Analysis of Farming Systems Issues in the Northern Cropping Region of NSW

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Abstract:

A number of farming systems projects are currently being conducted in the north eastern cropping region of Australia. These are jointly funded by the grains industry and state government R&D agencies, and conducted by the latter with some involvement of private industry. The issues which were the genesis of these projects are basically technological (ie productivity-enhancement) to maintain or improve farm income over time, and environmental to redress natural resource degradation associated with the current system. This paper is concerned with the analysis of results from these projects to provide information which helps grain growers in making decisions. In particular, we aim to consider the issues to be analysed and the characteristics of the systems involved in deciding the type of economic analysis to be conducted for these projects. Characteristics of farm production systems in the region include complexity, variability and dynamics, particularly in terms of tactical decision making. The most appropriate methods of analysis need to be carefully considered, but there is a rich history of experience to draw from in these choices.

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1. Introduction

The agricultural research and development process is broadly aimed at improving the understanding of the use of natural, technical, financial and human resources in commercial agricultural enterprises. Among a number of possible failures in the current developed system is a lack of knowledge about the consequences of management actions, in conjunction with variable climatic events, for both economic and resource outcomes. For instance, does the use of a new variety, tillage method, herbicide or fertiliser level lead to changes in financial returns and to beneficial or detrimental resource/environmental outcomes? The aim of this paper is to consider the issues and types of farming systems for the northern cropping region as a basis for deciding what type of economic analysis will be appropriate for a number of current farming system projects.

Agricultural research and development (R&D) is aimed at improving our understanding of biology so that 'better' decisions can be made. However, to achieve these outcomes the knowledge generated must be transferred to decision makers in a relevant context. In the end, information generated by R&D processes must be useful in making decisions, when these are made to improve the financial return to the commercial farm business. Although other incentives (eg environmental concerns) can be important in raising awareness of issues, farm decisions are based primarily on financial implications.

Based on the above premises, there are at least two distinct roles for economic analysis in the R&D process. One role includes providing direction to the R&D program, and cost-benefit evaluations (both *ex ante* and *ex post*) can be used for this purpose. The second and related role involves ensuring that the recommendations made or information provided is likely to lead to an improved financial and/or environmental outcome for the appropriate decision-makers.

There are three important implications of these roles. One is that the framework or basis for decision making and economic analysis is assumed to be profit maximisation. We argue that the relevant time frame is also important, ie there may be a need to distinguish between short-term profit maximisation and longer-term wealth maximisation. Profit maximisation in these terms refers to the aim of obtaining enough profit from the farm business to meet the goals of the farmer. These might include continuing farming, maintaining and improving farm resources, having a suitable quality of life, to obtain a suitable return on capital of the business, even to make enough money to pursue non-farm interests (Makeham and Malcolm, 1993).

The second is that there is usually a target group or audience at which the R&D results are aimed. The target group identified is one which has relative homogeneity with respect to key characteristics and for which consistent recommendations can be made. The issues that are of concern to this group are the driving force for the type of analysis that is conducted.

The third implication is that in drawing recommendations for management from R&D about those issues, the existing farming methods of that target group need to be considered. It is hypothesised that the characteristics and constraints of the typical farm of the target group have important implications for the management strategies that maximise returns. Therefore we must consider the farming system when conducting economic analyses of R&D results for the purpose of making recommendations.

In this paper, the implications above are considered in more detail for the northern cropping region of NSW. If we accept profit maximisation as a primary motivating force of commercial agricultural systems, then the paper concentrates on:

- defining relevant target groups;
- identifying the important issues and the farming systems associated with these groups; and
- drawing out some implications derived from the issues defined within the farming system, for the type of economic analysis necessary to develop relevant management recommendations from the R&D.

In the paper, Section 2 includes some thoughts on relevant target farmer groups. It contains a description of the region in terms of some statistical and farm financial information that is currently available. Section 3 contains discussion of current farming issues in the region and some implications of these for analysis. Then in Section 4 is presented a discussion of possible economic approaches to analysis of the issues and some comments on the relevant context for the analysis.

2. The region described

In geographical and statistical terms, one way of describing the northern cropping region of NSW is by use of the Australian Bureau of Agricultural and Resource Economics (ABARE) zonal definitions according to statistical local areas (SLAs). ABARE surveys of dryland broadacre agriculture divide states into the Pastoral (PZ), Wheat-Sheep (WSZ) and High Rainfall (HRZ) zones according to climatic characteristics. Figure 1 illustrates the northern NSW cropping areas in regions used in this classification. Regions 1211 and 1212 are respectively the western and eastern portions of the northern region of the WSZ in NSW. The local areas (Shires and Cities) are shown. The Figure also includes an overlay of the NSW Agriculture Barwon region, which includes the northern tablelands area of the state.

2.1 Classification by soil type

The soils of the Barwon region have been amalgamated for our purposes into 12 major types, as shown in Table 1. This classification was made on the basis of potential agricultural uses. The areas of soils within the region are shown in the table. Nearly one third of the region is comprised of black, brown or grey cracking clay soils.

The suitability of soils with respect to cropping systems lies in their inherent fertility and water holding capacity, although the fertility has been run down in many cases over time due to intensive cropping without fertiliser replacement. This is one of the major soil resource issues for the industry, ie the sustainable management of soils into the future. Of the soils listed in Table 1, the most suitable for cropping systems are, in order, the cracking clays, loams and the massive and friable earths, with the duplex soils and sands being least suitable.

2.2 Classification by landscape type

Ten landscape types are also used as a classification, these range from plains to mountainous. The areas of land within the Barwon region in each landscape type are shown in Table 2. One third of the land area is on the plains, and in this region these are mainly flood plains which has implications for farming systems and resources.

A cross classification of this region according to soil and landscape type is shown in Table 3. Again one third of the region is comprised of cracking clay soils on undulating or plains landscapes.

2.3 ABARE survey data

Selected farm survey results from ABARE dryland broadacre industry surveys (ABARE 1999) are shown in Table 4. These results are for 1996-97 for the Wheat and Other Crops (WOC) and Mixed Livestock Crops (MLC) industries combined. The mean value and the associated relative standard error are shown. Data are presented for regions 1211 and 1212. Table 5 contains data from a recent ABARE survey of irrigated broadacre agriculture in the Barwon region. This is a different agricultural region and industry, since the sample is selected on the basis of irrigated rather than dryland agriculture.

The results in Table 4 show generally that farms in the western area are larger, with more area cropped and higher livestock numbers than those further east. Farm cash income and capital values are higher, and there are indications of higher rates of return in the western compared to the eastern areas.

The irrigated farm survey results in Table 5 show that these farms are somewhat intermediate between the dryland regions in terms of area and farm cash income. However, invested capital is much higher.

2.4 ABS data

Australian Bureau of Statistics (ABS) data on a shire and local government area basis are also available. As an indication of changes in farming systems over time, Figures 2 and 3 show, from shire data, the total crop and sown pastures areas as a proportion of total farmed area in the ABARE regions 1211 and 1212 from 1954 to 1995. In the western region the cropped percentage has increased from near zero up to 13% in some years, while in the eastern region it has increased from between 5 and 10% to over 20% for a substantial period. The sown pasture area has also increased by a smaller amount over the same period.

2.5 Representative farms

The aim of this work is to define some representative farms within the area of interest which can be used to test the impact of new technologies and changes in farming systems in terms of economic and resource outcomes. A farm characterisation or definition can be made according to resources (soils/vegetation/topography), environment (climate/location) and types of farming enterprises (farm structure/enterprises) for the northern cropping region. This will be used to provide an initial way of thinking about different farm types as a basis for research and analysis, ie allowing a more specific differentiation between target groups of farms/farmers so that R, D and E can be more successfully carried out. Policy aspects can also be included, for example the investigation of socio-economic impacts of water reform within the irrigation industry can be undertaken within this framework.

The survey data presented above provide a broad outline of the scale of farm units in the region. However, a great deal of detail is lacking from such statistics that is useful for developing a model to measure the impacts of changes, especially at the local level. There are often substantial differences between neighbouring farms in terms of resources used, farming methods employed and the skills and outlook of the owner/manager.

One alternative method of obtaining necessary data for evaluation at the local level is the Local Consensus Data (LCD) technique (Jayasuriya, Catt and Young 1999). The LCD technique is a way of obtaining an accurate picture of the structure of farming for a group of farms in a particular locality. A small group of interested farmers meet with officers of the R&D agency to discuss all the practices which have a bearing on the costs and returns of a typical farm in the area being studied. As discussion proceeds, a consensus of opinion or agreement is reached on the size and nature of the 'typical farm' and on all aspects of production such as cultural operations, machinery used and time involved. Consensus is also arrived at about prices or costs of inputs, normal yields and expected returns. The aim is to develop comprehensive sets of data to adequately define the main 'modal' farm types in each district, to ensure that farm management analyses were relevant to existing conditions, and to provide suitable examples for extension advice.

Initial discussions with farmer groups in Coonamble and Walgett have been conducted about farm production in each district. An interesting outcome of the Coonamble meeting was the number of 'typical' or representative farms for the district. Based on a soils map constructed by a District Agronomist and on local knowledge, the consensus at the meeting was that there should be three representative farms based on different soil types - a black earth, a grey self-mulching clay and a red-brown loam.

The question of integration of crop and livestock activities in this district was also discussed. While cropping has increased dramatically in recent years, there are still livestock (cattle and sheep) on many properties in the area. The question is whether livestock activities are integrated with cropping, or whether they are run separately on different soil types or topographical areas within a representative property. At least on the dark cracking clay soils, farmers appear to be unwilling to run livestock on stubble, particularly during wet conditions because of the treading damage to surface soil structure. This question has ramifications for the complexity of the typical farm, which is already characterised by summer and winter crop options and the need to consider soil fertility and weed, pest and disease control in the context of adverse price movements and soil fertility decline.

Similar trends were observed at a meeting in the Walgett area, with stock tending to be kept off cropping paddocks (most soils are cracking grey clays) to avoid compaction damage. One problem noted by the group with crop sequences that include a pasture phase was what stock type to run on the pasture. There are management difficulties with pastures due to fences being removed in past years to facilitate crop growing in large paddocks. Table 6 shows details of the consensus reached from discussions at Walgett. The process of developing budgets for farm enterprises on a representative farm basis is continuing.

The livestock issue is relevant for the Western Farming Systems (WFS) Project DAN266NR ('Sustainable rotations and cropping practices for the marginal cropping areas of north west NSW and south west Queensland') which is partly funded by the grains industry. That project has a number of farmer core sites which contain relatively large scale plots representing broad farming systems ranging from exploitative to restorative. The experimental design of the project includes continuous cropping (the current 'exploitative' system), legume pasture reverting to cropping and summer grass pasture reverting to cropping.

The basic hypothesis of the WFS project is that the current cropping methods and practices are unsustainable and that the introduction of legumes (eg lucerne) and summer grasses into a cropping rotation will improve soil properties. These alternatives are further divided into combinations of tillage, nitrogen management and crop/pasture sequences. The plots are monitored for water and nutrient use efficiency, productivity and crop disease, so that profitability levels can be determined. Each site has a management team composed of project members, growers and agribusiness.

The economic analysis needs to include this design within representative farms. An issue in this region of substantial climatic variability is that the farm-level results for the small number of years of the project are only one combination of many possible climatic patterns. To overcome this problem agronomic simulation models (such as APSIM, McCown et al. 1996) are being configured and calibrated for the particular locations to be used as predictive devices to develop input to farm level analyses. Of particular interest is whether these models can represent agronomic outcomes in the abnormal climatic years.

3. Farming systems issues in the region and implications for analysis

3.1 Development of farming systems in the region

Most of the region lies between the 500 mm and 600 mm isohyets. About two thirds of the rainfall occurs between October and March. High intensity storms may occur during this period (Holland *et al,* 1987). The lowest and most variable rainfall occurs during autumn (Marcellos and Felton 1992) which is the sowing time for winter crops.

Due to the majority of rainfall occurring in summer, the production of winter crops such as wheat is susceptible to water stress. The production system has been characterised by a fallow period (where the area cropped is kept free of active growth) in the summer to store water in the subsoil for a following winter cereal crop. Fallow length varies between 5 and 19 months, with 6 months being common before sorghum and wheat. Weeds are often a problem during the fallow period, and tillage to control weeds has led to soil erosion in cases where the soil was left bare during fallow. The use of tyned implements, stubble retention and herbicides to control weeds has led to the development of no-till or stubble retention systems that reduce erosion.

Agricultural practices in the region have become more diverse in the last 60 years. Before the 1950s cereal residues were commonly burned after harvest. In the late 1940's 62 percent of farmers burnt crop stubble (Martin *et al*, 1988). During the 1950s tillage by shallow cultivation with disc ploughs and scarifiers drawn by low power tractors was the most common practice. 'Crop rotation' during this period usually meant continuous wheat with short fallow (ie between each annual wheat crop). Some farmers occasionally grew lucerne, oats or sorghum or used long fallow (Marcellos and Felton 1992).

In the 1960s cropping expanded rapidly as returns from grain increased above those of sheep and tractor power increased. Large areas of native vegetation were cleared between

1962 and 1975 (Marcellos and Felton 1992). During the 1970s tyned trashworking implements were introduced. The implications of this were that stubble retention and reduced tillage practices became more practical. Reduced tillage practices were recommended because they were more efficient at storing water in the profile during fallow periods and lessened erosion during rainfall events.

Strip cropping (growing crops in rotation in alternative strips) was more widely adopted in the Liverpool Plains during the 1970s due to damage caused by flood events. Fences were removed to avoid water channelling and runoff problems. The strips were between 20 to 100 metres wide and alternated between fallow, crop stubble and growing crop, using mostly wheat, sunflowers and sorghum.

In the 1980s a survey of crop rotation, tillage fertiliser use and weed control was undertaken for the years 1983 to 1985 (Martin *et al*, 1988) and covered the Shires of Moree, Narrabri, Yallaroi, Gunnedah, Inverell, Quirindi, Parry, Manilla, Bingara and Barraba. The survey found that adoption of new wheat varieties and herbicides was rapid, but adoption of the use of nitrogen fertilisers was slow. The study concluded that the change in crop rotation practices since the 1940's was only marginal, meaning that cropping paddocks were mostly kept in continuous production, particularly in the more western Shires. Eighty-one percent of farmers surveyed cultivated three to five times every year, implying a high cropping intensity. Rotations with pastures or with cereals grown every second year were more common in the eastern part of the area surveyed, which receives more annual rainfall on average.

The survey indicated 74% of farmers in the northern wheat belt practised conventional tillage, 14% practised reduced tillage and used herbicides and 1% used no-till (Martin *et al*, 1988). In the same survey, less than 30% of growers burned stubble. It was also found that 66% of farmers included sorghum, 28% lucerne, 20% grazing oats, 18% sunflower and 14% barley as alternatives to wheat. About half of the farmers surveyed used fertilisers, but the more northerly shires used the least (Martin *et al*, 1988).

Similarly Hamblin and Kyneur (1993) observed that crop rotations with pastures, or with a cereal crop every two years, were more common in the higher rainfall areas in the north-east. They concluded that cropping percentages (the ratio of crop area sown to pasture) were excessively high in the northern Shires of NSW, and that soil organic matter levels were declining.

3.2 Agricultural and natural resource issues

There is concern within both the general community and the grain-growing industry about agricultural and natural resource issues which impact the natural and socio-economic environment of the region.

Taking a river catchment perspective, the North West Catchment Management Committee (NWCMC) has produced a Situation Statement for the Namoi River Catchment (NWCMC 1996). The purpose of the Situation Statement was to bring together available information about the natural resources of the catchment in terms of their extent, the issues and their management. This is seen as the first stage in the development of a Namoi Community Catchment Plan for the entire Namoi Valley.

According to NWCMC (1996), land degradation has occurred and continues to occur for a variety of reasons. These include the historical aspects of adopting European practices in a fragile environment, the unpredictable and relatively arid climate, and associated previous government policies including closer settlement and incentives to clear land. More recently terms of trade, rural recession and drought have further exacerbated the situation causing farmers and graziers to "live off their assets" by working their land harder with less inputs and retaining their plant and equipment until it is outdated and of little value (NWCMC p. 5.13).

The land degradation identified by the NWCMC include:
- high levels of severe to extreme sheet, rill, wind or gully erosion and mass movement;
- severe to extreme sheet and rill erosion hazard on cropping areas;
- soil structure and fertility decline associated with both crops and pastures;
- weed invasion;
- flooding and floodplain instability and resulting siltation;
- existing or potential salinisation - dryland or irrigation; and
- tree decline, loss of biodiversity and invasion of feral pests.

Degradation issues are also identified with respect to surface water, the aquatic environment, groundwater and biodiversity.

For the grain-growing industry, the Grains Research and Development Corporation (GRDC) has published a Research Prospectus for 2000-2001 (GRDC 1999). The GRDC has a number of planned outcomes or investment objectives. These are (1) meeting quality requirements, (2) increasing productivity, (3) protecting and enhancing the environment, and (4) delivering outcomes.

In terms of protecting and enhancing the environment, the GRDC recognises that the maintenance and improvement of the industry's soil and water resources is vital to its long-term viability. It's objective is to protect the profitability of grain producers by enhancing the industry's capacity to produce grain of a consistent quality and yield over a long period. It has developed enabling strategies to build on previous research directions, including:
- identifying factors constraining the further adoption of conservation farming practices and develop better farming systems to protect the industry's substantial investment in productive capability and the community's future land use options;
- linking GRDC best practice on-farm research with broader community-based catchment studies undertaken by other agencies; assist grain producers to integrate best practice on-farm management with catchment studies to minimise the on- and off-site environmental impacts and meet growing consumer interest in environmental considerations, product quality and food safety; and
- improving grain-grower's skills in managing the risks associated with variable production and prices by developing decision aids to help promote self-reliance.

3.3 Currently funded projects

One way of considering the current issues is by reference to industry-funded projects. A selection of these for one organisation (NSW Agriculture) is shown in Table 6. The aims of the projects listed show a range of issues from on-farm crop and pasture management to impacts on groundwater, and also farmer decision making and risk management. The projects exhibit different philosophies on scientific R&D from strictly controlled experimentation to co-learning with farmers. In each case however, the projects emphasise the farming systems nature of the work and the environment being investigated. Some common themes from the research projects in Table 7 are:

- sustainability, however defined, sometimes having profitability included is a common theme, suggesting the longer temporal impact of actions, and the issue of making better tactical and/or strategic decisions;
- profitability, still the main driving force of agriculture but accounting for the impact of uncertainty is important;
- on-farm decision making, the focus is more at the farm than regional level in most projects;
- dryland farming systems, which are the main focus;
- crop sequence decisions, this is an important issue for selection of the type of economic analysis used;
- the potential impact on natural resources, soil erosion, soil fertility, deep drainage and soil water contamination; and
- the complexity of the northern summer rainfall dominant system is an important consideration.

3.4 Northern crop production - methods and issues

In the north eastern summer rainfall dominant cropping region of Australia there are several important characteristics that can be distinguished. The major one is that climatic variability (mainly rainfall) is more pronounced for the further north and east regions, compared to the south and west of the country. It is possible to grow crops in both summer and winter, increasing the number of alternatives to be considered. Another issue is that managing fallows is more difficult because of the summer rainfall.

The soils are potentially very productive but need careful management, especially for moisture storage. The presence of rivers and river catchments is an added complication compared to the west.

Another consideration is the presence of livestock on many farms and the degree of integration within crop enterprises. Unlike areas in the south-east and west of Australia, the livestock enterprises do not appear to be significantly integrated into the crop rotation. In some areas where large scale cropping has been taken up, the livestock infrastructure (fences, watering points) have been substantially removed. In the northern areas beef production is substantial on cropping properties, however it is not integrated into the crop cycle.

A further issue is the management of insects, especially *Heliothis spp.* in cotton and other crops. *Heliothis* is a major insect problem for cotton, but the insect uses other crops as hosts. Area-wide or cooperative management is being increasingly used to combat the mobile pest. This is a disadvantage for modelling. An advantage though is in the area of herbicide resistance, due to the presence of summer crops. The possible use of cultivation or herbicides in a summer fallow gives the manager more options to combat the development of resistance. However, this is another factor that needs to be considered in making and modelling farm management decisions.

In general the decisions on crop sequence, tillage method, fallow management, fertiliser application and herbicide spray have implications for both crop harvest outcomes and the levels of pests, weeds and diseases in subsequent crops. These implications provide a substantial degree of complexity to farm management decision making. In the northern region the climatic extremes in the last two seasons have shown that crop disease and disease management outcomes in extreme years are very important.

3.5 Strategic and tactical decisions

Hayman, Cox and Huda (1996) discussed the implications of climate variability for on-farm decision making. In investigating if, and how, variability should be accounted for, they described strategic and tactical decisions. A strategy is a long-term plan that can be used as a basis for decision making. In contrast, tactical farm management involves having a plan which can be varied based on interim observed outcomes, ie making adjustments in a flexible manner. Hardaker, Pandey and Patten (1991) referred to the same process as being an embedded risk (two-stage) decision, without naming it as tactical. Pannell and Glen (1999) discussed this in terms of Bayesian Decision Theory and the value of information under conditions of uncertainty. Pannell, Malcolm and Kingwell (1995) categorised strategic and tactical approaches as being static and dynamic, respectively. Hayman and Turpin (1998) evaluated strategic and tactical approaches to the decision on fertiliser nitrogen application for wheat in the northern NSW cropping region. All of these authors agreed that the relevant approach for representing on-farm decision making is the tactical (or dynamic) approach.

This issue can also have implications for whether a stochastic or deterministic model provides a better characterisation of farm-level issues. While remembering that it is always the particular situation being investigated that should determine the type of model used, Pannell, Malcolm and Kingwell (1995) showed that such a question is also determined by the degree of importance of the tactical aspects of the problem. In many cases they assert that the general lack of economic response in the region near the optimum (because the profit function is flat there) means that stochastic representations may not be necessary. However, if the nature of the variability is such that decisions in the extreme event years are important tactically, then a stochastic representation accompanied by a tactical analysis will be necessary.

Pannell, Malcolm and Kingwell considered that the inclusion of risk aversion (ie utility maximisation) into the objective function of models does not provide substantial improvement in the explanatory power of the analysis. They showed in their example that the addition of tactical options provided greater impact than the inclusion of risk aversion.

3.6 Levels of analysis

Three levels at which farm/resource decisions can be made are the paddock, the farm and the catchment. In general, the movement from paddock to farm and then to the catchment level involves a loss of resolution in terms of the level of detail at which analysis can be conducted (Peter Hayman, personal communication, Jan. 2000). This detail loss occurs due to information (eg biological, hydrological, geological) availability and the degree of complexity of modelling effort required at succeedingly higher levels.

For the two sources of information about farm/resource issues in the region mentioned in Section 3.2, the GRDC is primarily interested in the paddock-level outcomes, whereas the NWCMC is most interested in catchment outcomes. However, the basic decision unit for both these levels is the farm, or whole-farm, unit. Hence the focus by many economists on this level (eg Pannell 1996).

The farming systems projects (particularly WFS and EFS), which are partially funded by the GRDC, have been developed with a paddock focus for farming systems R&D. An interesting question, which is the main basis for this paper, is how to analyse the biological results from those projects in an economic and decision making context.

Pannell (1996) has argued strongly for economic analysis in a whole-farm context to simulate farmer decision making. The main basis for this position is that many management decisions made by farmers depend on factors external to the particular crop or livestock enterprise directly affected. In particular, issues which arise at the level of the whole farm, mainly the allocation of limited resources between alternative enterprises, can be difficult to analyse with other methods. There are a number of other benefits that arise from undertaking whole-farm modelling, these mainly accrue to the organisation that commits itself and its resources to a serious multi-disciplinary bio-economic approach to the process.

3.7 Farming systems

Many people talk about 'farming systems', the term is perhaps over-used. It is important to discuss what constitutes a farming system. Spedding (1988, p. 15) has warned that it is meaningless to let anything be a system. Unless important differences exist in the properties of a system and a non-system, it is not worth making the distinction between the two. The distinguishing property of a system claimed by Spedding was 'behaviour as a whole in response to stimuli to any part'. The definition used by the Open University in Britain has been described as a pragmatic working definition (Dyer 1993). This definition is: (1) a system is an assembly of components connected together in an organised way; (2) the components are affected by being in the system and are changed if they leave it; (3) the assembly of components does something; and (4) the assembly has been identified by a human being as of interest.

Key issues here are the notion of <u>interaction</u> and the subjective choice of <u>boundaries</u>. In the EFS project, at least, the emphasis has been placed on interactions but we need to be careful that we don't try to include everything. In terms of boundaries for that project, spatially the boundaries are mainly at the paddock level. Boundaries in time need to go beyond the sowing and harvest of a single crop, ie to look at crop sequences, but this may only include the previous fallow and what is left at harvest. It does not mean that we have to look at 5 year crop sequences in every situation. Conceptually the boundaries of the farming system need to be expanded to include both the bio-physical system and the human decision making process as legitimate areas of research. When studying the human decision making process the aim is to look at normative descriptive and action research approaches.

The fact that these projects are working at the paddock level does not mean that we ignore that paddocks need to be managed in a whole farm context and that farms occur in catchments. However, at higher levels (whole farm or catchment) some detail is sacrificed.

In the end farmers need their businesses to survive. In that context, the financial performance of the whole farm is vital and we can argue that this is the system that farmers need to consider. There may be sub-systems (livestock and cropping) that need to be analysed, but the whole farm context needs to be considered at some stage.

4. A farming systems analysis

The aim of this paper has been to consider the issues and types of farming systems for the northern cropping region as a basis for deciding what type of economic analysis might be appropriate for a number of current farming system projects.

For an analysis of the farming systems projects in Table 7, the following points can be distilled from the discussions in this paper:

- the farming system in the northern cropping region is especially complex due to the summer rainfall cropping option, and there appears to be considerable variability between farms;
- a number of the issues have a carryover or dynamic context;
- the purpose of the analysis is to simulate farmer decision-making behaviour and evaluate welfare effects of potential changes to farm management;
- tactical decision making has been identified as very important for farmers in this region;
- whole-farm issues are likely to be of some importance due to land, labour and machinery constraints, however many farmers appear to have invested heavily in machinery so that they have the capacity to plant, treat and harvest crops to the degree that climatic conditions allow, but without being constrained by machinery availability or capacity;
- in particular, livestock enterprises have been excluded from the farming system in a number of areas, but renewed interest (particularly in the north-west of NSW) in lucerne or pastures being integrated into the crop system will require a whole-farm approach so that a paddock analysis may not be sufficient; and
- the step from farm- to catchment-level analysis is still something to be undertaken after these results have been analysed.

The main issues identified in the projects appear to involve the sustainable management of farm resources for profitable cropping systems into the future. These currently involve relatively exploitative means of cropping and the alternatives being considered involve different crop and pasture choices, allied with currently available tillage and fallow management options. The impact of changes on soils (fertility, structure and erosive capacity), on soil moisture and deeper aquifer water conditions, and on other issues such as salinity, are important. The results of this work will have implications for management at the catchment level, but those are not being analysed in the current projects of economic analysis.

The purpose of the analysis is to simulate farmer decision making so that the technology changes or management practices proposed can be confidently promoted to farmer groups. Officers of public R&D agencies have an ethical responsibility, when making recommendations to farmers, to ensure that they understand how those recommendations are likely to affect farm profits.

The approach to be used will involve:

- continuing to meet with farmer groups and advisers to develop parameters and constraints for representative farms throughout the region;

- discussing and defining the systems of interest as a basis for modelling and analysis;
- constructing enterprise budgets and developing crop sequence budgets which incorporate constraints and carryover impacts;
- investigating key tactical management decisions using biological and economic simulation models;
- testing the construction of simplified whole-farm models to represent farming systems - these might be of a whole-farm budget (simulation) or whole-farm optimising (linear programming) type; and
- investigating the use of dynamic optimisation models to assess carryover or sustainability issues.

At the time of writing the NSW version of MIDAS (called PRISM, Faour et al. (1997), Faour et al. (1999)) has not been developed or applied further north than Wagga Wagga and Condobolin, ie summer crop options have not been incorporated. Greiner (1997) has developed and solved a whole-farm linear programming model for the Liverpool Plains area of NSW. The approach to be taken for analysis of these farming systems projects will be an incremental approach, developed in conjunction with farmer and advisory groups. The methods used will depend on the types of question needing answers and the context in which they are asked.

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Table 1
Areas of soil types
Barwon region

Type of soil	Area (million ha)	Percentage
Sands	6,631.5	6.8
Loamy soils	6,852.1	7.0
Friable loamy clays	679.5	0.7
Dark cracking clays	14,011.5	14.3
Grey and Brown cracking clays	17,794.5	18.2
Red massive earth	2,409.4	2.5
Yellow massive earth	3,652.7	3.7
Friable earths	7,822.9	8.0
Duplex hard setting loam - red/brown clay subsoil	15,913.0	16.3
Duplex hard setting loam - yellow mottled clay subsoil	12,388.7	12.7
Duplex friable loam - clay subsoil	2,259.9	2.3
Duplex sandy soil - mottled yellow clay subsoil	7,402.4	7.6
Total	97818.1	100

Table 2
Areas of landscape types
Barwon region

Type of landscape	Area (million ha)	Percentage
Plains	32,520.3	33.2
River terraces	919.3	0.9
Undulating	22,233.1	22.7
Hilly	18,900.2	19.3
Rolling	2,687.0	2.7
Steep hilly	2,335.2	2.4
Plateau remnants	1,024.3	1.0
Ridge and valley	1,058.0	1.1
Rugged	6,474.5	6.6
Mountainous	9,666.1	9.9
Total	97818.1	100

Table 3
Areas of landscape x soil types
Major groups
Barwon region

Soil type	Landscape type	Area (mill. ha)	Percent
Sand	Rugged	6,474.5	6.6
Loamy soils	Mountainous	5,826.7	6.0
Dark cracking clays	Plains	9,271.1	9.5
Dark cracking clays	Undulating	1,146.9	1.2
Dark cracking clays	Hilly	2,873.1	2.9
Grey and brown clays	Plains	17,536.4	17.9
Friable earths	Hilly	1,562.9	1.6
Friable earths	Rolling	1,493.7	1.5
Friable earths	Mountainous	3,038.4	3.1
Duplex hard setting loam - red/brown clay subsoil	Plains	4,203.1	4.3
Duplex hard setting loam - red/brown clay subsoil	Undulating	5,103.5	5.2
Duplex hard setting loam - red/brown clay subsoil	Hilly	4,859.2	5.0
Duplex hard setting loam - red/brown clay subsoil	Steep hilly	1,454.6	1.5
Duplex hard setting loam - yellow mottled clay subsoil	Undulating	5,963.6	6.1
Duplex hard setting loam - yellow mottled clay subsoil	Hilly	6,236.0	6.4
Duplex friable loam - clay subsoil	Hilly	1,151.7	1.2
Duplex sandy soil - mottled yellow clay subsoil	Undulating	4,799.9	4.9
Duplex sandy soil - mottled yellow clay subsoil	Hilly	1,689.9	1.7

Table 4
Selected ABARE dryland Broadacre survey results
Regions 1211 (west) and 1212 (east): northern WSZ of NSW
Wheat and Other Crops and Mixed Livestock Crop Industries combined
1996-97

Item	Unit	Region 1211 (west)		Region 1212 (east)	
		Mean	RSE (a)	Mean	RSE (a)
Farm population	no.	439		1,681	
Sample	no.	23		50	
Area operated 30 June	ha.	4,257	11.8	1,473	23.1
Area wheat harvested	ha.	1,111	7.2	288	35.2
Area barley harvested	ha.	40.8	44.6	84	25
Area grain legumes harvested	ha.	43.4	11.5	11.6	52.3
Area other crops harvested	ha.	89.8	26.8	85.6	65.5
Sheep numbers 30 June	no.	2,842	16.6	991	22.7
Beef numbers 30 June	no.	271	7.3	231	28.2
Wheat production	t	2,612	5.0	884	34.5
Fertiliser used	t	19	27.0	17	65.7
Total cash receipts	$	717,272	10.2	329,679	38.3
Total cash costs	$	518,290	11.8	236,876	40.1
Farm cash income	$	198,981	9.8	92,808	37.8
Total capital value 1 July	$	1,984,428	15.8	1,551,446	27.4
Rate of return excl. capital apprec.	%	9.6	11.5	4.9	45
Equity ratio at 30 June		79.7	3.7	85.7	2.7

(a) Relative standard error (%)

Table 5

Selected ABARE irrigated Broadacre survey results
Barwon Region in NSW
Irrigated cropping industries
1996-97

Item	Unit	Barwon Region	
		Mean	RSE
Estimated population	no.	557	
Sample	no.	74	
Area operated	ha.	2,012	12.3
Beef cattle numbers	no.	289	13.6
Sheep numbers	no.	461	35.6
Area cropped	ha.	727	9.5
Area crops irrigated	ha.	285	9.4
Area grazing irrigated	ha.	11	25
Total area irrigated	ha.	295	9.1
Area sown to wheat	ha.	379	13.6
Area sown to cotton	ha.	216	8.5
Area sown to barley	ha.	59	29.4
Area irrigated of wheat	ha.	50	35.6
Area irrigated of cotton	ha.	200	10.8
Total cash receipts	$	918,910	9.3
Total cash costs	$	741,579	7.5
Farm cash income	$	177,331	30.6
Total capital at 30 June	$	3,073,528	10.5
Total debt at 30 June	$	581,171	17.2

Table 6: Details to date from Walgett

Soils:	Grey clays
Farm Size:	7,000 to 8,000 acres (2,800 to 3,200 ha) with about 2,000 acres (800 ha, roughly 25%) cultivated/under crops
Enterprise interaction:	interaction between crop and livestock systems is decreasing, due to trying to avoid compaction of soils caused by livestock
Crop Options:	wheat (and durum wheat), barley, chickpeas, fababeans, canola, some trying safflower. Dryland cotton, but perceived as risky
Crop Rotations:	sorghum-short fallow- chickpeas, particularly if good autumn break cereal (wheat or barley) - legume or oilseed - wheat-LF summer crop-LF wheat
Management:	more recently people seem to have been more willing to invest in using fertilisers on summer crops
Tillage systems:	no till is problematic due to couch grass (particularly after the 1998 flood), nutgrass and barnyard grass, so some cultivation to control these weeds is necessary
Problems:	• the biggest economic problem in using a pasture phase with cropping is what to do with the pasture, whether to run stock or not and what stock enterprise type to run • western side of the Walgett Shire has major problems with crop predation by kangaroos and birds • dryland cotton is risky • ascochyta blight in chickpeas • location can be a constraint for some crops, eg proximity to delivery sites for certain wheat grades

Table 7
A selection of major GRDC-funded farming systems projects in northern NSW and southern Queensland

Project Number	Title	Aims	Location
DAN266 (WFS)	'Sustainable rotations and cropping practices for the marginal cropping areas of north west NSW and south west Queensland'	testing the introduction of pulse crops and pasture legumes into the existing crop farming system	low rain zone (450-500mm) west of Newell highway in NW NSW & Leichhardt highway in SW QLD, between Dubbo in NSW and Miles in QLD
DAN363 (EFS)	"Sustainable farming systems for the north-eastern grain belt'	the project visionparticipatory on-farm research is for farming systems practiced in the north-eastern grain belt to have benefited from farmers, advisers and researchers exploring together options for improved economic and environmental sustainability	higher rainfall zone (500-600mm) situated to the east of the Newell highway in NW NSW and Leichhardt highway in SW QLD, between Tamworth and Toowoomba
DAN159	'Cropping and pasture systems to manage rising water tables and salinity on the Liverpool Plains'	determining cropping and pasture systems to maintain productivity, reduce recharge of groundwater and lower water tables	Liverpool Plains in NSW
DAN23	'Tillage and rotation systems for sustainable wheat production in northern NSW'	developing more sustainable cropping systems for northern NSW based on no-tillage fallow and crop residue management	northern NSW
UWS17	'Decision support for improved climatic risk/opportunity management in dryland cropping systems'	provide a framework for researching how farmers currently assess and manage risks associated with grain production, work with farmers to identify and upgrade their skills in managing climatic risks and opportunities, and test, refine and apply learning packages for on-farm decision making and property management planning	northern NSW

Figure 1

Figure 2

Figure 3