AusAID-funded farming system projects: conceptual framework for a modeling platform

Introduction

Simulation modeling of the farming system has been included as a major activity in four AusAID-funded farming system projects. These models are dealing with complex phenomena, crop-livestock production system, Crop-trees-livestock system, with nutrients cycling, and the chain values. To increase the capacities of the project teams in modeling, each of the four farming system projects had a team member who attended the modeling training workshop organized in Addis Ababa in March 2011 by CSIRO. The finalization workshop organized in January 2011 in Dakar, recommended the development of a modeling platform. After the generalities about models, the conceptual framework of the “modeling platform” will be given.

Generalities about models

Models are representations of reality the same way a map represents a city. As in a map, one cannot expect to find all the details about a particular street, so models too cannot provide all the details of the realities. They are simpler than realities. In fact all models involve some kind of simplifying assumptions, because of limitations in the knowledge of the real world phenomena. Nevertheless, they are useful tools that can serve to describe, predict, take management decisions or to gain more insight into a complex phenomenon, the same way one can use a map to find his/her way in a unknown city.

Models can be as simple as the use of the logistic equation to describe human population growth or a linear equation that relates yield losses as a function of disease incidence. Simple models are usually reductionist, dealing with one factor at a time while the other factors are maintained constant. But models can also be complex as weather forecasting models or the crop growth simulation models. These complex models a constructed by use of a system approach, and they deal with many factors and their interactions. For instance, crop growth can be simulated as a function of soil nutrients status, soil types, rainfall, temperature, number of hours of sun shine, crop genotypes, presence or absence of diseases etc. The complexity of the model depends on the objective of the modelers, their understanding of the underlying processes and how they are affected by the external factors and their interactions, and their mathematical/statistical and computer programming expertise etc. The models can be stochastic (probabilistic) or deterministic. Crops growth simulation models are usually deterministic. The availability of microcomputers has vastly expanded our computing ability, so as more knowledge is gained in the areas of crop/plant physiology and other agricultural sciences, crop simulation models are becoming more and more complex but also accurate. The best simulation models usually have several components or modules dealing with different processes or aspects of the farming.
systems. Clearly, construction of simulation models is team effort, and an intensive knowledge-based activity. After construction, the models have to be tested and validated before they become operational.

**Modeling Platform**

Models are just tools; they are not an end to themselves. In farming system, simulation modeling is one way, albeit a good one, to identify and propose innovation processes, or to solve problems. If this is accepted then the “modeling platform” appears just as a component of the innovation platform, not a platform with an independent existence. It is should be managed by the research scientists. The role of the “modeling platform” role and its composition will be described

**Role of the modeling platform**

1. Define the objective (s) of the modeling

To set up the objective of the modeling two fundamental questions must be answered: What is to be modeled, and why to model? The answer to the first question must be very precise. The processes to be modeled must be stated unambiguously. Only when the process to be modeled is known that the factors which determine the process could be defined. Together the answers to the two questions will determine:

- The strategy for model construction, if for instance a new model has to be built.
- what type of plug-and-use model to acquire
- Or how the available model should be modified or adapted.

2. Acquisition of input data

Whence the objective of modeling is defined and the type of model to use is selected, the next question is how should the modeling be done? This relates directly to the acquisition of the input data. As stated earlier the factors and their interactions that govern the process must be determined. Not all factors are included in the model, but only the driving ones and their interactions. Only the subject matter specialists can identify these factors. However, the available time and resources should be taken into consideration. One should keep in mind that as the number of factor increases, so does the number of measurements as the effects of their interactions have to be captured by the model. For instance if four driving factors each at two levels are included, then for each repetitions the number of data points is 16 ($2^4$); if the measurements have to be repeated 3 times that will give a total of 48 measurements. If the number of factor is increased to 6 then the number of measurements will be 192. Now if each factor has 3 levels with four factors and three repetitions, the number of measurements will be 243. The amount of work needed to collect field data for farming system simulation can be high. Thus, a good planning of the data acquisition is essential for the success of the modeling. The
equipment for making the measurements must be available and field technicians must be well trained to use them in appropriate manner. Not all data are collected from field measurements. Part of the data could be acquired from baseline survey and literature review. This is very important if the economic outcomes have to be captured by the model. In all cases special attention should be paid to the data collection since the accuracy of the model is highly dependent on the quality of the input data. There is no substitute for high quality input data.

Model building/adaptation and validation

It is clear that the AusAID-funded projects do not aim at building a new computer simulation models, but rather to use highly performing existing ones such as APSIM, WANuLCAS or DSSAT, and in the process adapt them. Do the project teams have the expertise to carry out the process of adaption of these models? If not, then the support of CSIRO scientist is clearly needed.

After the model is adapted it has to be validated. The validation process implies that real data are compared to model predictions. The closeness of the predicted data to the real data determines the precision/accuracy, hence the usefulness of the model. How close the two data sets are can be measured by a looking at their correlation coefficient. The higher the correlation coefficient the higher is the precision of the model.

Composition of the platform

The platform comprises three categories of members:

- The agricultural scientists (agronomists, farming system specialists, crop physiologist, agro economists); they constitute the driving force and should manage the platform
- The modeling specialists; these are people who know how to run the computer simulation models. Ideally they are agricultural scientists highly skilled in computer programming and could help adapt the simulation models to suit the needs of the research team. The inclusion of CSIRO scientists is indispensable.
- Farmers and representatives of key stakeholders along the value chains; they will help identify key components of the farming system, and know the constraints and opportunities. Nobody knows better than the producers their own farming systems. Their inputs will be critical in running the simulation scenarios and finding the best management innovations. They will help with the field testing and data collection.

A close collaboration among the platform members is an absolute necessity. The platform offers a unique opportunity for people to learn from each other and to increase the capacity of the NARS by training young scientists in farming system research and the use of simulation modeling. NARS scientists involved in the modeling should be encouraged to form an active network of modelers in West and Central Africa.