

# Drivers affecting the adoption of plant-based options to manage dryland salinity

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## *Introduction*

Dryland salinity is considered to be among the most serious environmental and resource management problems in Australia (1998). Recent estimates, based on remote sensing, have suggested that the area currently affected by salinity in Western Australia is about 1 million hectares and the annual rate of increase is about 14,000 hectares (McFarlane *et al.* 2004).

In the subsoils of most Australian agricultural land, naturally occurring salts are found at high levels (Pannell and Ewing 2004). Some of the salts in the landscape have been discharged from weathering rocks (National Land and Water Resources Audit 2001b), but the majority have been transported inland from the ocean and deposited with rainfall (Hingston and Gailitis 1976). The replacement of native vegetation by agricultural systems that utilise less water has resulted in the rise of saline watertables. Compared with natural vegetation, where between 0 and 10 mm of rainfall penetrates to the groundwater each year, agricultural systems based on annual crop and pasture species experience leakage of more than 150 mm to the watertable (Cocks 2003).

Controlling the spread of salinity is substantially dependent on farmers voluntarily changing their farming practices away from a system based almost solely on annual plant species, towards much greater use of perennial plants (Anon. 1996) or adopting engineering solutions to remove runoff and/or lower watertables. The adoption of perennial species by farmers has been, in most districts, at a scale that is a small fraction of that recommended by hydrologists for the prevention of soil salinisation (Hatton and Nulsen 1999). Lucerne, saltbush, tagasaste and oil mallees are current plant-based solutions being employed across Australia to assist in salinity management.

Lucerne (*Medicago sativa* L.) is the most widely used herbaceous perennial legume in Western Australian farming systems (Pannell and Ewing 2004). Kingwell *et al.* (2003) concluded that lucerne is currently profitable on at least some areas of most grain-growing farms in southern Australia and would contribute to reducing soil recharge. Tagasaste (*Chamaecytisus proliferus*) is one of the most prominent and successful shrubs for salinity management and is estimated to have been planted on 100,000 hectares throughout Australia, with the majority being in Western Australia. Adoption of tagasaste has been promoted by its ability to recover water and nutrients on deep and infertile soils with poor water holding capacity (Pannell and Ewing 2004). In addition, commercial trees, in particular oil mallees (*Eucalyptus oleosa*), could play an important role in reducing dryland salinity and diversifying agricultural production in the wheatbelt, the latter aiding the stability of farming systems in this region (Cocks 2003). In contrast to these plant species that are used to prevent dryland salinisation, saltbush (*Atriplex* spp.) is a popular salt-tolerant plant employed on land that is already saline. Saltbush is often employed in alley-farming systems because these shrubs are able to lower the water table so that less salt-tolerant species, such as balansa (*Trifolium michelianum*) and Persian clover (*Trifolium resupinatum*), can establish in the inter-rows (O'Connell *et al.* 2006).

Research into salinity management strategies is an ongoing process that aims to develop innovations that are attractive to, and hence adopted by, landholders. This study aims to document the main drivers affecting the adoption of plant-based solutions to manage salinity. Although there is a significant amount of research highlighting the productivity of various plant-based systems, there is minimal scientific research detailing landholders' views regarding salinity management options.

Numerous studies have highlighted how particular characteristics of agricultural and land management innovations will impact their adoption (Cary and Wilkinson 1997; Pannell 2001b; Pannell *et al.* 2006; Rogers 1983). In order to gain an insight into the drivers of adoption and non-adoption of plant-based options, it is essential to understand the landholders' perceived limitations of the innovations and their attitudes towards them. The key hypotheses tested in this study are as follows:

1. the attractiveness of existing perennial plant-based options for dryland salinity management by farmers is determined by multiple criteria, such as the compatibility and profitability of the option;
2. farmers who rate an innovation as "attractive" are more likely to adopt that innovation; and
3. the perceived low relative profitability of these plant-based options is a primary driver in their low adoption.

It is found that the compatibility of an option with the current farming system is one of the main drivers of adoption. In accordance with adoption theory, the profitability of an innovation is also a key driver when considering the adoption of salinity management practices.

### ***Methods***

A draft survey was pilot tested with a small sample of the target population. This uncovered aspects of questions that caused difficulty for the participants (Pannell and Pannell 1999). The revised questionnaire was posted to 940 landholders in the wheatbelt region shires of Bruce Rock, Kondinin, Merredin, Narembeen and Westonia, and to the Great Southern region shires of Cranbrook, Gnowangerup, Jerramungup, Katanning, Kent and Tambellup in Western Australia's agricultural region (Figure 1).

The 940 landholders represented a stratified random sample of landholders in the Wheatbelt and Great Southern regions. The Wheatbelt region received 450 surveys (47.9 per cent), whilst the Great Southern region received 490 surveys (52.1 per cent). The sample was constrained to only include land holdings larger than 500 hectares. This was consistent with this study's focus on commercial farmers and their perceptions of a variety of salinity management options.

Key questions in the survey allowed the assessment of landholders' adoption of salinity management and their perceptions of plant-based options and salinity management in general. Respondents were asked to identify on what type/s of country (saline, slightly saline or non-saline) they had used the plant-based strategies. Responses to this question enabled the landholder to be identified as an adopter or a non-adopter of a particular plant-based option. Question 20 proposed nine statements regarding the attractiveness of five plant-based options (lucerne, saltbush or saltland pastures, commercial trees, native vegetation and other). The statements could be given an answer of either yes (+1), no (-1) or unsure (0). The statements were based on the key attributes of an innovation as highlighted by Robertson *et al.* (2007). The responses were then tallied to give an 'attractiveness' score for each plant-based option, ranging

from a lowest possible score of -9 to a highest possible score of +9. This question allowed the overall “attractiveness” of each strategy to be assessed, and identified the key attributes that limit adoption.

Question 21 proposed ten limitations to the adoption of salinity management options. This question was designed to gain an understanding of the landholders’ general perceptions of salinity management options.

The software program CART (Classification and Regress Tree) was employed to develop an understanding of the various decision pathways a landholder may follow when adopting a particular innovation. Classification trees were produced in this study to show the drivers affecting the adoption of plant-based salinity management options.

### ***Results***

Of the 940 questionnaires mailed out, there were 260 respondents (27.7 per cent). More than 70 per cent of respondents considered salinity to be a current or future problem on their property. The Wheatbelt region had a slightly higher response rate (55.8 per cent) compared to the Great Southern (44.2 per cent). The shires with the greatest percentage of saline land are Kent (10.73 per cent) and Westonia (11.44 per cent). However, the response rates for these shires were not significant (Table 1). The Kondinin Shire had the highest response rate for the Wheatbelt and presently has 26,680 hectares affected by salinity. The Jerramungup Shire had the highest response rate for the Great Southern and presently has 18,336 hectares affected by salinity and 12,418 hectares at high risk.

A profile of the ‘typical’ respondent across the surveyed region was constructed using the means of particular statistics drawn from the survey responses. The average property size is 3610 hectares and the average percentage of saline land per property is 6.5 per cent. The extent of salinity on-farm is slightly larger than would be expected based on the average percentage of saline land per shire being lower at 5.83 per cent. This suggests that farms with larger proportions of their farms affected by salinity are more likely to be survey respondents based on this result.

The average time that the respondents have spent farming is 30.8 years. More than half of the respondents are over 51 years of age and less than 4 per cent are aged between 21 and 30 (Figure 2). This is consistent with previous demographic studies that have identified an ageing population in rural Australia.

Nearly 28 per cent of respondents have graduated from university or a TAFE institution. In addition, more than half of the respondents were members of a local or regional catchment, land management or saltland pastures group. Nearly 43 per cent of respondents identified salinity to be one of the top three issues to affect their district and 36 per cent identified salinity to be one of the top three issues to affect their farm. This highlights that this land degradation issue is of primary importance to a significant proportion of survey respondents.

Native vegetation and saltbush have the highest adoption levels. Both lucerne and tagasaste have low-level adoption in both regions. This is most likely due to lucerne and tagasaste having larger water requirements than saltbush. In turn, this larger water requirement significantly influences the area suitable for the establishment of lucerne and tagasaste.

Financial constraints are the greatest limitation to implementing salinity management options, with 77.1 per cent of landholders in agreement. Profitability was identified as a key limitation by 61.8 per cent of respondents. They believed that salinity management options do not deliver enough profit.

The software program CART utilised numerous variables to classify survey respondents as adopters or non-adopters of a particular plant-based option. The most significant variable for lucerne adopters and non-adopters is the compatibility of lucerne with their current farming system. The profitability of lucerne, whether or not the landholder was a member of a landcare, catchment or saltland group, and the number of years responsible for farm decisions were other significant variables in the lucerne analysis.

The compatibility of saltbush with a farmer's current farming system is the most important variable for classifying survey respondents as adopters or non-adopters of saltbush. The percentage of salt-affected land, the size of one's property, the landholders' time availability and the affect upon one's social standing were other important variables in the CART analysis.

The most important variable for classifying survey respondents into being an adopter or non-adopter of native vegetation is the attractiveness rating. The size of one's property, the percentage of salt-affected land and the establishment costs were other significant variables in the CART analysis of native vegetation.

The compatibility of commercial trees with a farmer's current farming system is the most important variable for classifying survey respondents as adopters or non-adopters of commercial trees. The age of the landholder, the establishment costs, the percentage of arable land and the ease of discontinuance were other significant variables in the CART analysis of commercial trees.

### ***Discussion***

The relatively small sample size of landholders who consider salinity to be a current or future problem on their property (183 respondents) indicates that some care is required when generalising the survey findings. This sample, however, displayed little regional response bias with 45.9 per cent of respondents being from the Great Southern and 54.1 per cent of respondents being from the Wheatbelt region.

It is likely that of those surveyed within each Shire, those that had a current or future salinity problem would have greater interest in the issue and be more likely to complete and return the questionnaire. The response rate did suggest this, as 70.4 per cent of the surveys returned acknowledged that a salinity problem currently existed on their farm or could be expected to develop in the future.

Farm financial constraints are identified as the greatest limitation for survey respondents to implement salinity management options. This supports the findings from an Australia-wide land management and salinity survey, which found that the lack of financial resources was the main barrier for land management change for 67.6 per cent of non-irrigated farms (Trewin 2002). The profitability of salinity management options was found to be a key limitation among survey respondents. Even landholders with a low emphasis on making additional income are unlikely to adopt practices that incur large economic losses (Pannell *et al.* 2006). However, profitability may

sometimes be offset by issues such as time availability, lifestyle or risk. Time availability was another dominant limitation of survey respondents to implement salinity management options.

The survey respondents have highlighted that there is an urgent need for further research into the economic performance of plant-based systems for salinity management. The economic performance of perennial species at a farm level is very important because it is a major driver of landholder decisions regarding adoption.

In this study, financial constraints and profitability were the two major limitations identified by survey respondents as limiting their adoption of salinity management options. However in the CART analysis, the variable of profitability only featured in the lucerne classification tree. This may be due to the adoption levels of lucerne being the lowest out of all plant-based options. Therefore, the farmers' perceptions of its poor profitability were the major constraint to its adoption.

The CART-generated classification trees for lucerne, saltbush and commercial trees reveal that the compatibility of the plant-based option with the landholder's current farming system is the most important variable for classifying adopters and non-adopters. The adoption of an innovation can be diminished if it is not easily incorporated into the current farming system. Systems based on perennials often involve more intensive management than do annual plants (Cary *et al.* 2002). In contrast, compatibility was not an important variable for the CART analysis of native vegetation. This may be attributed to the common use of native vegetation as a permanent fixture within a farming system rather than as an integrated salinity management option like lucerne.

In this survey study, it was hypothesised that farmers who rate an innovation as "attractive" are more likely to adopt that innovation. Accordingly, the attractiveness rating was the most important variable when classifying adopters and non-adopters of native vegetation. The high importance of the attractiveness rating may be due to the adoption of native vegetation being more for environmental and sustainable reasons than say the productivity and profitability of the option.

The CART analyses for saltbush and native vegetation show that, in general, landholders with larger properties are more likely to be adopters. Generally larger farms have greater incomes and are thus able to support the adoption of new innovations, such as plant-based salinity management. An improved financial position aids adoption by reducing the prospect that a failed trial of an innovation will lead to ongoing economic hardship. Larger areas tend to increase the overall benefits of adoption of beneficial innovations and so increase the likelihood of adoption (Pannell *et al.* 2006).

The CART analyses for commercial trees and native vegetation reveal the importance of establishment costs as a driver of adoption. Establishment costs play a major role in adoption through its link to the capacity of a farm to fund these costs and its association with the time required to pay off a loan if money is borrowed to incorporate an innovation into a farming system. Pannell *et al.* (2006) states that land conservation practices are often characterised by large up-front costs and benefits that occur at some stage in the future.

### ***Conclusions***

Salinity management practices have been adopted by landholders in the surveyed regions, but not at the scale required for wide scale salinity abatement. Native vegetation and saltbush had the

greatest adoption levels across both regions, whilst lucerne had the lowest level of adoption. According to landholders' general perceptions of salinity management options, farm financial constraints were identified as the greatest limitation for survey respondents to implement salinity management options. The profitability of salinity management options and time availability were also found to be key limitations among survey respondents.

CART analyses of landholders' responses in the mail-out survey revealed that the adoption of plant-based options is influenced primarily by the compatibility of the option with the current farming system. Other key factors in the adoption of a plant-based option were the "attractiveness rating" of the option, the profitability of the option, farm size and the percentage of salt-affected land on-farm.

Current adoption of deep-rooted, perennial plants is currently too low to protect most parts of Western Australia from dryland salinisation. The adoption of these plants is substantially dependent on farmers voluntarily changing their farming practices away from a system based almost solely on annual plants. However, this study has highlighted that the limitations to adoption is largely to do with the characteristics of the option (eg. compatibility and profitability) rather than the characteristics of the farm or farmer. Unless research into improving the compatibility and profitability of existing and new plant-based options is continued and/or implemented, the adoption levels of salinity management options will not improve.

### ***References***

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