Effect of management decisions on farm and household outcomes in an integrated crop-livestock agro-ecosystem in Yucatán, Mexico.

Agriculture in Yucatán:
The traditional agricultural practice of the Yucatán Peninsula, Mexico, is a form of shifting cultivation, known locally as milpa. A two to three year cultivation period is followed by a ten to twenty year period of forest fallow. Livestock ownership, including horses, cattle, hogs, fowl, and bees, has long been a part of traditional agriculture. Ownership of hair sheep is more recent practice, but is becoming increasingly common, due to strong demand for mutton in Mexico City. For smallholder farmers this presents a development opportunity, with potential to diversity income and access potential complementarities between cropping and livestock.

Methods:
An overview of the integrated model is shown in Fig. 1. The APSIM model component uses climatic and soil data to simulate plant growth. Three APSIM ‘paddocks’ (milpa, Guinea grass, and corn) are simulated simultaneously. The Verisim™ model component details management, crop, livestock, and land use dynamics, optimising the simulated potential of locally available nutrients. The less integrated systems are those in which livestock and livestock activities make up of, but do not rely on, other mixed systems. Smallholder farming systems are extremely important in developing countries. They produce the largest share of total maize (34%) and milk (60%) and are the main system for smallholder farmers in many developing countries (Thornton & Herrero, 2001). Indeed, two thirds of poor livestock producers rely on mixed crop-livestock systems for their livelihoods (LEED, 2000).

Introduction:
1 Head farming systems are described by Saxe and Stnesfeid (1998) as those in which more than 10% of the dry matter fed to livestock comes from crop by-products or stubble, and more than 10% of the value of production comes from non-livestock farming activities. More simply, they are systems where livestock rearing and crop cultivation are, to a greater or lesser extent, integrated components of one farming system. The more integrated systems are characterized by interdependency between crop and livestock activity, optimizing circulation of locally available nutrients. The less integrated systems are those in which livestock and livestock activities make up of, but do not rely on, other mixed systems. Smallholder farming systems are extremely important in developing countries. They produce the largest share of total maize (34%) and milk (60%) and are the main system for smallholder farmers in many developing countries (Thornton & Herrero, 2001). Indeed, two thirds of poor livestock producers rely on mixed crop-livestock systems for their livelihoods (LEED, 2000).

The need for modeling:
• There is a general lack of knowledge of what actually goes on in these complex smallholder mixed systems.
• Modeling realistically offers the only way of identifying and quantifying the subtle but highly significant interactions that occur between the various components of smallholders’ systems (Thornton & Herrero, 2001).
• Modeling is simply a way of integrating information in a rational way.

Objectives:
• Develop a crop-livestock model to assess the biophysical and economic consequences of farming practices evident in Yucatán mixed systems.
• Link the biophysical system to the management system, and determine the consequences for labor needs and economic outcomes.

Scenario analysis:
What are the biophysical and household outcomes from differing:
1. Types of farms (sheep vs. crop vs. sheep & crop).
2. Management and use practices
3. Livestock feeding practices

Discussion:
Implications of model outputs:
• It is logical for smallholders make use of the natural resources available, e.g. socializing common land and native trees (e.g. Ceiba leucostachys). Supplementing to improve live weight gains can often decrease net income.
• Cut and carry systems can be more labor efficient than grazing systems (if continuous supervision is needed).
• Investment in increased integration through the use of crop by-products may not be a favorable option when common land is available.
• Investment in infrastructure to grow improved forages may lead to decreased returns to labor and net income.

Model limitations and improvements:
• Phosphorus is an important nutrient but the grass module in APSIM does not track P, and neither does SRNS.
• LAI is the only range of crop & forage modules are used in APSIM.
• Vigorization is not included in APSIM
• Only one soil type, and one milpa was simulated.
• Potential to define spatial relationship between locations.
• Lack of knowledge of the underlying processes of manure decomposition, particularly manure surface applied and in pile.
• Feed quality data that is not generated by APSIM (e.g. neutral detergent fiber, lignin) is needed to generate SRNS runs.
• A dynamic SRNS would offer numerous benefits.