Dryland salinity, coordinating action and economic policy: a role for contracts?

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Abstract

The problem of addressing dryland salinity at a landscape scale is considered in the context of using economic incentives to encourage change in land use by individual landholders to adopt salinity mitigating actions where a public asset of significant value is threatened.

This paper reviews the principal-agent problem and looks at mechanisms which give incentives to address natural resource management problems, and in particular, the role of contracts between the Government and landholders for achieving environmental objectives. Consideration is then given to the potential for empirical analysis of these policies in practice and their effectiveness in achieving the desired environmental outcomes.

Keywords: salinity, economic incentives, contracts, hidden information

Introduction

Knowledge of dryland salinity, its causes and effects, has increased significantly over the past twenty years. However, a majority of the options developed to address dryland salinity are not economically viable for the scale that is required to address the dryland salinity problem in Western Australia (Kingwell et al., 2003). Consequently, the State has turned its attention to prioritising funding for salinity investment to public assets of high value such as natural diversity, water supplies and infrastructure (DOE, 2003). A change in farming practices and adoption of salinity mitigating processes is seen as vital for the survival of these assets.

Various policy mechanisms are available to induce change in farming practices, such as taxes and subsidies, which aim to achieve particular outcomes at minimal cost. Change in farming practices from traditional forms to those that mitigate dryland salinity, will be more effective when adopted over a landscape scale. This is because groundwater flows and other characteristics which contribute to the state of a property do not recognise its boundaries and often occur on a much wider scale.

This paper aims to look the role of economic instruments in facilitating change in land use on a landscape scale, in particular, the role of contracts. The role that empirical analysis plays in verifying economic theory on incentives to induce change in land use will be considered in the case of revegetation works undertaken in South West Western Australia.

Dryland salinity: causes and consequences

Causes

Salinity refers to the presence of soluble salts in soil or water at levels which significantly affect such things as plant growth, soil structure, water quality for irrigation, industrial or drinking purposes and the breakdown of infrastructure (Peck, 1993; Martin and Metcalfe, 1998). There are two classes of salinity: *primary salinity* occurs naturally, where salt has been built up within soil as a result of natural landscape processes over thousands of years while *secondary salinity* occurs as a result of changes in land use management (Peck, 1993).

The *State of the Environment* (ASEC, 2001) report identifies the common cause of secondary salinity as being hydrological imbalance. In the case of dryland salinity, the imbalance can be attributed to the replacement of deep rooted native vegetation with shallow rooted crops and pastures, such that a greater amount of water percolates into groundwater systems. Native vegetation cover, through relatively high rates of transpiration, kept the water table below the root zone. European settlement and consequent changes in land use to annual crops with low rates of transpiration, have allowed the water table levels to rise. The implications of this process show themselves in the form of dryland salinity as the water table adjusts to a new equilibrium level closer to the surface.

Consequences

Western Australia's *Salinity Strategy* (GWA, 2000) estimated that approximately 6.2 million hectares of agricultural and pastoral lands are at risk of developing dryland salinity in Australia if no action is taken in the next 70 years. Western Australia is the worst state affected by salinity, with approximately 80 per cent of current national total area of salinity (NLWRA, 2001). Approximately 7 000 farms, just over half the farms in the state, and 1.2 million hectares are showing signs of salinity (ABS, 2002).

Costs of dryland salinity include the decline of water quality, hastened breakdown of infrastructure, loss of productive farming lands and biodiversity. The Western Australian *State of the Environment Report* (SERG, 1998) estimated the capital value of the land lost to salinity at $1.4 billion with a minimum loss of land capital value at $64 million annually until a new hydrological balance is reached.

Almost all estimates of the costs of salinity do not include the cost to the environment or cultural heritage. This is particularly pertinent to the Western Australian Wheatbelt, as it is a world recognised biodiversity hotspot (Myers et al., 2000; Keighery, 2000). The biodiversity of this region is seriously threatened from dryland salinity, with an estimated 450 flora species endemic to the lowlands of the Wheatbelt region at risk of extinction (Keighery, 2000). It has been estimated that up to 80 per cent of vegetation remnants on farms and up to 50 per cent on public lands (including conservation reserves) could be lost in Western Australia as a consequence of dryland salinity (AgWA et al., 1996).

Management options for dryland salinity

Management options identified to address dryland salinity fall under three broad categories and can be used in various combinations according to appropriateness (Pannell, 2001):

Prevention and protection — of regions at risk from salinity by undertaking native vegetation retention, adequate resource assessment and water-balance modeling

Remediation — recharge management and interception of fresh water to prevent or reduce the rate of rise of groundwater, and reduction of groundwater level to reduce impacts of salt.

Adaptation — managing saline discharge, development of alternative uses of saline land and water resources.

The severity of the dryland salinity problem has brought together various industries, non-government organizations, State, Local and Commonwealth Governments under the National Dryland Salinity Program (NDSP) and more recently, the establishment of initiatives such as the National Action Plan for Salinity and Water Quality (NAP) and the Cooperative Research Centre for Plant based Management of Dryland Salinity (CRC). Funding for investment in mitigating the impacts of dryland salinity is provided for in various government budgets as well as being available through the NAP, the National Landcare Program and the National Heritage Trust (NHT) fund.

Since its inception in 1989, the National Landcare Program has been successful in raising awareness of resource conservation and in some cases the change of land management practices. However, much of the programs efforts have been too small to prevent ongoing resource degradation and changes in policy approach towards direct public investments to be targeted and site specific, for assets of outstanding value has been pursued (DOE, 2003).

Dryland salinity and market failure

The presence of dryland salinity can be described, in economic terms, as a consequence of market failure. Markets result in the efficient allocation of resources if, and only if, the prerequisites for a competitive market system are met. Where prices fail to provide the proper signals to producers and consumers for the efficient allocation of resources, market failure persists (Pindyck and Rubinfeld, 1996). Fundamental causes of market failure in the dryland salinity case include property rights; externalities and information asymmetries.

Property rights and externalities

Property rights can be defined as the entitlements which govern the way producers and consumers use resources. In a competitive market economy, private property rights have the following characteristics:

> *Universality* — all resources are privately owned and all entitlements completely specified.
>
> *Exclusivity* — all benefits and costs accrued as a result of owning and using the resource should accrue to the owner, and only to the owner, either directly or indirectly by sale to others.
>
> *Transferability* — all property rights should be transferable from one owner to another in a voluntary exchange.
>
> *Enforceability* — property rights should be secure from involuntary seizure or encroachment by others.

When the characteristic of exclusivity is not present, externalities are likely to occur. An externality exists when:

> … a consumption or production activity has an indirect effect on other consumption or production activities that is not reflected directly in market prices … the word 'externality' is used because the effects on others (whether benefits or costs) are external to the market (Pindyck and Rubinfeld, 1996: 590).

As the above definitions suggests, externalities can be either positive or negative, and as such there will be either an under or over supply of goods being produced or consumed.

Dryland salinity as non-point source pollution

Negative externalities in environmental situations are often classified as pollution. Pollution, however, can be classified into two types: fund and stock (Tietenberg, 1996).

Where salt is flushed out of soils and out of water systems at levels not harmful to the environment it can be considered a fund pollutant. However, rainfall patterns, physical characteristics and the hydrogeology of the Wheatbelt region in Western Australia have resulted in the accumulation of salt in soils beyond the absorptive capacity of the environment and can therefore be classified as a stock pollutant. It has been estimated that the soils in this region have accumulated between 100 – 15 000 tonnes of salt per hectare (Pannell, 2001).

Pollution can also be categorised into the following sources:

Point source — generally discharges into the environment at a specific location, such that individual polluters can be identified and observed at a relatively low cost.

Non-point source — usually are dispersed into the environment in an indirect and diffuse way, consequently the cost of identifying and monitoring individual polluters is usually prohibitively high.

Mobile source — discharged into the environment from a temporary location.

Dryland salinity may be classified as a non-point source pollutant but whether or not it is a negative externality will depend on its range. The range of a pollutant can be classified as local, regional or even global (Tietenberg, 1996). A local pollutant is one where the damage is experienced near the source of the emission, while damage from regional pollutants is experienced at greater distances from the source. While a local pollutant cannot be regional, a regional pollutant may also be local, they are not mutually exclusive.

These classifications of a pollutant's range have similarities to classifications of groundwater flow systems as local, intermediate and regional. Dryland salinity may prevail as an externality rather than a private cost where groundwater flow systems encompass more than a single property.

However, an externality can also persist within property boundaries when non-market and non-use values such as presence of biodiversity and ecosystem functions are degraded. These costs are borne by the wider community who value their existence.

Externalities are not the only source of market failure and this must be kept in mind when developing appropriate policy to deal with dryland salinity, especially in targeting assets of high value (Pannell, 2001).

Information asymmetries

The other source of market failure which can be attributed to dryland salinity is information asymmetry. It is typically defined in a market situation where one agent (usually the seller) has more information about the good or service which is being sold than the other (usually the buyer). In agricultural policy studies it is usually assumed that producers are always better informed about their production process than the policy makers are, but this is not always the case. Two types of information asymmetries that occur are:

> *Hidden knowledge* — occurs when the landholder has exact information about his technology but the regulator or other landholders do not.
>
> *Hidden action* — is present when only the landholder has exact information on the conditions under which production activities such as fertiliser and pesticide applications.

These two types of information asymmetries will often result in the respective economic problems of adverse selection and moral hazard if not taken into consideration when designing the regulation mechanism. Adverse selection is often described in an insurance context where high risk individuals are more likely to buy insurance than low-risk individuals, and it becomes unprofitable to sell insurance when it is not possible to distinguish between the two types of individuals. Moral hazard occurs when an insured party can affect the probability or magnitude of an event against the occurrence of which it is insured.

Policy instruments available

There are three types of instruments policy makers can use to influence landholder behaviour: command and control; market based instruments and moral suasion through education.

Traditionally regulation or command and control approaches usually involve the setting of some standard against which the 'regulator' assesses each firm. In the case of dryland salinity management in Western Australia, regulations prohibiting the removal of native vegetation on private property without a permit were put in place under the *Soil and Land Conservation Act*. This form of environmental management requires only information about the parameter being regulated, in this case the area of vegetation removed.

Market-based instruments are those which use prices and information disclosure to influence behaviour. Such instruments include: taxes, subsidies, fees, and tradeable permits. Although generally more efficient than command and control approaches, they are often not as effective for a number of reasons such as: high information requirements, high transaction costs and difficulties in defining or establishing private property rights (Baumol and Oates, 1995).

Moral suasion through education is the third approach used to influence behaviour. This was the major approach adopted by the government in the decade of Landcare, using the Landcare Program to educate landholders of the value of revegetation in addressing land degradation problems such as dryland salinity.

Which policy instruments?

The Western Australian government's policy to invest in priority assets is looking to market-based instruments as a means of delivering cost efficient natural resource management strategies (ASWA, 2002). Examples of market based instruments in place include:

- The cost sharing arrangements for revegetation and other conservation activities being undertaken by the Department of Conservation and Land Management with landholders in key conservation areas (Mullan and Wallace, 2001).
- Auctions can be used when information is not complete and were implemented in Victoria for conservation contracts under the BushTender scheme (Stoneham et al., 2003).
- Direct subsidies for schemes to retire agricultural land such as the Environmental Stewardship, Conservation Reserve and Land Set-aside programs undertaken in the United States and the European Union (Bourgeon et al, 1995; Wu and Babcock, 1996).

Some instruments available to government to implement policy goals have attracted less attention because of the characteristics of the salinity problem (spatial and temporal dimensions make a tradeable permit system difficult) and also of the communities targeted to change their land use behaviour, where it may be politically infeasible to introduce an environmental levy.

In deciding which policy mechanism should be adopted for a particular area for desired environmental outcomes, each mechanism should be assessed on its:

- Effectiveness in achieving the outcomes and gaining greater participation, either by voluntary or compulsory means;
- Efficiency, it is the least cost method which achieves the desired outcomes;
- Equity in distribution of costs and benefits for participants, or the political feasibility of the scheme; and
- Information requirements of the mechanism, such that the costs of implementing the scheme do not exceed its benefits.

Some criteria may be given more weight than others. This may occur where effectiveness is desired above efficiency, where an asset is so highly valued that whatever means is required to induce a change in behaviour is adopted, regardless of whether it is the least cost approach. If a scheme is voluntary, it needs to meet the above criteria and also make those who participate in the program no worse off than if they had not.

In designing such a mechanism which induces a change in land use, the policy maker is disadvantaged by hidden knowledge. How much information about farmers should be known to design an efficient policy mechanism can be analysed as a principal-agent problem.

Principal-Agent problem

The principal-agent relationship consists of a principal who wants to induce another person, the agent, to take some action which is costly to the agent. The principal may be unable to directly observe the cost of the action to the agent and has the problem of designing an incentive payment scheme that induces the agent to take the best action from the viewpoint of the principal (Varian, 1992).

The principal-agent problem is characterised by hidden action and hidden knowledge, which was described earlier as an information asymmetry and source of market failure. However, hidden action is not as important in salinity management as hidden knowledge as most of the management actions such as surface and deep drains, perennial pastures, and revegetation are observable at a reasonable cost.

If a policy mechanism has not been designed to account for information asymmetries, such as hidden knowledge, there is then scope for agents to extract rent from the principal and reduce the efficiency of the policy. This behaviour is known specifically as rent seeking. In particular, in offering incentives for change in land use, adverse selection is likely where land holders will select incentives that are most profitable rather than those which represent their true cost of land use change. This behaviour must be considered in the design of the mechanism for the incentive.

The role of contracts in managing dryland salinity

Brousseau and Glachant (2002: i) define a contract as ‘an agreement under which two parties make reciprocal commitments in terms of their behaviour to coordinate’. The economic theory of contracts has developed over the years from the Walrasian market theory where supply meets demand at a given price, to three principal fields of study in incentive theory, incomplete contract theory and transaction cost theory. Contracts, at a theoretical level, provide an analytical framework for a number of issues such as (Brousseau and Glachant, 2002: 5):

- The exact nature of difficulties associated with economic coordination;
- Details of various provisions for coordination: routines, incentives, the authority principle, means of coercion, conflict resolution, etc;
- How agents conceptualise the rules and decision making structures that frame their behaviour; and
- The evolution of contractual mechanisms.

Moxey et al. (1999) describe how contracts can be used to give incentives to farmers to produce environmental public goods, and in doing so incur costs in compensating farmers to change their land use as well as information costs as part of the contracting process. Given the heterogeneity of farmers production costs and their values, the information costs involved in negotiating compensation to change their land use is likely to be substantial if this heterogeneity is not easily observable (hidden information). Moxey et al. (1999) suggest rather than offering a standard contract to all farmers, which is inefficient, or negotiating with each farmer, which incurs high information costs, that a menu of contracts is offered to farmers where they self select their type, revealing information about their costs.

Collective action

Coordinated management of natural resources can evolve out of collective action, which has been defined as a movement to address the social dilemma where rational individual actions can lead to irrational collective actions (Heckathorn, 1996). This is evident in the problem of dryland salinity, where it is individually rational for a landholder to replace native vegetation with profitable shallow rooted annual crops but collectively devastating for the landscape.

The collective action dilemma can be resolved in two ways (Heckathorn, 1996);

1. In moderate sized groups, it can be resolved through strategic interaction, that is, the reciprocity of cooperation; or
2. In larger groups, collective action requires selective incentives.

It is in this second category that there is scope to use contracts to coordinate actions on a landscape scale by providing incentives in the form of compensation for undertaking on-ground works to address salinity.

Spatial and temporal information problems

However, the contribution any individual is making to total salinity in a given time period in a given landscape, is prohibitively unmeasurable, making any contract to undertake action unverifiable. The difficulties in contracting individual actions to address a collective non-point source pollution problem have been analysed in Pushkarskya (2003) and Bystrom and Bromley (1998). Both suggest non-individual contracts between farmers and a regulating authority, with the former suggesting the use of a collective subsidy if the collective farmer group is under an ambient pollution standard set for a watershed, and the latter suggesting the use of a collective penalty if the farmer group is over the standard. By using a collective incentive scheme, the information requirement of the regulating authority can be substantially reduced.

Regardless of how the information requirement for contracting is addressed, dryland salinity is an environmental problem that has inter-temporal considerations that in some cases may span several decades. Contracts by nature have a defined duration, over which the agent undertakes some specified actions for some desired outcome at a specified price. A contract of sufficient length to address dryland salinity would face numerous problems, including no opportunity to adjust the price to reflect the cost of mitigation activities as technology develops. Shorter contracts face the problem of renegotiation, where after the first contract is undertaken the regulator will often have more information about the farmer’s costs and will try and exploit this knowledge and reduce the contract price. Laffont and Tirole (1994) describe this as the ratchet effect. As such, farmers are likely not to renew their contract, which for an environmental problem requiring a long term approach has potential devastating implications as well as reducing the value of the initial contract.

Relevant research on the principal-agent problem

There is an extensive literature body on the principal-agent problem, especially in contracting for environmental problems. There are a few studies which are particularly relevant.

Programs such as Environmental Stewardship, Conservation Reserve and Land Set-aside programs undertaken in the United States and the European Union have been analysed under the principal-agent framework, where farmers have private information about their land quality, for efficient mechanism design (Smith, 1995; Wu and Babcock, 1996; Bourgeon et al, 1995). Research by Moxey et al. (1999) and White (2003) addresses hidden knowledge issues through designing contracts which allow landholders to self select their type.

Krawczyk et al. (2003) devised a system of coupled incentives that stimulates economic agents to coordinate their actions using a principal-multi-agent game, where the principal chooses instruments sufficient to generate an environment friendly agent reaction. A specific coupled incentive scheme is defined where individual agents are rewarded for their joint actions' effect rather than their individual accomplishments.

Along similar lines was the paper by Parkhurst et al. (2002) where a voluntary mechanism of an agglomeration bonus was designed. This scheme is designed to protect endangered species and biodiversity by reuniting fragmented habitat across private land. The bonus is an extra payment for every acre a landowner retires that borders on any other retired acre, on top of the standard payment for retiring any acre the landowner wishes to retire.

Pushkarskya (2003) and Bystrom and Bromley (1998) address coordinating actions on a landscape scale by using a collective incentive arrangement to address non-point source pollution. In Pushkarskya's study, incentives are given to undertake management as a group and as such coordinate their efforts rather than acting in isolation. Hidden information is addressed in that associations consisting of farmers undertaking pollution mitigating actions, can observe other members within their region and discern their type and also their actions.

Limitations of this approach include ensuring equitable distribution within associations according to cost functions, rent seeking activities by members, and free riding behaviour.

The complexities of dryland salinity in where and when it appears as a consequence of certain land management practices, makes the application of the above theory on principal-agent problems difficult and many of the assumptions used are not applicable. Dryland salinity is a natural resource management problem that has both spatial and temporal aspects which cannot be modelled in a static setting and should be considered in a dynamic setting where solutions evolve and adjust to farmers changing costs in addressing this problem.

Empirical analysis

An empirical analysis is useful to verify the economic theory underlying the use of contracts. It also identifies the types of mechanisms used to induce coordinated land management change and observe how implementation was undertaken or is proposed to be undertaken in the management of dryland salinity.

Existing empirical verification of the economics of contracts can be found in econometric tests and case studies (Brousseau and Glachant, 2002). Econometric testing looks at variables such as the duration of the contract and the determinants of various clauses in contracts. Incentive theory and incomplete contract theory have assumptions which have made econometric testing difficult. Other obstacles identified by Brousseau and Glachant (2002) for empirical analysis of contracts include: gathering data, constructing a database and poor quality of data.

The application of experimental economic techniques, such as Agent-Based Modelling, can also be used to verify the economic theory being applied to contract design. This is particularly useful in the absence of data required for econometric analyses.

A potential empirical analysis of contract theory inducing change in land use to mitigate salinity would be that of the cost sharing arrangements undertaken in the Wheatbelt region to protect areas of natural diversity. Cost sharing arrangements between landholders and the government are generally not formal contracts, such that they are not legally binding, except in cases where there is a high proportion of government input (Mullan and Wallace, 2001). Examples of cost sharing schemes implemented in Western Australia include Bushcare, the Remnant Vegetation Protection Scheme and the State Revegetation Scheme. The Department of Conservation and Land Management (CALM) negotiate the terms of the cost sharing arrangements individually with each farmer participating in a revegetation scheme in Western Australia. A methodology for cost sharing was developed by CALM to use for the Dongolocking Project and also at Toolibin Lake and Wallatin Creek (Mullan and Wallace, 2001).

Incentive schemes to encourage landholder participation in the Catchment Demonstrative Initiative (CDI) being run by the Government of Western Australia, the Commonwealth and regional NRM groups provide another opportunity to analyse the economic theory behind any contracts which are successful at inducing change in land use. The CDI aims to demonstrate combinations of salinity management practices to recover saline land restrict its development and allow profitable uses of saline land and water.

By using the empirical information provided by successful/unsuccessful contracting arrangements to induce change in land use, contract design can be analysed so that a future arrangements to induce change in land use may be more cost effective in mitigating dryland salinity.

Conclusion

Contracts are just one policy mechanism which can be used to address the problem of dryland salinity at a landscape scale. The context in which they may be appropriate as an instrument to induce change in land use needs to be investigated further, with particular reference to empirical analyses where they have already be used in some form or another, especially where a public asset of significant value is threatened.

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