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Practical Issues in Developing a Whole-farm Bio-economic Model

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The task of building a mathematical programming model to represent both the biology and economics of a system can be a daunting task. This paper draws on the experiences of both past and present MIDAS modellers, collating them together to form a practical guide to the development of whole-farm bio-economic models.

Advice is given on the principles and issues associated with building models from scratch or converting old models to suit new regions. Important factors discussed include procedures to collect data, identify key stakeholders and important people and it includes tips on how to deal with those people who are less than co-operative. The strategy outlined indicates how to initiate and maintain a collaborative relationship with those people who play roles in the development of the model. The paper briefly discusses issues related to validation of the models.

Background

Development of a whole-farm bio-economic model is resource intensive. There are also a number of difficulties and potential pitfalls which can hamper the model building process. This paper is based on experiences since 1983 in the development of a whole-farm model called MIDAS (Model of an Integrated Dryland Agricultural System) (Morrison et al., 1986; Kingwell and Pannell, 1987; Pannell and Bathgate, 1994). The authors of this paper include members from both the old and new guards of MIDAS.

The farming environment represented by the MIDAS model is not static. There have been considerable changes to the system that was originally. Included amongst these changes is

the introduction of a structured premium payment system for wheat protein; the introduction of new cropping species such as canola and legumes for medium to heavy, alkaline soils and the recognition of sustainability issues such as herbicide resistance. Each of these changes has had implications for the continued relevance of MIDAS in its original form. The dynamic nature of the farming systems require that the models are continually updated and maintained to retain current relevance.

The varied uses and usefulness of the original Merredin or Eastern Wheatbelt version of MIDAS has been widely recognised (Morrison *et al.*, 1986; Pannell, 1996^a; Ewing and Pannell, 1987; Pannell and Falconer, 1986; Falconer *et al.*, 1988; Abadi Ghadim *et al.*, 1991; Morrison and Young, 1991; Ewing *et al.*, 1992; Bathgate *et al.*, 1992). This has led to demands for the development of further versions of the model that represent other regions of Western Australia. Currently Eastern Wheatbelt, Great Southern, Medium Rainfall Northern Wheatbelt and Low Rainfall Northern Wheatbelt versions of the model exist. South Coast and Central Wheatbelt versions are under development. The maintenance and updating of existing models together with demands for new models to represent different regions and systems requires continued employment of staff.

There is an unfortunately high turn over of staff involved in research. This presents problems for a continuously developing project such as MIDAS which has a high staffing requirement. There are often difficulties faced when refilling positions. Delays may exclude the possibility of a handover period occurring where new and old modellers can discuss issues of concern.

Studies of university graduates' places of employment has indicated that many graduates end up working in fields for which they have had little direct training (Candy *et al.* 1994). It is desirable to appoint staff who have the appropriate qualifications and experience. This is not always possible. In this circumstance an appointee may be someone who can demonstrate that they possess the ability to rapidly learn the desired skills. Any person entering a new job will require time to familiarise themselves with the work ethos, the model requirements and even the model building techniques. An appointee with limited prior experience may require a longer initiation period.

This paper offers some suggestions for those who may be new to the field of whole-farm bio-economic modelling or embarking upon the development of their first model. Many of the suggestions we make are also of use to people working in other fields. The paper outlines some basic strategies for the various stages involved in the building of a model from scratch and also offers suggestions on approaches for modifying existing versions of

models. It is a summary of practices that we have found useful in the development, application and maintenance of MIDAS.

Getting started

Building a model to represent both the biology and economics of a farming system is a daunting task. Being faced with the prospect of developing an idea into a model is difficult, particularly if there is no adequate plan outlining the process or model objectives. One of the most important initial steps in building a model is to define objectives and intended future uses. A basic outline of the task should be contained in the job description and/or in any funding proposals. This information will give a model builder a point to start from. It is important to consult various stakeholders in the model at this stage to ascertain their opinions. A modeller should also record her/his own expectations and discuss these with supervisors to correct any discrepancies between perceived and actual duty.

Once a more complete understanding of the requirements of the model has been determined it is then necessary to identify the key groups of assumptions and/or components that will need to be included. A useful strategy to employ at this stage is the use of flow diagrams or charts. These can be utilised to conceptualise the linkages that exist between the various components and their contributions to the objective function of the model.

After the key assumptions and components have been identified it is possible to detail information requirements. Each of the key components/assumptions can be broken down into defining characteristics. By recording the key components and their sub categories on a timeline or schedule estimates of the amount of time it will take to complete each task can be determined. The timeline or schedule can be used as a reference to measure progress and also as a reminder of issues which were considered important at the beginning of the project. It is possible to forget issues as time progresses and various complications arise.

The process for getting started described above is similar for those who are updating old models or converting existing versions to suit new regions. Again it is important to identify the key reasons for developing or revising the model. The next step is a review of the suitability of the main assumptions included in the existing model. In the case of creating a new MIDAS version for a different region it would be important review, as an example, the soil types included, cropping species, sheep flock structure and production issues, and machinery capacity.

A useful strategy for anyone commencing employment on any project including whole-farm bio-economic modelling is to complete a literature search of previous experiences in that particular field.

As with all remaining stages of the model building process, it is important for the modeller to document experiences of this initial stage. By keeping this information in a log book a record of who, where and why various people were spoken to, useful references that were read and various ideas or suggestions which are not yet able to be implemented can all be noted. This information can be revisited by the modeller at a later date. The log book will form an important resource for any person who may continue working on the model should the original modeller resign.

Involving other people

In order to maintain and increase the credibility of the model that is being built it is important to involve other people. Agricultural economists have often remarked on the difficulties of convincing other agricultural researchers of the value of their work (Mullen, 1996, Padburg, 1990; Pannell, 1996^b, Young, 1995, Zilberman, 1994).

Given the breadth of disciplines which a whole-farm bio-economic model is likely to cover it is clear that the modeller will be unable to complete the model without consulting other people. More over it would be foolish to fail to consult. The individual relationship of the modeller with people from other disciplines and the way that those involved in other areas view economists' output will influence the ease with which the modeller will be able to extract support from the non-economic contributors. The responsiveness to results will be influenced by the interpersonal relationships that exist.

An important first step is to identify a key person who can encourage support from other people either by acting as a model or by more direct means. Ideally, one hopes to enlist a person who will be vocal in their support of the model and held in respect by other researchers and/or be in a position of power/seniority. This person has an important role in that support for the modelling procedure will gain momentum through their actions. Those people who may have negative perceptions of bio-economic modelling or who may resent interacting with "non scientific" researchers may change their position once they recognise that the figurehead person gives strong support to the project.

Identifying the key stakeholders in the model is an extremely important process. The most readily identifiable of these will be those who contributed to the original planning and

perhaps the request for the model to be developed. These people are, however, not the only stakeholders.

Understanding the range of a completed model's capabilities will help highlight people who may not have been involved in the initial planning processes but who will more than likely benefit from the end product and thus, wish to contribute. Including these people at an early date will familiarise them with model capabilities, give them a feeling of ownership and increase the value of the end product. Another benefit arising from involving people from a variety of disciplines during the earliest stages of model development is that model transparency and their understanding of the model is increased. They will gain a greater feel for the type of data that they may be requested to supply.

It is important that there are not too many stakeholders making demands as this can become difficult to manage. A useful guideline to numbers would be to have a key contact person for each of the key areas of assumption or components defined for the model. In some cases there may be individuals who can act as the key person across several disciplines.

Once identified the key person or stakeholder must be consulted so that their expectations and desires in regard to the model capabilities can be learnt and recorded. It is important to give them some feel as to how well and when these desires will/can be addressed by the model. In some instances it may be that their desires are a longer term objective of the model rather than a short term goal.

The stakeholders are an important resource. They can suggest other people who have been inadvertently excluded. The stakeholders can also identify alternative people within their speciality who can be approached to provide additional information or data on the individual characteristics of each area of assumption.

For modellers who are replacing someone who has resigned, converting an existing version of a model to a new region or updating a model the best people to contact are those who have been involved in the project since the beginning. These people can assist the modeller in coming up to speed more rapidly. This process is made easier if the previous modeller has kept a record or documented who was the contact for various components. If they have not done this, the task will be more difficult and a likely catalyst to ensuring that the replacement modeller introduces the practice.

It is critical that the modeller foster and preserve the relationship formed with the people they involve in the model building process. The working relationship must be interactive.

The modeller needs to reassure those they have involved that they will receive benefit as a result of the time they are investing in the project.

The contributors should be involved at all stages in the process, not only at the time when they are required (e.g. data collection). It is important that they know how the information that they provided has been used. They may be very astute and able to identify holes that have not previously been seen or errors in the interpretation of data that they provided.

Data collection

The decision on type and quantity of data to be collected should be decided through joint consultation and discussion with stakeholders. For those assumptions where good expertise exists, the associated people should be met with to collect data, identify possible alternative data sources and discuss the appropriate structure. There will be instances when several means of representing an element of the system are suggested. If this circumstance arises it is important to discuss the merits of each alternative until a consensus is reached by the majority of those with input. Reasons for the final choice should be clearly documented.

It is possible that the model builder may have to model information on components of the farming system which they know little or nothing about. It is advisable in this circumstance to read enough to understand at least the basics before meeting with the "experts" from this area. A good policy to follow is to admit that your knowledge in this area is limited. People will be more understanding and willing to explain the complexities of the subject matter in simpler terms if they know from the outset the extent of your knowledge. This type of honesty can help foster a better working relationship.

On occasion it will be necessary to model components for which there is no or limited expertise available. If this situation arises get together groups of stakeholders to discuss the subject. It will be necessary to represent this component subjectively in the model. By discussing the topic with others a decision based on consensus should be reached.

Meeting Procedure

The majority of data collection will occur through a series of meetings held with relevant people. There are five simple questions that the convenor of any meeting should ask themselves prior to the beginning of a meeting. These are: What? Who? How? How much? and Why?

When calling a meeting it is important to arrive at the meeting knowing **what** it is wanted from the meeting. Other attendees also need to be aware of what is wanted. Preferably outline the purpose of the meeting prior to attending by forwarding an agenda or by discussing the content with people. Forwarding the agenda prior to the meeting can allow other participants the opportunity to raise any additional related issues that they would like included for discussion. Arrive at the meeting informed. Advanced review of available data will enable informed suggestions to be made at the meeting.

Who attends the meeting is an issue that needs to be considered. It is likely that most of the people who will be contributing to the model will have limited time that they can devote to assisting the model builder. Invite contributors only to those meetings of direct relevance or interest and to meetings that give overviews of progress.

The modeller must plan how they wish the meeting to proceed. The following suggestions are tactics that we have found to be useful. Offer to travel to where contributors are located rather than request that they come to the model building site. The scheduled meeting time should suit all who are attending. Ensure that the chosen venue meets all requirements, that it is comfortable, well lit, and has adequate climate control.

When beginning the meeting ensure that all participants are familiar with one another. Approach the remainder of the meeting initially with a general approach, perhaps an update of progress, then guide the meeting to the specifics. A general approach is important, particularly if you are uncertain of the area that you are investigating. Take a record of proceedings. These notes can be circulated to attendees after the meeting. Given that time is limited, it is essential that the meetings are chaired very strongly so that people are not allowed to be distracted from the task. It is important, however, to demonstrate some flexibility and to remain courteous. One method of ensuring that the meeting proceeds in an orderly fashion is to have task sheets and/or an agenda to guide the proceedings.

When determining how to run the meeting consideration should be given to **how much** information is to be collected or discussed. Meetings should be kept short for a number of reasons. One is that the longer a meeting proceeds the more difficult it becomes to retain interest. A second reason is that shorter meetings are often easier to fit into people's schedules. On the issue of how much data to collect it is important to consider the methods that you will be utilising to process the data. The way that data is recorded during the meeting will effect your ability to remember and utilise the data. It is better to gain a deep understanding of a little data rather than a shallow or fragmented understanding of a large quantity.

There are numerous reasons why a meeting should be called, most critical being that it allows personal interaction. A meeting environment provides the opportunity for focussed discussions with lowered incidences of interruption. Actually seeing the people with whom you are collaborating can increase their co-operation. A meeting environment can also enable those participating to learn who else is contributing to the project.

Dealing with difficult people

Unfortunately not everyone consulted will be co-operative. In our experience there are two key groups of difficult people that we have come across. These are:

- 1) ramblers who get side-tracked and spend a great deal of time discussing irrelevant issue
- 2) people who have negative feelings about the process being undertaken. These negativities may arise because they disagree with the methodologies being employed, disagree with the assumptions being made or fundamentally disagree with the concept of whole farm bio-economic modelling or don't like the expected result or who have had prior experiences.

Difficult people of the group 1 ilk may monopolise restricted time talking about irrelevancies. It is important to be firm and draw them back to the task being addressed. We are aware that this can be difficult particularly if the person is in a more senior position. If the person is bogged down on detail there are two options:

- a) be confident that what they are saying is largely irrelevant argue against their point,
- b) alternatively offer a compromise by informing them that the importance of the issue will be investigated and a decision made on the basis of that investigation.

Difficult people from group 2 have the potential to undermine your authority, confidence and the value of the project. In dealing with these people it may pay to get them on side.

- a) offer to investigate areas of opposition,
- b) have a counteracting voice present. By this it is suggested that invite people of equal or greater authority who are willing to argue the case for your position.

Building the model

If starting without a template begin with only a simple model. This should include key components and may only represent one small segment of the final model. Once this simple model has been completed, test it extensively to see if it works. Cross check the results it is producing with other interested parties and stakeholders. Once satisfied that

the simple model works it is possible to begin to add complications, additional components and/or segments

It is essential to test after each addition to ensure that there are no bugs. It is also essential to document the changes that you make (Pannell *et al.*, 1996). This can make the task of error detection simpler. A useful strategy to follow is to always save changes to a different file. This may protect you from corrupting a standard version and having to begin again. We cannot emphasise strongly enough the importance of having a standard model that is preserved in its original form at each stage of development and stored separately. We strongly recommend that regular backup copies of all work be made.

Eventually the modeller will have developed a completed version of the model. This model should be preserved and not be altered unless there is very strong evidence/argument for change. If a decision has been made to alter the model permanently a new version should be saved as the core model with a revised name

If in the position of updating an old model or converting an existing model to suit a new region there are a number of steps that we suggest be considered. Firstly always retain a copy of the original. Document all changes that are made. Test the model to see if it still solves after every change. Ensure that the altered model version is producing results that are consistent with the changes that have been made to data and/or model structure. This will prevent you reaching a point where many changes have been made and discovering that the model no longer solves. Contemplating the intended changes on paper first encourages you to think more carefully about the changes that are to be made.

Interaction with farmers

Farmers are an important resource when modelling farm systems. They can provide additional insight on issues which may have been ignored by other stakeholders. They have an appreciation of the complexities of the system that often escape those who are not farming (Pannell, 1996^a). It is possible to involve farmers at various stages of the model building process, particularly model validation (Schilizzi and Boulier, 1997). Given their intimate knowledge of farming systems they may detect inadequacies, errors and omissions. Farmers are the most reliable source of relevant yield data for traditional enterprises and farming practices. They can more easily distinguish between what a crop could have potentially yielded and what the most likely crop yield achieved would have been.

There are a number of approaches to involving farmers in the model building process. It is possible to survey farmers and collate relevant data or alternatively they can be included through one on one discussions with individual farmers. By going through the district office of the local Agriculture Department key farmers or groups of farmers could be identified. It is suggested if using individual farmers that half a dozen bench mark farmers are selected. It is important when requesting the recommendations from the Agriculture department that they are aware of the characteristics that you are looking for in the farmers selected. Ideally benchmark farmers would have farms located in different parts of the landscape of the region being studied.

Creating a support network

We have been very fortunate with our MIDAS experience to have had the opportunity to develop a support network. This network consists of modellers who are presently working on MIDAS and other economists who have historically been associated with MIDAS. All of the key people originally employed to develop the model have moved on to other employment in related fields. They are a critically valuable resource to the "new guard" of MIDAS modellers. We meet bimonthly to report on current progress and to discuss problems and current issues. Having this support network has helped make our jobs, particularly on arrival, much easier.

In Western Australia we are also fortunate to have the opportunity to work in environments which encourage interdisciplinary research. Support from high levels of institutional management has always been encouraging (Pannell, 1996). The collaborative work environment that have been created by the Co-operative Research Centre for Legumes in Mediterranean Agriculture has further extended the number of people in different disciplines and institutions with which we can interact freely.

Conclusion

This paper is a very personalised view of approaches to consider when building a whole-farm bio-economic model. The issues discussed are ones which we have found to be important during our experiences with the MIDAS models. They are by no means a conclusive list of issues that should be considered or will be faced by a new modeller or even more experienced modeller. It is hoped that this recording of our experiences will provide some guidance to both those newly initiated in the role of model developer and those already involved.

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