Economic and Environmental Impact of Improved Sorghum and Millet Technology in Mali

A Case Study Used to Develop Impact Methods to Predict and Assess Contributions of Technology (IMPACT)

Texas A&M University

ABSTRACT

Duration:
This research was conducted over a two and a half year period. It is ongoing.

Objectives:
To provide improved methods to assess the impact of introduction and use of technology resulting from USAID investments in agricultural research, a suite of integrated interactive models was created for use in developing countries. Economic, environmental, and biophysical models were developed to provide a holistic evaluation of the impact of new technology or policy options. Studies were conducted in East and West Africa. In this case study, the impact in Mali of the introduction of shorter season higher yielding sorghum varieties, ridge tilling for water retention, and enhanced use of inputs was estimated. Experimental data from INTSORMIL CRSP and ICRISAT, involving national research and extension partners and farmers' trials, provided estimates of costs of production and yields for both the current and new production systems.

Activities:
The research involved acquiring relevant data bases and expert opinions through collaboration with national partners, establishing a spatial framework using GIS methods to estimate production and environmental consequences of the technology and adaptation, and the use of crop simulation, economic sector and farm level models to estimate the economic and environmental consequences. Conservative estimates of adoption rates were developed through interviews of national research and extension workers and farmers.

Area:
Policy and Institutions

Region:
Sub-Saharan Africa

STAKEHOLDERS

Beneficiaries:
The results of development and evaluation of the suite of models in IMPACT provided proof of concept of the ability to use this new holistic approach to assessment of the impact of new technology or policy options. The results may be used broadly by developing countries, donors and research organizations to evaluate options, set priorities, and estimate outcomes. The ultimate beneficiaries of this analytic capacity are farmers in developing countries. Specifically, this case study applies to Mali and adjacent West African countries.

Research Partners:
This case study drew on the accomplishments of the participants in the USAID INTSORMIL CRSP which include both U.S. university scientists and their colleagues in the Malian Institute of Rural Economy (IER). In addition, vitally important information and insights were obtained from Malian Extension workers and representative NGOs in the country. Two partnerships are represented. First, was the collaboration with INTSORMIL scientists, which included sorghum breeders, agronomists, economists, and related disciplines in IER. Second, the development of the impact assessment models involved overlapping collaboration with IER economists and with scientists in the Institut du Sahel (INSAH). Data from the research done by ICRISAT was also valuable to the overall assessment of research impact.

Donors:
The United States Agency for International Development was the principal sponsor for the U.S.-BASED research done on both INTSORMIL and on IMPACT. INSAH and IER both contributed the time of researchers while their non-salary expenses were provided by USAID.

PROJECTS RESULTS AND IMPACT

Main Results:
The Almanac Characterization Tool (ACT) is a GIS-based analytical tool with the capacity for organizing, accessing, and interacting relevant natural resource, land use, and weather information (*inter alia*). An ACT for Mali was developed and used to provide input to models, and to organize model outputs in a spatially coherent manner. Using interpolated climatic surfaces, a growing season model was created to identify the five consecutive months that maximize water availability in the environment across the country. This was combined with soils data to create a set of unique environmental simulation zones across Mali (and other countries).

These zones provided sampling frames used to run crop simulation models which provide a spatially explicit projection of biophysical data needed as model input. These models are then used for estimating the economic and environmental consequences of use of the new sorghum production system across the country with current and new production systems. This method is particularly important in situations where reported or observed data on crop performance are limited or absent. In these cases, crop simulation models are used to estimate values for missing data. Looking ahead, the approach allows one to define areas of "geographic equivalence" which estimate the performance of the new technology where experimental data do not yet exist. In turn, one can estimate the economic and environmental impact of new technology in these areas.

National and regional agricultural sector models were developed for Mali. The models represent the major commodities produced in the country. In the agricultural sector model (ASM), social welfare is maximized when supply and demand functions are in equilibrium. The model generates estimates of prices and quantities of agricultural commodities, input use, crop mixes, and consumer and producer economic surpluses. Comparison of current practices and adoption of the new technology provides an estimate of the economic impact of the new technology at regional and national levels. Farm level models were also developed and evaluated using the same sorghum production system technology. Farm models provide more specific estimates of the impact of new technology by modeling households and estimating the future impact of new technology on the economic health of the enterprise.

The Erosion Productivity Impact Calculator (EPIC), which was used for crop simulations, also provides an estimate of environmental impacts of cropping systems. It was used to compare the environmental impact of the current and new sorghum production system with a focus in this initial study on water runoff and soil erosion.

The results of development and evaluation of the suite of models in IMPACT provided proof of concept of the ability to use this new holistic approach to assessment of the impact of new technology or policy options. The results may be used broadly by developing countries, donors and research organizations to evaluate options, set priorities, and estimate outcomes.

The Agricultural Sector Model (ASM) was used to estimate the economic consequences of adopting the new sorghum production system. It assumes an ultimate adoption rate of between 20 and 30% among regions of Mali. Demand is based on estimates of population growth in the year 2015 (World Food Summit target date) for the various regions of Mopti. The Mali ASM includes a new stochastic component that allows for modeling of risk at the household level. Total benefits include both producer and consumer benefits. The regional benefits of adopting the new sorghum technology are greater by between 40 and 100% compared to current technology. This is one of the several outputs of the ASM shown to illustrate the products from the model. This sorghum production system is but one part of the product of the total USAID investment in sorghum technology in Mali. It is representative of the broader USAID investment in research on other commodities and natural resources in West Africa. The annual total national welfare associated with adoption of the technology for all of Mali in this scenario is estimated to be FCFA 635 billion per year in the year 2015.

The EPIC model was run with 20 year simulations for all the simulation zones. The results include a comparison of runoff and soil erosion between current practices and the new sorghum production system. There were no significant differences in runoff between current and new practices across regions. However, in all cases, the model predicts a reduction in erosion using the new production system ranging from 1-3% in the Segou region to 30-43% in Kayes. The reduction is attributed to faster development of canopy cover and increased biomass exhibited with the new system. This is due both to the improved germplasm and the increased use of fertilizer. Thus, the EPIC outputs suggest that the economic benefits of the new production package are accompanied by positive environmental consequences through reduction in soil erosion. Other environmental factors seem to be unchanged between the current and new systems.

Dissemination of Results

This case study is part of a larger ongoing effort to develop, evaluate, and ensure the utility of the integrated suite of models referred to as IMPACT. The participatory approach used with national and regional partners has ensured that awareness and ownership are developed from the outset. In addition, a major workshop with participants in research and users of the product was held in December 1999 in Mali to evaluate the results to date and plan follow-on studies. A partnership has been established with the FAO Worldwide Agricultural Information Center (WAICENT) to conduct further research to package the models so they will be accessible and usable by developing country analysts. This includes ensuring that these and related capacities are available through a network organized by WAICENT that makes both models and related data bases available. The results of the IMPACT development are available at the CNRIT website at Texas A&M University and through related scientific and other publications.

Impact of the Project:

The total national welfare for all of Mali in the one case study on the improved sorghum production system reported here is estimated to be FCFA 635 billion per year in the year 2015. This gain is associated with a concomitant reduction in soil erosion of between three and 43 percent in different regions of Mali. This is illustrative of the pay off of research to enhance sustainable production of food in developing countries. The impact of the new holistic method for assessing the consequences of new technology and policy options is not so easily stated in quantitative terms. Improved decisions on research and other investments, avoiding bad decisions through objective analysis, and creating an environment in which the utility of research can be clearly stated are examples of the impact of improved tools for decision making. The same models have significant use in ex poste analysis of measured impact of the introduction of new technology or policy. The development of IMPACT is being continued under another USAID effort where the tools are being oriented to improve national decision making on matters of food security and natural resource management.

PARTNERSHIP

Role of Stakeholders:

Project Design: The development of IMPACT models for Mali builds on principles and experiences gained by the Texas A&M team over the past 20 years in the U.S. and other countries, including several in West Africa. The specific models developed in IMPACT for Mali were tailored to the agriculture and natural resources of the country. Contributions of national research partners were instrumental in determining “what works and what doesn’t” in establishing the scope of the evaluation and in determining available and missing data and other information.

Project Implementation: Project implementation involved an ongoing engagement between Texas A&M and our national collaborators. They participated in all phases of the project, including data acquisition, configuring models to reflect the national situation and in preparing, interpreting, and presenting results.

Project Management: This was generally done using a participatory approach where key “crossroad” decisions were made jointly with national partners and sponsors. Funds to cover in-kind expenses of national collaborators were transferred to the IER and a simplified system was used to ensure accountability.

Result Dissemination: National partners have a pivotal role in dissemination of results. An advisory committee of key agricultural experts in Mali for the ongoing project is chaired by one of the national partners. The in-country workshops are organized and led by national partners. Communication with counterparts in adjacent West African countries is facilitated by national partners (lateral transfer) and by regional organizations such as INSAH and AGRHYMET. WAICENT, as noted above, is having a major role in application of the IMPACT tools at multinational and global levels.

Added Value of the Partnership:

By choosing to evaluate the impact of a long term ongoing research partnership between Texas A&M and Malian scientists under the INTSORMIL CRSP, IMPACT was assured access to ongoing relationships and relatively high quality information about the technology to be evaluated. The existing network provided access to national extension workers, NGOs, and selected farmers collaborating on INTSORMIL. Because of overlap of U.S. and Malian scientists between INTSORMIL and IMPACT, there was an excellent transition from a crop development effort to one directed at developing impact assessment methods. The well-established criticality of close and continuing collaboration between scientists in developing countries and international “visitors” who inherently lack in-depth knowledge of the more general factors affecting the agriculture of developing countries was fully experienced again in these studies. Of special note is the need to develop better methods of assessing the socio-cultural factors that affect the adoption of new technology or policy. The consistent advice from national decision makers and other users of these methods is to ensure that the models are both useful and usable. Simplicity is of paramount importance. Among other things, building capacity among scientists and analysts in key parts of the government is top priority for successful use of the results.

CONCLUSION

The importance of quality input data for models such as IMPACT and its frequency scarcity or absence in developing countries was reaffirmed in these studies. The utility and validity of the holistic approach were verified through proof of concept of the models developed under IMPACT. The utility of models such as these depends on careful attention to packaging them so that they are usable by scientists and analysts in developing countries. The holistic approach provides an added benefit of developing estimates of missing biophysical and other data needed as input to economic and environmental models. Quantifying the socio-cultural factors affecting adoption of new technology remains a daunting task. Developing an ongoing institutional commitment to the application of these kinds of models is a key ingredient to their sustainable utility. Promoting this commitment, while perhaps not a part of the research agenda per se, can be neglected only at the peril of effective technology transfer. The current status of IMPACT models is believed to be "imperfect but usable." The research to further develop and refine the models is ongoing. The importance of national and regional partnerships increases as such models move from the research to practice.

The following illustration shows the economic impact of the new sorghum technology in various regions of Mali and is indicative of the results and the approach planned for the poster. In addition, maps and results of geospatial synthesis will be included in the poster.