Chapter 14

The Agricultural Model Intercomparison and Improvement Project (AgMIP): Integrated Regional Assessment Projects

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Introduction

The worldwide agricultural sector faces the significant challenge of increasing production to provide food security for a population projected to rise to nine billion by mid-century, while protecting the environment and the sustainable functioning of ecosystems. This challenge is compounded by the need to adapt to climate change

by taking advantage of potential benefits, and by minimizing the potentially negative impacts, to agricultural production. The goals of Agricultural Model Intercomparison and Improvement Project (AgMIP) are to improve substantially the characterization of world food security under climate change and to enhance adaptation capacity in both developing and developed countries (www.agmip.org).

To accomplish these goals, AgMIP organizes protocol-based intercomparisons of crop and economic models and ensemble projections to produce enhanced climate change assessments by the crop and economic modeling communities. These assessments focus on research related to climate change agricultural impacts and adaptation (Rosenzweig *et al*., 2012). This chapter describes the AgMIP regional integrated assessment projects in Sub-Saharan Africa and South Asia.

AgMIP Structure and Scientific Approach

The Agricultural Model Intercomparison and Improvement Project (AgMIP) conducts agricultural model intercomparison and future climate change assessments with participation from multiple crop and economic modeling groups around the world (Fig. 1). AgMIP research activities are organized under four project teams (Climate, Crop Modeling, Economics, and Information Technology), with guidance provided by a Leadership Team as well as a Steering Group and Donor Forum. In addition, there are three cross-cutting themes — Representative Agricultural Pathways, Aggregation and Scaling, and Uncertainty — which span the activities of all teams.

AgMIP Regional Activities

AgMIP Regions are geographical areas in which collaborative efforts are created to implement the protocols and provide outputs for use in the region and for use in global studies. AgMIP regional activities are underway in Sub-Saharan Africa, South Asia, North America, South America, and Europe and in development in Australia and East Asia (see Fig. 1). AgMIP is holding recurring regional workshops to bring together climate scientists, agronomists, and economists from leading regional and international institutions to build capacity and conduct simulations and analyses at field-to-regional scales according to the AgMIP protocols. Participation from scientists in important agricultural regions is crucial to AgMIP goals, as local expertise is vital to establishing grounded simulations for regional agriculture.

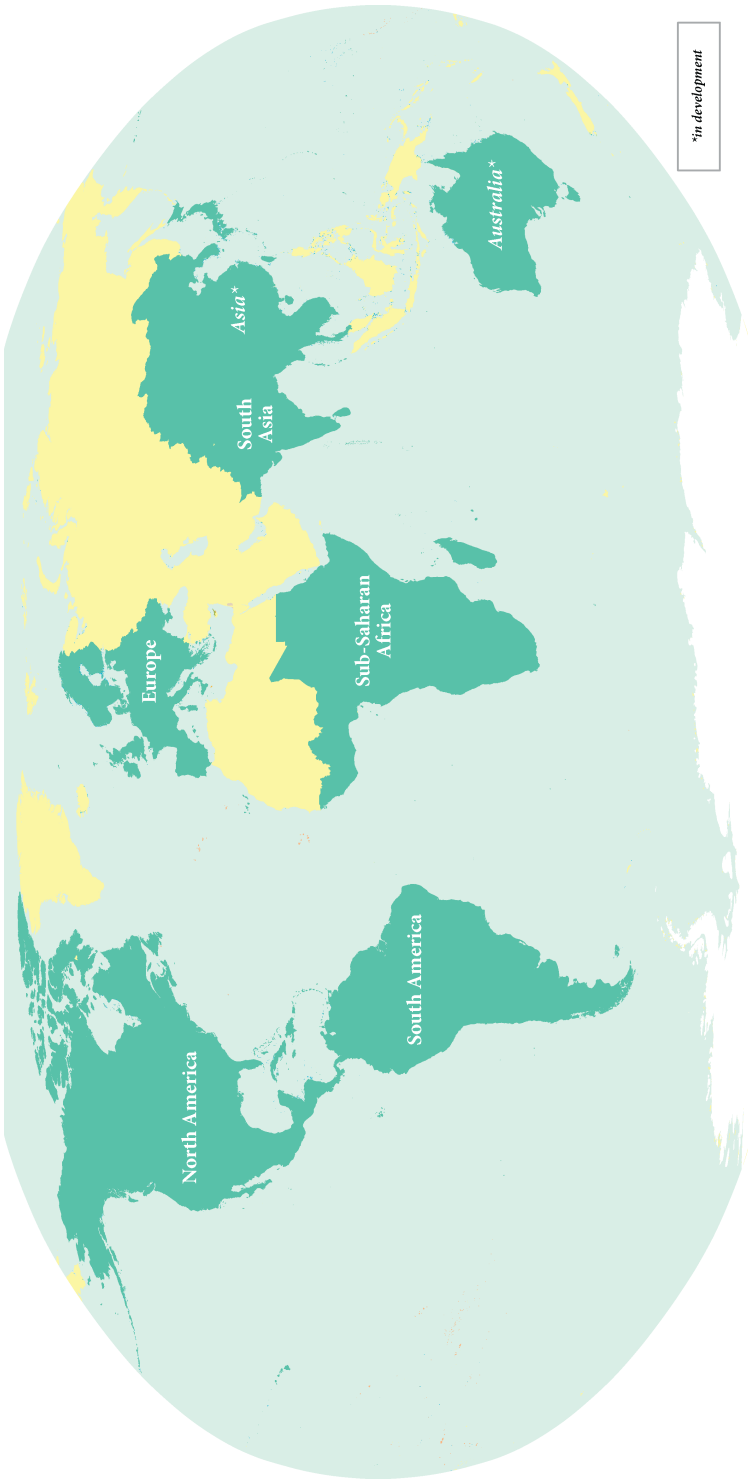

Fig. 1. Location of AgMIP regional activities.

AgMIP Sub-Saharan Africa Regional Projects

In Sub-Saharan Africa, four multi-disciplinary and international teams are undertaking integrated analyses of food production systems with a special focus on how climate contributes to food insecurity in the region, with a fifth team providing coordination across projects (Fig. 2).

Climate change impacts on West African Agriculture (CIWARA) — A regional assessment

Teams of crop, economic, and climate scientists in Western Africa are assessing climate change impacts on agriculture in semi-arid and sub-humid Western Africa (Fig. 3). The project is standardizing an open-access database, comparing

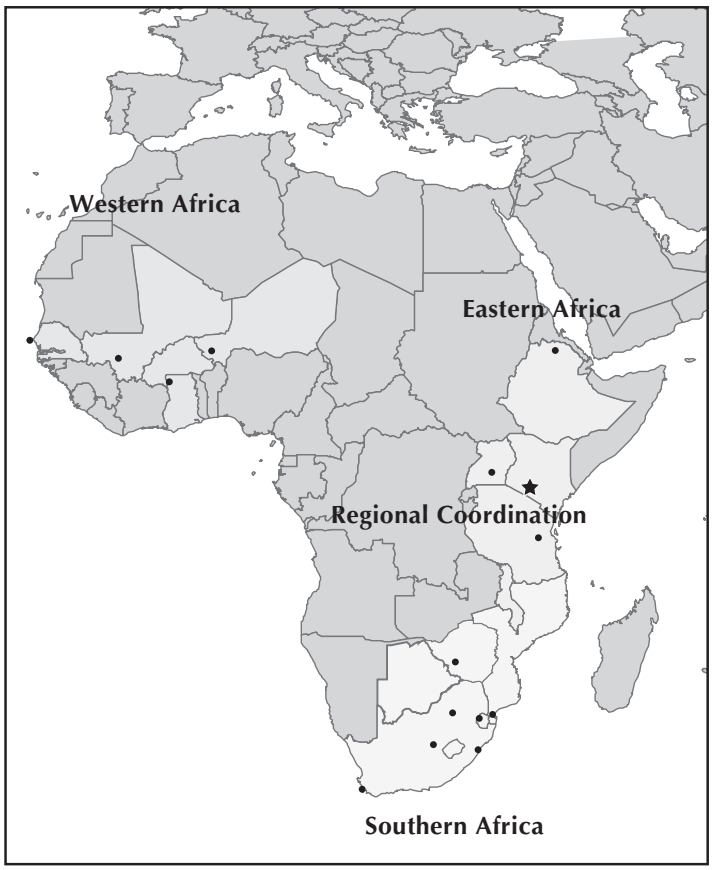

Fig. 2. AgMIP Regional Projects in Sub-Saharan Africa.

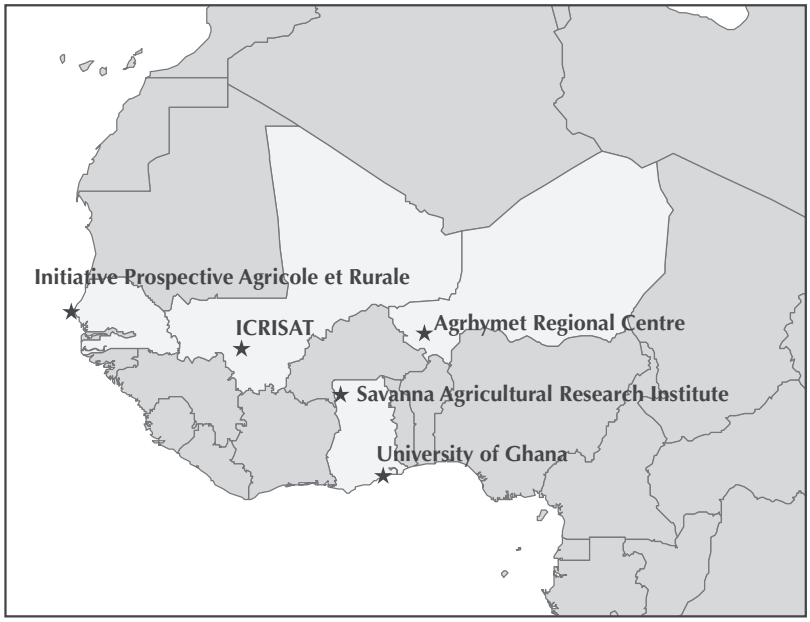

Fig. 3. AgMIP Western Africa Project region and institutions.

and improving crop model performance, improving spatial coverage of agro-meteorological advisories for smallholder farmers, updating selected policy instruments at the national and regional levels, and building research capacity for integrated climate change impacts assessments.

The project is led and coordinated by Professor Samuel G.K. Adiku of University of Ghana, with assistance from Drs. Ibrahima Hathie of IPAR; Jesse B. Naab of SARI; P. S. Traore of ICRISAT Mali; and Seydou Traore of Agrhymet Regional Centre. Key research staff include Drs. M. Adam of ICRISAT Mali; M. Diancoumba of SARI; D. S. MacCarthy of University of Ghana; and B. Sarr of Agrhymet Regional Centre.

This assessment will increase representation of climate, crop, and economic data in West Africa, enrich agro-biodiversity in crop models, apply representative agricultural pathways to study future regional climate change impacts, and will refine crop calendars and agro-meteorological advisories into location and ecotype specific decision support tools. West African policy-makers will be briefed on possible local impacts of climate variability and change, to inform decisions in adaptation and mitigation.

Capacity building will include graduate student internships, exchange visits, and technical training, as well as outreach activities for the media and policy-makers; data sharing and joint publication. The aim is to create a network of AgMIP alumni

from local universities in their country of origin who are continuously involved in the project's research activities.

The research project assesses regional climate change impacts on Western African agriculture by improving the characterization of food security risks due to climate variability and change and enhances the adaptive capacity of West African populations for changing environmental and technological conditions.

Impacts of climate variability and change on agricultural systems in Eastern Africa while enhancing the region's capacity to undertake integrated assessment of vulnerabilities to future changes in climate

The overall goal of the project is to conduct a systematic, comprehensive, and quantitative assessment of impacts of climate variability and change on agricultural systems that explicitly address the farm, local, national, and regional level impacts and identifies adaptation options with due consideration to the interactions between the key variables of climate, crop, and socio-economics in Eastern Africa. Operating from within the framework of the AgMIP global project, it works toward establishing country and regional teams with climate, crop and economic modelers and IT experts, enhancing their skills in the use and application of new science tools and conducting comprehensive assessment of impacts, vulnerabilities and adaptation options, applying cutting-edge science and interdisciplinary knowledge.

Teams of climate, crop, and economic modelers in Ethiopia, Kenya, Tanzania and Uganda are assessing the impact of climate change on important crops utilizing the AgMIP Protocols (Fig. 4). The project utilizes climate, crop and economic data to calibrate and validate models across a wide range of conditions for Eastern Africa. The integrated analysis of model results will enable systematic assessment of variable and changing climate on agricultural systems. Knowledge of likely climate impacts enables decision-makers to consider options for managing negative impacts and for capitalizing on favorable conditions.

The project is coordinated by Dr. K.P.C Rao, Principal Scientist of ICRISAT–Nairobi, with assistance from Dr. M. Tenywa of Makerere University, Uganda. Key research staff include Drs. B. Wafula, of Kenya Agriculture Research Institute; E. Mpeta of Sokoine University of Agriculture, Tanzania; and, A.A. Berhe of Mekelle University, Ethiopia.

In addition to in-country research, regular exchange of information will occur between country teams through training activities aimed to enhance skills needed to undertake the work. This includes hands-on sessions in data assessment and management, use of models and other tools, and write-up of results. It also includes training on methods for regional integrated assessments utilizing information from climate, crop, and economic models.

Fig. 4. AgMIP Eastern Africa Project region and institutions.

Southern Africa Agricultural Model Intercomparison and Improvement Project (SAAMIIP)

A team of climate, crop, economic, and IT research scientists in Southern Africa is evaluating the impact of climate change on the production and prices of important crops (Fig. 5). A simultaneous goal is to build human and institutional capacity to explore and evaluate these impacts and associated field management adaptation strategies on food prices and production.

The project team is testing the accuracy of models for staple crops, using these models to estimate regional-scale food production for the period of 2070–2099 for the IPCC's A2 climate and development scenario, identifying field-level adaptation strategies for maintaining or increasing yields, and evaluating economic impacts of climate change on different farming systems. This knowledge will build capacity across the disciplines of climate, crop, and economic modeling in the region.

The project is coordinated by Dr. Y. Beletse of South Africa Agricultural Research Council–Roodeplaat, with assistance from Drs. O. Crespo of University of Cape

Fig. 5. AgMIP Southern Africa Project region and institutions.

Town, and S. Walker of University of Free State. Key researchers include Drs. W. Durand of South Africa Agricultural Research Council–Potchefstroom; A. Singels of South African Sugar Research Institute; C. Nhemachena of Human Sciences Research Council South Africa; and M.S. Gamedze of Swaziland Meteorological Services.

The impacts evaluation and capacity-building activities are anticipated to result in validated crop models for maize, sorghum, sugarcane, wheat, and sweet potatoes — the staple and nutritionally important crops in Southern Africa. Inter-comparison of model outputs is likely to lead to improvement of the models. Estimated productivity levels from crop models will be used as inputs to economic models to enable simulation of economic outcomes for different farming systems given a range of climate change scenarios. The integrated analysis of outputs from linked climate, crop and economic modeling enables the assessment of a range of possible future socio-economic pathways. It also builds critical capacity among the team members in methodologies for conducting integrated assessments that will be shared locally through targeted workshops, meetings, training, and stakeholder outreach.

Crop-livestock intensification in the face of climate change: Exploring opportunities to reduce risk and increase resilience in Southern Africa using an integrated multi-modeling approach

Teams of crop, economic, and climate scientists in Southern Africa are exploring opportunities to reduce risk and increase resilience in Southern Africa using

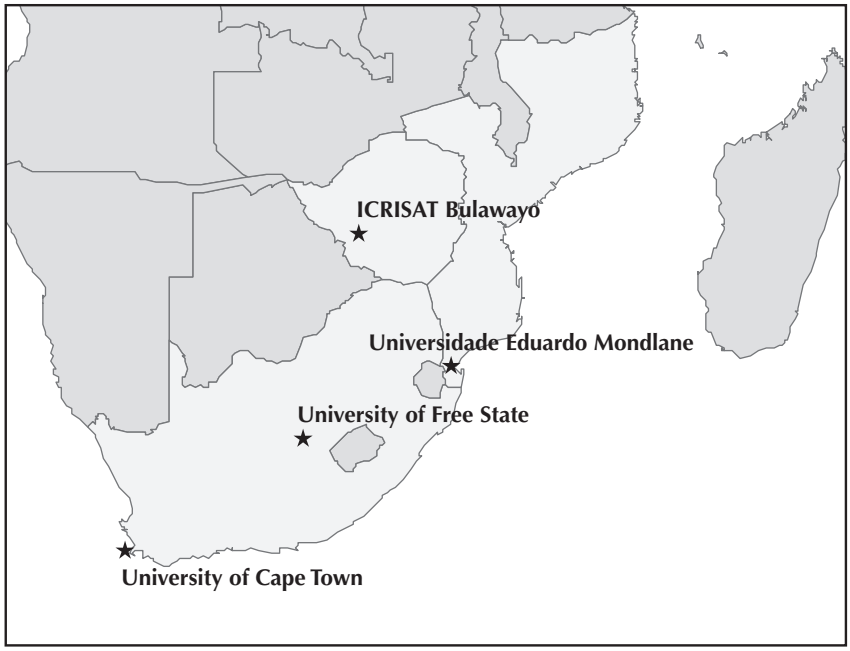

Fig. 6. AgMIP Southeastern Africa Project region and institutions.

an integrated multi-modeling approach (Fig. 6). The project characterizes selected mixed farming systems in Southern Africa in terms of biophysical and socio-economic characteristics, develops and evaluates crop-livestock management and climate change adaptation strategies that increase food production, agro-diversity and economic returns, and explores the interactions and synergies of increased diversity and integration and their contribution to reduce risk and increase system resilience.

The project is led and coordinated by Dr. P. Masikati of ICRISAT Bulawayo, with assistance from Drs. O. Crespo of University of Cape Town, and S. Walker of University of Free State. Key research staff include Drs. S. Homann Kee Tui of ICRISAT Bulawayo; L. Claessens of ICRISAT Nairobi; S. Famba of Universidade Eduardo Mondlane; A. van Rooyen of ICRISAT Bulawayo; and C. Lennard of University of Cape Town.

The project will increase understanding of challenges and opportunities in the current mixed farming systems of Southern Africa for better targeting of interventions to increase systems resilience and reduce climate-induced risk. It will also improve understanding of the interactions and synergies of production system components, such as which combinations bring about profitable production systems and how to use these to facilitate development along sustainable pathways.

Knowledge enhancement for modeling in climate change: Capacity-building in Southern, Western, and Eastern Africa

The goal of the project is to build capacity for trans-disciplinary climate change and agricultural research throughout the Sub-Saharan Africa (SSA) region. The aim is to prepare and publish integrated assessments of climate change impacts and adaptation for Western, Eastern, and Southern Africa (see Fig. 2).

The project is led by Dr. J. Kihara of CIAT. Key collaborating scientists include Drs. J. Huising and S. Koala of CIAT; S. Zingore of IPNI; D.M. Sefakor of University of Ghana; and J. Mangisoni of University of Malawi. The team, in coordination with the AgMIP Leaders (Drs. C. Rosenzweig, J. Jones, J. Hatfield, K. Boote, P. Thorburn, C. Porter, S. Janssen, A. Ruane, J. Antle, R. Valdivia, G. Nelson) will build curricula, develop individual and group learning modules, and teach in climate, crop, economic, information technology, and integrated assessments.

The Regional Coordination Team will liaise with designated members of the AgMIP Sub-Saharan Regional Research Teams, and with AgMIP Leadership, to enable collaboration. Research Teams will be advised on how to organize and prepare development of an inventory of data needed for regional assessments (e.g., weather, site experiment, soil, socio-economic parameters); preparation of presentation materials; guidelines for identifying IT goals of the project (e.g., data management plans, project website, etc.); establishing concise summaries of climate, crop and economic model analyses in planning or underway; and, identification of stakeholders whose engagement is likely to be mutually beneficial.

Workshop reports will summarize presentations and learning activities and will also provide guidance on next steps. This is likely to include consideration of training on specific topics to be advanced in partnership with national and international groups (e.g., NARS, CCAFS and others) that have expressed interest in co-sponsorship of special training sessions of value to multiple climate change and agriculture initiatives in the region.

AgMIP South Asia Regional Projects

In South Asia, four multi-disciplinary and international teams are undertaking integrated analyses of food production systems with a special focus on how climate contributes to food insecurity in the region, with a fifth team providing coordination across projects (Fig. 7).

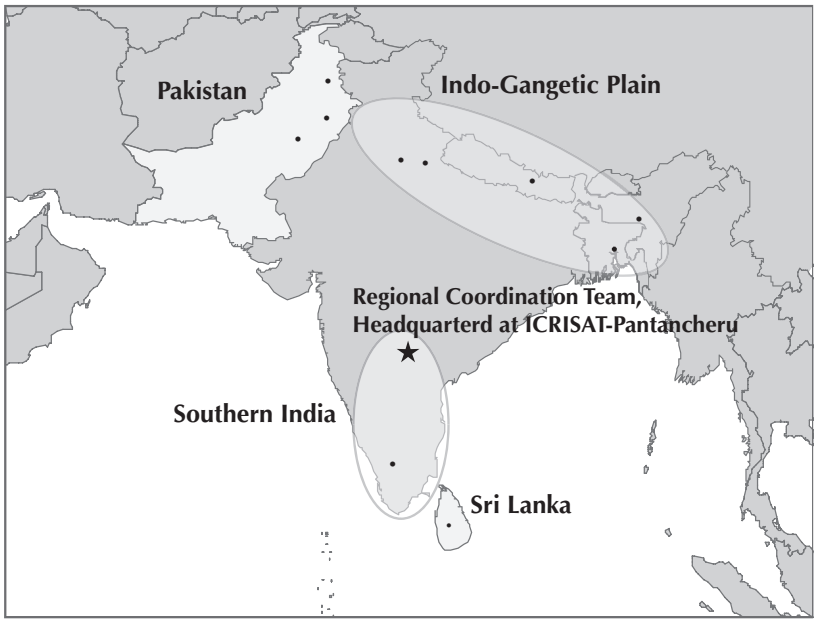

Fig. 7. AgMIP Regional Projects in South Asia.

Assessing climatic vulnerability and projecting crop productivity using integrated crop and economic modeling techniques

Wheat, rice and cotton are major crops in Pakistan not only in terms of local consumption but also in view of large exports. These crops are grown on approximately 8.81, 2.37 and 2.69 million hectares of land respectively, with a total production of 24.2 million tons of wheat, 4.8 million tons of rice, and 11.5 million bales of cotton. These crops are grown in different agro-ecological zones of Pakistan. Each zone represents diverse soil, social, hydrological and climatic conditions.

The overall goal of the project is the analysis of historic/current climate, as well as crop and economic data to determine the trends of climate change in the region and its likely impact on crop productivity and the economy. This includes calibration and validation of crop models for wheat, rice and cotton, regional economic models, as well as quantification of the spatial and temporal yield variability and yield forecasting under future climate change scenarios.

An expert team of climate, crop, and economic scientists are analyzing the possible impacts of variable and changing climate on wheat, rice and cotton production under the agro-ecological conditions of Pakistan. The AgMIP regional study

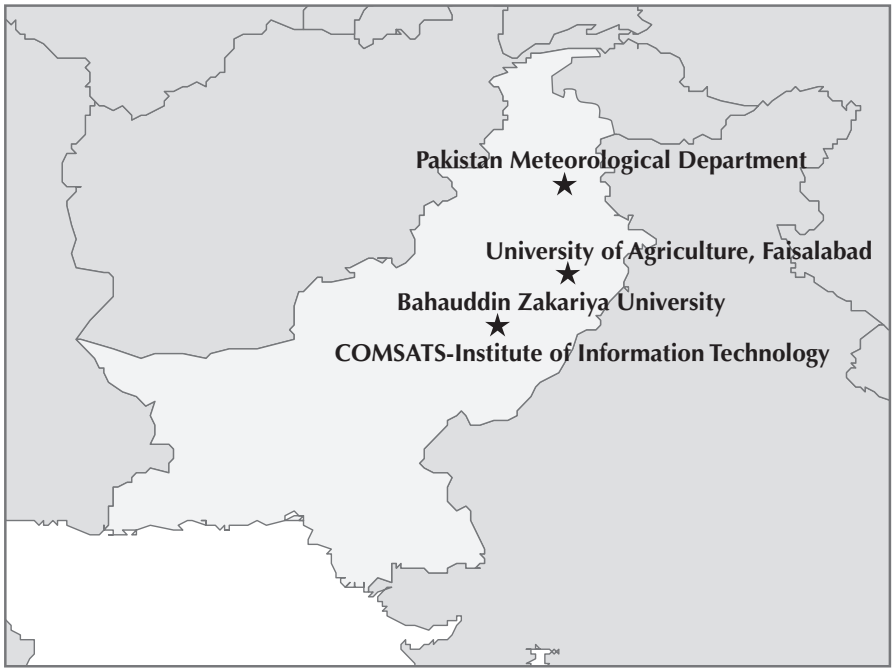

Fig. 8. AgMIP Pakistan Project region and institutions.

is anticipated to improve confidence in the performance of climate, crop and economic models by comparing them for the same input conditions utilizing the AgMIP Protocols.

The project is led by Dr. A. Ahmad, Professor at Agro-Climatology lab, University of Agriculture, Faisalabad (UAF). Additional investigators include Drs. S.A. Wajid, T. Khaliq, M. Ashfaq, and A.R. Sattar, all at UAF; S. Ahmad of Bahauddin Zakariya University; G. Rasul of Pakistan Meteorological Department; and W. Nasim of COMSATS — Institute of Information Technology (Fig. 8).

The project will enable improved confidence in predictions of likely climate change impacts and will also allow for rigorous analysis and scrutiny of concepts and assumptions underlying each model. Improved understanding of model behavior is likely to be helpful when communicating with the farmers and decision-makers who must plan for the outcomes of changing climate.

In addition to research, regular exchange of information will occur through training activities aimed to enhance skills needed to undertake the work. This includes hands-on sessions in data assessment and management, use of models and other tools, and write-up of results. It also includes training on methods for regional integrated assessments utilizing information from climate, crop, and economic models.

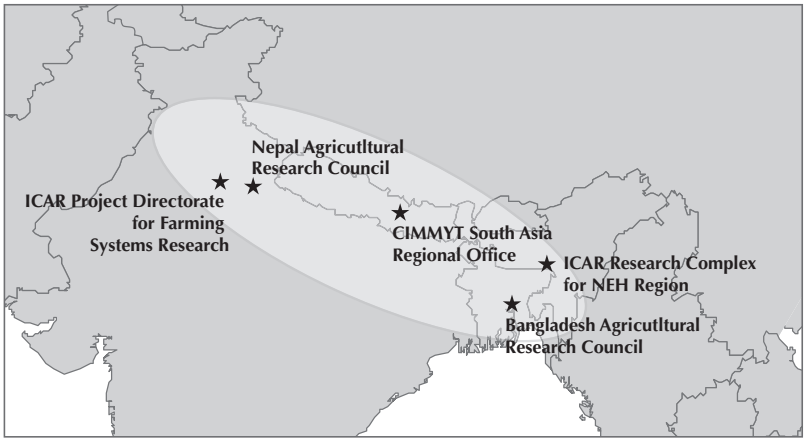

Fig. 9. AgMIP Indo-Gangetic Plain Project region and institutions.

Strengthening simulation approaches for understanding, projecting, and managing climate risks in stress-prone environments across the central and Eastern Indo-Gangetic Basin

This project focuses on cereal crop production regions in the Central and Eastern Indo-Gangetic Basin (approximated by the oval in Fig. 9). Agricultural simulation and climate modelers are teaming up with socio-economic scientists in Northern India, Nepal and Bangladesh, in partnership with AgMIP. Together, they will establish a multi-model framework of calibrated agricultural impact models to assess climate impacts. Climate, benchmark soil, and crop cultivar data are assembled for a set of crop models in each major production domain, and AgMIP Protocols are followed to simulate contemporary and future climate risks. The intent is to make a lasting contribution to methodologies for adapting agricultural systems to current and projected climate risks in South Asia.

The project is led by Dr. B. Gangwar, Project Director for the Indian Council of Agricultural Research (ICAR) Farming Systems Research Project Directorate (FSRPD). Additional investigators include Drs. N. Subash of ICAR/FSRPD; A. Das of ICAR Research Complex for the NEH Region; S.K. Ghulam Hussain from Bangladesh Agricultural Research Council; R. Darai from Nepal Agricultural Research Council, and A. McDonald of CIMMYT — South Asia Regional Office in Kathmandu Nepal.

This research strengthens simulation approaches for understanding, projecting, and managing climate risks in stress-prone environments across the Central and Eastern Indo-Gangetic Basin. The project team is also evaluating promising adaptation strategies, suggesting areas for model improvement, developing a qualitative

summary of the non-climate drivers of change, and, analyzing different policy scenarios by integrating an economic model with the crop simulation models. The project includes the creation of a synchronized database on climate, soil and crop information for the region for other researchers and experts to utilize in their own integrated analyses. The goal is to strengthen and broaden collaborative research in agricultural systems for this region.

Integrated assessment of climate change impacts on principal crops and farm household incomes in Southern India

Farmers in Tamil Nadu, Andhra Pradesh, and other Provinces of the Deccan Plateau are located in the rain-shadow of the Western Ghats, with meager annual rainfall averaging 500–900 mm (Fig. 10). The region is experiencing steadily decreasing soil fertility, falling water tables, growing dependence on groundwater for irrigation, and increasing fallow lands — characteristics that may be impacted by changes in long-term climate trends. Agriculture sustains over half of the region's population.

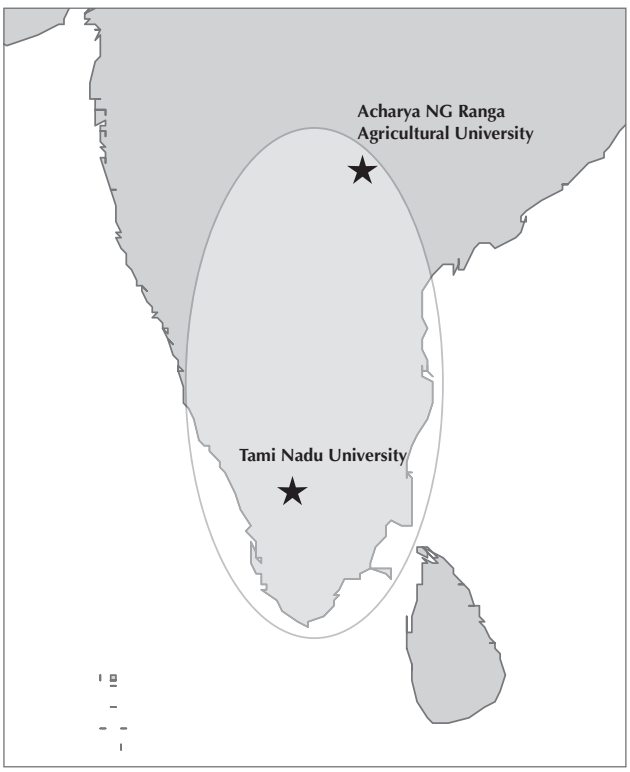

Fig. 10. AgMIP Southern India Project region and institutions.

Climate, crop, and economic researchers at Tamil Nadu Agricultural Univerity (TNAU) and Ancharya NG Ranga Agricultural University (ANGRAU) and partners are assessing the impact of climate change on agricultural production in Southern India and its implications for farm household income and food security. The team will apply AgMIP Protocols to integrate climate, crop and economic models and assess impacts. The goal of the project is to reduce uncertainty in climate change impacts and adaptation options.

The project is led by Dr. P. Paramasivan, Professor at Agricultural Economics, TNAU; Co-leaders are V. Geethalakshmi, Professor and Head of the Agro Climate Research Centre, TNAU and Dr. M. Gopinath, Professor of Agricultural and Resource Economics at Oregon State University. TNAU team members include A. Lakshmanan, Nano Science and Technology; K. Mahendran, Agricultural and Rural Management; and, R. Krishnan, Remote Sensing and GIS. ANGRAU team members include Dr. Raji Reddy, Head, Agro Climate Research Centre and Dr. D. Murthy, Soil and Crop Modeling, Agro Climate Research Centre.

This research project provides an integrated assessment of climate change impacts on principal crops and farm household incomes in Southern India. Following a characterization of farm household production systems in the region, the project will downscale climate change scenarios, simulate productivity and production impacts of crops under different systems and scenarios using hydrological and crop models, and, integrate climate model outputs with impact models. Operating within the framework of the AgMIP global project, this Southern India project is conducting a comprehensive assessment of impacts, vulnerabilities and adaptation options for the region.

Modeling the impacts of a variable and changing climate on rice and sugarcane agricultural systems in Sri Lanka

A team of climate, crop, economic and IT experts are modeling the impacts of a variable and changing climate on rice and sugarcane agricultural systems in Sri Lanka (Fig. 11). The AgMIP Regional Project will assess the impact of climate change on rice and sugarcane production utilizing the AgMIP Protocols. The project aims to reduce uncertainty in climate change impacts and adaptation options.

The AgMIP Sri Lanka Project is led by Dr. L. Zubair, Principal Scientist at Foundation for Environment, Climate and Technology (FECT), Sri Lanka, with co-leadership by Dr. S.P. Nissanka of University of Peradeniya. Additional investigators include Drs. W.M.W. Weerakoon and B.V.R. Punyawardhene from the Department of Agriculture, Sri Lanka; Dr. A.P. Keerthipala, Ms. B.D. Sandya Ariyawansa, Mr. K. Sanmuganathan, and Mr. A.L.C. DeSilva from the Sugarcane Research Institute; Dr. N. Fernando, Mr. S. Ratnayake, Mr. M. Weerasekera, and Ms. Z. Yahiya

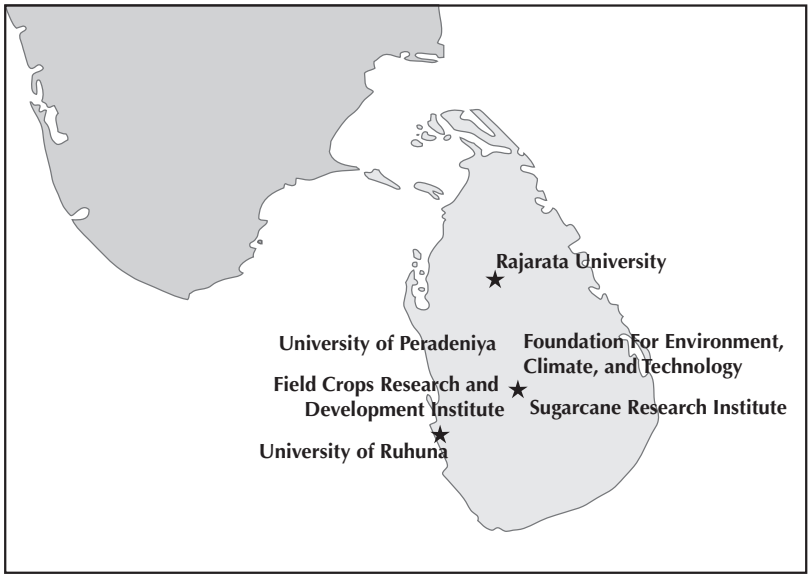

Fig. 11. AgMIP Sri Lanka Project region and institutions.

of FECT; Professor K.D.N. Weerasinghe from University of Ruhuna; Professor P. Wickramagamage and Dr. W. Athukorale from University of Peradeniya; Dr. W.C.P. Egodawatta and Mr. J. Gunarathna from Rajarata University; and, Ms. R. Bandara of Sabragamuwa University.

Anticipated beneficial outcomes of the project include: (i) advancement of state-of-the-art modeling of the impacts of a variable and changing climate on agriculture and food security at multiple scales to inform policy-making and resource management; (ii) harnessing of high quality data resources and expertise in Sri Lanka to contribute to global efforts to characterize the impacts of a variable and changing climate on agriculture; (iii) development of expertise, infrastructure, data and IT resources for climate, crop and economic modeling in the partner universities, departments and research institutes and; (iv) establishment of a multi-disciplinary network of collaborators in the fields of climate, crops and economics who will foster transdisciplinary research, with special attention given to the fostering of the next generation of scientists with training programs and access to project resources and outputs.

Enhancing capacities of the AgMIP South Asia regional teams through capacity-building workshops and knowledge-sharing platforms

The goal of this project is to strengthen the building of capacity for the AgMIP transdisciplinary research teams throughout the South Asia region through a partnership between AgMIP and the International Crops Research Institute for the Semi-Arid

Tropics (ICRISAT). The aim is to prepare and publish integrated assessments of climate change impacts and adaptation for Pakistan, the Indo-Gangetic Basin, Southern India, and Sri Lanka (see Fig. 7).

The project is led by Dr. D. Guntuku of IRCISAT Global Leader for Knowledge Sharing and Innovation, with contributions from Drs. C. Bantilan and R. Mula, Mr. S.V. Prasad Rao, and a Research Fellow to be determined (ICRISAT). In addition, the AgMIP Leaders (Drs. C. Rosenzweig, J. Jones, J. Hatfield, K. Boote, P. Thorburn, C. Porter, S. Janssen, A. Ruane, J. Antle, R. Valdivia, G. Nelson) and Drs. P. Singh, S. Nedumaran (ICRISAT) and D. Murthy (ANGRAU) are among those identified as expert contributors who enable curriculum building, development of individual and group learning modules, and teaching in climate, crop, economic, information technology, and integrated assessments.

The Regional Coordination Team will liaise with designated representatives from each AgMIP Regional Research Team, and with AgMIP Leadership, enable collaborative workshop development. Research Teams will be advised on how to organize and prepare for participation in each workshop. This includes development of an inventory of data needed for regional assessments (e.g., weather, site experiment, soil, socio-economic parameters); preparation of materials for presentation at the workshop; guidelines for identifying IT goals of the project (e.g., data management plans, project website, etc.); establishment of concise summaries of climate, crop and economic models analyses in planning or underway; and, identification of stakeholders whose engagement is likely to be mutually beneficial.

Workshop reports will summarize presentations and learning activities and will also provide guidance on next steps. In addition, the team will provide guidance on requested training on specific topics, to be advanced in partnership with national and international entities that have expressed interest in the co-sponsorship of specialized topic training that is needed for other initiatives in the region.

Conclusions

AgMIP has already developed strong international collaborations and research activities are underway in many regions. A major goal of AgMIP is to create capacity-building partnerships around the world, enhancing the ability of researchers in each agricultural region, as well as globally, to evaluate current and future climate impacts and adaptations, and thus to contribute to future food security.

Acknowledgments

The authors gratefully acknowledge the contributions of AgMIP Team Leaders for Climate (Alexander C. Ruane, *NASA Goddard Institute for Space Studies,*

New York, NY, USA), Crop Modeling (Kenneth J. Boote, *University of Florida, Gainesville, FL, USA* and Peter J. Thorburn, *Commonwealth Scientific and Industrial Research Organisation, Brisbane, Australia*), Economics (John M. Antle, *Oregon State University, Corvallis, OR, USA* and Gerald C. Nelson, *International Food Policy Research Institute, Washington, DC, USA*) and Information Technology (Cheryl Porter, *University of Florida, Gainesville, FL, USA* and Sander Janssen, *Alterra, Wageningen University and Research Centre, Wageningen, Netherlands*). The authors express sincere appreciation to Peter Craufurd for contributions in the role of AgMIP Principal Investigator at the *International Crop Research Institute for the Semi Arid Tropics*. Rex Navarro, R. Narsing Rao, M.S. Raju and others at the *International Crop Research Institute for the Semi Arid Tropics*; Tim Johnston, Kelema Jackson, Andrew Thibodeau, and others at *Columbia University*; and, Eileen Herrera and others at the *US Department of Agriculture* are acknowledged for their contributions to project operations and finance. Soyee Chiu and Shari Lifson at *Columbia University* provided technical, editorial, and graphical support. The *Columbia University* coordinated implementation of the AgMIP program for Sub-Saharan Africa and South Asia is possible owing to support from the British *Department for International Development's UK aid*, executed in partnership with the *US Department of Agriculture Agricultural Research Service* through Agreement Number 59-3625-1-745.

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