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A REVIEW OF FACTORS INFLUENCING THE ADOPTION OF CONSERVATION TILLAGE

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1. INTRODUCTION

This paper is drawn from a preliminary survey of literature on the adoption of conservation tillage. The survey was undertaken with a view to determining the need for and suitable approaches to research on this topic by the Soil Conservation Service of New South Wales.

After briefly reviewing advantages and disadvantages of conservation tillage, factors influencing adoption are identified and classified within a decision oriented framework. The paper concludes with some observations about policy implications and research directions.

2. WHAT IS CONSERVATION TILLAGE[1]

A viable conservation tillage system creates a suitable soil environment for growing a crop while conserving soil, water and energy resources. The essential elements of such a system are reduction in the intensity of tillage and retention of plant residues. Reduction in the intensity of tillage may mean less aggressive cultivation practices, less frequent cultivation, or both. Retention of plant residues really means not burning them, but leaving them on or in the soil to eventually become part of it.

Conservation tillage may be one component on a broader conservation farming system. In relation to cropping it is the vital component. Other components would include contour farming, crop and pasture rotation, judicious stocking management, pasture improvement, strip cropping and soil/water conservation works and practices where appropriate.

Just as conventional tillage practices vary, so too there is no single

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[1] This section draws heavily on Charman (1985)

conservation tillage system. Common terms to describe various levels of conservation tillage include reduced tillage, minimum tillage, zero or no tillage and direct drilling. Charman (1985) defines these terms as follows:

Reduced Tillage: A general term describing a conservation tillage system in which a crop is grown with fewer tillage operations than would be the case under conventional tillage. Herbicides and/or grazing may be used for fallow weed control.

Minimum Tillage: A general term describing a conservation tillage system in which the crop is grown with the fewest possible tillage operations. Herbicides and/or grazing may be used for fallow weed control.

No Tillage (Zero Tillage): A minimum tillage practice in which crop is sown directly into a soil not tilled since the harvest of the previous crop. Weed control is achieved by the use of herbicides and stubble is retained for erosion control. It is typically practised in arable areas where fallowing is important.

Direct Drilling: A minimum tillage practice in which the crop is sown directly into a soil not filled since the harvest of the previous crop. Weed control is achieved by grazing, burning or herbicides. Stubble may be retained or removed by grazing or burning. It is typically practised in mixed farming areas with reliable rainfall.

3. CONSERVATION TILLAGE IN NEW SOUTH WALES

As part of a commitment to protecting and improving the rural environment and preventing degradation of the State's soil and water resources the Department of Agriculture and Fisheries, and the Soil Conservation Service of NSW run a joint program on conservation farming (NSW Agriculture and Fisheries 1988). The program includes advisory, research and education activities related to conservation tillage, acid soils, salinity and trees-on-farms.

Conservation farming methods are demonstrated on landholders' properties and the principles of conservation farming are promoted through field days, meetings, show days and the media. Regional Committees report steadily increasing incorporation of conservation tillage into whole-farm management. Examples include the rapid adoption of direct drill, mulch sowing and reduced

tillage for pasture establishment on the North Coast; widespread acceptance of reduced tillage for sorghum in the North West; increased adoption of cover cropping in Hunter Valley vineyards; and buoyant sales of specialised seeders for direct drilling pastures in the South West.

Conservation tillage research throughout the State has an emphasis on direct drilling on the North Coast, nil or reduced tillage in the North West, reduced cultivation and direct drilling in the Central West and direct drilling in southern NSW.

4. BENEFITS/ADVANTAGES OF CONSERVATION TILLAGE

The primary advantage of conservation tillage (as compared with traditional tillage) is an improvement in virtually the whole range of soil physical conditions (Packer and Hamilton 1985). Increased organic matter and biological activity contribute to improved porosity and aeration, infiltration and moisture conservation, tillage draught and soil trafficability. Together with the extra plant cover these improvements are reflected in a much reduced risk of soil erosion.

Better conservation of the soil resource in this manner offers high potential for sustainable production in the medium to longer term. Offsite costs (externalities) may be reduced due to improved water quality, reduced flooding and less sediment deposition attributable to erosion.

From a management perspective, conservation tillage generally requires lower costs for equipment, labour and fuel. It offers farmers greater control over soil structural conditions and greater flexibility of farming operations. There is at least the potential for improved profitability, particularly in the longer term. Depending on the specific situation factors contributing to these advantages include reduced machinery costs, increased potential for double cropping, improved timeliness of farm operations, an extended sowing period and the ability to crop previously unsafe land.

5. PROBLEMS/DISADVANTAGES OF CONSERVATION TILLAGE

The primary disadvantages of conservation tillage (as compared with traditional tillage) are generally related to specific soil types -

particularly heavy and poorly drained soils - and weed problems. Technical solutions - machinery and chemicals - still require development before satisfactory levels of performance are available in all conditions. The greater dependence of conservation tillage systems on chemical weed, pest and disease control also presents a range of environmental concerns. Yields may be reduced in some situations. The greater flexibility and relative newness of conservation tillage systems does place greater demands on the management ability of the landholder.

6. GENERALISATIONS FROM THE LITERATURE

A search of the literature was undertaken to elicit factors which have generally been found to have a strong relationship with the adoption of conservation tillage. Very few Australian studies were found, the majority of references coming from the United States (see Appendix 1).

The results of these studies were not always consistent - certain variables were shown to be statistically significant in some cases but not others, and the nature of the relationship between adoption and certain variables differed markedly between studies. Certainly the direct and specific application of United States results to New South Wales is clearly limited by major differences in, amongst other things, climate, soils, agriculture and the institutional environment.

The interaction between the many variables is perhaps too complex to permit useful generalization. From the research examined in this review it is not possible to construct a priority listing of adoption-related factors which would be capable of widespread application.

Meaningful prediction and ex-post analysis of adoption of conservation tillage is most likely to be achieved at the level of specific technologies in particular locations. The procedural problems of defining, measuring and managing the critical variables are still significant at this level.

7. A DECISION FRAMEWORK

Farmers are generally perceived to be a "conservative" group yet they operate an inherently risky business. Crop yields and returns are notoriously subject

to the vagaries of weather and market conditions over which farmers have little control. What then persuades a farmer to decide for or against adoption of a given technical/managerial innovation?

Attempts to construct a general model of the adoption process meet the difficulty that the significant variables differ with the type of innovation and the circumstances of its introduction.

In the case of conservation tillage the innovation is primarily directed toward protection (enhancement) of the landholder's fundamental physical asset - the soil. Conservation tillage may offer short term benefits but its primary objective is to avert declining physical productivity of the soil and ensure its sustainable use. In this respect conservation tillage stands in contrast to innovations which promise a rapid increase in net returns from an otherwise unchanged level.

To express the distinction another way: all other things being equal, the cost of failing to adopt many innovations is the potential extra income forgone; but the cost of failing to adopt conservation tillage is an eventual decline in income. However, all other things are rarely equal. Declining productivity due to soil erosion or structural degradation may be masked by changes in other factors such as fertilizer inputs or crop varieties.

The fact that the productivity/economic effects of deteriorating land condition may for some time and to some extent be offset by other inputs, is compounded by the fact that the physical phenomenon of deteriorating land condition itself may not be accurately perceived.

These observations may be interpreted in a decision framework as follows. Adoption of an innovation such as conservation tillage is preceded by recognition of a 'decision problem'. This is triggered by some factor such as declining productivity and by the perception that land condition is at least partly responsible for the problem. Thus, following Sinden and King (1988) we identify a three stage decision framework where the first stage is perception of land condition, the second is recognition of a management problem and the third is the stage of actual decision to adopt (or not to adopt) conservation tillage. Figure 1 illustrates this framework and the various groups of factors which are significant at each stage. To the four groups of factors identified by Sinden and King (1988) we have added a fifth

group named technological factors. The composition of each of these groups of factors is discussed in the following sections and summarised in Table 1.

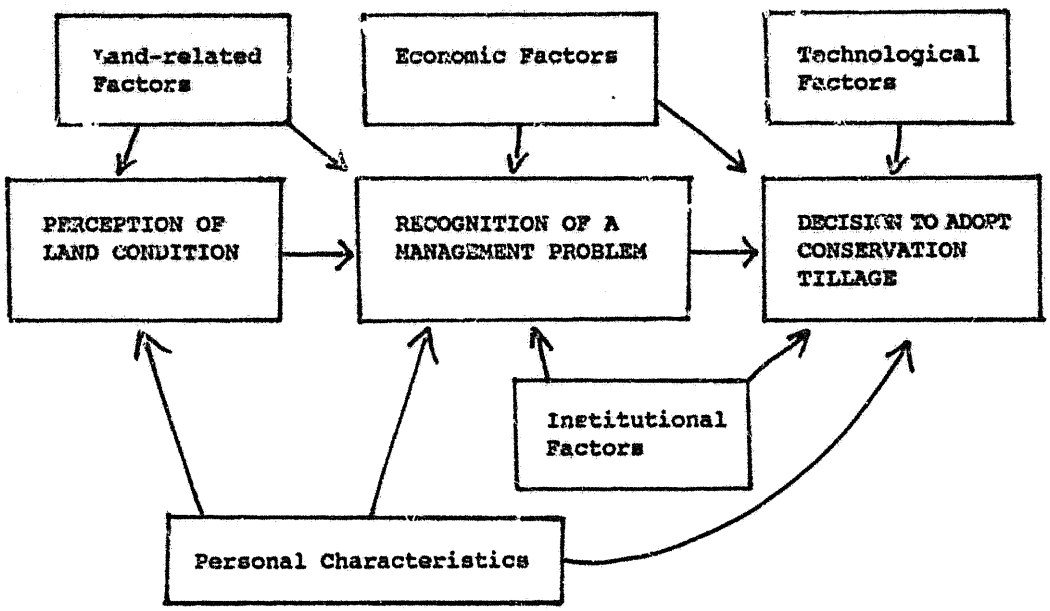

Figure 1. Adoption of Conservation Tillage: A Decision Framework.

7.1 PERCEPTION OF LAND CONDITION

It is reasonably well established that landholders recognise degradation on neighbouring land more readily and more accurately than on their own land. Perception of land condition depends not only on facts about the condition of the land but also on the personal characteristics of the landholder.

(a) Land-related factors

Some types of land degradation are more easily perceived than others. Gully erosion is more obvious to the untrained eye than is sheet erosion. Similarly, emerging salinity or acidity problems may not be recognised until they reach a certain threshold level. Topography (especially slope), soil type and ground cover are major influences on the form, the severity and the visibility of degradation. Previous land management also clearly influences current land condition.

Table 1: Factors Influencing Each Stage of the Decision Process with Respect to Adoption of Conservation Tillage

Stage 1: Perception of Land Condition

(a) Land-related factors

- existence of degradation
- type of degradation
- severity of degradation
- topography (esp. slope)
- moisture holding capacity

(b) Personal characteristics

- experience
- education/training
- exposure to information sources

Stage 2: Recognition of a Management Problem

(a) Land-related factors

- area affected
- proportion property affected
- change in physical productivity
- nature and extent of offsite effects

(b) Personal characteristics

- as for stage 1, plus
- personal goals
- attitudes to profit and risk
- time preference and planning horizon
- influence of peer pressure

(c) Institutional factors

- media coverage
- extension effort
- legal regulations/sanctions
- land tenure

(d) Economic factors

- contribution of cropping to income
- security of income
- cost of repairing erosion damage
- impact of declining yield on income

Stage 3: Decision to Adopt Conservation Tillage

(a) Personal Characteristics

- as for stage 2

(b) Institutional factors

- as for stage 2, plus
- credit facilities
- machinery markets

(c) Economic factors

- borrowing capacity (debt/equity)
- comparative costs and cash flow
- capital intensity of CT

(d) Technological factors

- complexity of CT technology
- compatibility with current practice
- reliability of CT technology
- scale

(b) Personal characteristics

Perception of land condition - accurate or otherwise - is dependent on the landholders innate powers of observation. These may be sharpened by experience, education or training, or by interaction with peers and land management professionals.

7.2 RECOGNITION OF A MANAGEMENT PROBLEM

Sinden and King (1988) describe this second stage as 'recognition of a problem worth trying to resolve'. Even if a landholder does recognise that his/her land is in poor condition or under threat of degradation, this may not be perceived as important enough to warrant serious attention. It may be accepted as normal or expected or inevitable. Factors which are thought to have a bearing on whether or not land condition is perceived as a management problem are discussed below and summarised in Table 1.

(a) Land-related factors

The area and proportion of land affected by degradation, the effects of that degradation on physical productivity, and the nature and extent of offsite effects are physical factors which partly determine the importance a landholder ascribes to any particular instance of land degradation.

(b) Personal Characteristics

Personal characteristics important at this second stage include those identified at Stage 1 plus personal goals, attitudes to risk and profit, time preference and the planning horizon of the landholder plus his or her susceptibility to peer pressure.

(c) Institutional factors

The institutional framework in which the landholder operates may be of considerable importance in precipitating or retarding management action in response to recognised cases of land degradation. The extent of media coverage of land degradation/land management issues, the nature and extent of extension effort by agricultural and land management agencies, the nature of land use regulations and sanctions, and the tenure under which land is held

are particular factors which may influence the landholder's response to the existence of land condition.

(d) Economic factors

Economic factors are likely to be highly important determinants of whether deteriorating land condition is perceived as a problem worth trying to resolve. In the current context the contribution of cropping to income and the impact of declining yields on income are of particular interest. Other economic factors which may be important are the costs of repairing erosion damage and the variability of income from cropping and other sources.

7.3 ADOPTION OF CONSERVATION TILLAGE

Recognition of land condition and perception of the need to manage the situation will be followed by adoption of conservation tillage only if there is a technically feasible solution which is acceptable to the landholder and which meets institutional and economic constraints.

(a) Personal characteristics

A similar set of personal characteristics as identified previously will operate again at this third stage.

(b) Institutional factors

In addition to the institutional factors operating to influence perception of a management problem, the operation of credit and machinery markets may be crucial to the landholder's response to that problem. The lending policies of banks and other financial institutions may restrict the availability of funds to finance a change of tillage practice. Similarly adoption of conservation tillage may be constrained by problems with the availability of inputs such as machinery and herbicides.

(c) Economic factors

Unless the innovation promises to pay for itself over a reasonable period it is unlikely to be adopted. The size, timing and certainty of costs and returns are all important considerations. The capacity of the landholder to finance a change to conservation tillage may be influenced by a range of

factors including the capital intensity of the proposed system and the landholder's asset/debt /equity situation.

(d) Technological factors

The nature of the proposed innovation is of course of primary importance. Even if conservation tillage offers financial benefits, as well as improved land condition, it may be resisted if the technology is not suited to the landholder. The complexity of the system, its compatibility with other farm operations, its amenability to trial and its reliability will all be important factors, operating in conjunction with personal characteristics and institutional factors, in determining whether or not to adopt conservation tillage.

8. POLICY IMPLICATIONS AND RESEARCH DIRECTIONS

Given the limited resources available to organisations charged with the responsibility to develop and promote the principles and practice of conservation farming it is necessary to determine how those resources can best be deployed. Neither the "diffusion model" of adoption which postulates that exposure to information is the critical variable, nor the economic constraints model which emphasises "ability to act" variables provides an entirely satisfactory guide. Rather, both models capture important aspects of the issue which cannot be ignored in the determination of policies to promote the adoption of conservation tillage.

There are at least two important, related aspects of the question of policy effectiveness - targeting of resources and the choice of policy instrument. Firstly, cost-effective deployment of resources would be aided by targeting them to landholders most likely to make a positive response. Our ability to do this at present is limited. A greater understanding of the personal characteristics which operate at each stage of the decision process is required. In addition, the ability to readily observe and measure those characteristics is needed if the required information is to be obtained without regular recourse to costly surveys

Secondly, the range of policy instruments which might be considered is very broad, ranging from do-nothing at one extreme to a heavily interventionist regulatory-prescriptive approach at the other. As in most similar cases a

middle course, implying a mix of regulations and incentives, of carrots and sticks, is likely to be the most feasible and effective. Options which might be considered include:

- extended zoning controls over land use;
- regulation of permissible land use practices;
- compulsory instruction and training in land management for landholders;
- advisory and research services;
- cross compliance policies;
- removal of contradictory incentives;
- compulsory farm planning;
- a user charge or tax on soil loss;
- financial incentives via a tax rebate or a subsidy on finance or other conservation tillage inputs;
- moral encouragement through competitions, prizes etc.

Drawing on the earlier discussion of factors affecting adoption of conservation tillage and the very brief reference above to policy options, some potentially fruitful topics for further investigation are identified below. Given the relative scarcity of local studies into factors affecting the adoption of conservation tillage the selected topics reflect a large amount of subjective judgement and also draw upon the observations and opinions of fellow officers of the Soil Conservation Service.

Firstly, it is hard to disagree with the statement by Packer et al (1988) that "insufficient emphasis has been placed on the economic aspects of conservation farming". In particular a high priority would be the analysis of the on-farm economics of specific tillage alternatives in particular locations. This would include assessment of comparative net returns and cashflow. For example the requirement for additional early season expenditure on chemicals may hinder adoption of conservation tillage. Awareness of this factor may influence the form of incentives provided or provoke some amendment to the recommended farming practice.

The management skills of farmers are critical at all stages of the decision process outlined earlier. They remain critical after conservation tillage practices have been adopted. It has been observed that conservation tillage generally requires a higher level of management ability than traditional practices, but that the skills of adopting farmers often fall short of those required. There is a need to examine the means of providing additional advice

and institutional factors.

There is considerable potential for conflict between the goals or the impacts of different policies, both within and beyond the agricultural sector. For example, the regulation of agricultural chemicals for environmental reasons may encourage greater mechanical tillage for weed and disease control. Similarly, it is conceivable that marketing arrangements or assistance provided to either agricultural outputs or inputs may tip the balance either for or against the adoption of conservation tillage practices.

The adoption of conservation tillage may be hindered by the absence of well developed markets for the inputs necessary for its successful, economic implementation. For example, the banking sector has been observed on occasion to be a reluctant lender for innovatory practices, and the price and availability of suitable tillage equipment has been a concern although a diminishing one. Issues such as these may be worthy of some further investigation in the New South Wales context.

8. SUMMARY

Having set out to obtain guidance from the literature as to the most important factors affecting landholders decisions whether or not to adopt conservation tillage we have met with limited success. Little Australian research has been conducted into this issue, but many relevant United States studies were found. In these studies a great number of variables have been identified and defined in various ways. A classification into land-related factors, personal characteristics, economic factors, institutional factors and technological factors is regarded as providing a helpful framework for analysis. Within each group the specific variables most relevant are likely to vary from one situation to another, making any more detailed generalization about what variables are the significant ones particularly hazardous. Moreover, the interdependence of variables within and between these groups, and the difficulty of suitably measuring many characteristics, suggests (a) that research is likely to be costly and (b) that cost-effective, meaningful results are most likely to be obtained either at a very "broad brush" level or from highly specific studies of particular technologies in particular areas.

Consideration of the factors deemed to have an important influence on landholders' decisions regarding conservation tillage leads to the question of how government agencies might best exercise some influence on those factors to promote the adoption of recommended practices. A range of policy instruments was identified but a discussion of the relative merits of each was beyond the scope of this paper. It was simply noted that a balanced policy of regulations and incentives, incorporating both carrots and sticks, is likely to be the most feasible and effective.

Finally, an attempt was made to relate the discussion to the current situation in New South Wales where the Soil Conservation Service and the Department of Agriculture conduct a joint program on conservation farming. This program includes a major emphasis on conservation tillage.

Of the many possible topics for further research and investigation the following four are judged to be of particular interest: analysis of possible competition between policies promoting conservation tillage and policies with conflicting goals or effects; analysis of possible constraints to adoption in the markets for conservation tillage inputs (credit, machinery, chemicals); situation specific analysis of the comparative profitability and cash flow of alternative cropping systems; and the investigation of ways to enhance the management skills of farmers who have adopted, or have an interest in, conservation tillage.

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