themselves, and thus they also bring to the discussion the values and objectives of land managers.

7) Advancements in an agent-based model (MABEL) that simulates land-bidding-land division behavior using Bayesian Belief Networks and GIS have been made so that the model uses the highly irregularly shaped land use/parcels in our case study regions. A set of spatial metrics and temporal agent-goals were applied to the case study regions in East Africa and compared to regions in the United States. Two papers have been written and submitted for publication in the last two months that focus on these ideas. One of these papers explored how an Monte Carlo approach can be used to examine the behavior of the model using a stochastic approach to model parameterization.

8) The Land Transformation Model (LTM) has been subjected to a battery of performance tests using several large regions in the United States. The tests will be applied shortly to data in our case study sites. Tests using a scaleable window metric, Kappa statistic, shape metrics (e.g., FRAGSTATS) and transition independent statistics (e.g., receiver operator characteristic) have been used to assess model accuracy between models differing neural network topology. We found that neural networks perform well in most situations, improve performance when training is extensive (e.g., over 60,000 cycles) and when locations used to train the model have had considerable about of change (e.g., > 25%).

9) The Land Transformation Model (LTM) has now been adapted to train on data for multiple types of land use changes. We have tested six different transition algorithms and have prepared a draft of a paper for publication that outlines these algorithms and describes the results in terms of model accuracy.

CROP-CLIMATE (NPP) ACTIVITIES

1. Crop modelling weather data: Daily weather files for 35 sites from the CLIP project window were extracted from archives, and assembled. Screening programmes were written and run to check on gross data inconsistencies and missing values. For each site, the original daily historical rainfall data was assembled in calendar format, measured in tenths of mm. In addition, a DSSAT-format climate description file was generated (Jones et al., 1998), together with a parameter file for the site for use with the MARKSIM, a third-order markov rainfall model (Jones & Thornton, 2000). We thus are able to use historical weather data for each of the pilot site windows in the study zone, and also we are able to generate long sequences of synthetic daily data with characteristics that match high-resolution climate surfaces for locations of interest. Daily weather data (rainfall, maximum and minimum temperatures, and solar radiation) are a key input for the crop simulation modelling.

2. Soils data collation. For most (if not all) of the CLIP sites, there is unlikely to be much if any soils data. In such situations, there may be no more information other than what can be gleaned from the FAO soils map of the world, nominally at a scale of 1:1,000,000 (FAO, 1995). In the past, we have used the FAO soils map to identify mapping units for each pixel or location; soil profiles have been assembled for each of the soil types that exist in the mapping unit; a crop model has been run for each soil profile, and the results weighted by the relative preponderance of each soil type within the mapping unit, to give an estimate of simulated yield for that general 'location'. The WISE database has been used in this way (Batjes & Bridges, 1994). WISE has data for 1125 soil profiles, and in previous work, 836 of these profiles have been put into DSSAT format, serious data errors affecting the remainder.

For the study sites where crop modelling will be undertaken, we are adapting this crude database approach, and trying to make 'generic' soils more suitable for particular locations, by assembling probability distributions, within each soil type, of a few key soil parameters. In this way, if more is known about the soils locally, a soil profile can be picked that is slightly more appropriate for the site of interest than the 'modal' or average profile for that soil type. To do this effectively, we need to define which are the key parameters for each soil type that vary widely across sites, and that may be expected to have substantial impact on the variables (such as water holding capacity) to which DSSAT crop models are sensitive. A short-term consultant based at ICRAF, Nairobi, was hired to assist with this. This work is involving the identification of the agriculturally-suitable soils in the CLIP window from the FAO soils map, the determination a priori of the (few) soil characteristics that are likely to have significant impact on key variables that affect the performance of the DSSAT crop models, assembling information on the ranges and fitting distributions to these key variables for each soil type in the soil profile database, and then defining a set of profiles for each soil type that consists of a median or average profile, and profiles corresponding to low and high values of the key variables identified. This work should be completed by the end of 2004.

3. Crop modelling work. Work was initiated on assembling existing crop and pasture data sets for case-study sites in the CLIP region, and on assembling information from the grey literature on farming systems in these areas. With the existing weather data assembled above, the soil profile databases developed, and information on local varieties and cropping calendars, this will form the basis for running baseline simulations with the crop models, to replicate current production levels and practices for the case study sites. The latest version of the DSSAT crop modelling software, version 4, has been obtained, and all datasets will be assembled in a format that can be run with this version of the software.

CLIMATE DOWNSCALING

1. Weather data collation. Time was spent collating the current holding of East Africa daily rainfall data. This included 26 sites for Ethiopia, 185 for Kenya, 32 for Tanzania, and 103 for Uganda. Collation involved splicing years together from different archives of the same station, and a limited amount of error checking. This holding of data was passed on to the climate modelers, to supplement their own holdings of East African data.

2. Trend analyses of monthly rainfall at fourteen stations located in the CLIP case study boxes in Uganda, Kenya and Tanzania have been carried out. Monthly series have been extended to 2000 where daily data were available. This analysis has included an examination of:
À interannual variability and regional homogeneity
À seasonality and seasonal trends
3. 3. For each of these analyses statistics i.e., averages, standard deviations, kirtosis, skewness, the coefficient of variation and linear trends have been calculate over a common period (1961-90), for which all stations have data, and the entire length of individual station series.
4. 100 years of daily rainfall data for ten of the fourteen stations included in the trend analysis of monthly rainfall have been created using a stochastic weather generator (LARS-WG) based on a 31 year observed series (1960-90). The synthetic data have been rigorously compared to the observed data at each station. Synthetic data for only ten of the fourteen stations have been generated due to the lack of daily rainfall data being available for four of the stations in Kenya.
5. collection of circulation indices (e.g. SOI, IOD, JMO)
6. collection of ERA-40 and NCAR/NCEP reanalysis data
7. collection of GCM output
8. provision of 10'gridded rainfall and temperature data for Africa.
9. identification of suitable observations for use in trend analyses and in the generation of long series of synthetic daily rainfall data
10. extension of monthly rainfall series where possible with daily rainfall data
11. generation of long series of daily rainfall data using a stochastic weather generator (LARS-WG)
12. preparation of paper entitled 'Simulating East African Rainfall using a Stochastic Weather Generator and Coupled Global Climate Models. Part 1: Model Calibration and Validation' to be submitted to Climate Research.

REGIONAL CLIMATE MODELING:

Climate modeling using a regional model is incorporated into CLIP in order to gain an understanding of the sensitivity of the atmosphere to changes in surface characteristics. The Regional Atmospheric Modeling System (RAMS) was chosen for its use of the LEAF2 land surface scheme and because of team members' experience in its use. The efforts to date in the use of RAMS have been aimed at finding a good mix of several model parameters, notably the trigger point velocity for convective precipitation and domain size and resolution, in order to produce an accurate and reliable simulation. There are considerable trade-offs with the domain size and resolution, as these determine the amount of computing resources that will be required to do the simulations. At the same time there are edge effects within RAMS that need to be considered, requiring that the edges of the domain be away from the main region of interest of the study. The acquisition of a cluster of eight dual-processor Intel-based systems, running on the Linux operating system, has aided with this problem, but our capabilities must still be used carefully. Additionally, the configuration of the cluster system and setup for running RAMS on it has required some up-front human effort. As the CLIP project progresses, RAMS will become more interactive with the land cover portion of the project, and become an integral part of the system for simulating full feedback within the climate-land cover system.

Findings:

LAND USE

Major findings from the land use expert workshop: Common expected land use change patterns across the countries include a. expansion of cropping to fill medium potential and increasingly large areas of semi-arid zones except where insecurity is expected to persist; b. intensive commercial agriculture and industry will expand into much larger areas around urban centers and transport corridors; c. protected areas (parks, reserves) are expected to remain natural areas; d. agricultural will expand into current wetlands, stream, lake and river banks, and wherever irrigation water is available; d. wood fuel collection and timber harvesting is expected to greatly affect identified zones outside of protected areas; and e. certain urban areas will greatly expand. This general pattern varies across the region, however, depending on the major factors identified such as levels of insecurity, peace and war, levels of government investment in roads and other infrastructure; government policies concerning agriculture (subsidies, prices etc), conservation and private investment (external and internal), and levels of human pressure (migration, population growth, agricultural system).

The urbanization study identified how rates of migration into urban centers and the growth of urban centers have varied over time and between countries. In Kenya, for example, high urbanization rates began in the 1960s and have continued high, and secondary centers have developed into cities themselves. The proportion of population in urban centers is already relatively high. In Tanzania, urbanization rates were lower until recently, when certain towns have grown extremely fast. Despite the growth of few secondary centers, the capital city remains dominant. Uganda has had the slowest urbanization rate and it appears to remain relatively low (except for the large number of internally displaced living in Kampala). The impact of urban centers on a country's land use includes providing a market for food, fuel and other commodities, providing a source of employment and income for rural family members, as a destination of out-migration affecting rural areas, and as a particular land use itself.

Role Play Simulation. The principal findings of the exercise were that in assessing alternative land use scenarios in semiarid areas under conditions of competition between groups over limited land and water resources, land managers are keenly aware of: cultural traditions, values and stereotypes; competitive resource needs û access to soil and water and the need for long term sustainability of land use; the importance of land ownership/land title; the relative productivity of different livelihoods; the importance of infrastructural investment, particularly roads; and the power of government authority, and the political imperative of compromise. Economic goals for land use have to be judged against societal and environmental goals.

The results of the simulation contribute to understanding of the drivers of land use change, the interactions among and between different land user groups, and the role of policy in influencing land use dynamics. These findings are also used to parameterize the land use models û LTM (spatial allocation model) and MABEL (Agent-Based Model). Some elements can be modeled quantitatively and others are more interpretive. They also portray a range of desired outcomes that reflect livelihood objectives, outcomes that can be used to assess model performance.

CLIMATE DOWNSCALING
It is difficult to generalize and summarize the character of rainfall over such large areas and diverse terrain.
Between the three regions there are some similarities, e.g. the seasonal regimes are similar in Kenya/Tanzania and Uganda along with some differences, e.g. interannual variability; SW Tanzania shows a stronger drying trend during 1961-90 than Kenya/Tanzania.
There is also considerable variation within the regions
There is reasonable coverage in terms of length; many of the stations need to be updated.
Without updates for these stations it is not possible to summaries very recent changes or trend in the study areas.
From 1961-90 mean annual rainfall ranges from 622 to 1434 in Kenya/Tanzania, from 625 to 1008 in Uganda and from 629 to 2500 in SW Tanzania.
The following seasonal regimes have been identified:
- Kenya/Tanzania and Uganda - MAM and OND - these seasons coincide fairly closely with the bimodal long and short rains often used for the region.
- SW Tanzania - one wet season - February to June.

Uganda and SW Tanzania show slight drying trend in annual rainfall during 1961-90. Kenya/Tanzania shows a mixed pattern of increasing and decreasing annual rainfall, unrelated to location.
The seasonal variability is even more complex, particularly for Kenya/Tanzania where wet and dry seasons show very mixed behavior during 1961-90. MAM (long rains) tends to show greater coherence in Kenya/Tanzania, but little difference in Uganda.
Coefficients of variation are highest in Kenya/Tanzania (24-42%) and lowest in SW Tanzania (17-21%). In general, there is no consistent change in rainfall over time
Specific conclusions include:
Some years stand out as very wet e.g. 1961 in Kenya/Tanzania and Uganda, principally in SON.
Linear trends in rainfall amount are highly sensitive to the time period being examined.

REGIONAL CLIMATE MODELLING
The ITCZ is poorly resolved in the model that we are using (RAMS) in terms of intensity, and is quite sensitive to cloud cover.
The accuracy of ITCZ location is heavily dependent on which observations are used as reference; NCEP data (which drive the boundary conditions) support model output better than the UEA-Climate Research Unit data.
Tropical profiles of cloud condensation nuclei (CCN) tend to have, at minimum, concentrations of ~50 million ccn per kg of air. Simulations at

higher ccn concentrations tend to diverge dramatically from observation (e.g. GOES satellite images).
Model results over certain areas are very sensitive to soil moisture initialization-- e.g. a 5% increase in soil moisture across the entire domain led to some areas having elevated relative humidity, with precipitation in a few localized areas raised by 10% or more.

Training and Development:

Dr. Olson used East African land use change information in geography classes at MSU
MSU and Purdue University graduate students (N= 9) learned methods and topics
Campbell and Pijanowski taught a 3-hour class at the University of Nairobi for MSc students (N=8) in Environmental Policy degree program.

Mr. Alexandridis, a PhD student studying under Dr. Pijanowski, has given several presentations at national scientific meetings and has given a lecture on agent based modeling approaches to a graduate student course.

Dr. Pijanowski has given a 7 hour lecture to in-service teachers, enrolled in a M.S. program, on the use of spatial analytical tools to study complex natural and human systems in the Laurentian and East Africa Great Lakes basins. These are unique teaching experiences for both of these project personnel.

Outreach Activities:

Dr. Pijanowski has given several presentations at public forums and non-technical groups in the last year that summarize the main approaches and early results of the project. For example, Dr. Pijanowski spoke to a 100-plus group of high school students and their parents who were visiting Purdue and interested in science and engineering. He also gave a similar presentation (title: 'Environmental Science, Computers, Pop Culture and How to Say Hello in Swahili') to the parents of new undergraduate students in the Department of Forestry and Natural Resources, where he is a faculty member. He also summarized this work for land use planners in Michigan who were interested in some of the scientific issues related to land use, society and climate change.

Journal Publications

Books or Other One-time Publications

Web/Internet Site

Other Specific Products

Product Type: draft papers

Product Description:

Konstantinos T. Alexandridis, Bryan C. Pijanowski, and Zhen Lei. Revised. In review. A Multi Agent-Based Behavioral Economic Landscape (MABEL) Model of Land Use Change. Journal of Environmental and Resource Economics.

Lei, Zhen, B. Pijanowski, K. Alexandridis and J. Olson. In review. Distributed Modeling Architecture of a Multi Agent-based Behavioral Economic Landscape (MABEL) Model. SCS Transactions in Modeling and Simulation.

Clair Hansen: ?Simulating East African Rainfall using a Stochastic Weather Generator and Coupled Global Climate Models. Part 1: Model Calibration and Validation? to be submitted to Climate Research.

Sharing Information:

These are in review for publication

Product Type: Data or databases

Product Description:

1. Crop modelling weather data: Daily weather files for 35 sites from the CLIP project window were extracted from archives, assembled and screened. It will be used as historical weather data for the crop and rangeland-climate modelling in the pilot site windows, and to generate long sequences of synthetic daily data. This data will be shared among international and national agricultural research institutions and universities.
2. Soils data collation. We used the FAO soils map to identify mapping units. Soil profile data (collected in previous research by several institutions) was then assembled for each of the soil types that exist in the mapping units. This soils database will be widely shared among

international and national agricultural research institutions and universities.
3. Roads. We assembled existing GIS roads layers at the national and continental level, and then harmonized, corrected and added attributes to each road segment (paved, unpaved/secondary or unpaved/tracks) from a variety of maps for the CLIP domain. This has already been distributed among international and national agricultural research institutions and universities.
4. A wide range of environmental and socio-econonomic GIS layers were assembled from a variety of sources, projected and clipped to the domain (to be used in the land use model).
5. Monthly rainfall data for East Africa (supplied by the Climatic Research Unit, University of East Anglia). These data have been extended using daily data (monthly totals) where available and/or required.
6. Construction of 100 years of synthetic daily rainfall data for 10 East African stations
7. A statistics database (mean, standard deviations, skewness, kirtosos, coefficient of variation, linear trends) has been constructed based on monthly rainfall data for two time periods ? the 1961-90 common period and for the entire length of the series for individual stations.
The data described in 5. to 7. are available to other CLIP researchers. The statistics database and the monthly and daily observed station data as well as the 10? gridded rainfall and temperature climatology of East African have been used to validate the regional climate model currently under construction.

Sharing Information:

Currently being used by project personnel.

Product Type: website

Product Description:

PROJECT WEBSITE

http://clip.msu.edu

A dedicated site with a link to the CLIP home site has been set up at: http://www.uea.ac.uk/dev/climate/impacts_8.htm

Sharing Information:

Online

Contributions

Contributions within Discipline:

The LTM and MABEL models bridge the scientific and engineering fields. Both models contain advanced technical capabilities that are not currently found in other land use change models. For example, the LTM can handle over a billion cells per time step (many current models are used for ~ 1000 cell simulations) whereas the MABEL model currently operates over a distributed network of computers with a client-server architecture that integrates several software packages, such as GIS, relational database management systems, statistical packages (e.g., Netica) and agent-based modeling software (Swarm). Publications to date include those submitted to a geographic information science journal (IJGIS), an economics journal (Journal of Environmental and Resource Economics), an engineering journal (SCS Transactions in Modeling and Simulation), and a social science journal (Journal of Simulation of Social Systems). Furthermore, qualitative social science methods (e.g., role playing simulation, expert judgment, Turing Tests) are being used to parameterize and test model performance.

The use of role play simulation, or table top exercises, is widespread in business and government but has been relatively infrequent in land use change research. There is considerable interest in such exercises both from the perspective of the type of information they produce about the decision-making processes that underlie land managers' decisions, and from that of using this information as a complement and contribution to modeling approaches.

The MABEL, agent based modeling paper that we submitted to Journal of Environmental and Resource Economics will be one of the first that outlines an agent based approach to modeling land transactions in a very simplified market model. This is a very difference approach to economic modeling.

Contributions to Other Disciplines:

Contributions to Human Resource Development:

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

Special Requirements

Special reporting requirements: None
Change in Objectives or Scope: None
Unobligated funds: less than 20 percent of current funds
Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Any Journal
Any Book
Any Web/Internet Site
Contributions: To Any Other Disciplines
Contributions: To Any Human Resource Development
Contributions: To Any Resources for Research and Education
Contributions: To Any Beyond Science and Engineering