Land and Water Salinity – A Threat or A Reality?

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The Issue

Salinity has increasingly been identified as one of the most serious environmental issues facing Australia (PMSEIC, 1998; MDBC, 1999). Although there has been an increase in awareness of salinity throughout the community there is still a perception that salinity is a soil related issue and that the major impact is on the agricultural sector. These perceptions and limited understanding of the processes contributing to salinity have led to many in the cotton industry dismissing salinity as a threat without considering the fundamental drivers of salinity and their relevance to cotton producing regions.

In this paper, I will attempt to provide a brief "report card" on the most significant salinity related issues for each of the major cotton growing districts. In some areas, salinity problems can be observed right now, although in many cases this paper will highlight the presence of significant "risk" factors for the future. The delineation of key risk factors for each region allows the industry to be pro-active in its management of salinity problems and examine management alternatives, which will minimise the impact of salinity on both agricultural productivity and water quality.

Although this paper does not intend to fully describe the processes contributing to salinity, it is important that there is a shared understanding of the fundamentals so that the industry is better placed to address the salinity issue. Some key definitions relevant for this paper are as follows:

Irrigation water quality salinity – the impact of increasing levels of salinity (and sodicity) in irrigation water supplies on root zone salinity levels and soil structural stability can be considered, "irrigation water quality" salinity. This has been the focus for much of the research effort through the Australian Cotton CRC and Cotton Research and Development Corporation and there is "leading edge" monitoring and modelling tools available to better delineate the potential risk of this form of salinity in cotton areas (for example Triantafilis et al., 1998).

Watertable salinity – when an increase in the amount of recharge entering the groundwater system exceeds the capacity for the system to accept or transport that excess water, a rising watertable will be created. This water mobilises salt stored within the system and can lead to concentration of salts within the root zone when the watertable rises to within approximately 2 metres of the soil surface, or alternatively will lead to an increase rate of discharge of saline groundwater into surface water systems. The impact of watertable salinity may be on agricultural productivity, water quality, infrastructure and the environment. In the last 3-5 years there has been a significant effort at the regional, State and Federal level to better understand the potential for watertable salinity problems to develop in both irrigated and dryland catchments.

It is also important to highlight the need for salinity to be considered as a catchment issue, Whilst the focus in this paper will be on the cotton industry, salinity will by necessity require an integrated management effort across all industries and stakeholders within a catchment. There is also a need to briefly explore some popular 'myths' that are relevant for any consideration of the threat of salinity.

1. *Zero drainage beneath irrigated cotton.*

There is an increasing body of evidence that drainage is a significant component of the water balance on cracking clay soils (Hearn, 2000, Dalton, 2000). The traditional concern with salinity in the cotton industry has focussed on the potential for salt to accumulate due to additional inputs from irrigation water. However, with the potential for drainage there will be a need to consider the potential for both irrigation water quality salinity and watertable salinity within cotton growing areas. It should be also stated that the cotton industry is still one of the most efficient irrigation industries, and this is reflected by the limited extent of watertable salinity issues currently being observed within the industry.

2. *Groundwater extraction exceeds any increased recharge beneath irrigated cotton.*

Whilst it is true to assume that the use of groundwater for irrigation will minimise the risk of watertable salinity, we need to more rigorously identify those areas where groundwater extraction is a significant proportion (> 20%) of the total water supply to an irrigation district. In some regions (e.g. upper Namoi, Wee Waa, upper Condamine), it has been well documented that groundwater systems are suffering from declining groundwater levels, but what proportion of the total area of irrigated cotton does this represent? There is very limited data on the spatial extent of irrigated cotton where the source of irrigation supply is delineated, but a purely qualitative estimate would be that groundwater dominant irrigation areas would account for less than 30% of the total area currently irrigated for cotton production. This begs the question, what do we know about groundwater levels beneath the surface water supplied (both regulated and un-regulated) irrigation areas? Unfortunately, in those areas where there has been no developed groundwater resource, our groundwater monitoring networks are virtually non-existent.

If we were to agree that the two primary contributors to salinity are a storage of salt in the landscape and an increase in recharge due to land use change (more drainage), the prognosis for the floodplains of western NSW and Queensland would not be good. Fortunately the expression of salinity is modified by other factors including soils, climate and hydrogeology. However, this does indicate the need to undertake a more thorough risk assessment of salinity in the cotton industry, where a multi-disciplinary approach is adopted.

Table 1. Salinity issues, the effects in cotton growing areas, and the maximum likely risk of occurrence. Specific local conditions will modify these risk estimates (adapted from Shaw and Gordon, 1994).

REGION	**DEGREE OF RISK**			
	Irrigation water quality (current)	**Irrigation water quality (future)**	**Watertable salinity**	
			Rising watertables	***Salt mobilisation***
Macquarie Valley	Low	High	High	High
Upper Namoi	Low	Moderate	High/Low[1]	High
Lower Namoi	Moderate	High	Moderate/Low[2]	Moderate
Border Rivers	Low	Moderate	Moderate	Moderate
Condamine-Balonne	Moderate	High	Moderate/Low[2]	High
Callide Valley	Moderate	Moderate	Low	Moderate
Emerald Irrigation Area	Low	Low	High	Moderate
Ord Irrigation Area	Low	Low/Moderate[3]	High	Low/Moderate[3]

1. Low risk in areas with significant groundwater extraction, High risk in both dryland and surface water supplied irrigation areas
2. Low risk in areas with significant groundwater extraction, Moderate risk in areas with predominantly surface water supplied irrigation
3. Low risk in Stage 1, where groundwater quality is “fresh”, moderate risk in proposed Stage 2 where groundwater quality becomes increasingly saline. (Note that de-watering is required in both Stage 1 and Stage 2 areas to alleviate rising groundwater levels).

Irrigation water quality

Overview and current extent

Irrigation water quality salinity issues have been previously linked to those areas where groundwater is the major source of irrigation water supply. The generally higher salinity levels in groundwater mean that there is a risk of increased root zone salinity and sodicity levels unless appropriate plant-soil-water quality guidelines are followed. The recently released Murray Darling Basin Salinity Audit (1999) highlights the need to consider catchment scale responses, where land use change in upper catchment areas is predicted to contribute to increasing river salinity levels into the future. A summary of the predicted increases of river salinity for major tributaries of the Darling river system is provided in Table 2. We can no longer assume that our surface water supplies will remain fresh indefinitely and the cotton industry will need to consider the implications of increasing salinity levels on future water supplies.

Table 2. Predicted future salinity levels for major tributaries of the northern Murray-Darling catchment (adapted from MDBC, 1999).

River Valley	Average River Salinity (uS/cm)			
	1998	**2020**	**2050**	**2100**
Bogan	730	1500	1950	2320
Macquarie	620	1290	1730	2110
Castlereagh	640	760	1100	1230
Namoi	680	1050	1280	1550
Gwydir	560	600	700	740
Border rivers (Qld)	310	1010	1010	1010
Warrego	210	1270	1270	1270
Condamine-Balonne	210	1040	1040	1040

Shaw and Gordon (1994) provide an overview of the potential risks of salinity and sodicity that could affect cotton-growing areas in Australia. Although the concepts discussed in that paper remain valid, there has been a significant shift in our understanding of the potential for watertable salinity to contribute to increasing salinity levels in our river systems. Therefore, the original risk table of Shaw and Gordon (1984) has been significantly revised to incorporate the latest information on salinity trends, particularly with respect to surface water supplies (Table 1).

There is a moderatè to high risk of increasing water salinity and subsequent impacts on root zone condition for irrigation areas within the Murray Darling Basin. It is not expected that surface water supplies within the Emerald, Ord and Callide Valley Irrigation areas will be significantly affected by salinity within the foreseeable future. However, drainage and groundwater pumping have been implemented to protect sections of both the Emerald and Ord (Stage 1) irrigation schemes from rising groundwater levels. This water is of good quality and is currently discharged to the river system or in some areas recirculated for re-use. Groundwater de-watering has been planned for the proposed Stage 2 of the Ord Irrigation area, however, this area is underlain by saline groundwater which will require more careful consideration of disposal or re-use options. Marginal groundwater quality has been historically observed within particular areas of the Condamine and Callide catchments. The use of groundwater for irrigation supply will continue to require guidelines to appropriately match water quality to particular soil types and production systems.

Management options

Cotton is a highly tolerant of salinity, hence management of irrigation water quality salinity need to consider the broader "farming system" that is desired in irrigation areas. Site specific guidelines which consider soil properties, water quality, crop type and climate can be derived using models developed within the cotton industry (Zischke and Gordon, 2000) to appropriately match water quality to soil types for longer term sustainable outcomes. These tools also allow a prediction of future soil salinity levels under a range of "projected" future river salinity levels. In many instances, irrigation water quality salinity will impact on the non-cotton components of the farming system, particularly salt-sensitive legumes that are being considered for rotational benefits including fertility and insect management.

Changes in irrigation water quality may also influence soil structural stability. Where waters of high proportion of sodium, expressed as Sodium Adsorption Ratio (SAR), are used for irrigation, there may be increased soil dispersibility, reduced water entry, and reduced soil profile water availability. The total concentration of dissolved ions in the soil solution is an important modifier of instability related to sodicity. Relationships have been established for many soils, which indicate the combination of salinity and sodicity where dispersion problems are likely to occur (Shaw, 1995; Shaw and Gordon, 1994). As for root zone salinity problems, an assessment of the irrigation water quality in relation to soil properties is the best method of avoiding these problems. There are appropriate management techniques to overcome many of the root zone salinity and sodicity problems of irrigation (DNR, 1997).

Watertable salinity

Overview and current extent

There continues to be a significant gap in our knowledge of groundwater systems in the floodplains of western Queensland and central and north-western New South Wales. The major groundwater supply in those regions is aquifers associated with the Great Artesian Basin or major alluvial aquifer systems. However an examination of bore logs and discussion with local drillers, highlights the presence of shallow, often saline groundwater systems in many regions. Due to both poor quality and limited supply, these systems have not been monitored and in many instances have been cased off to prevent contamination of deeper better quality supplies. In southern Queensland there has been emerging evidence over the last few years of watertable salinity developing under dryland cropping systems. If similar hydro-geological conditions exist in association with irrigation, then there is a high risk of salinity problems. Whilst I have assigned a moderate risk of watertable salinity in many catchments, a more thorough salinity risk assessment (incorporating a more refined understanding of hydrogeological processes) is required to provide a clearer understanding of the spatial extent of risk features within each of the major valleys.

In many areas there is a declining watertable level associated with groundwater extraction. These areas would have a low or negligible risk of watertable salinity, but it is difficult to provide details on the spatial extent of these areas within each catchment. Groundwater management units, as utilised in Queensland and New South Wales, are a coarsely defined groundwater systems, which are assumed to respond in a uniform manner. These units provide the framework upon which we have observed areas of declining watertable levels including sections of the upper Condamine, sections of the Upper and Lower Namoi and the Callide valley. There is an urgent requirement for monitoring of groundwater systems (particularly shallow systems) beneath predominantly surface water supplied irrigation areas.

History has demonstrated that rising groundwater levels are almost a certainty with any extensive irrigation development. This in itself does not warrant a high salinity risk assessment as appropriate planning and management can be implemented to minimise both the local and off-site impact of irrigation development. The reality is that most areas consider management options only when waterlogging and salinity affect significant areas, or irrigation development is contributing to water quality decline in downstream catchment areas. The opportunity is for the cotton industry to avoid significant "remediation" costs from irrigation water quality and watertable salinity problems by pro-actively implementing management actions that minimise future risk.

Management options

There are several approaches to the management of watertable salinity problems. Given the currently limited extent of watertable salinity problems in the cotton industry I will focus on management options, which minimise the future risk, rather than options for maintaining production in salt-affected lands. Many of the desirable management options are consistent with current industry initiatives including improved water use efficiency and the "whole of water balance" approach (Hearn, 2000).

Minimising deep drainage:

- Minimising losses from storages and distribution systems – consider lining of channels or pipes and fluming.
- Matching application technique to soil properties, particularly permeability.
- Field and farm layout to minimise excessive ponding and water accumulation.
- Improved irrigation scheduling to minimise the opportunity for irrigation or rainfall induced drainage.

Managing water balance at the catchment scale:

- Ensure there is a good understanding of the hydro-geological characteristics of the region prior to irrigation development.
- Consider water balance and groundwater response at the broader catchment level – where does the cotton industry fit into broader catchment management issues such as salinity?
- Consider pumping of water from aquifers within all irrigation areas (conjunctive use) where relatively good water quality is available to minimise groundwater rise.

A more detailed review of management options for cotton growing areas is provided in Gordon and Shaw (1996) and for general information on salinity management in the Salinity Management Handbook (DNR, 1997).

Conclusions

If we were to consider that salinity occurs either in response to deteriorating surface water or groundwater quality or rising watertables allowing salt accumulation into the root zone or discharge into streams, then salinity is a reality for many of the catchments in which cotton is currently grown. The extent to which the cotton industry alone is affected is more limited, but emerging evidence has highlighted the need for the industry to be pro-active in its management of the salinity problem. Emerging problems in the Emerald and Ord Irrigation areas, where groundwater pumping is a pre-requisite for sustainable irrigation are not widely considered salinity problems. However, it is only the absence of a significant salt load in those landscapes that has allowed de-watering and groundwater re-use to be viable options.

A more thorough, multi-disciplinary approach to salinity risk assessment is urgently required to further quantify the impact and implications of the emerging salinity problem for the cotton industry. This risk assessment should be supported with a more rigorous monitoring network, which provides the framework for evaluating the impact of management options on key indicators of salinity, including groundwater responses.

Several industry initiatives, including water use efficiency and best management practice provide a strong platform for farm scale actions which have the additional benefit of minimising the threat of salinity. It is also important that action occurs at both the farm scale and catchment scale to ensure the integrity and sustainability of all land and water uses within a catchment. The cotton industry, due to its geographical location in many catchments, will be a major beneficiary of a more holistic view of integrated catchment management.

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