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ECONOMIC IMPACTS OF DRYLAND SALINITY FOR GRAINS INDUSTRIES

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ABSTRACT

This paper explores some possible economic impacts of worsening salinity severity and extent in the grains industry across Australia. It also looks at the potential to increase agricultural profits through remediation. The analysis is based on a spatial model of agricultural profits and salinity related crop/pasture yield losses. It is estimated that grains industry farming profits across Australia would rise by an upper limit \$138 million per year were salinity costlessly removed from the landscape. It is also estimated that the present value of grains industry profit losses from worsening salinity extent and severity over the next 20 years is \$237 million. These amounts can be considered against the costs of repair.

INTRODUCTION

As Australia makes increasingly large investments in salinity mitigation, it is important to analyse the economic consequences of the business as usual or 'do nothing' scenario. This will allow informed assessments about the economic net-benefits of intervention and better targeting of resources, widely recognised as a major challenge facing policy makers (Hajkowicz and Young 2002, Pannell 2001).

This paper explores some possible economic impacts of worsening salinity severity and extent in the grains industry across Australia. It also looks at the potential to increase agricultural profits through remediation. The analysis is based on a spatial model of agricultural profits and salinity related crop/pasture yield losses. Data are presented by the Grains Research and Development Corporation (GRDC) regions, as shown in Appendix A.

It is estimated that grains industry farming profits across Australia would rise by an upper limit \$138 million per year were salinity costlessly removed from the landscape. This amount can be considered against the costs of repair. It is likely that the economic optimum level of treatment would not recoup this entire amount.

CONCEPTUAL MODEL OF SALINITY COSTS

Consider three alternative scenarios for grains industry profit resulting from salinity outcomes over the next twenty years (Figure 1). If salinity were costlessly ameliorated profits would rise to the unconstrained level, this is later referred to as the gross benefit. Clearly a costless 'fix' of salinity is not possible, in some regions the project costs may easily exceed the gross benefit.

If salinity is unchecked profits are expected to decline in problem-type locations over the next 20 years. This lower profit can be considered the impact cost. The shaded area in Figure 1 represents the present value of the impact cost over the 20 year time period. The net loss in profits over the 20-year period due to worsening salinity extent and severity is referred to as the impact cost of salinity.

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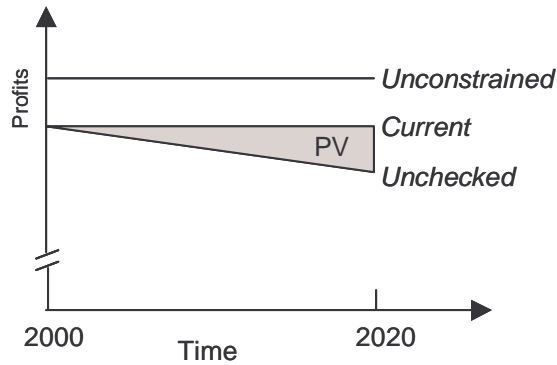


Figure 1 Conceptual model for grains industry profits

It is worth noting that the "unchecked" line represents a worst-case scenario. In practice, farmers will respond to worsening salinity problems through improved management practices and enterprise switches. This will have the effect of reducing the present value of costs.

RELATIVE YIELD

Crop and pasture yield loss is one of the main economic impacts of dryland salinity to grains producers. The amount of yield loss can be measured using relative yield. Relative yield is the ratio of actual yield, as currently recorded, divided by the potential yield that would occur if the soil constraint(s) were not present. Relative yield can be expressed as:

$$\text{Relative Yield} = \alpha = \frac{\text{Actual Yield}}{\text{Potential Yield}}$$

The relative yield for salinity was determined using data produced under theme two of the National Land and Water Resources Audit (NLWRA 2000). Surfaces of relative yield were mapped to a ~1km² grid with national coverage for 2000 and 2020. Data was drawn from hydrological salinity modelling. Similar surfaces were also produced for sodicity and acidity, two additional soil attributes that limit crop/pasture yield.

SPATIAL REPRESENTATION OF GRAINS INDUSTRY PROFITS

In order to determine the economic impact of yield surfaces over time, it is necessary to give grains industry profits spatial definition. This was achieved by mapping profit at full equity, which represents economic returns to the natural resource base (soil and water), managerial skill and human capital. The profit function can be written as:

$$\text{PFE} = [Q1 \times (P1 \times \text{TRN} + P2 \times Q2)] - [(QC \times Q1 + AC) + (WR \times WP)] - [FOC + FDC + FLC]$$

Where:

- PFE = Profit at Full Equity (\$/ha/yr)
- P1 = Farm Gate Price (\$/ha or \$/DSE)
- Q1 = Yield or Stocking Rate (\$/ha or \$/DSE)
- TRN = Turn-off Rate (Ratio), also symbolised as β
- P2 = Price of secondary product (\$/litre or \$/kg)
- Q2 = Yield of secondary product (litres/DSE or kg/DSE)
- QC = Quantity Dependant Variable Costs (\$/t or \$/DSE)
- AC = Area Dependant Variable Costs (\$/ha)
- WR = Water Requirement of Land Use (ML/ha)
- WP = Water Price (\$/ML)

FOC = Fixed Operating Costs (\$/ha)
 FDC = Fixed Depreciation Costs (\$/ha)
 FLC = Fixed Labour Costs (\$/ha)

The profit function relates to a single agricultural landuse, such as wheat, barley, sheep, canola and others. It is distinct from the notion of whole farm profit, which often comprises a mixture of landuses. It can be likened to a gross margin, less fixed costs of production.

A secondary product exists only for sheep landuses, namely wool. For all other landuses prices and yields of the secondary product are set to zero. Water price, as used here, represents the charge imposed on irrigators by the local water management authority. This charge varies for different water management authorities across Australia. Irrigation of grains industry related landuses is not common. An imputed cost for farm labour was used based on standard industry award rates. Fixed operating, depreciation and labour costs were sourced from ABARE data and State/Territory gross margin handbooks.

All variables comprising the profit function were mapped on a ~1km grid covering all agricultural land in Australia, including both intensively used zones and the rangelands³. A single landuse was assigned to each 1km grid cell, resulting in generalisations within intensively used irrigation areas.

Landuse data were derived from the National Land and Water Resources Audit 1996/97 landuse map. This provides a snapshot for landuse in the 1996/97 financial year. Some enhancements were made in order to map the locations of commodities.

Prices and Yields

Farm-gate prices were assembled from the Australian Bureau of Statistics (ABS) for almost all commodities. Prices for some commodities were not available from the ABS, these were taken from the Australian Bureau of Agriculture and Resource Economics (ABARE). The prices were generally assembled by Statistical Local Area (SLA), then spread over the 1km grid cells. For example, if the farm gate wheat price for an SLA was \$198/tonne - each grid cell within that SLA coded as wheat was also assigned a price of \$198/tonne. Milk and wool prices were not available at the SLA level and were taken from larger ABARE regional frameworks.

Yields were compiled from ABS production data at the SLA level. Given a known area of production and a known quantity of production, a yield is attainable by dividing production by area. This approach was applied, with a minor variation. Yield was determined by:

$$q1 = P \frac{NDVI_i}{\sum_{i=1}^{SL} NDVI_i} \quad (2)$$

Where:

q1 = The yield of the crop (tonnes), or number of livestock (DSE⁴), within the 1km grid cell;
 NDVI = NDVI score for the pixel⁵ i;
 SL = Total number of pixels in the Statistical Local Area

³ The rangelands are the extensively grazed low-rainfall regions mostly covering Australia's arid interior. Whilst formally defined as 'agriculture', these regions have extremely low per-hectare productivity.

⁴ DSE stands for Dry Sheep Equivalent. The conversion factors used for DSE were taken from Agricultural manuals: 1 Sheep = 1.5 DSE, 1 Dairy Cow = 10 DSE, 1 Beef Cow = 8 DSE.

⁵ A pixel is a single cell in a raster (grid) spatial dataset. In this study a pixel is approximately 1km².

P = Total production in tonnes for the commodity in the Statistical Local Area

The cloud-adjusted normalised difference vegetation index (NDVI) is taken from satellite data. It is derived from a satellite scanner referred to as the Advanced Very High Resolution Radiometer (AVHRR). This is a broadband scanner, sensing the visible, near-infrared, and thermal infrared portions of the electromagnetic spectrum. NDVI data is mapped on a 1.1km grid covering the Earth. Higher NDVI values are indicative of increased yields and vegetation health (Smith *et al.* 2001, Jackson *et al.* 1983, Tucker *et al.* 1991).

Fixed and Variable Costs of Production

Variable costs of production were assembled by 29 ABARE regions covering Australia. They were derived from ABARE records, Gross Margin Handbooks and Farm Management consultant data. Water use rates for each major crop type were determined for each major irrigation area within the each ABARE region. The data for water use and charges was primarily sourced from the Australian National Committee on Irrigation and Drainage (Alexander 2000 and Thomas *et al.* 1999).

Landuses Included

Landuses related to the grains industry were extracted from Audit databases., as mapped for 1996/97, the year of an agricultural census. Sheep, beef, wheat and barley occupy the greatest portion of Australia. Areas are given below:

Landuse	Area (000 ha)	Landuse	Area (000 ha)
Barley	6,175	Oats	309
Beef	40,964	Oil Poppies	0
Canola	444	Peanuts	19
Chick Peas	178	Safflower	1
Faba Beans	1,291	Sheep	54,522
Grain Sorghum	1,089	Soybeans	21
Lentils	55	Sunflower	126
Lupins	182	Triticale	692
Maize	153	Vetches	46
Millet	9	Wheat	9,084
Mung Beans	22		

GROSS BENEFIT AND IMPACT COST OF SALINITY

Gross benefit can be considered the increase in profit at full equity, were salinity costlessly ameliorated. As such it represents an estimated investment ceiling on salinity expenditure aimed at boosting crop/pasture yields. Gross benefit (GB) is determined by:

$$GB = \frac{q_1(\beta p_1 - v)}{\alpha} - q_1(v - \beta p_1) \quad (3)$$

Where:

GB = Gross benefit from salinity amelioration (\$/ha/yr)

q_1 = Yield of primary product (t/ha/yr or DSE/ha/yr)

p_1 = Price of primary product (\$/t or \$/DSE)

v = Variable costs (\$/t)

α = Relative yield

β = Livestock turn off rate (>0 and <1), set to 1 for crops

Equation (3) essentially means that gross benefit is the difference between current profit and profit without salinity. In practice, the increase in profit is likely to be somewhat less than this amount. Even if salinity

were removed other soil constraints, sodicity and acidity, would limit yields. Table 1 shows the gross benefits for salinity alone, and the gross benefit of salinity when constrained by sodic and acid soils.

Impact cost is defined here as the decline in profit over the period 2000 to 2020 due to worsening salinity extent and severity. It can be expressed as a present value using standard amortisation formulae. The un-amortised impact cost (IC) is determined as:

$$IC = \Pi_{\text{Current}} - \Pi_{2020} = \beta q_1 \left(p_1 - v - \frac{\alpha_2 (p_1 + v)}{\alpha_1} \right) \quad (4)$$

Where:

IC = Gross benefit from salinity amelioration (\$/ha/yr)

α_1 = Relative yield in 2000

α_2 = Relative yield in 2020

If we assume that the decline in profits over the 20yr period is linear then we can obtain a series of payments over time, which can be converted into a present value.

RESULTS

Table 1 below shows the gross benefit and impact cost of salinity for each grains region. Note that the gross benefit limited by acidic and sodic soils is less than one-third of the unlimited gross benefit. The impact costs are shown as present values over the period 2000 to 2020 using an 8% discount rate. The results show that grains industry profits could be raised by \$138.2 million if salinity were removed, or \$38.6 million with acid and sodic soil constraints included. If salinity were left unmanaged, profits would decline by 3% causing losses of \$237 million in present value terms.

These results should be tempered by some important considerations. Firstly, there are many locations where gross benefits and impact costs are very high. These may be overlooked by broad regional aggregate statistics. Secondly, the impact cost does not incorporate any farmer response or adaptation. It merely assumes the current practice is continued in the face of worsening salinity. In practice, impact costs would be significantly lower because farmers would adapt new practices to avoid salinity related damages.

Table 1 Gross benefits and impact costs of salinity in grains regions¹

GRDC Zone	Gross benefit, unlimited (\$000/yr)	Gross benefit, limited by sodic and acid soils (\$000/yr)	Impact Cost Present Value 2000 to 2020 (\$000) ²
NSW Central zone	117	0	4,552
NSW Northeast - Qld Southeast zone	2,787	531	17,081
NSW Northwest-Qld Southwest zone	49	0	684
NSW Vic Slopes zone	3,868	240	43,542
Qld Atherton zone	122	0	563
Qld Burdekin zone	0	0	4
Qld Central zone	3,533	34	10,353
SA & Vic Mallee zone	4,130	319	8,179
SA Mid-North Lower York Eyre zone	11,232	190	10
SA Vic Bordertown Wimmera zone	20,084	640	58,825
Tas Grain zone	765	296	807
Vic High Rainfall zone	3,231	576	21,246
WA Central zone	46,458	17,601	39,242
WA Eastern zone	20,701	9,497	0
WA Northern zone	10,384	2,317	0
WA Sandplain zone	10,677	6,444	32,378
All Regions	138,138	38,685	237,464

1. Refer to Appendix A for a map of these regions.

2. Determined using an 8% discount rate. A high discount rate was chosen as many of the economic impacts will be endured by private landholders.

DISCUSSION AND CONCLUSIONS

Immediately apparent in the results presented above is the drop in gross benefit when sodic and acid soils limit crop/pasture yields, a difference of about \$100 million/yr. This suggests that policies directed at correcting only soil salinity, without accounting for other limiting factors, will lead to much lower levels of benefit. The additional costs from an integrated soil remediation program may be relatively low.

Ultimately decision makers managing salinity in grains industries will be seeking to make investments where benefits exceed costs. This study falls short of benefit cost analysis, showing only estimates of benefit. However, other studies into salinity management show that costs of changing landscapes to the required amount are very high. For example, studies of Western Australian catchments show that as much as 70-80% of the catchment must be revegetated to have a significant reduction in salinity levels (George *et al.* 1999).

When landscape change of this nature was subject to benefit-cost analysis by Hajkowicz and Young (2002) on the Lower Eyre Peninsula in South Australia, a predominately grain growing region, all revegetation options were found to deliver negative net present values. This was despite considerable variation of prices and salt yield loss scenarios.

On the brighter side, though, evidence is emerging that some salinity benefiting agricultural plants may be able to approximate, or even exceed profits from current landuse. For example, Lucerne, a deep-rooted perennial fodder shrub, has been found to provide profits nearing or equal to current annual crop/pasture production (Bathgate and Pannell 2002, Hirth *et al.* 2001). The study by Hajkowicz and Young (2002) suggested that salinity-mitigating plants need only be 75-90% as profitable as current landuse options to make benefits of landuse change exceed costs.

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APPENDIX A: GRAIN REGIONS

These are developed by the Grains Research and Development Corporation (GRDC).

