At the national level, uncertainty was incorporated into the agricultural sector model by calculating the optimal allocation of resources under different expected climatic states of nature and risk aversion preferences. The expected long-run welfare implications of a new technology is reflected in the weighted average of the probabilities of each state of nature. Use of this approach again provided insights that were not captured by the static model. One insight in particular was the gain in producer surplus observed under the stochastic scenario that was not captured under the deterministic analysis.

6.11 Verification of Models Relative to Measured Data and Conditions

Verification of the output of economic models required comparison of the base runs of the models with the observed yields and land allocation at subregion and national levels noted in statistical data for the starting year. If the percentage difference in the base model output was within a range considered acceptable, generally less than 10% of the observed data, the model was considered to be correctly calibrated.

Verification of biophysical models can be accomplished by locating actual field data with accompanying information on such things as soils, weather, animal attributes, etc., and running the models to determine if yield response (crops, forage, livestock) are tracking observed data. Another method to confirm yields of widely reported crop species is to develop a spatial stratification of soils and weather, generate yields within each resulting simulation environment (polygon), and produce an area-weighted yield corresponding to administrative reporting districts.

We felt that the models were performing well if predicted yields were within 15% of reported yields across 80% of the reporting districts for each crop. If deviations occurred, we had to explain the cause in terms of markets and home consumption, or we had to reparameterize the biophysical models. Other forms of verification involved knowledgeable experts reviewing output to determine if the input data and the yield responses are within the domain of acceptable response for a given biophysical and managerial environment. In the case of hydrologic response, it is critical to have access to streamflow gauge data and sediment loading data to both calibrate and verify projections at the watershed scale. Normally the up-stream gauges are used to calibrate the model and the outflow basin gauge used to verify model accuracy.

6.12 Status of Modeling Environmental and Natural Resources Impact of New Technology

The overall state of the art in modeling environmental and NRM consequences of technology innovations is paced by the state of knowledge about plant-animal-natural resources interactions and behavior at the fundamental level. Researchers and NRM managers at all levels are looking for better indicators of the status of natural resources and the time course of changes in NRM characteristics as a function of their use in farming over time. The EPIC model and several hydrologic models have been used in IMPACT as tools that are available and that seem to be representative of the state of the art. Our group does not aspire to engage in the badly needed fundamental research to define the needed indicators and underlying biology to improve such models. However, we do aspire in our future work to develop linkages with those who do this kind of research and to apply the results to improved environmental models that describe the overall state of the ecosystem as a function of agricultural operations to provide improved food security.