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Farming Systems Consultancy Australian co-operation with the national agricultural research project Thailand

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AUSTRALIAN CO-OPERATION
WITH THE
NATIONAL AGRICULTURAL RESEARCH PROJECT
THAILAND

FARMING SYSTEMS CONSULTANCY

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REPORT TO ACNARP:

FARMING SYSTEMS CONSULTANCY

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WA Department of Agriculture

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TABLE OF CONTENTS

RECOMMENDATIONS

1. The FSRI should make a major contribution to Thai agriculture by researching wholefarm systems. This would clearly distinguish its role from that of other groups who look in detail at only part of the farming system. To do this efficiently, it must develop a method for wholefarm analysis of the impact of new enterprises, new technology and alternative practices. So far it does not have such a method, although the work at Suphanburi could be viewed as the very first stage in developing one.

2. The method should represent farm resources, some of the biological relationships of the farming system, interdependencies between enterprises, and account for farmer objectives. Wholefarm modelling, using MATHEMATICAL PROGRAMMING, if used skilfully, is well suited to meeting these requirements and should be tried by the FSRI.

3. In building a wholefarm model, the FSRI must draw on information from the different disciplines of agricultural science (e.g. studies of economics, plants, animals, soils) to build a wholefarm model. The FSRI should not duplicate the specialist work of others, but integrate inputs from the various disciplines.

4. The FSRI should continue its Suphanburi lowland model building project as a pilot study to develop wholefarm modelling skills, and for evaluation of this approach before committing many more resources to it. It is preferable to concentrate scarce modelling skills on the one project to give it the best chance of success, rather than to build many models simultaneously. An

alternative starting point for wholefarm analysis would be to locate the work near to Chiang Mai because of good prospects for co-operation between Chiang Mai University and the FSRI staff. However, the investment in the work at Suphanburi to date, Mr. Duangpiboon's location there and the commitment of FSRI leadership and staff at Suphanburi mean that initially, it is probably best to start there.

5. The Suphanburi lowland model, as assembled during the training course, should be treated only as a useful starting point for farm modelling. Considerably more development, review and revision is required before it is a useful model. It is essential for the success of the project that:

   (i) it is fully documented so that all data and assumptions can be checked by people who may have no expertise in model building, but who can help to provide the best data;

   (ii) a wide range of experts are involved in further model development, data specification, model review and model use. Those who should be involved on a part-time basis are others in FSRI, specialist researchers in the DOA, others in Thailand with farm modelling expertise (universities, OAE), economists (either the OAE or an economist within FSRI), extension workers and farmers. Failure to involve others will mean a poorer model, which will lack credibility and be criticised rather than used.

6. In the short to medium term, the Economic Analysis Branch of the WADA needs to monitor the whole-farm modelling

performance of FSRI staff and give advice where it is requested, or where Economic Analysis Branch staff judge it to be necessary. This will require that FSRI staff regularly report progress and send updated LP MATRICES and documentation to WADA by post.

7. ACNARP should consider use of University Research Grant funds to promote continued co-operation between the FSRI and Chiang Mai and Khon Kaen Universities. The funding could be used to provide for university staff to travel to the FSRI and for FSRI staff to travel to the universities. Also, it could help with software purchase.

8. Post-graduate training of several FSRI staff in techniques of modelling the wholefarm should be undertaken to give FSRI staff higher level modelling skills and a better theoretical understanding of modelling. This would enable the FSRI to phase out the inputs of external advisers and would mean they have similar skills to modellers at the universities.

   An alternative to training existing staff would be to recruit a bright young researcher from a university and have him/her work on the farm modelling team.

9. For wholefarm modelling to be successful, there must be a strong commitment to it from the senior staff of the DOA and FSRI. A policy needs to be developed at the highest levels of the DOA and FSRI for implementing farm modelling and to specify how it will fit into the FSRI structure. In the case of the DOA leadership, it is important that they indicate to other parts of the DOA that the work has a high priority and that collaboration

is expected. Commitment at an even higher level, the Ministry of Agriculture, may be required to ensure co-operation between DOA, OAE and DOE staff.

10. FSRI staff should promote the involvement of others by making them feel part of the project, and by offering them co-authorship of papers on the model and model results. Model results should always be supplied to those who have had a major input and special series of runs should be undertaken to look at particular issues of interest to non-FSRI people who are involved.

11. Model results should not be taken seriously until the model has been widely used, widely reviewed, constructively criticised and revised.
This process may take up to 18 months before there is general recognition that the model is useful. Model builders must take criticism as a positive input - it is far better that people criticise aspects of the model than that they ignore it. It is unusual for Thai people to have to accept criticism, but one measure of the early success of the project will be whether or not many people will offer constructive criticism. General and destructive criticism from those who are ill-informed and/or feel threatened by the work is may occur, but can be discredited as the usefulness of the model is demonstrated.

12. There appeared to be considerable disagreement between FSRI staff on the accuracy of the data which could be used for farm modelling. Differences of opinion between experts need to be addressed by a round table conference to decide which are the best available data. Where there is great uncertainty surrounding a data source or

data estimation, sensitivity analysis must be conducted to test the change in the model solution with different plausible assumptions about those data.

13. As the model becomes more complex, it will grow beyond the capacity of the GULP program. Modellers must examine output to see whether errors are starting to appear in the output and, when they do, change over to a more sophisticated program. Economic Analysis Branch at the WADA, and possibly the OAE, can help in this regard. LP88, which is already in use at the OAE and universities, should be adequate for the next stage of development. If the model expands even further, a program called AESOP would be adequate.

14. The necessary computer hardware is IBM compatible machines with at least 640K of RAM and a hard disk, for each person working on the project. Computer speed is an advantage so that if the faster AT computers are available at a similar price to XT computers, they should be purchased. In the future, when microcomputers using the '386 chip' are available, they may be worth purchasing.

15. FSRI needs to identify and document its computer hardware and software requirements for wholefarm modelling on the basis of recommendations 13 and 14. The documentation of requirements should then be included in the DOA computer procurement plan.

16. Other farming systems analysis should proceed in parallel. That is, SIMULATION modelling should be undertaken to examine biological processes with specialist researchers and spreadsheet-based budgeting

should be used in co-operation with OAE staff, or by an economist appointed to the FSRI. SIMULATION modelling should take advantage of the links already established between the FSRI and the University of Western Australia, with an evaluation of priorities for simulation. WADA staff, in particular Dr. Bill Bowden, could assist in this review.

GLOSSARY OF TERMS

ACTIVITIES: These are the variables in a MATHEMATICAL PROGRAMMING (MP) model. When the model is run, the combination and level of ACTIVITIES which will maximise/minimise the OBJECTIVE, while meeting the CONSTRAINTS, is selected. In the case of a wholefarm model, they represent alternative enterprises and alternative ways of running enterprises.

CONSTRAINTS: These are the equations in an MP model which limit the selection of ACTIVITIES to those which are feasible. In the case of a wholefarm model, this means that resource use has to be limited to the level of available resources (i.e. activities cannot use more than the available area of land or labour) and that the biological limitations of the farm must be accounted for.

EXPERT SYSTEM: This is a special kind of computer program designed to capture the decision rules and knowledge of an expert in a particular subject. A properly constructed EXPERT SYSTEM can provide the same kind of analysis as the expert or experts who were involved in its construction. In agriculture, for example, it has been used to help diagnose diseases in crops.

INDIVISIBILITY: In LINEAR PROGRAMMING (LP) the level of an ACTIVITY selected often does not equal a whole number. While this does not matter for some ACTIVITIES (e.g. 10.5 rai of rice may be selected) it may be unrealistic for some inputs such as machinery and livestock. Where it does matter, it may be necessary to use integer programming in combination with LP.

INTERDEPENDENCIES: The reason for modelling a whole farm is that a different answer is usually obtained when the whole farm is analysed than is obtained when only part of it is analysed. The reason for this is that the different parts of the farm are interdependent. The different enterprises use the same resources of land, labour and capital and they may also have further effects on each other, e.g. straw from the rice enterprise may be eaten by livestock, and legumes in rotation can increase yields in following corn and rice crops.

LINEAR PROGRAMMING (LP): The best known and most widely used form of MATHEMATICAL PROGRAMMING (MP). LP MODELS have in common an OBJECTIVE to be OPTIMISED, alternative ACTIVITIES to be evaluated in terms of the OBJECTIVE and CONSTRAINTS which limit the ACTIVITIES which can be selected. Using LP rather than the more sophisticated forms of MP, may mean that some simplifying assumptions have to be made about a farm system. If it is used skilfully, simplifying assumptions may be minor and of less concern than the problem of obtaining accurate data. The case for using LP is the great efficiency of OPTIMISATION and ease of use in relation to other forms of MATHEMATICAL PROGRAMMING.

MATHEMATICAL PROGRAMMING (MP): This is a broad class of mathematical techniques suited to representing different kinds of systems and computing an optimum solution for that system. For example, a farm system can be represented and a profit maximising strategy can be computed. LINEAR PROGRAMMING (LP) is the most widely used type of MP. Other forms of MP such as non-linear and integer programming can be very difficult to use and interpret.

LP MATRIX: A table representing LP OBJECTIVE, ACTIVITIES and CONSTRAINTS. ACTIVITIES are represented as columns and CONSTRAINTS as rows.

MODEL: A MODEL is a representation of something. In this report, MODEL commonly means a mathematical representation of a farming system using either MP or SIMULATION techniques.

MODEL DOCUMENTATION: This is a full description of a model so that all assumptions and data can be easily checked by someone who is not an expert in the modelling technique. It is essential that models are fully documented and that the documentation is widely circulated and reviewed.

MULTIPERIOD LINEAR PROGRAMMING: This is a version of LP in which time is represented as a number of discrete periods, rather than the single period of standard LP.

NON-LINEAR PROGRAMMING: A form of MP in which non-linear relationships can be represented exactly rather than the approximation used for them in LP. It is more difficult to run, less efficient at finding an optimum solution and more difficult to interpret than LP.

OBJECTIVES: In an MP model, this is something to be maximised or minimised. For farm models, the OBJECTIVE is commonly profit maximisation, cost minimisation or risk minimisation. In RISK PROGRAMMING the OBJECTIVES of maximising profit and minimising risk may both be accounted for.

OPTIMISATION: The procedure of computing which solution is 'best' in terms of the objective, e.g. the combination and level of ACTIVITIES which will maximise farm profit.

SHADOW COSTS: Output from an LP MODEL which shows how far other solutions are behind the OPTIMUM solution, e.g. in a rice farm it may show that high yielding rice is 7 baht/rai less profitable than the OPTIMUM native variety rice (see Appendix B).

SIMULATION: A modelling technique which is very flexible in representing some kinds of systems but not well suited to finding an optimum solution. It is well suited to representing biological processes in farming systems.

RISK PROGRAMMING: MP techniques which can account for the variation in season and price with which farming systems have to cope. As well as having an objective, such as profit maximisation, it will also have as an objective the minimisation of risk.

1: INTRODUCTION

The purpose of this consultancy is to strengthen farming systems research methodology in the Thai Department of Agriculture (DOA) and in particular, the Department's Farming Systems Research Institute (FSRI). It follows from:

(i) the consultancy of Martin (1984) who found that DOA staff were having difficulty working out how to analyse farming systems; and

(ii) the three month stay in Australia of Pairat Duangpiboon to introduce him to the modelling techniques used in the Western Australian Department of Agriculture to analyse farming systems.

Modelling skills are not easily learned. In Australia, agricultural systems researchers usually learn about analytical techniques in their undergraduate studies and apply them in post-graduate studies. Apart from Mr. Duangpiboon's brief stay in Australia, FSRI staff have had little training in methods for analysis of whole farms.

The objectives of this consultancy are to:

(i) Review FSRI progress and design a suitable training programme in farming systems analysis.

(ii) Conduct a course with emphasis on:
- the role of farming systems analysis in farming systems research and research co-ordination;
- the use of Thai data to demonstrate farming systems analysis principles;
- the hands-on participation by trainees in manipulation and analysis using Thai data.

(iii) Demonstrate farming systems analysis procedures to senior staff with emphasis on their relevance to allocation of research resources.

(iv) Present a brief evaluation of the training course's effectiveness, commenting on the present state of farming systems analysis in Thailand and making recommendations on the future needs of farming systems analysis in the Thai Department of Agriculture.

This report is to meet the last of the above requirements. It is an attempt to consider developments in farming systems analysis appropriate for the FSRI, for the DOA as a whole and for co-operation between the DOA and other organisations.

Firstly, the analytical approach is described, then its relevance to Thai farming systems is discussed and the resources available for whole-farm analysis in Thailand are reviewed.

Finally, directions for Thai farming systems analysis are suggested and recommendations are made.

2: WHOLEFARM SYSTEMS APPROACH

This section is a brief introduction to an approach to wholefarm systems analysis - reasons for it, the technique and description of a model building procedure.

2.1 Need for a quantitative wholefarm approach

Quantitative analysis of the wholefarm is an essential part of farming systems research. It is is not a panacea to cure all the problems of farming systems research but a way of improving farming systems research, thereby giving direction in the allocation of research resources and the development of extension policies. It provides direction for farming systems research and a purpose for data collection. It necessitates a multi-disciplinary approach and requires an explicit statement of all assumptions. It forces specialists to consider their work in a wider perspective.

The farm can be analysed at many different levels; the wholefarm, the enterprise, a single organism, part of an organism, etc. The wholefarm level is the most important level in terms of the farmer's objectives and for decision-making. If farming systems researchers are to conduct wholefarm analyses, they need to be concerned about the objectives of farmers, the farm's resources, alternative uses of farm resources, interdependencies between different parts of the farm, relationships between inputs and outputs, costs paid and prices received, and they need to be able to consider all these things simultaneously. The human mind can qualitatively consider relevant information about the wholefarm, but it cannot quantitatively analyse the wholefarm system.

2.2 Farm modelling and modelling technique

Computer models can be used to analyse a farming system quantitatively. They are called models because they represent a system, in this case a farm system. They cannot represent a farm exactly but good models represent it well enough to produce credible and useful answers to questions about the farm system.

There are many different kinds of models, but those which are used for most farm modelling are SIMULATION and MATHEMATICAL PROGRAMMING (MP). SIMULATION is very good for representing biological processes. For example, it may be used to compute how rice will grow on a daily basis as a result of different levels of inputs. It is not so well suited to whole-farm economic analysis and is an inefficient method to find strategies which will best meet farmer objectives.

LINEAR PROGRAMMING is the most widely used form of MP. It is not as flexible as simulation for modelling biological processes but it efficiently finds the strategies which will best meet farmer objectives and it is better suited to whole-farm economic analysis.

LP models have three parts:

- an OBJECTIVE which can be either maximised or minimised. For a farm, this would be maximise profit or minimise cost or minimise risk.

- CONSTRAINTS which limit the level of achievement of the OBJECTIVE. In a farm model these would include the limited farm resources of land, labour and capital, and representations of biological CONSTRAINTS to production.

CONSTRAINTS should also include specification of the interdependencies between different practices and the different parts of the farm. For example, the yield of a crop may depend on the previous use of the land, while the labour available to service one crop will be effected by the other demands on labour at that time.

- ACTIVITIES which can represent the alternative enterprises and practices which a farmer could adopt. As well as the established alternatives, these can include new or proposed farm practices. A table representing these parts is referred to as an LP MATRIX.

Computer runs of LP models find the combination of ACTIVITIES and the level of each ACTIVITY to maximise/minimise an OBJECTIVE while meeting all CONSTRAINTS. This may be, for example, that the following maximises profit: five rai of long-stem rice on flooded land and ten rai of high-yielding rice, with 20 kg of fertiliser per rai, on low land, and five rai of a corn/mung bean rotation. Computer output from an LP model will also specify how far alternative enterprises and practices are behind the best combination. For an example of LP output see Appendix C.

Thus MP has advantages and disadvantages as a technique for farm modelling. These are summarised in the following table:

Table 1: Advantages and disadvantages of linear programming (LP) for farm modelling

Advantages	Disadvantages
Very efficient at finding a 'best' solution.	Inflexibility - unable to represent accurately some biological processes as precisely as simulation.
Provides information on closeness of other options to 'best'.	
Suited to representing a whole-farm: Farmer objectives; limited resources; interdependencies; and the alternative enterprises and practices.	

The inflexibility of LP is often over-stated. In the hands of an experienced LP modeller, the technique can be quite flexible; non-linear relationships can be closely approximated, time can be represented in multi-period LP, variability of price and season can be accounted for, objectives other than profit maximisation can be represented and the indivisibility of some inputs can be represented by integer programming in combination with LP (see Morrison *et al*., 1986, for examples of this flexibility). Limitations of LP are usually less of a problem than the limitations of the model builder's skills and the data used. There is less reason for concern about the flexibility of LP at the wholefarm level where biological detail is less important than for an analysis of a single enterprise. Because they have different strengths and weaknesses, LP and SIMULATION are complementary, with LP being well suited to a whole-farm economic analysis which includes representation of some biological relationships and SIMULATION representing biological processes at the farm enterprise and lower levels.

2.3 Model building procedure

Building a good wholefarm model is a difficult and time consuming task, requiring input from people of different disciplines. Modelling a complex farming system should include the following steps:

2.3.1 Define the farming system to be modelled - the type of farm and the region of which it is representative.

2.3.2 Identify the following through discussions with a variety of research and extension people, farmers and others experienced in this farming system:

- Farmer OBJECTIVE(S) and preferences.

- Resources available for production such as land, labour, machinery and credit (resource CONSTRAINTS). Where a resource is not of uniform quality, the distinction must be made (e.g. different land classifications, labour of different characteristics, credit sources at different interest rates).

- Interdependencies and biological relationships (e.g. crop response to fertiliser) which are important at the wholefarm level.

- Alternative enterprises which the farmer can conduct (for each soil type) and alternative ways of running those enterprises (ACTIVITIES).

2.3.3 Use the information from 2.3.2 to outline the model's structure. That is, specify the OBJECTIVE to be maximised, or minimised ACTIVITIES and CONSTRAINTS of the model in LP matrix form. This structure will determine the data requirements of the model.

2.3.4 Complete the LP MATRIX by collecting and entering necessary data for a typical farm in the region. This includes data on the level of resources, the use of resources by ACTIVITIES, the relationships between inputs and outputs, interdependencies and the relationship of ACTIVITIES to the OBJECTIVE. (This will be costs and prices if the objective is profit maximisation).

2.3.5 Document all data and assumptions used in the collection or calculation of the data. It is essential that the data are fully documented in such a way that they can be checked by anybody interested in model results. Data may have to be collected from a number of sources. Where experimental plot data are used rather than on-farm sources, it may be appropriate to adjust yields slightly downwards. Where prices and costs are being collected, it is appropriate to involve economists, especially where the concern is future costs and prices.

2.3.6 Run the model, check results and correct the model for obvious errors.

2.3.7 Circulate the first apparently sensible model output and documentation amongst those who are experts on this farming system (e.g. farming systems researchers, research agronomists, soil scientists, animal production scientists, economists, farmers). Encourage critical review by these experts and ask them to:

- identify any results they do not expect. Although the unexpected solution may be better than the one expected by the expert, this is a good check for model errors or inadequacies;

- reconsider, in the light of model results, whether there is anything which has not been included but

which could have a significant effect at the wholefarm level, e.g. a farmer OBJECTIVE, an alternative farm practice, a limited farm resource, or important biological relationships which have not been represented;

- criticise the data and provide better data wherever possible.

2.3.8 Modify the model and its documentation in the light of 2.3.6. It will probably not be desirable to include everything that is suggested and there may be a need to decide which data or estimates should be used. These issues are best resolved by round table discussions with experts and potential users of model results.

It is desirable to encourage the involvement of others who are expert in the farming system. The involvement should be to the extent that people have a stake in the model and feel that it is 'theirs'. The modellers may have to argue the case for keeping things out of the model, only relenting where a very strong case is made for inclusion. This is because the bigger the model is, the more costly it will be to develop and run, the longer before it is can be used and the greater the chance of error.

2.3.9 Repeat the process - run the new version of the model and circulate output and documentation (as in 2.3.6 above) and modify model (as in 2.3.7 above).

After a number of revisions (which may take up to 18 months) the model should be good enough to be credible to all those involved in the project. Even then, this review process should be continued - as long as the model is used, it should be critically examined and

improved where change is warranted. This will mean that it will evolve.

Where model building or model review shows that there are important data gaps, then it is a valuable function of the systems analyst to identify the information needed, and experimentats or surveys should be employed to find those data. In the meantime, the best 'subjective' estimates should be used but with sensitivity analysis to test the robustness of the answer to varying the estimates over the plausible range.

When the model is used, shadow costs should be examined to see how far behind alternative practices are and it may be appropriate to conduct range and sensitivity analysis. Where a particular aspect of the farm system is being looked at in detail, a series of model runs can be used to investigate a particular question in the wholefarm context. Examples of this include use of the MIDAS farm model to estimate:

- the value of a new crop (Ewing et al., 1986)
- the profitability of alternative livestock management practices (Falconer and Morrison, 1987)
- the likely value of alternative directions for pasture research (Ewing and Pannell, 1986).

The model must be run to represent different resource levels and input/output relationships of a range of farm types in a region (e.g. to represent a farm with different areas of soil types, different amounts of family labour, or labour productivity which is different from the representative farm).

3: RELEVANCE TO THAI AGRICULTURAL SYSTEMS

.1 Wholefarm systems analysis is as relevant to Thai farming systems as it is to other farming systems. There is a need for farming systems research based on the approach described in Section 2 to address questions about directions that specialist research work should take and to provide an analytical tool to help decide extension messages. The kinds of questions models could be used to address from the wholefarm point of view are:

- Does a new high yielding, but high input (labour, fertiliser, irrigation) variety of rice fit into the best use of farm resources? Alternatively, what yield do plant breeders need to achieve with a new variety before it is worth growing the new variety?

- Is it worthwhile for farmers to grow a new tree crop (e.g. mangoes) and if so, over what area?

- How valuable are new types of labour-saving machinery?

Wholefarm modelling in Thailand using LP could provide a focus for farm systems research and a purpose for data collection.

Modelling Thai farming systems is not easy. The complexity of most Thai farming systems means that it is difficult to represent them accurately. From my recent exposure to Thai farming systems (mainly Suphanburi lowland), I can see that care is required in representing the following:

- <u>Farm labour</u>
  This is a crucial resource in Thai agriculture so that it needs to be represented in detail. It

should be represented monthly for most of the year and at peak times it may need to be represented weekly. Family labour probably should not be represented as homogeneous as its productivity and the tasks it can perform will depend upon the age and perhaps the sex of family members. The wage received for off-farm work and the cost of hiring labour may vary seasonally. While it can be easily represented in LP form, it will need to take up many activities and constraints in the model.

- <u>Cash flow</u>
  This should probably be represented monthly with allowance for different sources of credit at different interest rates and with different borrowing limits. Cash flow coefficients need not be duplicated in the objective function but can be represented once.

- <u>Market uncertainties for products sold</u>
  This may require the assistance of an economist to help with the assessment of the future prices of commodities, especially where a product is largely sold on the price-inelastic domestic market. Sensitivity analysis and possibly even risk programming may be required.

- <u>Time</u>
  This is important in an investment such as planting mango or cashew trees, where major costs are incurred in early years while there is no product to be sold. A particular cause for concern in these kinds of investment is the way the market for a product can change between the decision to invest and the investment coming on-stream. This is particularly so for a product sold on the domestic market in a situation where many farmers are

expanding production of this crop. Multi-period LP can be used to represent time and the input of an economist can help with market outlook.

- <u>Farmer OBJECTIVES other than profit maximisation</u>
  It may be necessary to represent a farmer's concern with minimising risk or at least having enough rice to eat in a worst season, or growing a crop for preferences not represented in the model. The Suphanburi model assembled during the course (Attachment A) includes the second of these OBJECTIVES (represented as a CONSTRAINT) in addition to profit maximisation. Where a farmer has a preference for growing a crop that neither adds to profit nor is necessary for home consumption, the model can be used to show the income foregone as a result of that preference.

- <u>Seasonal variability</u>
  In order to represent this fully, it requires use of some risk programming techniques.

- <u>Many diverse farms</u>
  It is not possible to build a model of every Thai farm; however, a farm which is typical of a region can be modelled and other farm types in that region can be represented by modifying this model. This requires the definition of a region, careful selection of a representative farm and a decision as to how many different variations of that representative farm need to be modelled if the analysis is to be relevant to all farms. These matters can be looked at statistically but inevitably involve some judgement.

- <u>Interpretation of results</u>
  Assumptions of the technique, treatment of time in the model and data inadequacies mean that skill is

required in the interpretation of output. This skill can only come with good training and experience.

- <u>Diverse activities within farms</u>
  These activities are often small-scale involving, for example, opportunistic grazing of animals of different kinds. Data on these ACTIVITIES seem limited, making it difficult to represent them accurately.

4: PRESENT STATUS OF WHOLEFARM MODELLING IN THAILAND

Whole-farm modelling using LP is sophisticated research. A fundamental issue to consider in this consultancy is whether it is an appropriate technology for Thailand. As discussed in the previous sections, I have no doubt about the value of the technique and its relevance to Thai agriculture, but to be successfully implemented, it will require good co-operation between people of different disciplines and considerable skill to build, run and interpret model results. It is therefore important to consider the level of expertise in farm modelling in Thailand and the opportunity for and likelihood of co-operation.

4.1 The course

The course gave me a good opportunity to help develop and to observe the modelling skills of participants (for an outline of the course, see Appendix A). The participants had very different backgrounds in terms of exposure to modelling, computing and English. This made it difficult to present a course at a level which was relevant to everyone.

The modelling skills of some participants developed rapidly throughout the course, in particular those of Kamol Ngamsomsuki from Chiang Mia University. Pairat Duangpiboon, because of his previous background, had some competence in wholefarm modelling and this developed further during the course. His ability to work hard and his dedication mean that he can make a useful contribution to wholefarm modelling in Thailand. Others whose performance on the course was noteworthy was Wina from FSRI, who participated well and appeared to learn quite quickly; Rattana Sungsittnisawad, who teaches LP at Songkla University; Pawini from FSRI, who appeared to understand some of the techniques used and

Pairat's assistant, who worked well despite her lack of English. The others co-operated well but communicated very little with me during the course, and it was difficult to assess their progress.

The modelling skills of participants are not yet comparable with those of the people who have initiated the wholefarm modelling in Australia. This is to be expected, given that Australian farm modellers have usually received a large amount of training relevant to farm modelling, including honours and post-graduate experience with modelling techniques.

During the course, participants built a model representative of a Suphanburi lowland farm. The exercise was successful but this version of the model can only be viewed as a starting point for wholefarm modelling. It is at about the start of stage 4 in the procedure for model development that is outlined in section 2. The MATRIX is shown in Attachment C.

4.2 Resources which could contribute to farm modelling

The following is a brief review of the potential resources for wholefarm modelling in Thailand, as I have assessed them during my brief stay:

(i) The Farming Systems Research Institute (FSRI): As discussed above, staff have some modelling skills as a result of the course and previous training of Pairat Duangpiboon. Mr. Vichien Sasiprapa, Pairat Duangpiboon's boss at Suphanburi, seems to have some understanding of wholefarm modelling and to support continuation of the work at Suphanburi. The Director of FSRI, Mr. Chanuan Ratawarhana, has a general understanding of the technique. Amongst FSRI staff there were obvious disagreements about the accuracy of different sources of data. If the

disagreements promote debate about data, then that could provide better data for farm modelling; however, it is important that the disagreements do not lead to negative criticism and a lack of co-operation.

The FSRI is an obvious place to base wholefarm modelling research. This is because:

- Unlike other institutes and departments, the FSRI's charter is to research the wholefarm, rather than being confined to any one discipline.

- In the absence of an analytical tool for the wholefarm, FSRI research may lack focus.

- FSRI staff have some modelling skills, although it is highly desirable that they be enhanced by co-operation with other organisations and the further education of staff (see below).

(ii) Other sections of the Department of Agriculture: Although I had little time to meet them, other researchers should contribute to whole-farm modelling because of their expert knowledge about parts of the farm, and because they can benefit as users of model results. If they are to be users of model results, they need to understand and have confidence in its inputs. Their contribution should be by reviewing sections of the model and in return receiving information on how their work fits into the wholefarm, and how much it contributes to or could contribute to the wholefarm objective. Thus, for example, staff from the Rice Research Institute could review the input/output relationships assumed in the model for each rice

variety on each soil type. In turn, they should be provided with model results showing the rice activities selected in the optimum solution and shadow costs on rice activities.

(iii) University staff

Although I found little or no wholefarm modelling projects currently underway at the universities, there are some highly qualified and enthusiastic staff in the farming systems and agricultural economics sections at Chiang Mai and Khon Kaen Universities. Some, mainly at Chiang Mai, were familiar with LP and although they have not built sophisticated wholefarm models, they have a general understanding of modelling techniques. Because of this and the interest and aptitude shown by Kamol Ngamsomsuki on the course, and his ready rapport with Pairat Duangpiboon, there is a good opportunity for joint research between the FSRI and Chiang Mai University. The University staff's contribution could be particularly valuable in helping to add more complex components to the model and checking the theoretical soundness of the work and the validity of the interpretation of results. There should be opportunities to publish descriptions of the models and examples of their application.

At Khon Kaen University, I was impressed with their enthusiasm to find a tool for quantitative wholefarm analysis. They expressed an interest in applying EXPERT SYSTEMS at the wholefarm level. This is an interesting suggestion, although my understanding of EXPERT SYSTEMS leads me to believe it is not as suitable a tool as LP for wholefarm analysis because:

- it has most successfully been used for problems of diagnosis applied to part of a farming system;

- unlike an LP model, an EXPERT SYSTEM is designed to copy the decision processes of the human expert, so that it can substitute for an expert or experts. It cannot offer any different analysis from the expert or experts used in its creation. LP models, although created by experts, simultaneously account for a large amount of data describing the farm system and compute 'best' solutions - something the human mind cannot do.

One of the economists at Khon Kaen University had some experience with LP and had used partial budgeting widely. She also appeared to have a good understanding of the complexity of the farm labour resource and would be a suitable person to comment on this aspect of wholefarm models.

(iv) Office of Agricultural Economics (OAE)
Staff here have experience with wholefarm LP. The farm models that I have seen of theirs are about as sophisticated as the one developed over the course at Suphanburi, but they are clearly more experienced in LP than FSRI staff. They have the skills to make an important contribution to wholefarm modelling in the following areas:

- Providing expert advice in some aspects of model building and model running.

- Providing an economic input to the project, particularly estimation of activity costs and estimation of the future selling price of products.

An example of the need for their input is the issue previously raised about which price to assume for a product such as mangoes (Section 3). Obviously OAE staff will never predict future prices perfectly, but they are likely to make a better estimate than FSRI staff can by themselves.

(v) Department of Agricultural Extension (DOAE)
I did not have the opportunity to contact staff from this organisation but through their close contact with farmers, they are likely to have the background to make useful comments on the model and model output. In Australia the use of LP has acted as a very effective means of improving co-operation between extension and research, by focussing on their common interest in the farming system.

(vi) Farmers
Farmers have always had to think about the wholefarm system and thus will make some of the most valuable comments on the model and model results. Good wholefarm models cannot be built without talking to farmers, asking them about their objectives and preferences and seeking criticisms of early results and some assumptions. This involvement may be limited by Thai cultural traditions and the lack of effective liaison between the DOA and the DOAE, but the FSRI at Suphanburi obviously has a good relationship with some farmers.

(vii) Others
Other people and organisations who could contribute or whose work is relevant to wholefarm modelling in Thailand are the consulting firms Coffee and Partners and ACIL, Dr. Larry

Harrington, IRRI, overseas universities and my Branch at the Western Australian Department of Agriculture.

- ACIL and Coffee and Partners conducted a study in which they built a series of LP models of farms in the Pitchit area. These models are fairly simple and well documented (Feldman, 1986) and would be easily understood by most FSRI staff who attended the course. They would be a good starting point for future work in the Pitchit area.

- Dr. Harrington, although not using wholefarm modelling, has conducted wholefarm analysis using partial budgeting and a methodology similar to that outlined by Perrin et al. (1983). This makes him a useful resource person for farm systems analysis.

- Overseas universities are likely to provide the opportunity for relevant post-graduate research into wholefarm modelling which could be of benefit to FSRI staff. The University of Western Australia's Department of Agricultural Economics could provide good post-graduate training.

- The Economic Analysis Branch at the Western Australian Department of Agriculture has considerable experience with wholefarm modelling and, since my trip to Thailand, we have some understanding of Thai farming systems. Postal requests for advice and problem solving can be sent to me, and I may be returning to Thailand to review progress in the next year or so and would be available to review progress.

- IRRI has a strong agricultural economics group and it is likely that they have produced publications relevant to wholefarm modelling in Thailand.

5: WHERE TO FROM HERE?

From the foregoing, I consider that wholefarm modelling would be of value to Thai agriculture, that there is sufficient expertise available for wholefarm modelling research to be successful, and that it is therefore worthwhile for it to be tried properly. It is also logical to base this work in the FSRI because it is concerned with wholefarm research rather than researching part of the farming system, and because quantitative methods for wholefarm analysis are an important focus for farming systems research.

<u>But</u>, if wholefarm modelling is to be successfully implemented, attention needs to be paid to the following:

- <u>Concentration of resources</u>
  Initially it is a good strategy to concentrate resources on an achievable modelling project rather than to spread resources too thinly. A single region could be represented initially, requiring the full-time commitment of only a few staff. When this has been proven successful, more resources could be allocated to modelling projects in other areas.

- <u>Farming region and type</u>
  A farming region and farm type need to be selected. Suphanburi lowland farming is probably the best system to start with, given the work of Pairat Duangpiboon and the work done on the training course, although modelling work carried out in Pitchit Province (Feldman, 1986) by the OAE and the Universities at Chiang Mai and Kohn Kaen means that there is a start to modelling in other locations. The next best option to Suphanburi is probably Chiang Mai, because of the modelling expertise at the University and the rapport between Pairat Duangpiboon and Kamol Ngamsomsuki.

- <u>Model building procedure including model review and modification</u>

  This should follow the steps outlined in section 2. If the Suphanburi lowland farm type is chosen, then the modelling procedure is already at the beginning of stage 4 in section 2.

- <u>Involvement of others in data specification and model review</u>

  The success of the project depends upon the involvement of a broad range of people. It needs to be multi-disciplinary. Firstly there should be two or three FSRI staff working full-time on the project, with part-time co-operation from other FSRI staff, involvement of people with specialist knowledge of the farm system being studied (other DOA research staff, OAE staff) and the involvement of extension workers and farmers. Incentives which may encourage such involvement are the opportunity for joint publication of the models and model results, and recognition by the specialists of the usefulness of this analysis to their work.

- <u>Priority of wholefarm modelling work</u>

  The FSRI and DOA need to define wholefarm modelling as a legitimate and high priority function of the FSRI and to identify where it will be carried out in the FSRI structure. Strong leadership commitment to the project is required to ensure co-operation and that the work is given a high priority, especially at the senior levels of the FSRI and the DOA. There is good reason for this to be forthcoming because this project can give the FSRI a better focus for their work and clearly establish them as having an important research role. The product of their research will be better information and it should soon be recognised that this can be just as valuable as the output from more traditional research. Leadership

support for co-operation with the OAE and the Universities' farming systems units is also desirable.

- <u>Use of appropriate computer hardware and software</u>

  Computer hardware is no longer a problem for wholefarm modelling - it is now possible to buy a microcomputer which is powerful enough to run large-scale LP problems so that computer hardware will be adequate if there is one 640K IBM or IBM clone with a hard disk, for each person working on the project. (Note that the good clones seem to be as good as IBM's and they are much cheaper).

  There is a need to be concerned with computer software as LP models become more complex. GULP, the program at present used by FSRI staff, is easy to use and excellent for teaching. As models become much larger than the one assembled for Suphanburi, GULP will be inadequate and will start to produce answers that are first of all slightly wrong, then greatly in error. As a rule of thumb, there is a need to be cautious with GULP as the number of activities approaches 100 and the number of constraints approaches 85. LP88, a program which has already been purchased by the OAE and Universities, appears to include the necessary mathematical procedures to avoid such errors for moderately large models. Where the models exceed about 1000 activities and/or 255 constraints, the capacity of LP88 is exceeded and a still more sophisticated program, such as AESOP, is required.

- <u>Modelling challenges</u>

  There are a number of challenges facing those who build models of Thai farms. I have suggested some in section 3. They can all be overcome but to ensure that they are, I suggest the following:

- That FSRI staff working on wholefarm models read publications relevant to modelling Thai farming systems. Publications by IRRI, agricultural systems journals and some agricultural economics journals should be reviewed. At a more applied level, FSRI staff should be aware of the farm modelling work by Feldman (1986), the universities and the OAE.

- Collaboration with others in development of modelling techniques and output interpretation. Those organisations which have the necessary skills to make a useful joint contribution are Chiang Mai University, the OAE and Kohn Kaen University. Because of the modelling background of Chiang Mai farming systems staff and the co-operation between Kamol Ngamsomsuki and Pairat Duangpiboon, collaboration with Chiang Mai University should be fostered. Also the OAE has useful skills to contribute, but in the past there appear to have been barriers to co-operation between the OAE and the DOA. Efforts should be made to remove these barriers.

- Post-graduate training of some FSRI staff in wholefarm modelling should be undertaken. Such training would mean that FSRI would have staff with a strong theoretical understanding of the modelling, who are able to deal with difficult model building problems and assess the strengths and limitations of the models. FSRI staff would then not have to rely on any outsiders for these skills.

I think it is desirable for the WADA Economic Analysis Branch to have a small, ongoing involvement in the project, assessing progress and working out ways to model other important aspects of the farming system. This contribution would be mainly by correspondence and

contribution should be phased out once there is effective collaboration with Chiang Mai University and/or the OAE and as FSRI staff improve their modelling skills.

While proceeding with the wholefarm modelling, the FSRI should also use other techniques for farming systems analysis:

(i) SIMULATION should be used at the level of the farm enterprise; it should complement wholefarm analysis, providing information for wholefarm models and providing a greater understanding of biological processes. There are several groups with relevant expertise in the use of simulation at the WADA and the School of Agriculture at the University of Western Australia (UWA). Those at the UWA already have links with the FSRI through post-graduate training. This link should be maintained and priorities for simulation assessed. Dr. Bill Bowden at the WADA is an experienced farming systems analyst with considerable experience modelling biological relationships in agriculture, who may be worth involving in future.

(ii) Farm budgeting, based on spreadsheets run on micro-computers, is also a useful tool for whole-farm analysis. Although not as powerful a tool as wholefarm modelling, when properly applied it is a valid way of investigating the contribution of a new technology to farm profit. It has the advantage of being more easily understood by users who are inexperienced in modelling. There are people within Thailand, although not at the FSRI (e.g. Dr. Harrington, OAE), who are extremely competent at partial budgeting. It would be best applied by either joint work between FSRI and the OAE, or by the introduction of an economist to the OAE. Lotus type spreadsheet software would be suitable for this kind of analysis.

REFERENCES

Ewing, M.A. and Pannell, D.J. (1985). Development of regional pasture research priorities using mathematical programming. In: Proceedings of a Review Conference on Pasture Research in Southern Australia.

Ewing, M.A. Pannell, D.J. and Morrison, D.A. (1986). The place of lupins in the farm rotation: a wholefarm modelling approach. Proceedings of the International Lupins Conference, Geraldton, Western Australia.

Falconer, D.A. and Morrison, D.A. (1987). Lambing time. In: MIDAS, a bioeconomic model of a dryland farm system. Kingwell, R.S. and Pannell, D.J. Eds. Pudoc, Wageningen.

Feldman, D. (1986). The economics of cropping systems in the Pitchit land reform area. A joint consultancy by Coffee and Partners Pty. Ltd. and ACIL Australia Pty. Ltd. for the Agricultural Land Reform Office, Ministry of Agriculture, Thailand.

Martin, B.R. (1984). Farming systems analysts in the Thai Department of Agriculture. Report on consultancy to the ACNARP project.

Morrison, D.A., Kingwell, R.S., Pannell, D.J. and Ewing, M.A. (1986). A mathematical model of a crop-livestock farm system. Agricultural Systems 20 No. 4 pp. 243-268.

Perrin, R.K., Winkelman, D.L., Moscardi, E.R. and Anderson, J.R. (1983). From agronomic data to farm recommendations: An economics training manual. Information Bulletin 27, International Maize and Wheat Improvement Centre, Mexico.

APPENDIX A - COURSE OUTLINE

The course was based on three things: a series of lectures on farming systems analysis, LP model building and output interpretation; exercises building, running and interpreting Thai examples of LP models; and building a model of a lowland farming system at Suphanburi.

Day 1: Lectures on farming systems and the need for a quantitative approach. Lecture to introduce LP. An exercise building and running a very simple LP model of a Thai farming system. Interpretation of optimal activities in the output.

Day 2: Least-cost rations exercise. Lecture on interpretation of other parts of the output - shadow costs, shadow prices, range analysis and sensitivity analysis. Exercises in interpretation of full output and sensitivity analysis.

Day 3: Lecture on how to build transfer rows, rotations, commodity selling activities, labour buying and selling activities, and input/output relations into an LP model. Exercises to practise building these into models.

Day 4: Lecture and exercises on representation of segmented approximation of non-linear relationships, cash flow and household rice requirements. LP exercise comparing high-yielding variety rice with native varieties. Commencement of project to model the Suphanburi lowland farming system.

Day 5: Suphanburi lowland modelling project. Defining objectives, activities and constraints. Farm visit to ask farmer questions about the lowland farming system and his objectives.

<u>Day 6</u>: Development of Suphanburi lowland model structure. Tuition on more advanced LP - multi-period LP (for some students only) and an introduction to risk programming.

<u>Day 7</u>: Completion of first version of model structure. Collect necessary data and start entering into matrix. Lesson to more advanced students on a more sophisticated representation of cash flow. Completion of first rough version of lowland model and first model runs.

<u>Day 8</u>: Crash course for senior FSRI staff. Continued work on lowland model - checking, revision and review of data.

<u>Day 9</u>: Model revision. Inclusion of a rudimentary risk constraint. Running revised model. Lecture on limitations of LP models and interpretation of lowland model.

APPENDIX B

SAMPLE OUTPUT FROM AN LP RUN

The following tables are an example of LP output from an exercise in the course. It is the full LP output showing the optimum solution, shadow price, shadow cost and range analysis.

It can be interpreted as follows. There are two tables headed ACTIVITIES and CONSTRAINTS. Under the heading ACTIVITIES the names of activities are listed under the sub-heading 'Name' and the levels at which the activities are selected in the optimum solution are listed under the sub-heading 'Level'. For example, reference to the ACTIVITY and level shows that 25 rai of rice and about 4.4 rai of irrigated rice are selected in the optimum solution. To do this, seven units of irrigation water are required (the irrigate activity) and 35 units of labour would have to be hired at the peak period (Labbuypk), while surplus labour is sold at other times of the year (Labsel). A zero level for an activity means that it is not selected in the optimum solution.

Shadow costs indicate, for activities which are not selected, how many baht/rai they are behind those selected. Thus the high yielding variety irrigated rice (HYIric1) is about seven baht/rai behind the irrigated ordinary variety rice (irr.rice). Lower and upper 'obj' show at what point the optimum solution would change. This ACTIVITY 1, rice (unirrigated) is selected but if the costs of this activity were 225 baht/rai (instead of 211), less rice would be selected. INFINITY indicates that the plain will not change for any cost less than 211 baht/rai.

The table headed CONSTRAINTS indicates the status of constraints in the optimum solution. Under the heading Slack

a zero indicates that the constraint is fully used up. For example, all non-irrigated land is used up. Under the heading Shadow price, the number shows the value of an extra unit of that constraint. For example, it shows that an extra unit of non-irrigated land (non-irr.la) would be worth 14 baht/rai/year. Also, an extra unit of water is worth 53.5 baht/thousand cubic metres (water lim.). The slack for credit indicates that the credit limit has not been fully utilised and that 5112 baht of the credit limit are unused.

Optimal solution

Problem name: TEACHSUP.1
Problem direction: MAX
Objective function value: 12544.6 Baht
Number of iterations: 12

ACTIVITIES

No	Name		Level	Shadow cost	Lower Obj.	Objective	Upper Obj.
1	rice	A	25.0000	0.0000	-225.0000	-211.0000	INFINITY
2	irr.rice	A	4.3860	0.0000	-545.6000	-540.0000	INFINITY
3	HYIric1	Z	0.0000	7.0175	-INFINITY	-560.0000	-552.9825
4	HYIric2	Z	0.0000	13.7719	-INFINITY	-610.0000	-596.2281
5	HYIric3	Z	0.0000	90.5263	-INFINITY	-660.0000	-569.4737
6	corn	Z	0.0000	127.0000	-INFINITY	-230.0000	-103.0000
7	soy	Z	0.0000	164.0000	-INFINITY	-290.0000	-126.0000
8	mungric	Z	0.0000	11.5895	-INFINITY	-860.0000	-848.4105
9	mung irr.	Z	0.0000	213.7544	-INFINITY	-275.0000	-61.2456
10	irrigate	A	7.0000	0.0000	-153.5088	-100.0000	INFINITY
11	labselpk	Z	0.0000	6.0000	-INFINITY	29.0000	35.0000
12	labsel	A	234.2105	0.0000	18.7791	20.0000	21.7500
13	labbuypk	A	35.0877	0.0000	-38.5000	-35.0000	-33.2778
14	labbuy	Z	0.0000	15.0000	-INFINITY	-35.0000	-20.0000
15	sell-rice	A	8300.8772	0.0000	2.0440	2.1000	2.2486
16	sell corn	D	0.0000	0.0000	0.0000	1.7400	2.1633
17	sell-soy	D	0.0000	0.0000	0.0000	5.9000	7.5400
18	sell mung	D	0.0000	0.0000	0.0000	6.1300	6.2588
19	eat rice	A	800.0000	0.0000	-INFINITY	0.0000	2.1000

CONSTRAINTS

No	Name		Slack	Shadow price	Lower Lim.	Limit	Upper Lim.
1	irr.land	L	2.6140	0.0000	4.3860	7.0000	INFINITY
2	non-irr.la	L	0.0000	14.0000	16.2281	25.0000	35.0053
3	lab pkdj	L	0.0000	35.0000	-46.0777	100.0000	135.0877
4	labour	L	0.0000	20.0000	265.7895	500.0000	INFINITY
5	credit	L	5112.7193	0.0000	4887.2807	10000.0000	INFINITY
6	water req.	L	0.0000	153.5088	-7.0000	0.0000	4.1720
7	water lim.	L	0.0000	53.5088	0.0000	7.0000	11.1720
8	rice tr	L	0.0000	2.1000	-8300.8772	0.0000	INFINITY
9	corn tr	L	0.0000	1.7400	-0.0000	0.0000	INFINITY
10	soy tr	L	0.0000	5.9000	-0.0000	0.0000	INFINITY
11	mung tr	L	0.0000	6.1300	-0.0000	0.0000	INFINITY
12	need rice	G	0.0000	-2.1000	0.0000	800.0000	9100.8772