



Economic tools to tackle

# Dryland Salinity

in Western Australia

OCTOBER 2001



Department of Treasury and Finance  
Government of Western Australia

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As noted in the Foreword and at the commencement of this paper, the views expressed in the paper are those of the author, Dr Pannell. They do not necessarily reflect the views of the State Government.

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ISBN 0 7307 4503 1



**ECONOMIC TOOLS TO TACKLE DRYLAND  
SALINITY IN WESTERN AUSTRALIA**

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## FOREWORD

As part of its economic research program, the Department of Treasury and Finance decided earlier this year to examine economic and public finance aspects of salinity management in Western Australia, particularly the use of economic tools<sup>1</sup> for tackling the salinity problem. The purpose was to build our capacity to advise the Government in this area in both the short and longer term, and to stimulate discussion on these issues.

In March this year, Dr David Pannell, a nationally recognised expert in salinity management from the University of Western Australia, and other experts on salinity from the Water and Rivers Commission and Department of Agriculture, were invited to a workshop convened by Treasury. Dr Pannell was then commissioned to write this paper, addressing the issues raised in the attached Treasury scoping paper.

Dr Pannell was subsequently also appointed to a Western Australian Government taskforce to review the existing *State Salinity Strategy*. While the views expressed in this paper are Dr Pannell's personal views, they are broadly consistent with the recently released findings of the taskforce.

This paper is the first in an occasional series that will be published by the Department of Treasury and Finance's economic research group.

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<sup>1</sup> Initially, "economic tools" were to be defined as tradeable permit systems. However, the focus was subsequently broadened to encompass most forms of Government intervention, including subsidies to farmers to encourage them to alter their land use or to implement engineering works.



## SCOPING PAPER

### ECONOMIC TOOLS TO TACKLE SALINITY

- **Background on causes, costs and solutions generally.**
  - Including brief overview of Western Australia's dryland salinity versus irrigation related salinity in other parts of Australia.
  - Lost production, damage to infrastructure, increased propensity for floods etc.
  - Brief overview of the gamut of measures - revegetation, tree planting, engineering solutions, economic tools etc.
- **Market failure/externalities in the context of salinity.**
  - Role that the various forms of market failure/externalities may have played in the evolution of the problem in Western Australia over the last century.
  - Market failure/externalities associated with various treatments for salinity [this might be best placed in subsequent sections of the paper].
- **Theory of economic tools/market based systems in the context of salinity (illustrated).**
  - Description of the range of measures that might fall under this heading, including taxes and subsidies, auctioning etc as well as tradeable permit systems.
  - Illustrated by simple hypothetical or actual examples – especially for the more complex measures such as tradeable permit systems (assume a laypersons' audience).
- **Practical issues associated with market based systems.**
  - For example, under a tradeable permits system, how would the permits be defined, how would they be issued (auctioned versus grandfathered etc), and how could they be enforced (given difficulties in measuring salinity emissions etc)?
- **Circumstances in which market based systems might be applied (on a cost-benefit basis).**
  - Drawing together the theory and practical issues, and having regard for current technology etc, in what circumstances (including in what type of geographical locations) might the benefits of market based systems outweigh the costs in tackling salinity?
  - To what extent is the scope for successfully applying market based systems greater where the objective is improved water quality as opposed to land protection?

- **Winners and losers under market based systems.**
  - What is the likely distribution of costs and benefits, even assuming there are net benefits in aggregate?
- **Any case studies**
  - Include small selection of any real life examples of the actual application of economic tools to protect land and/or water resources from salinity (perhaps one example re land and one re water).
- **Optimal allocation of salinity management funding - market based systems versus other measures.**
  - At a broad level, with Commonwealth and State governments showing an increased willingness to invest money in addressing salinity, how can they get the best return (eg. how much should go into subsidising revegetation vs tree planting vs engineering solutions vs market based systems etc)?
- **Current policy gaps**
  - Where do the current national policies (eg. as reflected in the *National Action Plan on Salinity and Water Quality*) and State Government policies on salinity management appear to fall short, both in terms of proposals re market based systems and more generally?

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## ECONOMIC TOOLS TO TACKLE DRYLAND SALINITY IN WESTERN AUSTRALIA

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Notice: This paper was completed prior to David Pannell's appointment to a Ministerial taskforce to review salinity policy in Western Australia. It expresses the personal views of David Pannell, and not those of the taskforce.

### Executive Summary

The proportion of agricultural land in Western Australia which is salt-affected is currently around 10 percent and may exceed 30 percent within the next 50 to 100 years.

As well as reducing agricultural productivity, dryland salinity has impacts on a range of non-agricultural assets, including rivers, lakes, flood risk, roads, buildings, nature reserves, remnant native vegetation, and water resources for domestic or commercial use.

Three broad types of salinity management may be considered:

- Prevention (using deep rooted perennial plants planted over large areas, and shallow drainage to capture and divert water before it enters the groundwater table);
- Remediation (lowering groundwater tables on a large scale is technically difficult, and economically prohibitive in most instances); and
- Adaptation (using methods to cope with shallow saline water tables, such as deep open drains, pumping, salt-tolerant plants, salt-resistant infrastructure, and desalination).

The scales of treatments required for prevention of dryland salinity are extremely high. In recent years, we have lost earlier hopes that large-scale preventative impacts on salinity could be achieved by clever selection and placement of relatively small-scale treatments, or by changes to the management of traditional annual crops and pastures. In many cases, engineering works will be the most cost-effective method for protecting high value public assets, especially where processes of water table rise are well advanced.

Even with large-scale intervention, continuing salinisation of resources is inevitable and unpreventable, although without such intervention the scale of salinity would be greater still.

Spillover effects or “external costs” from agricultural land to non-agricultural assets have been emphasised in past discussions about the design of and rationale for government policies to deal with salinity. However, external costs from off-site discharges of saline groundwater are

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less important in Western Australia than has been commonly perceived. In most locations, the non-agricultural benefits from salinity management on agricultural land are small per hectare of agricultural land treated.

In recent policy documents for salinity, there has been considerable interest expressed in the use of economic policy instruments, such as tradable emissions permits, auction-based systems for allocating rights, charges and subsidies

Economic instruments work by altering the financial incentives and/or risks faced by individuals whose behaviour is targeted (in this case, mainly farmers). Their effectiveness depends entirely on the strength of incentive they provide and the strength of incentive that farmers would require in order to change practices.

Economic instruments cannot alter the overall desirability of a set of farming practices (from a community-wide perspective). They can only help to increase the adoption of practices which are already socially desirable but are not being adopted for whatever reason. In effect they redistribute the benefits and costs of the salinity treatments such that farmers are given greater incentive to act.

An absolute requirement for use of any economic instrument to be desirable is that the total benefits (private and public) of the farming practices being proposed must exceed the total costs of implementing the farming practices.

If financial incentives are paid to farmers, they must be less than the resulting non-agricultural benefits.

There is a range of practical difficulties in implementing economic instruments for salinity management, including: the difficulty of choosing a suitable variable to use as the basis for trade or bidding; transaction costs; choosing the initial allocations of rights; and distributional effects.

The main benefits from use of market-based instruments will be in a small proportion of locations where off-site benefits from on-farm revegetation are outstandingly high. For the majority of agricultural land, off-site benefits from revegetation are low, or on-site costs are high, or both. In these situations, use of market-based instruments are unlikely to be effective in altering farm management on the scale needed for technical effectiveness against salinity, unless the incentives created are greater than the off-site benefits which are the object of the exercise. The use of such large incentives would actually reduce economic efficiency, rather than increase it, because they would encourage adoption of treatments in situations where the total costs exceed the total benefits.

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For any form of government intervention to address salinity externalities to be desirable from the point of view of economic efficiency, the following conditions would be required:

- Groundwater systems responsive to changes in land management.
- Opportunity cost of land use change not excessive.
- Assets of high value at risk.

For a combination of reasons, these conditions are more likely to be met in higher rainfall regions than in lower rainfall regions. It appears that water resource catchments (e.g. the Collie River catchment for the Wellington Dam) are examples where substantial government action to alter farming practices is more likely to be in the community's best interests. Some areas of high environmental value would also fall into this category. There remains the question of which type of policy instrument will be best. This is not a straightforward question, and requires further investigation.

Broad areas identified as priorities for government spending in salinity in WA are as follows:

1. Develop profitable industries based around production of perennials of various types. A range of different profitable perennials is needed for different locations and different soil types.
2. Conduct R&D to identify and test a bigger range of salt-tolerant species and work with farmers on ways to use them. A number of non-agricultural uses for saline land and water also appear promising and deserving of support for their development.
3. Conduct R&D in engineering methods. We need to better understand the existing engineering options and, if possible, develop better ones, including drainage, pumping and perhaps desalination.
4. Expenditures specifically targeted to protect particular public assets (towns, rivers, water resources, nature reserves and so on). For different public assets, the most cost-effective combinations of off-farm and on-farm treatments will vary widely. A systematic and rigorous approach is needed to evaluate what combinations of treatments are needed, what they will cost, what their benefits will be, and whether or not they are actually worth the investment.

The State Salinity Council has recently developed an "Investment Framework" which recognises these four needs and attempts to develop a method for evaluating potential investments under category 4.

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## Glossary

**Annual plants:** Plants with a life span of less than one year, including the main crop and pasture plants grown in Western Australia (wheat, barley, canola, lupins, clover, etc.). These annual plants have relatively shallow roots, and also do not grow during summer, allowing some water to move down the soil profile into the groundwater table.

**Command-and-control regulation:** Traditional type of government regulation, requiring adherence to a particular defined standard (e.g. an environmental standard) with well-defined penalties for breaches.

**Discharge:** When groundwaters reach the soil surface, they “discharge”, meaning that they flow over the soil surface, either entering a waterway or re-entering the soil further down slope. See also “recharge”.

**Discount rate:** An index used to deflate costs and benefits from future periods in order to express them in present day terms. A higher discount rate implies a greater reduction in future costs and benefits when expressed in present value terms. The discount rate represents the productivity of the financial resources used in an investment if they were to be used in their best alternative use.

**Dryland salinity:** Salinity occurring on land which is not irrigated. “Dryland” does not mean a deficit of rainfall.

**Engineering methods for salinity management:** Covers a range of techniques, including shallow drains to capture surface water before it recharges; deep drainage, intended to intercept shallow saline groundwaters; pumping; re-engineering infrastructure to make it less susceptible to salt damage; desalinisation of saline water.

**Eutrophication:** An unnaturally high level of dissolved nutrient levels in a waterway (e.g. due to increased surface water runoff from farm land) resulting in algal blooms and increases in other vegetation. It is also associated with reduced levels of oxygen in the water. Heavy eutrophication reduces the number of plant and animal species in the water. A few species benefit, but at the expense of all the others.

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**Flow systems:** See Groundwater flow systems.

**Groundwater:** Underground water, accumulated by recharge.

**Groundwater flow systems:** Regions over which groundwaters are linked and can move, generally from relatively high in the landscape to relatively low in the landscape. See “Local”, “Intermediate” and “Regional” groundwater flow systems.

**Intermediate groundwater flow systems:** Regions where the points of recharge and discharge of groundwaters are between 3 and 10 km apart.

**Local groundwater flow systems:** Regions where the points of recharge and discharge of groundwaters are less than 3 km apart, so that they are likely to be within the same farm.

**Moral suasion:** Persuasion based on moral or ethical arguments.

**Opportunity cost:** A cost which must be given up (often indirectly) in order to achieve a particular benefit. For example, an opportunity cost of switching land use from wheat to trees is the profit which would have been earned from wheat production.

**Perennial plants:** Plants with life-spans of some years. Perennials are able to grow (and use water) during periods of the year when annual plants have died. Many also have relatively deep rooting systems, further enhancing their ability to capture and use water.

**Private discount rate:** A discount rate used by private individuals and private firms when making investment or consumption decisions.

**Public discount rate:** A discount rate for use by governments when making long term decisions. It is most commonly argued that public discount rates should be lower than private discount rates.

**Public goods:** Goods for which there may exist a free-rider problem (an inability to exclude those who do not contribute towards or pay for the goods) (e.g. quarantine), or for which the costs of provision do not vary with the number of people consuming the good (e.g. information).

**Recharge:** Movement of water down the soil profile, beyond the root zone of plants and into groundwater. See also “discharge”.

**Regional groundwater flow systems:** Regions where the points of recharge and discharge of groundwaters are more than 10 km apart, so that they are likely to span several farm boundaries.

**Transmissivity:** A soil property describing the extent to which water is able to be transmitted through the soil. Low transmissivity means that the soil resists water movement. In Western Australia, many of the agricultural soils with relatively high clay contents have low transmissivity.

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## 1. Background

### 1.1 Causes

Salt, mainly sodium chloride, occurs naturally at high levels in the subsoils of most Australian agricultural land. It has been carried inland from the oceans on prevailing winds and deposited in small amounts (20-200 kg/ha/year) with rainfall and dust (Hingston and Gailitis 1976). Over tens of thousands of years, it has accumulated in sub-soils and in Western Australia it is commonly measured at levels between 100 and 15,000 tonnes per ha (McFarlane and George 1992).

Prior to European settlement, groundwater tables in Australia were in long-term equilibrium. In agricultural regions, settlers cleared most of the native vegetation and replaced it with annual crop and pasture species, which allow a larger proportion of rainfall to remain unused by plants and to enter the groundwater (George et al. 1997; Walker et al. 1999). As a result, groundwater tables have risen, bringing dissolved accumulated salt to the surface (Anonymous 1996). Patterns and rates of groundwater change vary widely but most bores show a rising trend, except where they have already reached the surface or during periods of low rainfall. Common rates of rise are 10 to 30 cm/year (e.g. Ferdowsian et al. 2001). Given the geological history and characteristics of the Australian continent, large-scale salinisation of land and water resources following clearing for agriculture was inevitable.

In the Murray Darling Basin of eastern Australia, as well as the causes of “dryland salinity” outlined above, there is the additional concern of “irrigation salinity”. (“Dryland” means non-irrigated, not a deficit of rainfall). Irrigation causes a rise in naturally saline watertables because the volume of irrigation water applied exceeds use by plants<sup>1</sup>. Irrigation salinity is of relatively minor concern in Western Australia.

### 1.2 Impacts and extent

The National Land and Water Resources Audit (2000b) estimates that the area of land in Australia with shallow watertables (i.e. at risk of being salt affected) is currently 5.7 million ha and will exceed 17 million ha by 2050. Western Australia has by far the greatest affected area, with 80 percent of current national total, and 50 percent of the 2050 forecast area. Ferdowsian et al. (1996) estimated that the area of agricultural land in Western Australia affected by salinity<sup>2</sup> was 1.8 million ha in 1996 (approaching 10 percent of the total area of cleared agricultural land).

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<sup>1</sup> Irrigation water itself also adds to salinity by a gradual accumulation of salt. This occurs because transpiration by plants evaporates water but not salts.

<sup>2</sup> Defined as land on which wheat yield would be reduced by 50 percent or more.

The proportion of agricultural land in Western Australia which is salt-affected may exceed 30 percent within the next 50 to 100 years (Ferdowsian et al., 1996).

Shallow saline groundwaters have a multitude of costly consequences, as summarised in Table 1. Although traditionally seen primarily as an agricultural problem, it is now appreciated that the non-agricultural costs are likely to be at least as significant.

*Table 1. Examples of costs caused by dryland salinity*

<b>Type of salinity cost</b>	<b>Agricultural impacts</b>	<b>Non-agricultural impacts</b>
Preventative action	Costs of establishing preventative treatments: areas of perennial plants, surface drainage.	Costs of engineering works (pumps, drains, evaporation basins) and revegetation to protect buildings, roads, bridges and other infrastructure.
Replacement, repairs and maintenance	Repairs to buildings, replacement of dams, establishment of deep drains to lower saline groundwater.	Repairs to houses and other buildings, desalination of water resources, repairs to infrastructure, restoration of natural environments.
Direct losses	Reduced agricultural production, reduced flexibility of farm management.	Extinctions, loss of biodiversity, loss of amenity, loss of aesthetic values, loss of water resources, eutrophication of waterways, loss of development opportunities on flood plains.

Salinity is rising in most rivers of southern Australia (Hatton and Salama 1999), including rivers currently or likely to become used for potable water supplies.

According to George et al. (1999b), in Western Australia, without massive intervention, most or all of the wetland, dampland and woodland communities in the lower halves of catchments will be lost to salinity. There are at least 450 plant species and an unknown number of invertebrates which occur only in these environments and are at high risk of extinction (State Salinity Council 2000; Keighery, 2000).

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Increased flood risks have been studied for only a small number of case studies (e.g. Bowman and Ruprecht 2000). Extrapolating from these, George et al. (1999b) concluded that, with the predicted three- to four-fold increase in area of wheatbelt land with shallow watertables, there will be a three- to four-fold increase in flood flows.

Infrastructure at risk has also been identified and valued in case studies. For example, Campbell et al. (2001) estimated for a sub-region of south-west Western Australia<sup>3</sup> that 1200 buildings (15 percent of all buildings in the region), 3,300 km of roads (28 percent) and 16,000 farm dams (44 percent) face damage or destruction from salinity. Campbell et al (2001) did not estimate the costs of these impacts.

### 1.3 Treatments

The above impact forecasts are generally based on a “business as usual” scenario. Three broad types of salinity management are possible: prevention, remediation and adaptation.

#### *Prevention*

The scales of treatments recommended by hydrologists for preventing the various impacts of dryland salinity are extremely high. In recent years, we have lost earlier hopes that large-scale preventative impacts on salinity could be achieved by clever selection and placement of relatively small-scale treatments, or by changes to the management of traditional annual crops and pastures. The new scientific consensus is that large proportions of land in threatened catchments would need to be revegetated with deep-rooted perennial plants (shrubs, perennial pastures or trees) for at least part of the time<sup>4</sup>. The perennials would need to be integrated with engineering works, particularly shallow drainage for surface water management.

Even with massive changes in land use, the long-run potential to prevent salinity is believed to be limited in many catchments of WA, particularly many of those in lower rainfall areas. This is because the catchments in low rainfall regions tend to be larger, flatter and less well drained than elsewhere.

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<sup>3</sup> The region comprises the Western South Coast (Mt Barker Landsat TM scene) and the Upper Blackwood Catchment (Dumbleyung and the Bunbury scene as far west as the Towerinning Catchment). The total area is about 30,000 km<sup>2</sup> (3 million ha).

<sup>4</sup> Some of the proposed systems for perennial production involve phases of perennials for some years, followed by some years of traditional annual crops or pastures. In other systems, perennials may be grown more or less permanently in belts or blocks.

Figure 1 shows the range of results of modelling studies for several catchments in Western Australia (Campbell et al. 2001). If recharge across a catchment were reduced by 50 percent, implying perennials on approximately 50 percent of the land, the final equilibrium area of salinity in the catchment would be reduced by between 10 and 40 percent (i.e. to between 60 and 90 percent of the area at risk). Note that the vertical axis gives percentages of the potential area of salinity, not percentages of the area of the catchment.

To clarify further, assume that the total area at risk of salinity is 30 percent of the catchment (consistent with Ferdowsian et al., 1996). That is, 100 percent on the vertical axis of Figure 1 corresponds to 30 percent of the catchment. Then, a 50 percent reduction in recharge would result in protection of 3 to 12 percent of the catchment (10 to 40 percent of the 30 percent at risk).

The ratio of 50 percent revegetation to achieve protection of 3 to 12 percent of land has very strong implications for the economics of such a strategy. Unless the plants used for the revegetation are very nearly as profitable as the farming enterprise they replace, they will not pay their way through salinity prevention. The benefits of salinity prevention are small relative to the direct and indirect costs of establishing the perennials.

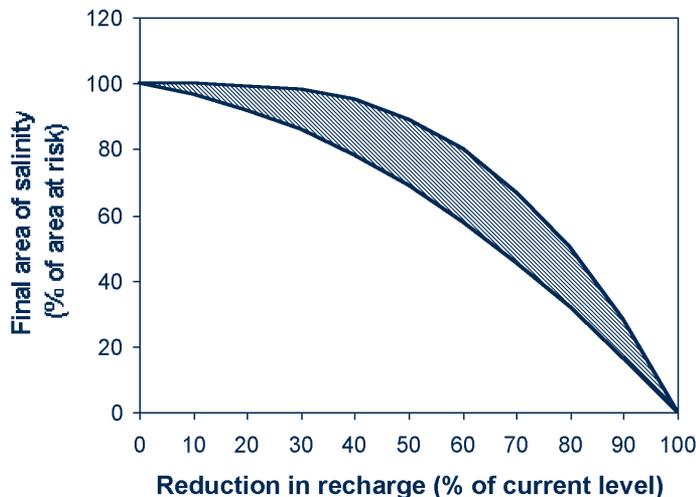


Figure 1. Final equilibrium area of saline land (as a percentage of the area for a “business as usual” scenario) in a range of catchment types of Western Australia as a function of reducing recharge to groundwater as a result of revegetation and engineering works. The graph shows the approximate range of results for a set of different catchments.

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The timing of treatment impacts is also important. On the positive side, even where equilibrium areas of salinity are reduced little, the implementation of large-scale revegetation programs is likely to delay the process of reaching that equilibrium by several decades (Campbell et al. 2001). On the negative side, given the slow rate of development of salinity, the benefits of treatments implemented now may be well into the future.

Although local reductions in watertables can be achieved within a year or two (George et al. 1999a), catchment-scale impacts, such as reductions of saline discharges into waterways, will be very much slower. In catchments having regional groundwater flow systems<sup>5</sup>, much of the benefits will probably be a century or more in the future (Hatton and Nulsen 1999; Hatton and Salama 1999; Heaney, Beare and Bell 2000). This is because regional flow systems are large and, particularly in Western Australia, groundwater movement within them is generally slow.

Even with massive intervention, continuing salinisation of resources is inevitable and unpreventable. For example, in Western Australia hydrologists have estimated that, if radical large-scale changes to farming practices are made immediately, the area of saline land would increase by at least two million ha from current levels (noted earlier as 1.8 million ha in 1996) before stabilising. The reason for this is that the salinisation processes already under way will take many years to reach equilibrium even if future recharge rates are reduced. Water which has been added to groundwaters over the past decades will continue to discharge over steadily larger areas in coming decades. Without radical changes to land use, the area of saline land would increase by approximately four million ha.

Engineering methods provide an alternative or a supplement to perennial vegetation. Pumping of saline groundwater into evaporation basins is expensive and has only local effects on groundwater, but it may be a viable strategy where particularly valuable assets are at stake (e.g. the infrastructure of a town, or an important environmental asset). In situations where a valuable asset is located in a catchment where the process of watertable rise is well advanced, the benefits of revegetating the catchment may be too little and too late to save the asset. In these cases, pumping is the only strategy available with the technical capacity to protect the asset (Campbell et al. 2001).

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<sup>5</sup> In a regional groundwater flow system (e.g. a large, flat wheatbelt catchment), groundwaters may move slowly over long distances (e.g. greater than 10 km), crossing several farm boundaries before discharging low in the landscape. At the other extreme, in local groundwater flow systems (e.g. in relatively undulating landscapes nearer to the coast) recharge and discharge are likely to occur close enough together to be within the same farm.

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In many cases, engineering works will be the most cost-effective method for protecting high value public assets, especially where processes of salinisation are well advanced. This is because of the technical effectiveness of engineering, but also because of the long lags in achieving catchment-scale benefits from revegetation. The Murray-Darling Basin Commission is using pumping extensively to intercept saline groundwaters before they discharge into waterways. Engineering works currently planned for the Murray-Darling Basin will cost approximately \$60 million.

### ***Remediation and Adaptation***

Clearly, once the hydrological balance of a catchment is disturbed, prevention of salinity is very difficult. Once land is salinised, returning a catchment to a non-saline state is even more difficult. Chemical changes in salinised soil reduce the ability of water to pass through the soil and flush out salts. Even without these chemical changes, it is easier for watertables in a catchment to rise than to fall. A rising watertable only requires water to move a relatively small vertical distance under the pull of gravity (from the ground surface to the water table). On the other hand, a falling watertable requires lateral water movement over much greater distances and over slopes much lower than 90 degrees (from recharge areas high in the catchment to discharge areas low in the catchment)<sup>6</sup>.

Rather than remediation, adaptation is generally a much more practical, realistic and economically viable strategy. Farmers in Western Australia with large areas of salt-affected land are already trialing and implementing farming systems based on salt-tolerant species. Many farmers are also implementing deep open drains on salinised land, intending to lower watertables locally and allow a continuation or resumption of traditional agricultural practices between the drains. Although very expensive to implement and maintain and despite evidence of poor drain performance in some situations (e.g., Ferdowsian et al. 1997; Speed and Simons 1992) many farmers feel that such drains offer their best option in response to salinisation of land. Given the emphasis during the 1990s on revegetation with perennials, there was, perhaps, a neglect of drainage, with insufficient agency resources allocated to the understanding and design of drainage systems. This is beginning to be redressed.

Where water resources are salinised, adaptation in the form of desalination is another option which appears to warrant further investigation. Other situations where engineering methods to adapt to adverse developments may conceivably be economically more efficient than prevention include engineering works for flood mitigation, and replacement of damaged infrastructure with

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**6** In this paper, engineering methods such as deep drains and pumping are considered as methods of adaptation, rather than remediation, because they do not deal with the causes of salinity and would not prevent a recurrence of salinity if the engineering works were removed.

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structures designed to better withstand salinity. A variation on the theme of “adaptation” is pumping to intercept rising saline groundwaters before they discharge into rivers or sites of biodiversity. In this way, impacts can be reduced without successfully treating the underlying cause of salinity. Pumping was discussed further at the end of the previous section, “Prevention”. It was noted that pumping saline water to evaporation basins may be the most cost-effective means to protect some public assets, especially where the processes of salinisation are well advanced.

Finally, an option which is available to landholders is to allow salinity to occur unchecked and make do with smaller productive areas, perhaps with some intensification of production. In situations where treatments are expensive and/or slow to show benefits, and the assets at risk are not sufficiently valuable, such an option may conceivably be the most efficient course of action, not just for the farmer but also for society more generally. As noted earlier, if this “business as usual” strategy was applied generally, the proportion of land that is at risk of being salt-affected (to some extent) would eventually plateau over the course of the next century at approximately 30 percent.

## 2. Market failure in the context of salinity

Resource economists in Australia have tended to focus on externalities as being the key policy aspect of dryland salinity, and internalisation of externalities as being the most important role for government in relation to salinity (e.g. Hayes 1997). This reflects a widespread belief about why dryland salinity has developed to such an extent in Australia and why farmers are still not adopting farming practices that would prevent its ongoing spread. One farmer’s management (or non-management) of salinity has impacts on others through movements of saline groundwater and/or saline discharge into waterways. Economists use the term “externalities” to describe these impacts of one economic agent on others. The impacts may be on neighbouring farms, natural ecosystems, rural towns, water resources, roads and other infrastructure. If farmers whose farms are the sources of salinity were to properly factor in these broader impacts, it is believed that they would act to prevent salinity to a greater extent than they currently do.

There is no doubt that dryland salinity does result in external costs. However, Pannell et al. (2001) have argued that externalities have been given excessive attention in the design of public policy. They outlined six reasons why external costs from off-site discharges of saline groundwater are less important in Western Australia than has been commonly perceived.

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- (a) For a proportion of the landscape, little groundwater moves across farm boundaries. Groundwater flow systems are localised in many situations (National Land and Water Resources Audit 2000a). In “local” flow systems, recharge and discharge often occur within the same farm.
  - (b) Even in large “regional” groundwater flow systems spanning several farms, it can be possible for treatments to be effective locally, at least temporarily. This is particularly relevant to landscapes with low slopes and low transmissivity of soils<sup>7</sup>, such as the wheatbelt valleys of Western Australia.
  - (c) Damage to key rivers will continue for many years (centuries in some cases) even if large-scale revegetation programs are implemented (Hatton and Salama 1999). The reason is the slow rate of lateral water movement, as outlined earlier. Even if recharge is stopped immediately, water already in groundwater flow systems will move slowly downhill and continue to discharge over decades. This means that these externalities are not technically avoidable, and so are not amenable to resolution by any policy measures.
  - (d) As the process of farm consolidation and enlargement continues, it is increasingly likely that discharge and recharge sites occur within the same farm. In other words, fewer farmers are suffering from saline discharges that originated outside their own farm.
  - (e) Discounting of future benefits and costs is necessary to allow valid comparison of economic impacts occurring at different times. Given the slowness of some key off-site benefits from perennial plants, discounting causes the significance of these benefits in present day terms to be small.
  - (f) Given the adverse economics of currently available perennial plant systems (particularly in drier regions), the optimal balance between the costs and benefits of salinity prevention measures may involve very little prevention of salinity, even when off-farm benefits are considered. The findings reported earlier about the large scale of revegetation needed to prevent salinity on relatively small areas of land reinforce the finding that external benefits per hectare of treatment are low.

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<sup>7</sup> Low slopes and low transmissivity combine to mean that (a) lateral water movement of groundwater is very low and (b) transmission of water pressure laterally is very low. Therefore, treatments can lower water tables locally without being rapidly swamped by lateral movement of water in from the sides of the treated area.

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For some public assets, the greatest need and justification is for highly localised treatments, within or adjacent to the assets themselves, rather than treatments dispersed across surrounding agricultural land. The impacts of dispersed, catchment-wide treatments alone would be too little, too late to prevent severe damage to the assets. In some cases this is because the primary cause of rising groundwaters is recharge on the site of the non-agricultural asset, rather than recharge in the surrounding catchment. This applies to some rural towns in Western Australia which have been evaluated under the state's Rural Towns Program (e.g. Matta 1999).

Nevertheless, there is variation in both the responsiveness of off-site impacts to treatments (National Land and Water Resources Audit 2000a) and in the value of the off-site resources at risk (environmental, economic and perhaps social). In some locations, the combination of hydrological responsiveness and asset values at risk will be such that the public benefits of on-farm treatments are high. However, it is now clear that this will apply to only a minority of agricultural land. Catchments used to capture potable water are likely to be an example where the values at risk are particularly high. Whether the responsiveness of salinity to preventative treatments is sufficiently high may vary on a case by case basis.

The focus on externalities has perhaps resulted in neglect of some other causes of market failure from dryland salinity:

- Divergence between public and private discount rates (Tietenberg 1996). Given the long time scales involved in achieving some of the benefits from salinity mitigation, any divergence between public and private discount rates may have an impact on evaluation of investment decisions. An example is investment in R&D to develop improved farming systems based on perennial plants. Time scales on such R&D can be long, and must be added to the time lag between establishment of perennials and avoidance of saline discharges.
- Divergence between public and private attitudes to risk. Bell et al. (2000) emphasised the considerable uncertainties that remain regarding the links between specific salinity treatments and specific salinity mitigation benefits. These uncertainties are difficult to reduce because of the long time lags involved and the geological complexity and diversity of catchments. For farmers, the normal route to reducing uncertainty about an innovation is a small-scale trial, but for several reasons<sup>8</sup>, the value of information about salinity effects from such a trial is likely to be low. Uncertainty about long term prices of products from woody perennials may also be higher than for traditional agricultural products, even if only because the products are less familiar to farmers.

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<sup>8</sup> Reasons include the low observability of impacts of treatments on groundwaters, the long time scales involved and the low effectiveness of small scale treatments in reducing groundwater levels (Pannell, 2000).

These uncertainties are highly likely to inhibit farmer adoption of new perennial-based farming systems, even in situations where the perennials would, in fact, be beneficial to the farmers (Pannell 1999a, 1999b). High uncertainty about payoffs is also a feature of long-term R&D, and may have contributed to the very limited private investment in development of commercial perennials for low-to-medium rainfall areas.

- Information and some environmental benefits are “public goods” which may not be adequately provided by the market. In the case of information, this argument is commonly proposed as a potential justification for government investment in R&D and information provision services such as agricultural extension (e.g. Alston et al. 1995; Marsh and Pannell 2000). For salinity the argument is reinforced because some of the benefits at stake are themselves public goods. In particular, non-market environmental values are under threat. Despite the limited available evidence, there are reasons to expect that in some locations the values at stake are high.

In some situations this last issue points to an externality problem, where on-farm management is needed to protect an environmental asset. However, in others, the greater requirement is for direct government management of the public assets under its care and control. Protection of physical public infrastructure can also fall into this category of requiring government action because the management problem is already predominantly within the sphere of government. They have responsibility for the asset, and the socially optimal salinity management strategy does not require actions by others in the community (e.g. drainage in a roadside reserve to protect the road).

### 2.1 External costs of treatments

Some of the treatments used to manage salinity may themselves generate external costs. Heaney et al. (2000) noted that revegetation with perennials results in a reduction in surface water runoff and emphasised the importance of this effect in the Murray Darling Basin. Fresh water from runoff in the Basin provides domestic water for the city of Adelaide and other towns, irrigation water for important intensive agricultural industries, and environmental services of various kinds. In an analysis of the Macquarie-Bogan catchment, Heaney et al. (2000) found that perennials may have higher external costs due to reduced runoff than their external benefits due to groundwater management. This is, in part, because the impacts of revegetation on runoff are rapid, while the impacts on discharge of saline groundwaters are often very slow. This conclusion from the Murray Darling Basin is likely to be relevant in only a small part of Western Australia, in particular the high rainfall areas of catchments used for water resource supplies.

Another case where salinity treatments may generate external costs is the use of deep drains in the wheatbelt. The problem is disposal of saline waters captured by the drains. There have been anecdotal reports of some drains discharging into CALM nature reserves.

The problem of saline effluent disposal also applies to other potential measures, such as desalination plants, or pumping. In some cases, choices need to be made about whether the protection or treatment of particular assets is important enough to warrant the external costs generated by disposal of saline effluent (e.g. into inland waterways).

### 3. Theory of economic policy instruments for salinity

In recent policy documents for salinity, there has been considerable interest expressed in the use of economic policy instruments, such as tradable emissions permits, auction-based systems for allocating rights, charges and subsidies (e.g. Bell et al. 2000). These approaches have been given priority for further investigation in the National Dryland Salinity Program, in the Commonwealth Government's National Action Plan and in at least two of the state salinity strategies, including that of Western Australia.

Table 2 lists a range of measures which can broadly be considered as economic policy instruments (or "Economic tools" or "Market-based instruments"). The common feature shared by the various instruments is that they work by altering the financial incentives and/or risks faced by individuals whose behaviour is targeted (in this case, mainly farmers). None of the instruments provides a magic bullet. In all cases, their effectiveness depends entirely on the strength of incentive they provide and the strength of incentive that farmers would require in order to change practices.

*Table 2. Possible economic instruments for addressing salinity*

- Enhanced tax deductibility.
- Tax rebates.
- Subsidies on particular inputs/practices.
- Rewards for outcomes.
- Define and enforce property rights, facilitate negotiation or trading of rights, tradable permits, auctions of rights or permits.
- Regulation/penalties/standards/duty of care.
- Cross compliance mechanisms (making other government benefits or subsidies conditional on compliance with environmental standards).
- Cost sharing.
- Share farming (e.g. a government agency may offer to grow commercial trees on a farmer's land, with the eventual proceeds divided between farmer and government).

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In most discussions of policy options, regulatory approaches are considered to be separate from economic instruments. However, there are good reasons to consider them to be part of a continuum of measures. Like taxes and subsidies, regulatory measures have their impact by altering financial (and other) incentives facing individuals. This helps to highlight that regulatory measures for salinity management will not be successful unless their monitoring, enforcement and penalties are sufficient to provide adequate incentives to farmers.

The options in Table 2 vary widely in terms of:

- Who benefits (farmers, other identifiable individuals or groups, the broad community);
- Who pays (farmers, taxpayers, consumers, beneficiaries);
- Ease of targeting incentives to where they are required;
- Administration costs and transaction costs; and
- The amount of information/judgement required centrally to make the instruments operational.

The following examples provide brief illustrations of how some of the key economic instruments might work in practice. They are based on an example of one of the Water-Resource Recovery Catchments, which are managed by the Water and Rivers Commission (W&RC).

1. Government pays based on temporary buy-back. The W&RC could compulsorily purchase all properties in a recovery catchment and then place caveats, or other legally binding restrictions, on the titles to exclude all those activities which should not continue if the water quality targets are to be achieved. Having modified the titles, the W&RC would then re-sell the properties, presumably at a price lower than the purchase price.
2. Polluters pay based on regulatory restrictions. This could be implemented by using regulatory powers to exclude all those activities that should not continue if the water quality targets are to be achieved.
3. Government pays based on sealed bids. An approach to natural resource management on private land, which has been used extensively in the United States for many years is termed the Conservation Reserve Program (CRP). The CRP involves the United States Department of Agriculture (USDA) identifying the level and types of works (usually in the form of changed land use) it wants to be implemented, and then calling on landholders to bid for funding to undertake those works on their properties. In the context of the recovery

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catchments, the W&RC might advertise that it wanted particular changes, say increased plantings of trees or lucerne or construction of surface drains, in a particular management unit for the next ten years. All landholders in that area could then make offers ('bids') to implement those actions and inform the W&RC of the amount of funding assistance they would require, say, in terms of annual grants to supply their proposed areas of land. The W&RC would firstly establish whether there were sufficient bids which, if all were implemented, would more than achieve the objectives. If so, the W&RC would then allocate grants to those landholders with the lowest bids for a given level of implementation.

4. Polluters pay, or Government pays, based on tradeable permits. The W&RC would determine the mix of land uses that it wanted across a total management area. Permits would then be allocated to each landholder and they would allow only the land uses wanted by the W&RC. Landholders and the W&RC would then be allowed to trade in those permits in order to achieve a suitable mix of land use across the management area.
5. Cost sharing. The W&RC could offer to partially subsidise farmers to change their land use, with the level of subsidy reflecting criteria such as, costs being shared in proportion to benefits.

In considering whether economic instruments have a contribution to make, the following considerations are highly relevant:

1. Economic instruments cannot alter the overall desirability of a set of farming practices (from a community-wide perspective). They can only help to increase the adoption of practices which are already socially desirable but are not being adopted for whatever reason (e.g. see Pannell 1999a). They do so either by rewarding farmers who act "appropriately" or penalising farmers who do not. In effect they redistribute the benefits and costs of the salinity treatments such that farmers are given greater incentive to act.
2. An absolute requirement for use of any economic instrument to be desirable is that the total benefits (private and public) of the farming practices being proposed must exceed the total costs of implementing the farming practices. Indeed, they must do so by enough to exceed the administrative and other costs of implementing the scheme. It is quite possible (and likely in some situations) for the overall costs of some approaches to exceed the benefits, especially where the practices are highly unprofitable on-farm, or the off-farm benefits of on-farm treatments are low.

3. If financial incentives are paid to farmers, they must be less than the resulting non-agricultural benefits. For example, if changes in a catchment would result in non-agricultural benefits of \$1,000,000 then any payments to farmers intended to secure those non-agricultural benefits must be less than \$1,000,000. If the payments equal \$1,000,000, it means that farmers are capturing all of the community's benefits associated with the treatments. If the required payments exceed \$1,000,000, it means that the changes are resulting in a net cost to the community, rather than a net benefit.

Figure 2 illustrates potential consequences of combining rules 2 and 3. Scenarios A and B are where the recommended practices are somewhat profitable, although not sufficiently so to be more attractive to farmers than their existing farming systems. In scenarios C and D the practices are much less profitable than existing systems. The levels of non-agricultural benefits resulting from the treatments are relatively high in scenarios A and C and low for B and D.

In scenario A, the combination of agricultural and non-agricultural benefits is such that it is possible for an economic instrument to change farm practice and to be beneficial overall. The instrument could provide sufficient incentive to exceed the farmer's break-even requirement (mainly determined by the profitability of their existing land use) and prompt a change of management without violating one or more of the principles outlined above. In the three other scenarios, either the treatment is not sufficiently profitable at the farm level, or the non-agricultural benefits are too small or both.

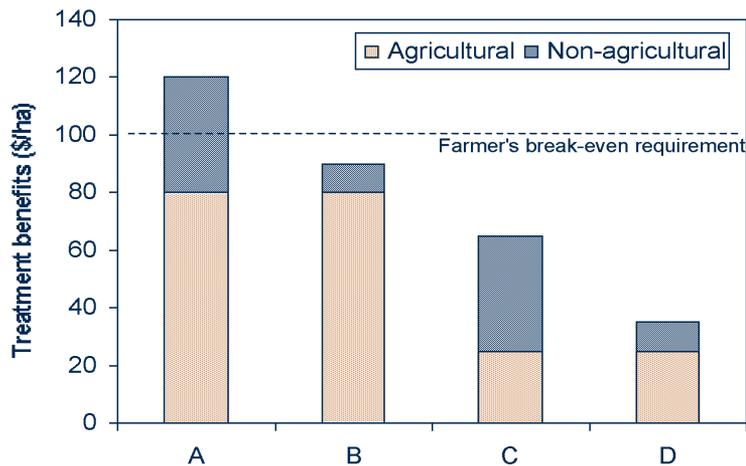


Figure 2. Agricultural and non-agricultural net benefits from salinity treatments (e.g. planting perennials) in four scenarios.

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## 4. Practical issues associated with economic policy instruments

The simple explanations provided above obscure some important practical issues involved in practical implementation of economic policy instruments. These include the following:

- **Defining the variable.** A number of the approaches require the definition of a variable to be used as the basis of trading, regulation, or bidding. In the case of salinity, the variable might take a wide range of forms, potentially including (a) the amount of salt leaving a farm in ground or surface waters, (b) the area of land with saline groundwaters discharging at the surface, (c) the depth to groundwater on average or at specific locations, (d) the level of implementation of some specific salinity treatments. Ideally the variable used would be cheap to observe, measurable with some accuracy, affected by treatments in ways which are understood and predictable, and directly linked to external damage. It would accurately reflect the level of external costs being imposed on others, and it would do so in a way which is consistent on different farms. It is easy to see that none of the four types of variables suggested above meets all of the “ideal” criteria. Indeed, they would each meet only a minority of the criteria.
- **Transaction costs.** These would include costs of administration, collecting scientific information, monitoring and enforcing agreements. For the schemes which are more attractive in theory (e.g. tradeable permits), these transaction costs are likely to be high.
- **Initial allocations of rights.** For example, should permits be auctioned, or allocated on the basis of some historical precedent. Should farmers be considered to have the right to farm without concern for off-site effects, or should the community have the right to a clean environment.
- **Distributional effects.** Depending on the allocation of rights, there may be very substantial distributional effects, with important social and political consequences. For example, in some cases, farmers required to prevent salinity to a certain standard may be forced out of business, particularly in catchments where the technical difficulty of salinity prevention is great (i.e. much of the wheatbelt). On the other hand, subsidies for changing land use may be obtained by farmers with levels of assets which are well above average for the community. Depending on the design of the instruments, and the details of their implementation, the full range of distributional consequences is possible.

- **Identifying market failure.** The existence of market failure from externalities is a necessary (but not sufficient) condition for the use of economic policy instruments against salinity to be economically desirable. It may not be straightforward to determine for any given catchment whether externalities are in fact resulting in market failure in land use decisions for that catchment. Difficulties will include, the level of available information regarding hydrological processes in the catchment, knowledge of future salinity levels and impacts if treated or if not treated, and the difficulty of valuing some of those impacts (e.g. environmental, social).

Most of the practical experience at implementation of economic policy instruments for environmental management has been in the USA. Table 3 is based on a document prepared by the U.S. Environmental Protection Agency, summarising US experience with different types of instruments, and highlighting their pros and cons.

## 5. Where are economic policy instruments most likely to be successful?

While market-based instruments do, no doubt, have a role to play in promoting change on farms, recent developments in our understanding reveal that it is likely to be a somewhat limited role. The main benefits from use of market-based instruments will be in a small proportion of locations where off-site benefits from on-farm revegetation are outstandingly high. For the majority of agricultural land, off-site benefits from revegetation are low, or on site costs are high, or both. In these situations, use of market-based instruments are unlikely to be effective in altering farm management on the scale needed for technical effectiveness against salinity, unless the incentives created are greater than the off-site benefits which are the object of the exercise. The use of such large incentives would actually reduce economic efficiency, rather than increase it, because they would encourage adoption of perennials in situations where the total costs exceed the total benefits.

This also has implications for other policy approaches, such as command-and-control regulation, and use of moral suasion. To the extent that these are successful in altering farmers' management strategies, they run the risk of reducing social welfare unless carefully targeted to situations where off-site benefits are greater than on-site costs.

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These comments (in the two previous paragraphs) apply generally to all forms of government intervention. For *any* form of government intervention to address externalities to be desirable from the point of view of economic efficiency, the following conditions would be required:

- Groundwater systems responsive to changes in land management. This is more likely on land with greater slope, and with more “transmissive” soils. Both of these conditions tend to be more common in the higher rainfall regions of the WA agricultural district than in the low-rainfall wheatbelt.
- Opportunity cost of land use change not excessive. If the private opportunity cost is too high, it will exceed the public off-site benefits. Again, this tends to favour higher rainfall regions as the more likely sites for effective government intervention, because perennials tend to be least competitive with existing land uses in low rainfall regions.
- Assets of high value at risk. In general, to justify government programs to influence on-farm action, we would need a public asset of outstanding value to be (a) at risk and (b) cost-effectively protected by on-farm treatments. A likely example is the water resource catchments, all of which are in relatively high rainfall zones. In the case of threatened country towns, most of the effort needs to be within the town boundaries rather than on surrounding farms, so the use of economic instruments to influence the farmers is not relevant. Threatened environmental assets (e.g. lakes, nature reserves) are likely to vary in their need for on-farm action. In some cases, government intervention may be justified. For built infrastructure (mainly roads), the preferred solutions have not been evaluated, but may be engineering measures in many cases, which would make them similar to the situation for towns. There needs to be further analysis to assess whether and when on-farm treatments are cost-effective for protection of roads.

Table 3. Pros and cons of different types of economic policy instruments

Incentive	Examples	Pros and cons
Pollution charges taxes	Emission charges	<p><b>Pros:</b> stimulates new technology; useful when damage per unit of pollution varies little with the quantity of pollution.</p> <p><b>Cons:</b> potentially large distributional effects; uncertain environmental effects; and generally requires monitoring data.</p>
Input or output taxes and charges	Carbon tax Fertilizer tax Levy on wheat production	<p><b>Pros:</b> administratively simple; does not require monitoring data; effective when sources are numerous and damage per unit of pollution varies little with the quantity of pollution.</p> <p><b>Cons:</b> often weakly linked to pollution; and uncertain environmental effects.</p>
Subsidies	Payments to farmers for land use change	<p><b>Pros:</b> politically popular; targets specific activities.</p> <p><b>Cons:</b> financial impact on government budgets; may stimulate too much activity (appears unlikely in case of salinity); and uncertain effects.</p>
Marketable permits	Emissions permits	<p><b>Pros:</b> provides limits to pollution; effective when sources are numerous and damage per unit of pollution varies with the quantity of pollution; and provides stimulus to technological change.</p> <p><b>Cons:</b> potentially high transaction costs; and requires variation in marginal control costs.</p>
Legal liability	Nuisance, trespass Duty of care Natural resource damage assessment	<p><b>Pros:</b> can provide strong incentive (provided legal recognition of liability and enforcement are high – probably not the case with salinity).</p> <p><b>Cons:</b> assessment and litigation costs high; burden of proof large; and few applications.</p>
Voluntary programs	Landcare	<p><b>Pros:</b> low cost; many possible applications; and way to test new applications.</p> <p><b>Cons:</b> uncertain participation (in case of salinity, participation much too low); and presumes viable technologies are available (not the case for salinity in many areas).</p>

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Overall, it appears that water resource catchments (e.g. the Collie River catchment for the Wellington Dam) are likely to be the prime example where any substantial government action to alter farming practices is likely to be in the community's best interests (although some areas of high environmental value may also fall into this category). There remains the question of which type of policy instrument will be best. Table 3 reveals that this is not a straightforward question. It clearly requires further investigation. However, even without that, some observations about the policy options are possible:

- For the marketable permits, the challenges for effective implementation for salinity abatement in a water resource catchment appear particularly great. The number of farmers in the market is probably not great enough for effective competition, obviating much of the attraction of a market-based system. In the case of the Wellington Dam catchment, the farmers are not only well known to each other, but many also share the same agricultural adviser. The issue of deciding exactly what should be traded is also a difficult one. The ideal would be the level of salt entering waterways from the property, but this is not observable, so some sort of proxy would be needed. Transaction costs of administration, monitoring and enforcement would be high.
- A cost-sharing approach has been favoured by the Water and Rivers Commission. It appears that this approach will not be accepted by farmers over large enough areas, given the level of payments offered.
- Voluntary programs, such as Landcare, clearly have not been effective against salinity.
- A regulatory approach will impose the liability for costs onto farmers, and will be politically difficult.
- A sealed-bid approach may be effective, where farmers offer land use changes in response for subsidies at levels they bid and compete for. This has a number of attractions, but also has some of the same problems as the marketable permits approach.

Further investigation is required to determine the best approach, but the key point for this report is that, even in a water resource catchment, which has been identified as the most likely environment for successful application of economic policy instruments in WA, the problems for successful and effective implementation of any type of economic instrument remain substantial, and unresolved.

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It is notable that the drier agricultural regions, where the most serious salinity problems are expected in the long run (Anonymous, 1996)<sup>9</sup>, are highly unlikely to be in circumstances where direct government expenditures on on-farm treatments are economically efficient, with the possible exception of cases where high environmental values can be protected.

## 6. Case studies

There are many examples of partial subsidies being paid to landholders or others to advance public resource management objectives. Often these are paid under the banner of “cost sharing”. The most significant example has been the provision of partial subsidies for on-ground works under the Natural Heritage Trust. While these have been valuable for achieving some environmental outcomes, their impact against salinity has been negligible because of the disparity between actual and required scales of implementation. Given the envisaged scale of public investment, this disparity will remain. This is not a criticism of the level of public investment. The information presented here indicates that greater funding for NHT-style programs for salinity prevention would be economically inefficient in most cases.

The Greenhouse Gas Abatement Program offers subsidies to relatively large schemes for abatement, and this may be relevant to major coordinated tree planting schemes. Like the Natural Heritage Trust payments, GGAP payments are simply subsidies paid to producers for implementation of works perceived to have public benefits.

There are relatively few examples of application of market-based economic policy instruments for resource management in Australia. In the case of salinity, the prime example has been the Hunter River Salinity Trading Scheme. This involved the Environmental Protection Agency in NSW issuing licences to 11 coalmines and Pacific Power to discharge saline waters into the Hunter River. The licences specified different allowable rates of discharge depending on flow rates in the river (allowing for the possibility of dilution when flow rates are high). The participants in the scheme are permitted to trade rights for high-flow discharge. Early experience with the scheme was considered positive.

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<sup>9</sup> The long run salinity hazard of a location depends on a range of factors, including salt storage in the soil, recharge rates, geology and topography. The relatively low rainfall received in central and eastern wheatbelt areas combined with the flatness of the landscape means that there is little flushing of salts from the landscape, so that salt storage in the soil is very high. The flatness of the landscape in these areas means that the valley floors, where salinity tends to occur, are a large proportion of the area. The flat landscape also makes it more difficult for treatments to be effective over a large area.

However, this success probably depends on particular characteristics of the case which will differ substantially from the situations of interest in WA. In particular, the emitters in the Hunter Valley system are clearly identified (they are so-called “point source” emitters), with the emissions being cheap and technically easy to monitor. This differs sharply from the case of farming properties, where emissions occur from many unidentified sources, underground, across entire property boundaries, rather than from localised pipe outlets.

## 7. Past and Present Policies

There are numerous government programs in place across Australia which are intended to promote conservation of land and water resources (e.g. Industry Commission 1997). Although salinity is one of a number of causes of resource degradation, it has increasingly been seen as the most serious and important of them, as reflected in the growth of major policies and programs targeted specifically at salinity. This subsection is a brief review of only the major policies relevant to dryland salinity over the past decade, including the new National Action Plan.

### 7.1 National Landcare Program and Natural Heritage Trust

Concerted efforts to address salinity in Australia began with the National Landcare Program (NLP), launched in 1989 from the foundation of the National Soil Conservation Program. The NLP started with the premise that land degradation in agriculture could be solved by awareness-raising, education, and catchment planning processes for groups of farmers (Curtis and De Lacy 1997; Vanclay 1997). A stewardship ethic was to be cultivated among farmers. For over a decade, this paradigm has been the dominant force shaping resource management policies for agriculture. The NLP approach has been very successful in raising awareness of resource conservation issues among farmers, and in some cases this awareness has led to changes in farming practices. It has also clearly had benefits in areas other than salinity. However, for dryland salinity, the changes achieved have been too small to prevent ongoing resource degradation. To be fair, the land use changes required to effectively prevent salinity are now known to be very much more substantial than was believed when the Landcare program was conceived. However, the contributors to Lockie and Vanclay (1997) identified a range of problems with the objectives and underlying assumptions of the NLP. Barr (1999) notes the inadequacies of relying on voluntarism and a stewardship ethic: “There is a significant body of research that demonstrates that links between environmental beliefs and environmental behaviour are tenuous,” (p. 134).

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The primary instruments used within the Landcare program have been provision of paid facilitators and organisers for Landcare groups, often without strong agricultural or technical backgrounds, the development of catchment plans, and subsidies for partial funding of relatively small-scale on-ground works. The NLP was subsumed within the Natural Heritage Trust (NHT) in 1997. The basic approach and philosophy of Landcare has continued and has also been applied to other programs within NHT such as Bushcare.

Although reported levels of membership of Landcare groups are high, farmers are increasingly jaded with the Landcare approach. Many are dismissive of the unrealistic expectations embodied in the Landcare program. Landcare coordinators and committed farmers are frustrated at the difficulty of involving the broader farming community in Landcare efforts.

A concern is that, despite this, and despite our new understanding of the salinity problem, some areas of government continue to advocate the Landcare paradigm for salinity management. Although “empowerment” and “participation” (buzzwords within Landcare) are important elements of good extension practice, they are not sufficient weapons against salinity. After a decade of exhorting farmers to action on the basis that “every little bit helps”, it will be difficult indeed for those deeply wedded to the Landcare program to accept that it may not. Given what we now know, continuation of the Landcare policy approach to address salinity is, in many situations, inequitable, and inefficient.

The Natural Heritage Trust is to be continued into a second phase. It is to be hoped that there are major changes to its operation. One important change would be for an emphasis on enhancing the technical and agricultural knowledge of the group coordinators employed by the program, so that they can contribute more directly to the development and testing of the farming innovations that are needed. Another would be a commitment to full and honest disclosure to farmers about the problem and the results of high quality evaluations of the treatments. Honesty needs to temper the spirit of forced optimism which has fuelled the Landcare program to date.

## **7.2 Integrated Catchment Management**

Ghassemi et al. (1995) observed that, “In Australia, since the early 1980s an emerging enthusiasm for the concept of integrated management of water and land resources on a catchment-wide scale has become evident” (p. 84). Most of the national and state salinity policies have included so-called “Integrated Catchment Management” (ICM) as a prominent theme. The mantra of ICM has had a strong influence on thinking about salinity and its management. One outcome has been a common belief among farmers, agricultural extension agents and others that localised management activities will not generate benefits unless

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replicated across the entire catchment. As noted earlier, Pannell et al. (2001) have argued on several grounds that in Western Australia this is frequently a misconception.

The concept of ICM has also influenced planning processes, at least in the sense of them being spatially inclusive of entire (surface water) catchments. However, the task of integrating all elements of the salinity problem into a meaningful planning process at the catchment scale seems intractable. It would entail consideration of hydrology, economics, social impacts, environment, agriculture, spatial variability<sup>10</sup>, and timing. The perceived requirement for consultation and participation would not ease this burden. In practice, most plans developed for agricultural catchments have involved consultation and participation but have been technically weak. They have also lacked mechanisms to achieve implementation, beyond the Landcare approach outlined above.

### 7.3 National Action Plan

The 2000 National Action Plan is an evolution from Landcare and ICM. The document released to announce the program, “Our Vital Resources – National Action Plan for Salinity and Water Quality”, emphasises “Integrated Catchment/Region Management Plans” to be developed “by the community”. The community is to be supported in this by the existing facilitator and coordinator support network, by skills development programs, by extension of technical information, and by a major public communication program “to promote behaviour change and community support”. In all this, the program sounds disappointingly similar to the existing programs.

Novel elements of the National Action Plan include that it requires targets for salinity to be set and that funding to achieve these targets is directed to community-based groups in the regions. The setting of targets for each catchment or region raises a number of issues. If they are not based on detailed analyses which account for the hydrological and economic realities of the catchment, targets might easily define outcomes which are inferior to a business as usual approach, in the sense that its overall costs exceed its overall benefits<sup>11</sup>. If they are based on scientifically credible analyses, targets for the available budget will be very modest, even allowing for unrealistic expectations about the sacrifices to be made by farmers.

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**10** Spatial variability arises in several ways. Within a farm, some areas are susceptible to dryland salinity, while others are not. There are spatial differences in the tendency for recharge to occur due, for example, to soil type differences. Farms within a catchment vary in their salt risk and in their impacts on salt risks elsewhere in the catchment. There are differences between sub-catchments in the flow lengths of groundwater flow systems. Flow systems may be local, regional or intermediate.

**11** Attempts to achieve such targets are likely to reduce the level of salinity to some extent. The point is that the overall costs of achieving that reduction may exceed the overall benefits.

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It is apparently intended that targets should enhance accountability, which has been a serious weakness in previous programs. However, long time lags and scientific uncertainty erode this advantage. Many of the benefits from the policy, if they occur, will be decades in the future. Even a retrospective evaluation of the policy at that time will be difficult because of uncertainty about what would have happened without it, and achievement or otherwise of the specified targets will provide only a loose indication of success or failure.

The regional groups to which funds are to be channelled will find the task of managing and making decisions about the funds very difficult. The groups will need very high levels of information and leadership if they are not to allocate the money in ways that will be socially and politically attractive but technically and economically inefficient. It may be expecting too much of them to make the difficult but necessary decisions about priorities, especially where it involves fewer funds going directly to farmer members of their communities, many of whom are suffering financial hardship. Provision of high levels of technical information from government and research organisations will be essential for the process to operate effectively.

The other relatively new element in the plan is an improved “governance framework”, including clarification of property rights for water, limits on land clearing and greater use of economic policy instruments (salinity credits, subsidy payments, etc.). These changes seem broadly positive, although I have argued earlier that achievement of benefits from use of economic policy instruments is likely to be highly site specific.

A high profile component of the plan is airborne geophysics using electro-magnetics and other techniques to identify salt deposits and flows. While information from these methods no doubt has some value for diagnosis and planning, it does not in itself address the core problem in most locations of lack of viable technologies for salinity prevention.

## 8. Policy Needs

The technical and economic information presented earlier in this paper and the experience from policy measures over the past decade point to the need for a clear change of policy approach. Key implications for policy from the foregoing discussion are outlined below.

In most locations across the agricultural regions of Australia, the salinity-related benefits from perennials are small relative to their costs and direct production-related benefits. It is therefore unlikely that policy instruments to provide incentives for adoption of perennials, whether economic or regulatory, would be socially desirable except in one of two situations.

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Either the perennials would need to be almost as economically attractive as existing farm enterprises (which is currently only true in a minority of situations) or they would need to be in locations where they provide protection to assets of outstanding value.

This points to the need for direct public investments in salinity prevention to be carefully targeted and site specific, rather than distributed broadly across rural areas (Heaney et al. 2000). A proportion of this targeted investment would not be directed to farmers, and much of it will be directed to engineering works<sup>12</sup>. This conclusion has consequences which are likely to be highly unattractive to some politicians and to those with a stake in the existing approach. Farmers are already concerned that salinity money is not all spent on farms (Industry Commission 1997), and farming lobby groups have regularly stated that it should be.

The other way that public money could be targeted to achieve benefits from salinity prevention would be by investment in development of new farming systems based on profitable production of perennials. This option has been neglected in past funding decisions. Its attractions include the following.

- Scientists believe that substantial improvements in the range and scope of profitable perennials are achievable. The current paucity of profitable perennials reflects a low investment in development rather than intractability of the task.
- Some benefits are probably only achievable if profitable perennials became available (e.g. diffuse benefits such as avoidance of flood risk, protection of remnant native vegetation on farms, prevention of salinity on agricultural land where groundwater flow systems are intermediate or regional in scale).
- Where subsidies for perennials on farms are used, the subsidy can be reduced by any profit improvement achieved. Less costly perennials increase the area over which economic policy instruments could be beneficial.
- In the case of woody perennials, profitable options will attract private sector finance to meet the establishment costs, which are beyond the means of many farmers.

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**12** It was noted earlier in the sections on “Prevention” and “Remediation and adaptation” that engineering works such as pumping saline water to evaporation basins may be the most cost-effective means to protect some public assets. This is because of the technical effectiveness of engineering, but also because of the long time lags in achieving catchment-scale benefits from revegetation.

- Given that the use of direct subsidies or other economic instruments is not economically justified in the drier agricultural regions, where the worst salinity problems are ultimately expected<sup>13</sup>, failure to very substantially support development of improved perennial options leaves these regions no realistic prospects for salinity prevention.

Of course, the challenges involved in creating a new perennial-based industry are formidable. The tasks required vary from one case to another, but for shrubs, for example, they would include screening of plant species, identifying potential products, developing harvesting and processing technologies, conducting market research, establishing marketing bodies, obtaining finance, and establishing perennials over large areas. For perennials pastures, the technical challenges of development are probably less, but the reliance on livestock to convert plant biomass to marketable products may be seen as a weakness. So this strategy involves delays and uncertainties. However, perennials are the only prospect for prevention of salinity on most of the threatened agricultural land. The community may consider that the value of protecting agricultural land in the very long term is not adequately reflected in discounted Net Present Values.<sup>14</sup> Investment in development of profitable perennials is likely to be the most efficient and effective way of achieving this protection.<sup>15</sup>

Inevitably there will be large increases in the area of salt-affected land. Investment in development of improved systems for making productive agricultural use of saline land appears certain to be attractive. Like development of perennials, this too has been under-resourced in past and present programs.

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**13** Reasons for this were given in a footnote at the end of Section 5, “Where are economic policy instruments most likely to be successful?”.

**14** For example, weight may be given to unpriced values relating to the social costs of increased rural hardship, or to visual aesthetics of a landscape substantially degraded by dryland salinity.

**15** That is, even if non-commercial motives are cited as the reason for seeking to protect this agricultural land, improving and developing the potential for commercial (or at least semi-commercial) production of perennials is likely to be more cost-effective than an approach based on direct financial assistance to promote existing unprofitable perennial options. Given the scales of revegetation which would be required, and the direct and indirect costs of that revegetation, direct assistance would be required at extremely large levels (probably hundreds of millions of dollars per year in WA). Success in developing commercial perennials would at least reduce, if not remove, the need for direct assistance, and could do so over large areas. It would also attract private-sector resources to finance the establishment of perennials.

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Engineering methods for use on-farm are already attractive to farmers. Shallow drains for surface water management are widely used and accepted. Deep drains are more controversial, but it does appear that they may be technically effective in salinity management in some areas. Their cost-effectiveness is likely to vary widely. R&D to improve and better understand the available engineering methods is another priority which has been neglected in the past.

Aspects of the existing plans deserving of support include: protection of remaining native vegetation, and economic policy instruments (if carefully targeted). Given their current roles, the investment in the network of coordinators and facilitators appears hard to defend (at least from the point of view of salinity prevention), but a reorientation towards advice about resource management technologies and participatory research may see them make a valuable contribution.

### **8.1 Optimal allocation of salinity policy funding**

There are many potential uses of public funds for salinity management, including the following:

1. Extension, broadly defined to encompass Landcare facilitators and coordinators.
2. Use of economic policy instruments (e.g. subsidies to farmers) for on-farm works/land use change.
3. Research into processes, impacts and treatments.
4. Development of new technologies for salinity management.
5. Industry development/market research etc. for new products from perennials.
6. Monitoring of rates of salinisation or remediation.
7. Enforcement of legal requirements.
8. Engineering works and other direct measures for protection of public assets.
9. Administration of programs.

To date, programs appear to have been developed without adequate consideration of the balance of investment across these possible uses. Under Landcare, funding was used predominantly for category 1, while the NHT has emphasised category 2. It appears that the designers of the National Action Plan envisage no substantial deviation from the emphasis on these two categories. However, it is clear from the evidence which has been summarised here that this represents a seriously flawed allocation of funds.

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Briefly, the problems with it are that:

- extension will remain an ineffective option while the available management technologies remain unprofitable;
- use of subsidy-style approaches needs to be very carefully targeted, and will be ineffective and wasteful on the broad scale over which it is currently used;
- technology development and industry development are needed at significantly greater scales to ensure that viable management options are available; and
- for those public assets with an acute need for protection, on-site engineering works are probably the only effective methods available.

Overall, relative to past policies and the proposed National Action Plan there is a clear need for funds to be reallocated away from categories 1 and 2, and towards categories 4, 5 and 8. Ongoing research (category 3) is also needed to ensure that suitable targeting of funds in categories 2 and 8 is possible.

There is a greater appreciation of these issues among Western Australian policy makers (both in the public service and on the State Salinity Council) than among their Federal counterparts. Recently, an investment framework has been developed by the State Salinity Council which is intended to better guide the prioritisation of public expenditures in the state in future. A detailed presentation of the contents of the investment framework is beyond the scope of this paper. However, the principles on which the investment framework is based are given in Appendix A.

Of concern is that expenditures within WA may be constrained by conditions of the National Action Plan such that the outcomes of the new investment framework cannot be implemented. Unless a suitable agreement can be reached with the Federal Government, there is a risk that the National Action Plan will tie State expenditures into areas of low effectiveness. Unless this can be avoided, it is likely to be in the State's best interest to forego funding offered under the Plan.

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## Appendix A. Principles for Setting Priorities Embodied Within the State Salinity Council's Investment Framework

The principles for setting priorities and subsequent public investment in salinity action are as follows:

1. **The top priority public investments are those which generate the greatest public benefits per dollar of public investment.** Whether protection of a particular asset falls into this "top priority" category depends on the costs of preventative treatments, the effectiveness of the treatments and the values of the assets. "Values" include social and environmental values, as well as economic values.
2. **Direct financial assistance to landholders to undertake salinity action should be strategic and should not exceed the public benefits that result.** (i.e. focused on priority areas with high value and high probability of success).
3. **Where the priority is high and net public benefits are sufficient, Government should be prepared to take strong action to ensure protection of the asset** (e.g. Compensation or structural adjustment, regulation, monitoring to ensure achievement).
4. **Where the public priority is low but there are extensive private assets at risk, the public investment should be aimed at industry development** (i.e. profitable systems to prevent or contain salinity or to adapt to saline land and water).
5. **Inevitably, a targeted investment strategy in salinity management will result in an unequal distribution of investment across the state.** Over time, funding priorities will change as new information becomes available and programs adapt, goals are met and new challenges arise.
6. **Government must fulfill its statutory obligations for land, natural resources and functions (such as research) when it sets its priorities for investment in salinity action.**