Drivers and Determinants of Natural Resource Management Adoption at the Farm Scale

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EXTENDED ABSTRACT

The environmental degradation caused by agricultural practices in the Australian grains industry has caused a change in the way we think about the industry and its effect on the environment. Emphasis is now placed on achieving economic social and environmental outcomes, the triple bottom line. Government, regional and industry organisations are using various instruments of influence to exert pressure on grain growers to implement better on-farm natural resource management (NRM) practices. Past strategies aimed at influencing the grower by appealing to their land stewardship and altruisms have proved worthwhile, as evidenced by increasing grower understanding of NRM problems. However, there has been a failure to deliver significant on-ground changes. Research into the adoption of NRM has suggested that the major factors that influence uptake are farm income, education and future farm planning. Other factors, such as individual farmer and social characteristics, have been identified as less important.

A study by Gallopín (2002, pp. 361-392 in: Gunderson, L.H. and Holling, C.S. (eds), *Panarchy: Understanding Transformations in Human and Natural Systems*, Island Press, Washington) suggests that decision making processes for sustainable development are hampered by a (1) lack of political willingness, (2) a deficiency in understanding of environmental problems and their consequences and (3) the insufficient adaptive capacity (both financial and social) to act on the changes needed in the realm of physical possibility. This characterisation of the decision domain provides a useful model of the NRM adoption situation in Australia. The authors suggest that the pressure groups identified above will drive the willingness and understanding of future growers perceptions; whereas capacity is solely left to the individual grower. Here any decision to undertake NRM is based on uncertainty of the consequences of this adoption. There is much scope for research into the physical capacity of the farm to undertake NRM i.e. what are the benefits and costs of adopting NRM strategies. The application of precision agriculture technology into this area can reduce the uncertainty in the decision making process by being able to quantify both the short-term effect on grower's income and long-term effect on environmental degradation.

The aim of this paper is to highlight the drivers and determinants of NRM adoption at the farm scale. This paper also identifies additional information that will be needed if any real on-ground changes are to occur on ground. The "farms capacity to change" should be examined ahead of the grower's capacity to adopt if the grower's uncertainties about NRM practices are to be diminished. This paper identifies precision agriculture as a technology for reducing the uncertainty in the decision making process because data is collected at a scale in which these NRM decisions are made. Precision agriculture can estimate the opportunity costs associated with NRM adoption and further help in the understanding of the degree to which a farm can adopt NRM practices. Growers cannot be green if they are in the red.

1. INTRODUCTION

Australia's landscapes are not well suited to agricultural production and the environmental degradation caused by agricultural practices in Australia has been well documented. Degradation of the landscape can take many forms but the problems receiving greatest attention are salinity and water quality. Solutions to these problems can be found in the reassignment of land uses to alternatives that use water more efficiently such as native vegetation and deep-rooted perennials. There has been a shift within society to a more environmentally friendly paradigm given the increased insight into degradation problems and their negative effects on agricultural regions. Government, regional and industry organisations are using various instruments of influence to exert pressure on grain growers to implement better on-farm natural resource management (NRM) practices. These groups highlight the need for growers to adhere to a triple bottom line approach, i.e. one that has a balance of economic, social and environmental factors in order to sustain a profitable and resilient industry and rural economy.

For growers this may mean a choice of how they continue to farm. Growers could continue farming the land until the degree of degradation causes production to become unviable, a less environmentally damaging approach is the adoption of NRM practices. For the grower who wants to attain an increase in environmental outcomes on farm, the decision to apply NRM practices is clouded by local factors such as the spatial variability of yield and the potential environmental benefits of NRM. This decision is further exacerbated by external factors such as climate variability and the volatility of the international commodity markets. Therefore decisions making about the adoption of NRM practices will be unpalatable to the landholder because of uncertainty about the impacts on their own triple bottom line.

This paper presents a brief account of the different pressure groups that will drive growers to undertake NRM within the Australian grains industry. The paper also highlights the current research into the determinants of NRM adoption and the additional benefit of precision agriculture technology in the decision making process.

2. DRIVERS FOR NRM ADOPTION

This section briefly discusses the different NRM pressure groups and the situations which have arisen to create them. We believe that these groups will apply various instruments of influence to exert pressure on grain growers in Australia to implement better on-farm NRM.

2.1. Government and Regional Catchment Management Authorities (CMA)

The Australian federal government, in agreement with States and Territories, have identified the need to develop regional investment strategies for the integrated delivery of NRM priority issues. The assessment for prioritising objectives was based on the National Land and Water Resource Audit that identified areas significantly affected by environmental degradation and the potential for cost effective preventative action. A total of 56 regions were identified with each region creating its own targets and priorities in the form of a regional environmental action plan. This redistribution of decision making from state and federal policy makers to the regions is aimed at empowering the community by identifying local community issues. In order to develop targets, regional catchment bodies consult with all members of their community to develop a single vision for the region. The plans identify the shaping forces and threats to the NRM asset base as well as priorities, goals and opportunnities for the region. With this as a basis, the CMA also identifies the region's investment strategies and framework as well as the monitoring, reporting and evaluation frameworks. The plans must be consistent with state and federal policies and strategies and once accredited are the basis for the distribution of regional investment from both the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality.

In its regional NRM strategy for the Northern Agricultural region of Western Australia, the Northern Agricultural Catchments Council (NACC 2005) highlighted the broadness of the approach taken. NRM problems are complex and occur on various spatial and temporal scales. They are also likely to involve difficult trade-offs between alternative land uses and different community aspirations and values – at local, regional, state and national level.

2.2. The Grains Industry

In 2004 the Grains Research and Development Commission (GRDC) developed its single vision framework for the Australian grains industry (GRDC 2004). The strategy highlighted key themes which emerged from grower interviews and a national grains industry conference namely that the future focus of the grains industry should be on a commitment to the triple bottom line of economic, environmental and social sustainability. The GRDC envisions that this approach embraces good farming practice as well as good environmental stewardship as the key to regional and industry prosperity. One major outcome of this appraoch is sustaining the industry's image of clean and green production ("the Green Continent" global branding GRDC (2004)) in order for product differentiation in the global market. The document highlights a pathway from 2005 to 2025 where curent production systems will use water more effeciently and the farming systems will be redesigned in terms of restoration of land and natural vegetation capabilities. By 2020, GRDC expects that the industry will be seen to have a shared responsibility as a partner for NRM and regional community development.

2.3. Farming Federation Groups

These triple bottom line objectives are further supported by the National Farmers Federation and their comparative state-based affiliates. In 2004 the South Australian Farmer Federation (SAFF) reported that a triple bottom line approach was needed out of necessity to stabilise declining rural populations. In its report, SAFF addressed the emerging triple bottom line objectives that are essential ingredients in modern day thinking about life in Australia. Their initiative builds on the identification of increased opportunities for providing environmental and community services in rural areas that the whole South Australian community can value and reward (SAFF 2004).

2.4. Regional Farming System Groups

Ridley, 2005 identifies the progress of larger high profile farming system groups (such as the Liebe Group in Western Australia) towards sustainable farming in Australia. The creation of these groups has been in response to regional issues and provides growers with an avenue to discuss local issues and act on options and opportunities which work locally in their region. Actions are firstly undertaken at the plot scale and if applicable are expanded to paddock or farm scale. Research from these groups focuses mainly on profitability and economic viability. Focus on environmental issues has been in response to the urgency and visibility of a problem or to a particular environmental 'champion' who raises awareness amongst the group (Ridley 2005). A major obstacle for research into environmental issues by these farming groups has been the lack of funding from research and development agencies which growers' identify with (Ridley 2005) rather than the group's appreciation for environmental outcomes. The establishment of these groups has led to a common vision, ownership of environmental problems and they should be now more ready to tackle environmentally sustainable issues in a more meaningful way (Ridley 2005).

Wilkinson and Barr (1993) highlight the effects of peer pressure within communities dealing with complex environmental problems. They suggest that voluntary solutions were more palatable than compulsory solutions. But compulsory solutions could work where the community engagement and leadership was strong, and the problem was seen as urgent leading to local community pressure.

3. ACTIONS BY THE GROWER

With this increased focus on NRM to improve environmental outcomes the problem exists that the objectives of the grower are not those of the greater community. Adoption of NRM in Australia therefore has been limited. In order to understand the adoption of NRM at the grower scale, research has focused on the economic, sociological and pyschological attributes of landholders. Table 1 summaries the research into the determinants and factors that effect uptake of NRM and the adoption of specific NRM practices by the grower. These determinants can be classed into four main areas: 1) economic; 2) individual grower and social characteristics; 3) institutional issues, and; 4) adoption of a particular NRM practice. The literature suggests that understanding these factors and capacity for individual landholder to make NRM decisions will ensure more realistic and more effective catchment and regional plans. Unfortunately, studies using survey research into these grower attributes provided very few statistcially significant explanatory variables (Cary et al. (2002), Herr et al. (2003) and Nelson et al. (2004). The majority of farmers adopting sustainable farming practices were members of Landcare or production groups. Economic factors including farm size, off farm income and level of farm equity also influenced the likelihood of adoption of NRM practices (Nelson (2004).

Table 1 Determinants of NRM adoption in Austalia.Taken from Cary et al (2002); Herr et al (2003); Nelson (2004); Nelson et al (2004); Ridley (2005).

Economic	level of farm income, business characteristics, farm size, equity, income needs, property management planning, off farm income, labour avaiable, type and access to consultant
Indivivdual grower and social characteristics	values, goals, culture, peer group, cultural expectations of farming, motivation , adaptation, attitudes to NRM and NRM organisations, altrusim, risk perception, education, skills, age, family, succession, participation in groups, demographics and socio-political structure in the community or catchmment where the grower lives, ability to uptake specialist, strategic or organisational knowledge, local knowledge within catchment
Instituion	Regulatory environment, government agency support structures, incentive schemes and taxation arrangements, adoption of Environmental Management Systems
Adoption of a particular NRM practice	Cost, relative advantage, complexity, risk characteristics, compatibility, trialability, observability, local information and effectiveness, neighbourhood uptake

Of greatest significance were the studies undertaken by Cary et al. (2002) and Herr et al. (2003) which found a negative link between equity (the degree to which a farm is debt-free) and adoption of NRM. Two plausible solutions have been offered for this negative correlation. Cary et al (2002) suggested that managers with high equity ratios could be more risk adverse and thus less inclined to adopt what they might see as risky resource management technologies. Herr at al, 2003 offers an alternative insight with the quantification of the equity measurement. Equity can be seen as an absolute term and therefore grower's with low value properties could have a low value of equity while growers with a high value property may have less equity. These results and views are contrary to the suggested theories that higher equity indicates better financial capacity to undertake NRM changes and therefore provide higher adoption rates.

Figure 1 provides further abstraction of Table 1 and was adapted from a study into the decision making process in sustainable development (Gallopín (2002)). The study highlighted three major obstacles and their interactions (Table 2), willingness (W), understanding (U) and capacity (C). The author suggests that the factors limiting sustainable development are a lack of political willingness, a deficiency in the understanding of environmental problems and their consequences and the insufficient adaptive capacity (both financial and social) to act on the changes needed. Figure 1 also shows the interaction between physical feasibility and the decision process by including the variable physical possible (P). By definition the capacity to do what is physically impossible cannot exist. Understanding and willingness allows for the acceptance of what is and is not physically possible.

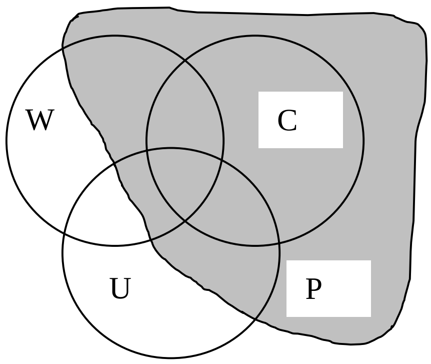

Figure 1 Intersections between physically feasible and decision processes (Gallopín (2002)) where W = Willingness, U = Understanding, C =Capacity and P = Pysically Possible.

Table 2 Actions taken from NRM adoption (Gallopín (2002))

Intersection	Actions
W and U	willing and wise but unable in terms of capacity - twarted actions
W and C	willing and able - ignorant and wrong actions
U and C	Wise and able but unwilling - inaction or cosmetic actions
W, U and C	Willing , wise and able - appropriate action

The decision domain highlighted by Gallopín (2002) can help understand the situation of NRM adoption by landholders in Australia. Both economic and social capacities have been found to increase the likelihood of adoption. Although studies by Cary et al. (2002) and Herr et al. (2003) indicate that adoption of NRM may not be purely based on the financial situation of the farm business. In terms of understanding; the concept and introduction of the Landcare organisation has provided 10 years of information exchange into the understanding and identification of NRM degradation and strategies. A survey of broad acre and dairy farmers by Nelson (2004) reported that more than half of growers surveyed reported signs of degradation while 23 percent reported a significant degradation problem. It was further reported that only 7 percent of farmers faced with significant degradation felt that they were unable to effectively manage the problem mostly because effective management options were either unavailable or beyond their resources. This increase in understanding of the environmental degradation and strategies for ameloriation was highlighted by Nelson (2004) stating that very few farmers indicated a need for further skills or information to help them address degradation issues. In terms of willingness, focus has been on incentives rather than regulatory policy to influence NRM by institutional organisations. Incentives such as tax write offs, auctions and bush tenders have been developed in order for growers to change farm management practices. Willingness to adopt has been limited due to uncertainty of the longer term benefits of NRM alteratives. The focus for government natural resource management programs in the future is to create new technologies for addressing recognised degradation issues, and enhancing economic incentives for their adoption.

Table 2 identifies the interactions between all 3 areas of NRM adoption. The pressure groups we have highlighted in section 2 can be ssen to focus their influence on the willingness and understanding obstacles and the conceptual intersection between the two. What limits appropriate adoption of NRM is that capacity is based on each individual's grower's position. If growers believe that they have the capacity, are willing and have the understanding of how to adopt NRM, adoption may still not be beneficial to the grower. The decision for adoption still will be based in an environment of uncertainty of the resulting consequences.

What is needed is information on the physical and production characteristics at the sub-paddock, paddock and farm scale as well as how these scales interact at the greater landscape scale. Information at these scales will provide an understanding of the farm's ability to provide environmental benefits as well as the financial implications to the grower. Unfortuantely, local information, impacts and knowledge needed for tackling land and water degradation is often deficient (Cary et al. (2002)). The capacity to make decisions at this scale is further pointed out by catchment groups when dealing with the issue of salinity. Advice at a paddock scale is essential for landholders to make informed management decisions. At this point in time there is clear market failure in providing this "on farm" advice. (NACC (2005)).

Research into the area of NRM adoption has been limited in terms of farms physical capacity for adoption. Focus should be firstly on the actual farm's capacity to adopt NRM rather than grower's capacity. The emphasis on the later may explain the lack of signifcant uptake of NRM by growers in terms of their already good understanding of environmental problems and strategies. Understanding the degree to which the farm can uptake NRM options based on the trade-offs between production and the actual environmental benefit will influence the growers willingness to adopt. Being able to quantify the costs and benefits of the proposed situation will help reduce grower uncertainty to the short term consequences of the longer term change. This in term will help the grower understand its effect on the future capacity of the farm business.

4. THE APPLICATION OF PRECISION AGRICULTURE

Cook and Bramley (1998) identify the concept of precision agriculture (PA) as a set of crop management methods which recognise and manage within paddock spatial and temporal variations in the soil-plant-atmoshere system. The practice is to use a range of technologies such as yield mapping or remote sensing, to identify and explain the spatial variation of yield across a paddock or farm and apply inputs in a more site specific manner.

Several studies into the use of PA technology have shown that yield and gross margins vary considerably across individual paddocks (Cook and Bramley (2000), Blackmore (2000), Joernsgaard and Halmoe (2003), Blackmore et al. (2003)). Studies into grain yield over time in Australia routinely show yield ranges of between 0.5 and >4 tonnes per hectare within a single paddock (Cook and Bramley (2000), Wong and Lyle (2003)). These low yielding areas of the paddock due to the inherent landscape properties, consistently lose money independent of seasonal variations (Wong and Lyle (2003)).

For a particular grower if this situation holds true there will be some scope to firstly gain production information at the sub paddock and paddock scale. At a farm scale this knowledge can be used to help guide decisions and create scenarios of where to maximise environmental outcomes and minimise the financial effect on the grower. In theory, these areas could be earmarked for NRM depending on their NRM benefits while increasing overall farm profits. Lyle and Wong (2003) attempted to understand these compromises between farm production and environmental outcomes based on the spatial modeling of financial and environmental tradeoffs in the Wheatbelt of Western Australia. At the farm scale, the reassignment of land based on a compromise between two differing by individually important outcomes showed the loss to grower in terms of profits foregone in the short run in order to gain environmental benefits in the longer term. Although this study was an introductory insight into the way PA technology can help NRM decision-making it shows a possible approach through quantification of both yield and identification of areas where there were imminent environmental problems. The use of PA technology can help understand the degree and capacity to which the farm can change on ground and identify the risks of impact to the farm business from adoption of NRM. We believe that this approach has room for further investigation.

5. CONCLUSIONS AND DISCUSSION

Growers in the Australian grains industry are under more pressure than ever to adopt NRM practices to combat environmental degradation. A shift of responsibility from the State and Federal governments to local catchment management has placed environemntal issues solely at the regional level. The fact that the processs of distributing money to the CMA's on completion of an agreed environmental action plan may well place unrealistic targets and evaluation criteria on the farming community. Pressure to adopt NRM practices is also being exerted from the grains industry itself. The industry wants to hold on to the image of 'clean and green' production so as to access niche markets in the future. The industry, national and state farming federations as well as regional farming systems groups all now realise the need to be committed to a triple bottom line approach, with farming practice and good environmental stewardship the key to both short and longer term prosperity. What is important however, are that the environmental and remediation decisions are made at the sub paddock, paddock or farm scale by the grower. These decisions will be made in uncertainty and although farming system groups may help provide some information on what the likely impacts may be, the potential loss to the business will be farm and paddock specific. This uncertainty in the decision making process will naturally lead to lack of NRM adoption. This lack of adoption has been researched quite thoroughly with the main determinants suggested as economic, individual and social characteristics, as well as institutional factors. We have highlighted that NRM adoption in Australia followed the theory outlined by Gallopín (2002) that willingness, understanding and capacity were major drivers of adoption. The second section of this paper highlighted the different pressure groups which will drive the willingness and understanding of future growers perceptions; whereas capacity is solely left to the individual grower. One area that has had limited research into is the physical capacity of the farm to undertake NRM i.e. what is physically possible in terms of the actual benefit and costs of adopting NRM strategies. The application of PA technology into this area, may be able to help reduce the uncertainty and ignorance in the decision making process by being able to quantify both the short term effect on grower's income and long term effect on environmental degradation. This approach will be looked at in future research.

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