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Executive Summary

Introduction

Salinity of river water and soil has been a long standing problem in Australia, in particular in areas with significant irrigation development, such as the lower reaches of the Murray-Darling Basin. The problem manifested strongly in the 1980's and 1990's, which led to significant research effort into ways to mitigate it. Around the same time, the use of market based instruments (MBIs, an euphemism used in Australia, with the same meaning as EPI) was lauded by economists. As a result, many initiatives to explore the possibilities to use various MBIs for salinity mitigation were put in place. The largest was the Australian Government's initiative to fund two rounds of National MBI pilot programs for natural resource management. The two rounds took place between 2003 and 2008, and comprised 20 projects with total funding of about $10 million. Several funded projects had to do with pilot testing MBIs designed to mitigate irrigation induced salinity, including couple of salinity offsetting programs.

Definition of the analysed EPI and purpose

This report reviews three salinity offsetting programs in Australia – two that were piloted under the National MBI pilot program: Coleambally Irrigation Area (CIA) and Ulan Coal Mine (UCML), and one under the South Australian (SA) Irrigation Zoning Policy – with an aim to evaluate their performance and to discern the noted shortcomings of the programs, or the noted features that have been working particularly well. An additional aim is to identify aspects where possible improvements in the existing offsetting programs could be achieved. This will be used to inform the activities, findings and recommendations of the EPI-Water project.

Legislative setting and economic background

The contexts, scales, and policy goals and targets of these offsetting programs have many similarities, but also have clear distinctive features. The unifying theme for all three offsetting programs is that they aim to mitigate salinity caused by irrigation in a cost-effective way. In all three cases other policy alternatives have been considered, but the evidence suggested that offsets offer an adequate and cost-effective solution to the problem. Thus, economic motives stand very strongly behind the establishment of the offsets. Another similarity between the three offsetting programs is that they all represent a significant institutional innovation in dealing with the problem of salinity. While engineering and direct regulatory approaches were the dominant strategies to address salinity problems in Australia in the past, there was a significant move towards incentive based approaches, including offsets, over the last ten years.

Main differences among the three programs are in relation to the scale of the potential salinity impact (UCML has impacts on a local scale, CIA has a shire to regional scale impacts, and Irrigation Zoning in SA has large, state level impacts). In addition, the legislative setting is quite different in the three cases: UCML operates the salinity offsets as a part of their environmental protection license (a license that all industrial enterprises are required to have); CIA operates their net recharge offset policy through the statutes of the local irrigation cooperative; offsetting under Irrigation Zoning in SA is implemented through state legislation.

Brief description of results and impacts of the proposed EPI

The review was approached by collecting, collating and processing significant amount of publications and data pertinent to the case studies. In addition, several people involved in various aspects of the management of the three offsetting programs were interviewed. It was evident from the available literature and the interviews that there has not been much evidence that can be used for *ex-post* evaluation of these programs. The present report is a first scholarly attempt in that direction.

The findings that emerged from the collected evidence are mostly consistent across the three considered offsetting programs. In terms of environmental effectiveness, it is not possible to clearly discern the effects of the offsetting programs from the effects pertinent to the climatic and hydrologic conditions over the last 7-8 years. At any rate, the salinity threats in Australia have abated over the period, and various salinity mitigation initiatives, including offsets, can probably claim at least some credit for it. The real environmental effectiveness of the offsets will be tested when the climatic conditions allow for improved irrigation water availability, as is currently the case.

Conclusions and lessons learnt

The economic effectiveness of the salinity offsetting programs is clear. In all cases, salinity offsets provided a cost-effective way to mitigate salinity, when compared to alternative approaches. In addition, salinity offsets have desirable distributional effects, as they transform the costs associated with the environmental damage borne by the public at large, to costs associated with providing the offsets borne by those who cause the environmental damage. The social effects of the offsets are minor, and in principle they can be seen as enhancing social equity in relation to environmental health.

The institutional innovation represented through the implementation of salinity offsets is probably the most exciting and promising feature of these programs. Incentive based approaches to deal with environmental problems, including tradable permits, taxes, and offsets, have become widely accepted in Australia over the last decade. Given that this type of approach effectively corrects for an outdated institution that has governed resource use and environmental management (i.e. the institution of 'open access') in the past, it is satisfying to witness that new institutions that highlight the importance of 'property' or 'use' rights, are slowly but surely taking the front stage in this domain.

The shortcomings of the reviewed offsetting programs relate to potentially high transactions costs and the widespread uncertainty, especially in relation to the environmental outcomes from salinity offsets. While in some cases the transactions costs appear to be acceptable (UCML) due to the small number of affected agents, they are likely to be very high in other cases (Irrigation Zoning in SA). In the latter case, there is clear opportunity for the Government of SA to provide some services (e.g. register of interest for salinity offsets in the high salinity impact zones) that will reduce the transactions costs for the prospective participants in salinity offsetting. Governments (or governance bodies more generally) can also be instrumental in improving the performance and uptake of salinity offsets by supporting further research into quantification and management of the uncertainty related to environmental offsets in general, and salinity offsets in particular. Better understanding of the uncertainty, and finding ways how to manage it, will lift the doubt about the environmental effectiveness of offsets that many people still have.

Overall, this report finds that salinity offsets in Australia have been reasonably successful since their implementation. Their very existence is a positive development, and an important addition to the policy mix to deal with future environmental and natural resource challenges.

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1 EPI Background

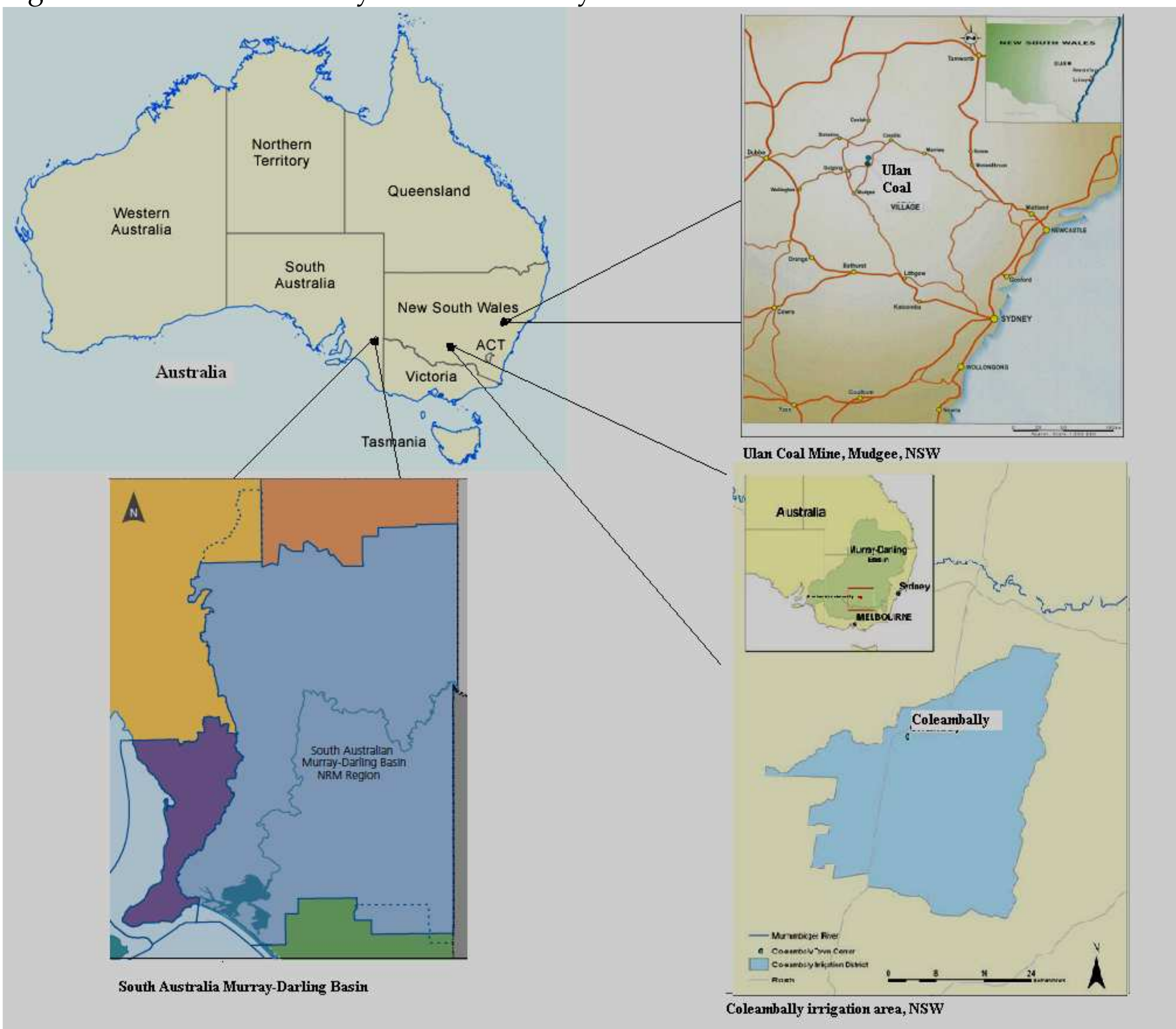
In general, offsets can be defined as actions that are undertaken away from the physical location of an activity to compensate for its negative environmental impact. A pollution offset can ensure with some level of confidence that there is no net increase in the load of a particular pollutant entering the environment as a result of a given activity (Tietenberg, 2006). Offsetting allows new or expanding pollution sources to commence operations in a given area where there are attainment standards for a particular pollutant, provided they acquire sufficient offsetting credits from existing sources.

Offsetting is cost-effective in comparison to the conventional regulatory approaches (e.g. standards) as it allows environmental improvement to be achieved at greatly reduced cost. Used appropriately, offsets present an opportunity for emitters to use their limited resources to achieve greater environmental improvement than they could achieve using on-site measures alone: once all cost-effective on-site measures have been exhausted, further cost-effective impact reduction is still possible using offsets. Offsets have been recently implemented in environmental policy in Australia (e.g. the South Creek Nutrient Offset and Green Offsets for Sustainable Regional Development in New South Wales, and Gorgon gas project on Barrow Island in Western Australia (DEC, 2005)), and globally (e.g. Kate Valley landfill biodiversity offset in New Zealand, Kennecott Utah Copper biodiversity offset, and Minnesota Wetland Banking program in the US).

Salinity offsets are designed to compensate for salinity impacts from a given agricultural or other productive activity by providing a commensurate reduction of salinity impact elsewhere. The end result is that there is no net increase in the overall salinity impact. For instance, salinity impact of an irrigated agricultural activity can be compensated by establishing new perennial pastures or by revegetation, both of which have an effect of reducing salt loads. Salinity offset programs can also be used to reduce salt exports to inland waterways at a cost that is an order of magnitude lower than using on-site measures alone to achieve the same reduction. In the presence of irrigation zoning policy (e.g. as the one currently in place in South Australia), salinity offsetting can allow for less costly and more effective reduction of salinity compared to a policy without offsetting (Spencer et al., 2009). Under salinity offsetting there is a possibility for new irrigation enterprises to locate in high salinity impact areas provided that the salinity impact from these new irrigation developments is offset by reducing salinity impact elsewhere. This reduces the cost of meeting a given overall salinity load target.

Policymakers in Australia have been active in considering, testing and implementing policy instruments based on economic incentives in relation to water and salinity management. Many initiatives to explore the possibilities to use various market based instruments (MBIs) (an euphemism used in Australia equivalent in meaning to EPI in the EU context) for salinity mitigation were put in place. This was evident in the two rounds of the National MBI pilot program for natural resource management undertaken between 2003 and 2008, which comprised 20 projects with total funding of about $10 million. Six out of the 20 funded projects had to do with pilot testing MBIs designed to mitigate irrigation induced salinity, including salinity offsetting programs. The present case study will review two instances were salinity offsetting program has been implemented: in the Coleambally Irrigation Area (CIA) and in the Ulan Coal Mine (UCML); both of which were piloted under the MBI program. In addition, the case study will investigate the tradable offsets for salinity impacts under the irrigation zoning policy implemented in the state of South Australia (SA) (Figure 1).

Figure 1: Location of salinity offset case study areas



The Coleambally Irrigation Area (CIA) is located in South Western New South Wales (NSW) within the MDB. It was developed for irrigated agriculture between 1958 and 1970 using the diversion of water via the Snowy River Scheme. The area currently holds a bulk water license of 629 GL There are about 500 irrigated farms in the region, comprising about 80,000 ha (CICL, 2011). Population of the area is about 1200 people. Main crops that are grown are rice and other cereal crops and pastures. Coleambally has experienced significant problems of waterlogging and salinity (Whitten et al., 2003). To address these problems, a Net Recharge Offsetting Policy has been implemented in the area since 2005.

Ulan Coal Mine (UCML) is located in the Central West of NSW, and comprises of areas that are a part of the Upper Hunter and Macquarie River catchments. It is a 'surplus water' mine: more water is generated through underground mine dewatering than can be re-used through mining activities. This surplus water has historically been released into the Goulburn River which is a tributary of the Hunter River. As Ulan mine is the only major mine within the Hunter Valley Catchment not involved in the widely known and studied Hunter River Salinity Trading Scheme (Shortle and Horan, 2008), it has developed an offsetting program to mitigate salinity impacts resulting from irrigating agricultural crops using the water from the mine.

The South Australian Murray-Darling Basin covers 70,000 square kilometres (about 7% of South Australia), and its landscape varies from the low-lying coastal plains of the Coorong to the flat expanse of the Mallee to the steeper slopes of the Eastern Mount Lofty Ranges. Highly saline groundwater naturally flows into the River Murray from the surrounding landscape. Irrigation has accelerated the rate at which the saline groundwater is now entering the River Murray and the floodplain. To address the issue, irrigation zoning policy that restricts the location of new irrigation developments to areas where salinity impact is relatively low has been in place in the irrigation regions along the River Murray in South Australia since 2005. Salinity offsets are a part of this policy, and have been investigated in the academic and policy circles, but their implementation in practice has been low.

2 Characterisation of the case study area

Australia is a major developed economy. It has a population of 22.5 million, and per capita GDP of $42,279 (World Bank, in current USD). It has one of the strongest economic growth performances among developed economies, with a GDP growth of 3.3% in 2009/10. In terms of hydrology however, Australia is the driest continent in the world on the basis of runoff per unit area. This is due to the high rate of evapotranspiration, the unparalleled temporal and spatial variability of rainfall intensity and frequency, and the generally flat topography across most of the continent (Australian Water Resources, 2005). Nevertheless, given the large land area and the history of European settlement since 1788, significant irrigation activities have been established, mostly throughout the 20^{th} century. For example, the irrigated area has grown from 350,000 hectares in 1941 to more than 2 million hectares in 1997 (ANRA, 2008).

Australia is a major agricultural producer and exporter. The agricultural sector in a broad sense—comprising farming and the related industries—earns about $155 billion/year, representing a 12% share of nation's GDP (NFF, 2011). It provides jobs to 1.6 million Australians, representing almost 17% of the national workforce. More than 60% of all agricultural products are exported, representing some 76% of the total gross value of production (NFF, 2011). Irrigated agricultural land comprises 0.5% of all agricultural land, but contributes almost 25% of Australia's gross value of agricultural production (DSEWPC, (2011). Total area under irrigated agriculture in 2009-10 was about 1.85 million hectares, and the total volume of water used in agriculture was 7,359 GL (ABS, 2011). A large proportion of irrigation—52% of total irrigated land—takes place within the Murray-Darling Basin (MDB) (Table 1).

Table 1. Agricultural water use by source – Murray-Darling Basin, 2009-10.

Basin State	Surface water		Groundwater		Other sources (a)		Total water use	
	Volume (GL)	Proportion of total water consumption (%)	Volume (GL)	Proportion of total water consumption (%)	Volume (GL)	Proportion of total water consumption (%)	Volume (GL)	Proportion of total water consumption (%)
New South Wales	1,201	61	718	36	55	3	1,974	100
Victoria	947	86	129	12	21	2	1,100	100
Queensland	370	80	87	19	8	2	467	100
South Australia	238	80	55	18	6	2	299	100
Murray-Darling Basin	2,757	72	990	26	90	2	3,837	100
Outside the Basin	2,017	57	1,336	38	169	5	3,522	100
Australia	4,774	65	2,325	31	260	4	7,359	100

Source: ABS (2011).

MDB accounted for 40% of Australia's irrigating agricultural businesses (ABS, 2011). Recent available data show that more than 3,500 GL of irrigation water was used for agricultural production in the MDB (ABS, 2011).

Irrigation industry in Australia and in the MDB coexists side by side with significant water-dependent ecological assets. There are approximately 16.5 million hectares of woodland in the MDB, mostly situated in national parks and other reserves. It includes more than 30,000 wetlands, sixteen of which are recognised as internationally significant (listed as Ramsar wetlands). An indicative figure for the value of the ecosystem services provided by the rivers, wetlands and floodplains of the MDB has been put at about $187 billion per annum (Thoms and Sheldon, 2000).

An inadvertent follower of the agricultural and irrigation development, salinity is one of the most significant environmental threats in Australia (Table 2). Surface, groundwater and soil salinity has been a longstanding problem in many parts of the country, most notably in South Australia, Western Australia and within the Murray-Darling Basin (CSIRO, 2008). It affects the ecological health of rivers, wetlands and streams, and reduces the productivity of crops and pastures. In addition, drinking water quality in the Lower Murray in South Australia, which serves as water supply for the city of Adelaide, has been poor as the salinity parameters have often exceeded the acceptable thresholds (MDBMC 2000, p. vi). The estimated cost of environmental degradation due to salinity is substantial. Total annual cost of land and water degradation in Australia was estimated at $1.365 billion, large proportion of which can be directly or indirectly attributed to salinity related degradation (Pigram, 2006). Current estimated annual costs of salinity include $130 million in lost agricultural production, $100 million in infrastructure damage, and at least $40 million in loss of environmental assets (CSIRO, 2007).

Table 2: Area of land in Australia affected by salinity

State	*PMSEIC 1999*	*NLWRA 2001*	*ABS 2002*
	Area of salinity affected land [(a)] thousand ha	Area at risk of salinity [(b)] thousand ha	Area showing signs of salinity [(c)] thousand ha
New South Wales/ACT	120	181	124
Victoria	120	670	138
Queensland	10	n.a.	106
South Australia	402	390	350
Western Australia	1,802	4,363	1,241
Tasmania	20	54	6
Northern Territory	0	0	2
Total Australia	2,476	5,658	1,969

Note: (a) As determined by experts; (b) As estimated from water table heights; (c) As reported by farmers. Source: ABS (2002).

Numerous policies to address increasing water scarcity and salinity problems have been instigated in Australia in general, and in MDB in particular, over the last two decades (Lee and Ancev, 2009; Connell and Grafton, 2008). The Australian Government is currently implementing the "Water for the Future" program with a total budget of $12.9 billion, which includes infrastructure development to improve water management, purchasing water for the environment, and a renewed commitment to water reform nationally (DEWHA, 2010). Policies specifically targeting salinity have also been implemented. These include the Joint Works Program (Basin Salinity Management Strategy) and the Natural Heritage Trust, National Action Plan for Salinity and Water Quality, and the current National Water Quality Management Strategy (Lee and Ancev, 2009).

Salinity offsets have been a part of the policy mix in addressing salinity problems. The report focuses on three cases in various parts of Australia where salinity offsets have been implemented.

Colleambally Irrigation Area

The Coleambally Irrigation Area (CIA) is located in the southern Murray-Darling Basin and uses irrigation water diverted from the Murrumbidgee River. The irrigation infrastructure consists of a main canal of from the Murrumbidgee River with length of 41 km, supply channels with total length of 477 km, and a further 734 km length of drainage channels. The water is diverted into the Coleambally main canal upstream of Gogelderie Weir, near Darlington Point. Water supplies are regulated from two major Snowy River scheme dams, Burrinjuck and Blowering. The area comprises 486 irrigation farms containing 79,000 ha of irrigated land supplied through open earthen channels.

Irrigated agriculture often leads to recharge of the regional groundwater systems that is greater than what those systems can absorb, resulting in elevated groundwater table causing salinity and water logging problems. Coleambally Irrigation (CI) area has been experiencing such problems, with watertables rising from approximately 20 meters below the surface prior to the extensive irrigation development, to less than 2 meters from the surface during the 1990's (Whitten et al., 2007). A range of policy instruments have been used in CIA to address this irrigation induced salinity threat including: regulatory approaches that limit areas that can be planted with rice; specifying maximum crop water use; identification and sealing of leaking channels; and direct incentives through the Land and Water Management Plan (LWMP) to improve on-farm water management (Whitten et al., 2007).

Under the National Market Based pilot program (Round 1), a pilot project entitled 'Tradable net recharge contracts in Coleambally Irrigation Area (Lachlan-Murrumbidgee, NSW)' was undertaken to investigate the potential application of a cap & trade approach to salinity mitigation, which involved the use of tradable recharge credits. The findings of the pilot indicated that significant economic gains could be realised from a tradable recharge credit system compared to other options. A number of issues that surround the introduction of tradable recharge credits were identified, including: who should own net recharge credits, and what information on the owner is needed; how to initially allocate salt discharge rights; and when and how the cap should be met (DesignerCarrot, 2011). There was also evidence of limited trading in recharge credits among the participating farmers involved in the economic experiments conducted under the pilot program (Whitten et al., 2007). Therefore, the pilot proposed that offsets, rather than a fully fledged cap & trade scheme for net recharge might be a more viable option in the CIA. Partly as a consequence of these findings, the CIA adopted a net recharge offsetting policy in 2005. The offsets are in the form of planting certain crops that are capable of reducing the level of groundwater recharge, or directly reducing groundwater table. Agricultural crops have varying effects on the groundwater table, dependent on soil type, the root system of the crops, and the volume of irrigation water applied. Some crops, particularly rice, are generally recharging crops (i.e. they add to the height of the water table), whereas winter crops and other deep-rooted crops (e.g. lucerne) are generally discharging crops (i.e. they help reduce the height of the groundwater table). The present study will evaluate the effects that the adoption of this particular type of salinity offsets has had in the Coleambally Irrigation Area.

Ulan coal mine

The mining activities of the Ulan coal mine, owned by Xstrata Corporation involve pumping around 11 ML per day of saline water (electrical conductivity 1000 to 1200 micro Siemens per centimetre (μS/cm)) from an underground aquifer to allow the underground mining galleries to operate. This saline water was in the past discharged into Ulan Creek, which is a tributary of the Goulburn River in the Hunter River Catchment. The Hunter River Catchment has a large proportion of salt bearing sedimentary rocks and soils. Salt is naturally loaded into the river via surface and underground drainage. Activities such as coal mining, power generation, and land clearing have increased the level of salinity in the river. To address the saline water discharge problems into Hunter River, NSW government has implemented the Hunter River Salinity Trading Scheme (HRSTS) (OEH, 2011). This scheme allows mines and industry to discharge their excess saline water during periods of high flow, thus maintaining in-stream water quality. In addition, participants are allowed to trade in discharge rights in times of low flow, provided that maximum specified salt load is not breached.

As Ulan mine opened after the establishment of the HRSTS, and it is physically located on the boundary of the Hunter River Catchment, it had to find alternative ways to deal with its salt load. Under a pollution reduction program administered by the NSW Department of the Environment and Conservation (DEC), the mine was required to stop its discharge to Ulan Creek (except under extreme rainfall conditions), and offset any salt loads that could be attributed to the pumping and discharging water from the mine. Consequently, the mine now separates the wastewater it extracts from its underground galleries into a highly saline stream, and a low-salt stream. Highly saline water is being used for dust suppression in the open cut mine. The mine has built a large dam to store the low-salt water, which is subsequently used to irrigate pastures on 250 hectares of land that it owns. However, under the environmental licence, the mine must ensure that as the result of this irrigation program: (a) the level of soil salinity does not inhibit plant production, and (b) water quality objectives are not compromised in local streams or ground water as a result of the irrigation activities. A model commissioned by the mine has predicted that a residual salt load of around 280 tonnes a year will leach into local shallow aquifers as a result of the irrigation program. To comply with the environmental licensing condition the mine has developed an offsetting program to progressively offset this salt load. Under this program the mine is implementing land-use and land-management changes to reduce salt exports from other agricultural land it manages that are outside its licensed premises, including revegetation, establishment of perennial pastures, and changing grazing regimes and destocking remnant vegetation. Land use changes under the offsetting program are taking place on 4,460 hectares.

Irrigation Zoning in South Australia

Rising salinity level as a consequence of drainage from intensive irrigation industry in the South Australian portion of the River Murray has been recognized as a significant threat to agricultural productivity and the environment. Various technical solutions have been implemented to control irrigation induced salinity, including dilution flows and salinity interception schemes (Heaney et al., 2001, Connor, 2004). In addition, irrigation zoning policy that restricts the location of new irrigation developments to areas where salinity impact is relatively low has also been in place in the irrigation regions along the River Murray in South Australia since 2005. The zoning policy is likely to reduce the salinity impact but it will also increase aggregate irrigation costs for the region. Since the low salinity impact zones are typically located further away from the river channel, zoning will increase aggregate costs of irrigation as a result of higher water delivery costs due to increased costs of piping and pumping water (Spencer et al., 2009).

The possibility to use offsetting credits that will allow new irrigation development in high salinity impact zones provided that the salinity impact from this new irrigation developments is offset by reducing salinity impact elsewhere is a recognised feature of the policy. In light of this possibility some academic papers and some policy discussion papers have explored the advantages and disadvantages of implementing such an offsetting policy. For example, Spencer et al. (2009) have developed a conceptual model of an irrigation zoning policy with and without offsetting. The salinity offsets can achieve greater reduction of the overall salinity impact level and at significantly lower cost compared to the standalone zoning policy. This is a result of greater flexibility in location choices. Despite the documented economic advantages of offsets, and their aplicability under the current zoning policy, the evidence to date suggests limited use of salinity offsets in practice in South Australia. The case study will investigate the reasons for this.

3 Assessment Criteria

The assessment criteria are presented for each of the three individual case studies separately.

3.1 Coleambally Irrigation Area

Prior to irrigated agriculture, watertables in the CIA were about 20 meters below the surface. This was followed by dramatic increases in the period between 1981 and 1991 due to deep drainage of irrigation water below the root zone of the crops, and into the shallow aquifer (Rowe, 2005). The area with a watertable within 2 metres of the surface was about 26,800 ha in 2000/2001. It was predicted that the land area within the CIA under which the watertables are very shallow (less than 2 m from the surface) would rise to 50,000 ha by 2013 and to 60,000 ha by 2023 if no further watertable and salinity management actions were taken (Rowe 2005). It was also predicted that at least 25% of the land area would be affected by salinity by 2023. The Coleambally Land and Water Management Plan (LWMP) was developed by the irrigation district in collaboration with the local community to address these issues and to ensure that the CIA remains viable and sustainable. As the best way to keep watertables below the root zone is to control net recharge to the shallow aquifer, number of strategies have been endorsed to control net recharge on farms in the CIA (Rowe, 2005), which include:

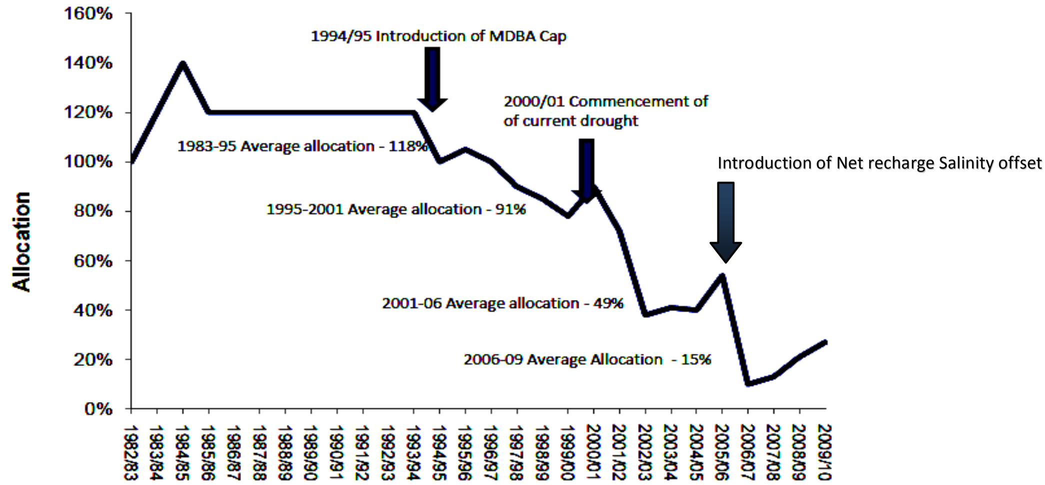
(a) reclassify marginal rice land over two years using soil sodicity testing;
(b) establish link between total rice area and farm water use to the net recharge for each farm;
(c) establish link between rice area and total farm water use to the area of CIA watertable less than 2 m;
(d) establish cropping offset ratios (i.e the Net Recharge Offset Policy) that will alleviate the need to reduce the area planted with rice;
(e) the target watertable height of less than 2 m from the surface to be reduced from 40,000 ha to 10,000 ha for the whole CIA area; and
(f) new financial incentive to be put in place for change of land use and related activities that will lead to significant reductions in net recharge.

The CIA is currently implementing the Net Recharge Policy to mitigate salinity impact of irrigation farms. The offsets under this policy are in the form of planting certain crops that are capable of reducing the level of groundwater recharge, or directly reducing groundwater table. Under the current CIA net recharge policy parameters, the area required to balance the leakage to the watertable from one hectare of rice is: (a) one hectare of perennial species (e.g. Lucerne or other perennial pasture, agro-forestry, native vegetation, Old Man Saltbush), or (b) two hectares of annual species (e.g. winter crop sown into rice stubble) (CIA 2010). On the other hand, the area required to balance the leakage to the watertable from one hectare of row-cropping is: (c) half a hectare of perennial species, or (d) one hectare of annual species. However, the annual and perennial offsets can be combined to produce total offsets, with the reduction in salinity impact achieved from one hectare of total offset being equivalent to the salinity impact generated by one hectare of rice.

3.1.1 Environmental Assessment Criteria

Figure 2 shows the announced annual allocations for general security water entitlements for the period 1982/83 to 2009/10 in the Murrumbidgee Valley, in which CIA is situated. As is apparent from the figure, the annual allocations have been significantly reduced due to the effects of the introduction of the Murray Darling Basin Cap and the effects of the prolonged drought during 2002-2008 (Grafton et al., 2007).

Figure 2. Announced annual allocations for general security entitlement since 1982/83 in the Murrumbidgee Valley.



Source: CICL (2010).

As a consequence of this dramatic restriction of annual allocations, but also partly as a result of activities designed to mitigate salinity, including the Net Recharge Offset policy, the area with groundwater levels within 2 metres from the surface in the CIA reduced from over 40,000 hectares in 1994 to less than 1500 ha in 2004 (CICL 2004; Rowe 2005), which was its lowest level since 1990. The area of land with watertable within 2 m from the surface reduced further from 1,700 ha in September 2006 to just 400 ha in 2007 (CICL 2007). In September 2010 the area of watertable within 2 m of the surface was 258 ha (CICL 2010a). This is much lower than the LWMP target of 10,000 ha, which triggers enhanced net recharge management activities, including the requirement for farms to provide net recharge offsets.

Table 3 shows the monthly average salinity in the last three years, including a benchmark year. It is observed that the salinity level at the two licensed discharge sites and one licensed monitoring site has remained below 200 µS/cm for the last three years, which indicates a significant improvement in comparison to the benchmark salinity. Lower salinity at the drainage monitoring sites is due to the lowering of groundwater tables within the CIA. The reduction in water-tables below the level of the bed (base) of the drainage channels means there is no salt intrusion from watertable into drainage water. The average monthly salinity has remained below 200 µS/cm due to drainage water at this site predominantly coming from excess flows off the main canal, and is therefore not contaminated with either farm drainage or groundwater intrusions.

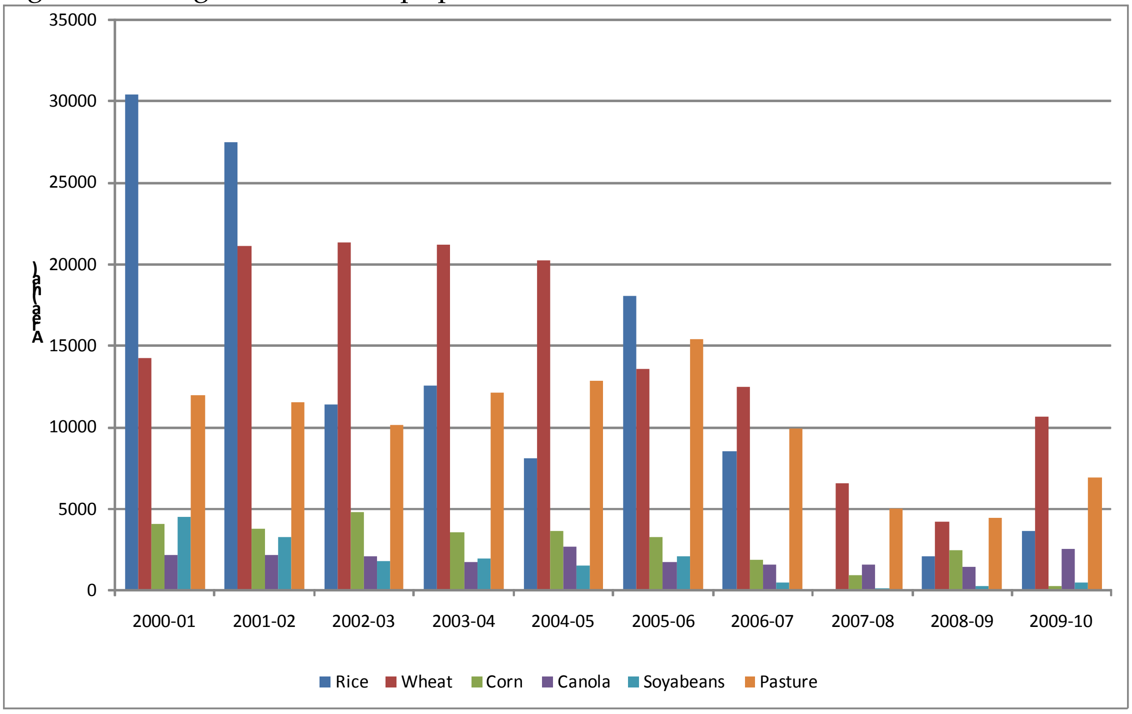
Table 3. Average monthly salinity (μS/cm) at three licensed discharge points and one monitoring point, CIA

Location	Benchmark*	2007/08	2008/09	2009/10
Coleambally catchment drain	117	115	161	138
Coleambally drainage channel	510	151	272	232
West Coleambally channel (discharge point)	660	45	167	154
West Coleambally channel (monitoring point)	712	163	108	159

Note: * Benchmark includes average data from 1996/97, 1997/98 and 1998/99.
Source: CICL (2010a).

It is observed that there is a declining trend in the area planted to rice from 30,440 ha in 2000-01 to 3668 ha in 2009-10, reflecting the trend of significantly reduced irrigation water availability over the period. Nevertheless, rice remained the dominant irrigated crop in the CIA using 46% (2009-2010) of the total irrigation water supplied by CICL. Figure 3 shows the change in area of the main crops planted in the Coleambally Irrigation Area over the last ten years. The area under wheat, corn, soybeans, canola and pastures has fluctuated over this period in response to the availability of irrigation water, and to changes in commodity prices.

Figure 3. Change in area of crops planted in CIA, 2000-2010.



Data source: CICL (2010a).

3.1.2 Economic Assessment Criteria

The economics of net recharge policy for Coleambally Irrigation Area (CIA) can be assessed by evaluating net farm income (gain/loss) from changing farming activities, which are affected by net recharge policy. The costs and benefits of the net recharge policy depend on the changes in areas planted with perennial and annual deep rooted crops, in relation to area planted with rice, since the annual rice area limits are set in accordance to the net recharge policy. For example, if it is not observed that farmers plant perennial and deep rooted crops, it means that this is not their profit maximising crop choice. This suggests that the cost of the net recharge offset to farmers could be estimated based on the difference between expected profits under optimal cropping pattern (i.e. not including perennials or deep rooted crops), and profits under the cropping pattern required by the net recharge offsets.

It may be argued that the net recharge salinity offset would be more cost-effective than any other available option to reduce groundwater table, in terms of operational and implementation cost. For example, the initial and operational cost of pumping saline groundwater, and placing it in an evaporation pond, would be much greater than the cost of the net recharge salinity offset policy. This difference in cost with alternative approaches can be used as an approximation of the benefit of having the offset policy.

Studies conducted under the auspices of the MBI pilot program presented some estimates of farm profitability (measured by gross margins) for alternative policies to address salinity. Those estimates indicated that the cap on recharge (consistent with the net recharge policy) with and without trading, and a cap on area planted with rice would be superior in terms of overall profitability to a policy that imposes a cap on irrigation water use (Table 4). The difference in gross margins for the whole CIA between the former two and the latter was substantial, at around $9 million (Whitten et al., 2007).

Table 4. Gross margins under alternative policy scenarios for salinity mitigation in CIA

Policy	Total gross margin (AUD million)
Rice Quota	33.5
Cap on water allocation	24.8
Cap on Recharge – No trade	33.4
Cap on recharge – With trade	34

Source: Whitten et al. (2005)

3.1.3 Distributional Effects and Social Equity

The initial salinity problem in this case is a clear example of an ownership externality. Each individual irrigator has an incentive to apply irrigation water to their crops, parts of which will drain in the shallow groundwater, raising the water table and aggravating the salinity problem for everyone. Thus, the distributional effects of the offset program are to 'privatise' a 'public bad', which is achieved by requiring each farm to take into account its contribution to the raising water table and, when the circumstances are critical, to offset that contribution.

All salinity mitigation programs in CIA, including net recharge offsetting, contribute to long term social equity and sustainability, as they contribute to overcoming the possibility of wide spread soil salinisations, which could seriously threaten farming in this region, and consequently threaten the affected rural communities.

3.1.4 Institutions

The net recharge offset policy is being implemented under the management of Coleambally Irrigation Cooperative Limited. The use of offsets within the cooperative is an excellent example of institutional innovation, where the community itself (in this case the community of irrigators) recognises the inadequacy of the existing institutions (i.e. open access treatment of the environment), and comes up with a new institution that is designed to deal with environmental problem.

Other institutions partly involved in this program include the Murrumbidgee Catchment Management Authority, NSW Office of Water, Department of Primary Industries (NSW), Coleambally Outfall District Water Users Association, Department of Land & Water Conservation (now DNR), and Department of Environment and Climate Change. The Coleambally Irrigation Cooperative Limited is currently taking part in activities under the "Water Smart Australia" program under the Australian Government's Water for the Future plan to reduce the environmental footprint (including salinity) of irrigated agriculture.

3.1.5 Policy Implementability

There are number of principles underlying the net recharge policy that serve the purpose of its implementation. The CICL undertakes an annual assessment of farm-based irrigation intensity across all farms within the CIA against two specific criteria (CICL 2010b):

(a) If total farm water use (including on-farm bores) exceeds 6.5 ML/ha, the shareholder must demonstrate that net recharge is being controlled by using the Swagman Farm Model or Net Recharge Offsets.

(b) If the area of the CIA with a watertable within 2 m of the surface is greater than 10,000 ha (based on piezometer data) and if total farm water use (including on-farm bores) exceeds 5.5 ML/ha, then the shareholder must demonstrate that net recharge is being controlled by using the Swagman Farm Model or Net Recharge Offsets.

There is a range of prescribed penalties for breaching the above irrigation intensity limit including sanctions against noncompliant rice growers. Within the corporation, rice growers who contravene the environmental policies will be invited to discuss the issue. If a breach is deemed to have occurred, sanctions can be applied, including:

- reductions in rice area and/or refusal to supply water. In some instances rice growing is withdrawn from the identified breach area until further investigations.
- mandated soil testing.
- other penalties as determined by the relevant jurisdiction.

3.1.6 Transaction Costs

Transaction costs are an important factor to consider while assessing the feasibility of market-based instruments for managing water resources and environmental quality. Under the cap and trade system the initial costs of setting up an enabling framework for trade including unbundling land and water rights, are thought to be high. In a recent study, Ancev (2011) found that the transactions costs of mandating the agricultural sector in a tradeable permit scheme for Green House Gas mitigation would be high. This is in line with previous findings specific to the CIA (Whiten et al., 2005), which suggested that cap&trade mechanism for salinity mitigation in this case is not feasible, at least partly due to high transactions costs such as early implementation cost, establishing a register of permits, and the costs of trading in salinity permits. There are also ongoing public costs associated with administering salinity permit trades, monitoring water use and maintaining the integrity of the trading system through enforcement.

On the other hand, transactions cost for implementing the net recharge salinity offset policy in the CIA would include monitoring cost of net recharge program in particular assessing the groundwater level and the farm-based irrigation intensity. However, these costs are perceived as reasonably low, not only in comparison to the earlier proposed cap&trade mechanism, but also in comparison to other possible alternatives. For example, the CICL's policy document on the net recharge offsets mentions reduced administration costs as a result of adopting particular design features of the policy (e.g. 'single farming unit') (CICL, 2010b).

3.1.7 Uncertainty

One of the crucial factors to implementing the salinity offset program in CIA is the estimation of the farm-based irrigation intensity, which is depended on the total farm water use. Uncertainty around water supply can affect total water use in an irrigated farm: e.g. inadequate supply of irrigation water implies low water application rate, and subsequently lower expected rate of deep drainage below the root zone, and consequently lower recharge of aquifers.

Swagman Farm Model has been used to estimate net recharge at the farm scale in the CIA. This model involves a number of complex biophysical assumptions, which create difficulties to define the likely damage path resulting from continued net recharge (Whitten et al 2007). Quantifying the uncertainty about Swagman model predictions has been conducted through model validation by Edraki et al. (2003) and through sensitivity analysis by Khan et al. (2003).

As the cost of providing net salinity recharge offsets are related to profitability of alternative cropping patterns (with or without winter and deep rooted crops), the change in relative prices of the crops grown in the CIA may also be a source of uncertainty. The cost of providing offsets will wary with the relative price of rice to other crops, and the associated uncertainty may create significant difficulties for farmers when making cropping decisions.

3.2 Ulan Coal Mine

The Ulan coal mine creates a significant water surplus from its mining activities, generating approximately 8.2ML more water per day than its operational requirements. This water is quite salty, and posses a problem for the mine in terms of where to discharge it. The Bobadeen Irrigation Scheme (established in 2003) at the time was seen as an industry-first 'environmental' solution for the management of surplus saline mine water. Previous to the establishment of the irrigation scheme, the mine released surplus water into the Ulan Creek, which flows into Goulburn River. This created concerns about the increased salinity downstream. With commissioning of the Bobadeen Irrigation Scheme (BIS), surplus mine water was used to irrigate about 250 hectares of land under perennial pastures. Surplus mine water is first pumped into a holding dam (Bobadeen Dam), and subsequently water from the dam is used to feed five centre-pivot irrigators that are used to irrigate the pastures. The pasture is kept at an optimal level by carefully monitored rotational grazing by beef cattle and the production of fodder.

As part of the implementation of the BIS, a salinity offset area was established to offset residual salt loads from irrigation activities. Under the requirements of the environmental protection license issued by the NSW Department of Environment, Climate Change and Water (DECCW), Ulan Coal Mine Limited (UCML) has established offset conservation area whereby a mix of native vegetation, revegetation and regeneration activities have replaced traditional grazing practices that were taking place prior to the offsetting program. The Department of Land and Water Conservation indentified that 4460 hectares of land should be used to offset the salt load associated with the operation of the Bobadeen irrigation scheme (DLWC, 2003). For the purposes of the offsets, changes in land use entailed a shift from open woodland and poor pasture landscape, to a landscape characterised with more densely forested areas and improved pastures. Water retention by the vegetation cover is expected to be higher as a result of these changes, and consequently it is expected that less salt will be exported from these areas (UCML 2008). These land use changes should result in (a) a shift from degraded native forest and poor pastures, to a landscape with improved conditions, and increase in the area of native forests and pasture land, paralleled with improvement in both quality and quantity of native vegetation, and (b) a reduction in salt exported from the offset areas and into the catchment due to an increase in water use by recovering native vegetation (UCML, 2008).

3.2.1 Environmental Assessment Criteria

The BIA and associated salinity offset program is integrated in the UCML's environmental management system, which is in turn aligned with the principles of ISO 14001 (World Coal, 2004). The salinity offset program has had positive environmental outcomes. Under the new grazing management practices, the longevity and diversity of pasture species has increased, with a corresponding reduction in water leakage through the soil profile (UCML 2006). The areas that were set aside, and destocked, to enable native vegetation to recover are showing an increase in biodiversity over the past few years, as well as reduced deep drainage of water through the soil profile. The salinity offset program is enabling UCML to meet its environmental protection license requirements.

During the period 2009-2010 the average daily discharge of water at Ulan Creek was calculated to be 6.78 ML/day, while the mining activities involved discharging around 11 ML/day before salinity offset program in 2004-05 (Table 5). The pH range for the discharged water was 6.5-8.5 for 2009-2010, with the average pH calculated to be 7.41. The average Electrical Conductivity (EC) was 730 μS/cm, with the maximum EC recorded at about 1000 μS/cm. (Table 5). The above values can be compared to the measurements taken before the offsetting program was implemented. In 2004-2005, the pH and EC of the sampled groundwater near Ulan Creek and BIA was quite variable. The pH ranged between 6.7 and 9.82, and the EC of the groundwater varied between 1000 μS/cm and 1200 μS/cm (Table 5).

Table 5. Change in some environmental variables before and after salinity offset program, Ulan Coal Mine

Environmental variables	2004-05	2009-2010
Daily discharge of water (ML/day)	11.0	6.78
pH range	6.7-9.8	6.5-8.5
Electrical Conductivity (μS/cm)	1000-1200	277-1013

Source: UCML (2005), UCML (2010).

According to the World Coal (2004) the establishment of the BIA has lead to the following achievements:

(1) Reduction of discharges of salty mine water into Ulan Creek under normal operating conditions;
(2) Ongoing production of high-quality rye-grass, lucerne silage and hay;
(3) Environmental best practice in land management has been implemented across an area of approximately 4500 ha;
(4) UCML has effectively utilised a 'waste product' and transformed it to produce vigorous perennial pastures that are used to grow cattle;

(5) UCML has addressed community concerns over the discharge of salty mine water in the environment.

3.2.2 Economic Assessment Criteria

There is evidence that the offset program was considerably less costly than other options at disposal to UCML, which included desalination by reverse osmosis. The salinity offset program required an initial investment by the mine of an estimated $1.4 million, with annual operating and maintenance costs of about $94,000 (DEC, 2005). Establishing a desalinisation plant that would have been used to treat the effluent discharge from the mine to the locally acceptable stream ambient concentration levels would have required an initial investment of about $15 million, with ongoing operational cost of about $6 million per year. This represents a net present value saving of approximately $91 million over the next 20 years (DEC 2005a). In addition, the implementation of the cost-effective offsetting program based on land management changes has resulted in avoiding a range of costly waste management activities on the part of UCML.

The cost-effectiveness of the salinity offsetting program for UCML can be assessed based on the annualised cost of the program, and the estimated residual salt loads that are avoided as a result of the program. Assuming a total productive life period of 20 years for the mine, the annualized cost of the initial investment ($1.4 million) into the offsetting program can be estimated at $132,150 using an interest rate of 7%. Adding this to the annual operational costs of $93,500 gives a figure for the total annual cost of the salinity offset at $225,650. Combining this figure with the predicted residual salt load of around 280 tonnes a year avoided as a result of the offsetting program, gives the unit cost for salinity impact reduction through salinity offset program at $806 per ton of salt load avoided. This compares very favourably with the costs of any other alternatives. For example, the average cost of a credit in the Hunter River Salinity Scheme in 2010 was around $1,600. As credits in that scheme are specific for each sector (block) of the river basin, the per unit cost of avoiding salt impact are heterogeneous. However, an example that was worked out for block 2010-198 on the Hunter River suggests that the cost of avoiding one ton of salt load under the HRSS was about $14,500.

3.2.3 Distributional Effects and Social Equity

The distributional effects of this offsetting scheme are in relation to the transformation of the environmental damage cost to the public (when the salty water was directly discharged in the river system) into abatement cost to the private entity that is the source of the environmental threat (the cost of the offsetting scheme to the UCML). This is a desirable outcome in its own right. The success of this scheme is even more apparent when the magnitude of the abatement costs is considered in relation to other possible alternatives. It can be argued that improvement of distributional effects from environmental degradation has been achieved in a cost effective way.

Social equity issues do not seem to be prominent in this case. The area itself is sparsely populated, and large parts of the community are directly involved with the mine (employees, contractors, suppliers, etc.). A social equity issue would have arisen in the process of establishing the offsetting activities (revegetation), which required that the existing farming operations on the 4800 ha. relocate elsewhere. However, there was only very small number of farmers involved, who were fully compensated for the early termination of their contract (Imrie, 2011). However, the mine decided to manage the land on its own in order to implement the offset program, and has therefore terminated leases with farmers that had been using that land. The early lease termination costs to the mine were about $755,000.

3.2.4 Institutions

The salinity offset program for the BIS is operated by the UCML as a part of its environmental protection licence that is issued by the NSW DECCW. The license stipulates that UCML must develop a program, in consultation with the DECCW, to offset the residual salinity load arising from the irrigation of mine-water generated at the premises so that there will be no net increase in salinity load in the Macquarie and Hunter catchment areas as a result of the irrigation activities. Other institutions such as the Hunter-Central Rivers CMA, the local council and the community consultation committee were involved to implement the salinity offset program.

A broader institutional setting includes the Hunter River Salinity Scheme. In response to the need to control saline water discharges into the Hunter River, the NSW Office of Water and the Environment Protection Authority, with the cooperation of other interested organisations, developed the Hunter River Salinity Trading Scheme (OEH, 2011). This scheme is an innovative method which reduces saline levels in the river while allowing mines and industry to discharge their excess water during periods of high flow thus maintaining instream water quality. In Australia, there is a relatively positive attitude of the public towards economic policy instruments. Offsets have been used for other purposes in the state of NSW. In light of this, the institutional context was favourable for establishing this type of offsetting program for the Ulan Coal mine.

3.2.5 Policy Implementability

The offsetting program was implemented under the environmental protection licence, which is stemming from the *Protection of the Environment Operations Act* of NSW. The offsetting was first instigated under a pollution reduction program negotiated between DECCW and UCML, before becoming the part of the environmental protection licence. The implementability and enforceability of the program is straight forward, as incentive compatibility of the offsetting instrument to the objectives of the mine is evident.

3.2.6 Transaction Costs

Transactions cost in this situation are not overly high. This is mainly due to the limited number of agents that bear costs of transacting in relation to this scheme. Foremost, transactions cost pertain to the UCML. These involve the costs of: producing reports and other compliance documents; cost of publishing those reports; cost of monitoring of ambient environmental quality; cost of early termination of lease contracts with farmers.

Early implementation costs of the salinity offsetting program were estimated at about $921,000. This amount is made up of particular transaction cost items as shown in Table 6.

Table 6. Early implementation costs for the salinity offset program, Ulan Coal Mine.

Transaction cost	$AUD
Initial licence and pollution reduction program negotiations with EPA	$5,000
Scoping of available modelling, initial and supplementary modelling	$5,500
Assessment of available lands for use changes and definition of their current condition	$5,500
Design and set-up of monitoring regime	$150,000
Negotiation and implementation of offset program land lease arrangements/changes	$755,000
Total	$921,000

Note: Over 80% of these transaction costs were a result of the decision to change lease arrangements on the offset lands.
Source: DEC (2005b).

3.2.7 Uncertainty

There are a number of challenges and uncertainties to implementing salinity offsets program, which include: (a) it is difficult to predict and measure salinity impact from the Bobadeen Irrigation Area, (b) offset measures based on impacts from a diffuse source (such as the BIA) are much less understood in comparison to offset measures that involve a single point source, (c) the environment in which salinity impacts are felt is a series of complex systems that interact with each other and that are not fully understood in their own right, (d) it is not possible to isolate the system being studied from the surrounding systems (e.g. observed changes in stream salinity may be affected by changes that are taking place in the sub-catchments above and adjacent to the offset area, and finally (e) it may take many years for environmental benefits to be fully accrued where offsets involve land-use changes, such as in the case with the UCML salinity offsets.

3.3 Irrigation Zoning in South Australia

Irrigation zoning has been recently gaining popularity in Australian jurisdictions. For example, an irrigation zoning policy that restricts the location of new irrigation establishment to areas where salinity impact is relatively low has been in place in the irrigation regions along the River Murray in Victoria since 1994 (Sunraysia Rural Water Authority, 2002). This zoning policy has been augmented by the introduction of a system of salinity levies in the irrigation region of Sunraysia in 2002. The levies are applied to permanent transfers of water rights into a given low salinity impact zone, whereas permanent transfers of water rights into high salinity impact zones are not allowed.

An irrigation zoning policy of a similar nature was recently introduced in the South Australian portion of the River Murray (DWLBC, 2005). Under this policy, new irrigation developments in areas that are deemed to have high salinity impact are restricted. The zoning policy establishes the following three salinity impact zones along the River Murray (DWLBC, 2005).

(a) Low Salinity Impact Zones: transfer of water licences into these zones will be approved providing the salinity impacts of the new irrigation activities can be offset by salinity credits that the state of South Australia holds in the interstate salinity register (Young et al. 2000). This ensures that no net increase in salinity impact can occur in the SA portion of the Murray.

(b) High Salinity Impact Zones: transfer of water licences into these zones will only be approved if the salinity impacts of the new irrigation activities can be completely offset by retiring existing irrigation activities with commensurate salinity impact.

(c) High Salinity Impact (Salt Interception) Zones: transfer of water licences into these zones will only be approved if the salinity interception scheme servicing that zone has the capacity to mitigate the salinity impact of the new irrigation activities (i.e. no offsets are allowed)

Spencer et al. (2009) provide an *ex ante* analysis of the economic and environmental benefits from including offsetting in the salinity zoning policy. They assessed two possible policies for the high salinity impact zones: (i) standalone irrigation zoning, and (ii) irrigation zoning with offsetting policy (commensurate with (a) and (b) above). The standalone irrigation zoning does not have the feature of offsetting, so by implication, new irrigation activities cannot be established in the high salinity impact zones. New activities can be established in low salinity impact zones, provided that the state of SA has surplus credits in the interstate salinity register. On the other hand, the offsetting policy allows the possibility for new irrigation activities to take place in the high salinity impact zones provided that the salinity impact from these new irrigation developments is offset by reducing salinity impact elsewhere. Offsetting of this type is recognised as a feature of the government irrigation zoning policy (Government of South Australia, 2005).

Up to the present time, there have been no *ex post* analyses of the salinity offsetting under the Irrigation Zoning Policy in South Australia. For the purposes of the current report, some data were collected from the Department of Water, SA. These are displayed in Table 7. In the table, 'conjunctive applications approved' refers to approvals given to new irrigation development in high salinity impact zones. The condition for their approval is that the request is submitted simultaneously with evidence that the volume of water is bought from another irrigation enterprise located in a high salinity impact zone, thus providing commensurate reduction in salinity impact. Most of the water transfers are permanent, with few temporary allocation transfers.

Table 7. Offsets in high salinity impact zones under the Irrigation Zoning Policy in SA, 2006-2011

Year	Number of conjunctive applications approved		Volume of water involved (ML)
	Permanent entitlements	Temporary allocations	
2006/07	23	0	1,465
2007/08	15	2	1,271
2008/09	26	3	4,488
2009/10	1	0	468
2010/11	1	0	354

Source: SADW (2011)

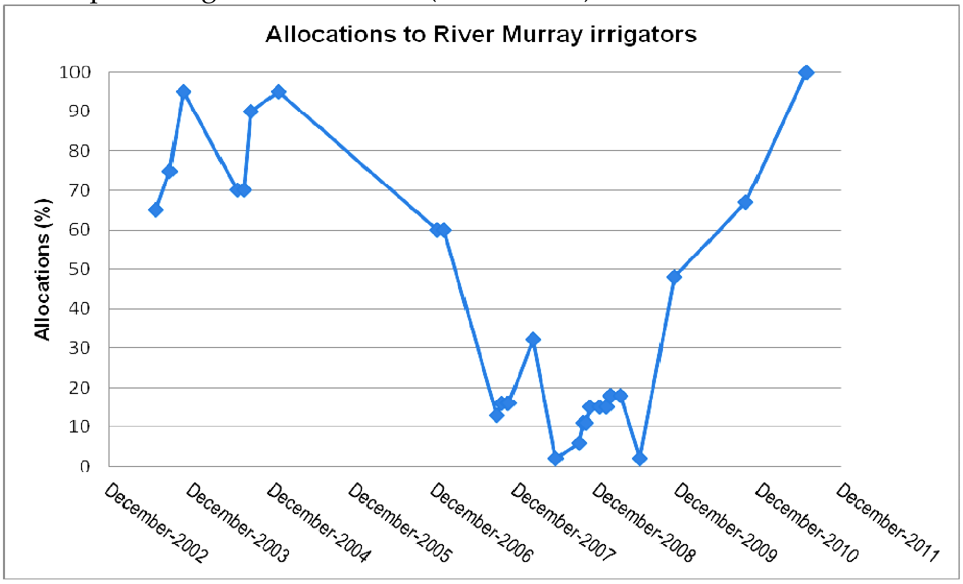
3.3.1 Environmental Assessment Criteria

Inflows into the River Murray in South Australia have been at record lows over the last 7-8 years, with an absolute minimum of 360 GL in 2007. Such dismal water availability was paralleled with severe restrictions of water allocations to irrigated agriculture (Figure 4).

This situation was reflected in significantly reduced interest in establishing new irrigation activities within the SA Murray. The trends of area under irrigated crops, and the number of agricultural businesses that irrigate are given in Table 8. This reduction in irrigation area and number of businesses that irrigate has in turn meant that there was probably less need for salinity offsetting during this period, which is a reason for the modest number of observed transactions in salinity offsets.

The reduced river flows over the last ten years also had implications on the dynamics of salinity itself. One possible implication is that due to minimal water inflows which may be insufficient to dilute the natural saline inflows, there could be significant rise in river salinity.

Figure 4. Announced allocations to water entitlement holders along River Murray, SA, as percentage of entitlement (2003 – 2011)



Source: SADW (2011)

Table 8. Irrigated area and number of irrigating businesses in the SA portion of the MDB, 2005-2010

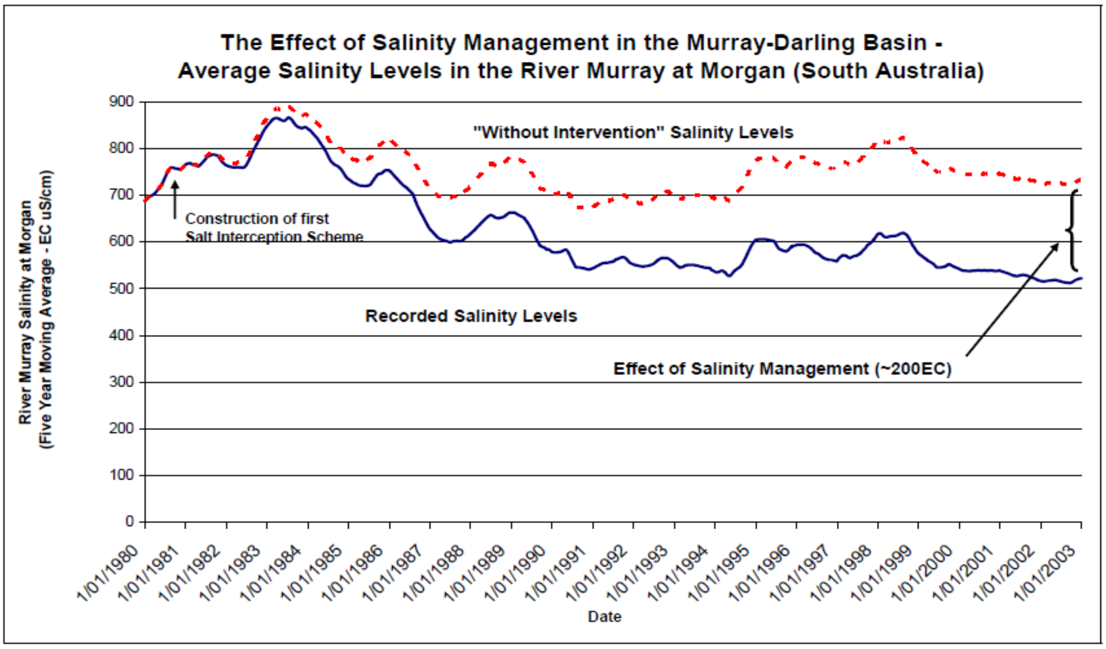
Year	Total area irrigated (ha)	Number of businesses
2005/06	71,000	2,504
2006/07	73,000	2,456
2007/08	72,828	2,320
2008/09	58,765	1,996
2009/10	55,296	1,811

Source: ABS, 'Water use on Australian Farms', 2005/06; 2006/07; 2007/08; 2008/09; 2009/10.

On the other hand, as a result of actions taken at the MDB level (e.g. Murray-Darling Basin Salinity and Drainage Strategy implemented 1988-2001 (MDBC, 2003)), the salinity pressures in the lower parts of the River Murray eased. The long-term average salinity levels measured at Morgan since 1980 are shown in Figure 5.[1] Measurements of electro conductivity taken in 2003 were averaging about 525 µS/cm, which was considerably lower than the previous 20-year average. Time series data for salinity reading at Morgan for the last three years are given in Figure 6. Current measurements of electro conductivity at Morgan are around 300 µS/cm (Figure 6).

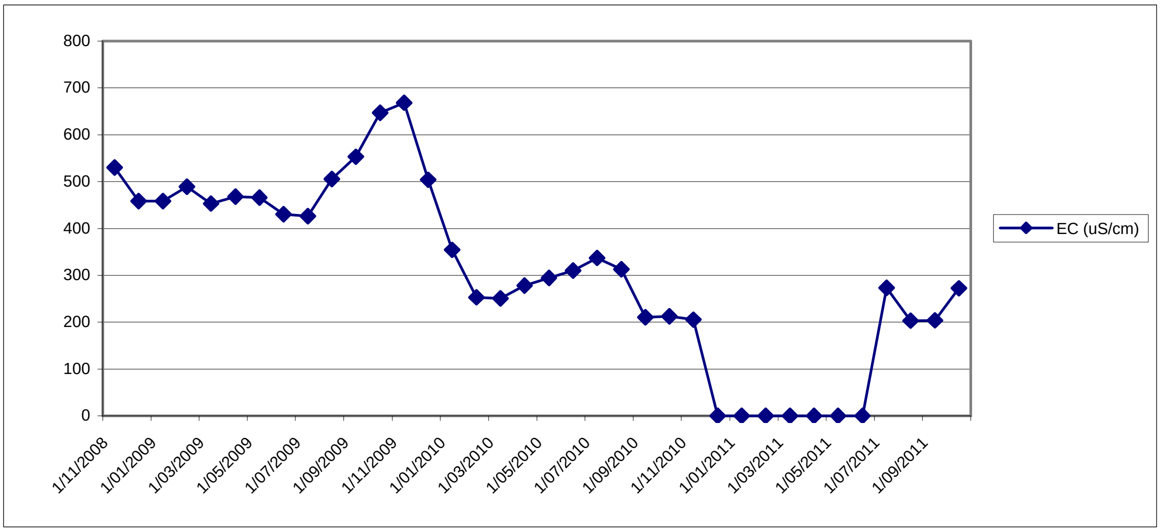
[1] Morgan is a town on the River Murray in South Australia, which is often used as a location for benchmarking water quality, especially salinity, as the salinity readings at Morgan are good indication of the possibility to use river water for drinking water supply to the city of Adelaide. The 'magic' number is 800 EC (electroconductivity) units (or µS/cm), which is the maximum allowed value for the elotroconductivity indicator for drinking water.

Figure 5. The impact of salinity management in the South Australia MDB.



Source: MDBC (2003).

Figure 6. Electro conductivity reading at Morgan, SA (November, 2008 – November, 2011)



Source: (River Murray Data, 2011; http://data.rivermurray.sa.gov.au).

3.3.2 Economic Assessment Criteria

There is currently no *ex-post* information available on the value, costs, or prices involved with salinity offsets. Spencer et al. (2009) compared *ex-ante* the cost effectiveness of standalone irrigation zoning policy to an irrigation zoning policy with salinity offsets. They simulated three scenarios using optimisation methods: a baseline scenario under which the location of new irrigation enterprises was unregulated, a standalone irrigation zoning scenario, and a salinity offsetting scenario. The study found that the overall annual net revenue from new irrigation development activities for the whole region under the baseline scenario was $3,627,733. The average long-run expected salinity impact from new irrigation development under this scenario was estimated to be 2.5867 electro-conductivity (EC) units per annum at the monitoring reference point at Morgan. Salinity impact at this rate over a decade or more would lead to a substantial and unsustainable increase in river salinity, which clearly calls for an action on salinity prevention. If no action was taken significant crop yield losses and water infrastructure salinity damage costs can be expected (MDBMC, 1999).

Under the standalone irrigation zoning scenario any new irrigation activity has to locate only in a low salinity impact zone. The overall annual net revenue for the whole region under this scenario was estimated as $3,168,833 (Spencer et al., 2009). The salinity impact under this scenario was estimated to be 0.267 EC units per annum as measured by the expected increase in EC reading at Morgan. This represents a considerable reduction in the salinity impact compared to the baseline scenario above.

Under the offsetting scenario, new irrigation can be located in high salinity impact zones, provided that the salinity impact from new developments in high impact zones are fully offset by reducing the salinity impact elsewhere. The estimated annual net revenue for the whole region under this scenario was $3,270,232 (Spencer et al., 2009). Net salinity impact under this scenario was estimated to be 0.187 EC units per annum as measured by the expected increase in the EC reading at Morgan. The estimated equilibrium quantity of salinity offsets was 0.02 EC units per annum (at Morgan, SA parity), which was about 11% of the overall annual salinity impact.

Under the standalone irrigation zoning scenario a reduction of 2.32 EC units per annum is achieved compared to unregulated irrigation location scenario. The total cost of achieving this reduction, measured as a decrease of net revenue to the irrigation industry in the region was estimated to be $458,900 (Spencer et al. 2009). This amounts to an average cost of $197,830 per 1 EC unit reduction (Table 8). The average cost of salinity reduction for the salinity offsetting amounted to $148,980 per 1 EC unit reduction as measured at Morgan, SA. This highlights the cost-effectiveness of the offsetting, as compared to the standalone irrigation zoning policy.

Table 8. Comparative cost of alternative policies to reduce salinity impact to River Murray, SA

Policy	Average cost of reducing salinity (AUD/1 EC unit/year)
Standalone irrigation zoning	197,830
With salinity offsets	148,980

Source: Spencer et al. (2009).

Spencer et al. (2009) suggest that both standalone irrigation zoning and irrigation zoning policy augmented with offsetting will substantially reduce salinity impact when compared to the baseline scenario, and will do so at very reasonable costs. Direct comparison of the standalone zoning and offsetting scenarios however shows that offsetting will result with a better salinity outcome, and a lower cost than standalone zoning policy.

3.3.3 Distributional Effects and Social Equity

The irrigation zoning policy has a clear distributional effect of favouring established irrigation activities over new irrigation activities. Perhaps inadvertently, this policy effectively applies 'grandfathering' to the 'right' to generate salinity impact. The offsetting feature rectifies this bias, by clearly expressing the opportunity cost of irrigation activities in terms of their salinity impact. Standalone irrigation zoning policy provides perverse incentives for old, possibly technologically obsolete irrigation enterprises that may be using irrigation water inefficiently and creating substantial salinity impact to remain in operation, as they will not be able to capitalise on their implied 'right' to create salinity impact, due to the restricted transferability of water rights among salinity impact zones (e.g. without offsetting, an existing enterprise in a high salinity impact zone will not receive any reward should they decide to cease their operation). The offsetting removes this perverse incentive, as an established operation can get a monetary reward by 'selling' their offset, should they decide to cease operation.

In light of these effects, offsetting is also a more socially equitable policy instrument, both considering the community of irrigators, and the wider community concerned with salinity impacts on River Murray in SA.

3.3.4 Institutions

The institutions of property, or 'use', rights which are implied by the salinity offset in this case have been gaining popularity in water management applications in Australia. These institutions are increasingly better understood and accepted by the public.

Within SA, the irrigation zoning policy is administered by the South Australian Department of Water (SADW). Other agencies concerned with management of salinity along the River Murray in SA are the Murray-Darling Basin Ministerial Council, and the South Australia Murray-Darling Basin Natural Resources Management Board.

3.3.5 Policy Implementability

The salinity zoning policy has been developed in relation to the salinity management goals of the Water Allocation Plan for the River Murray. This policy ensures that South Australia's salinity management is in line with the salinity management provisions of the Murray Darling Basin Agreement. Under the Agreement, the states of New South Wales, Victoria and South Australia have committed to keep an up-to-date salinity register, which is used to record all activities that reduce or increase salt loads. Actions that increase salt loads, such as new irrigation developments, result in a debit, whereas actions that mitigate salt loads result in a credit (Young et al. 2000). Under the agreement the register needs to be in surplus (credit) at all times. These provisions are directly related to the provisions of the Irrigation Zoning Policy for new developments in the low salinity impact zones.

3.3.6 Transaction Costs

The existence of significant transactions costs are possibly another reason for observing so few salinity offsets in practice in SA. While there are currently no estimates of transactions costs pertinent to the salinity offsetting within the irrigation zoning policy is SA, it is known from the literature on other economic policy instruments, especially ones based on tradable permits, that transactions costs can be substantial, and that they may in fact be greater than the benefits of instituting a particular economic policy instrument (Betz et al., 2010, Ancev, 2011, Jaraite et al. 2010).

Currently, it appears that no activities have been taken by the South Australian government in relation to aiding potential participants in salinity offsetting: there is no register of offsets, trade register, or some sort of clearance house. These usually represent a large proportion of the early implementation costs, and the fact that these activities have not been undertaken means that the costs have not been incurred. However, this probably makes transactions costs for potentially interested irrigation developers prohibitively high. Because there is an absence of structured government approach towards salinity offsets within the irrigation zoning policy, the requirements on individual participants willing to buy or sell offsets are very large. This comprises the need to search for a counterparty, the need for adequate contracting, the need to navigate through administrative requirements, and the need to ensure compliance with the policy. The costs of these are likely to be very high, which probably acts as a deterrent for potentially interested parties.

3.3.7 Uncertainty

As with any other offsetting program, there are always concerns about the adequacy of offsetting actions in relation to newly established activities. Questions like: 'Would ceasing of operation on *x* hectares under *y* irrigated crop in salinity impact zone *z*, would be sufficient to offset the salinity effect of a new operation on *q* hectares under *m* irrigated crop in salinity impact zone *n*'?, illustrate the uncertainty that surrounds offsets. To attempt to answer these questions, one could look into the assessment of the uncertainty related to the models that are regularly used to estimate salinity impact of irrigated agriculture. A good general overview of the treatment of uncertainty in terms of salinity modelling is provided in Lowell (2007). For the specific case of SA, the salt load and the salinity impact from each of the salinity impact areas under a given distribution of crops could be estimated with the SIMPACT model, which also allows some accounting for the associated uncertainty, and has been used previously in context of irrigation zoning in SA (Miles et al., 2002).

4 Conclusions

Salinity has been following irrigation since its very beginnings. With the advent of wide spread irrigation during the 20th century, salinity has risen to prominence yet again in many parts of the world, including Australia, the USA, and many irrigation regions in Central, South and South-East Europe. Engineering fixes and direct regulatory mechanisms were used in the past in an attempt to address the growing salinity problem. However, realising that these approaches have a limited potential to deliver salinity mitigation at acceptable cost, economic policy instruments (or market based instruments) have been gaining popularity in policy and research circles in the last decade of the 20th and the first decade of the 21st century.

Offsetting the salinity impact is one such instrument. It has been conceptualised and initially implemented in the 1970's and 1980's in relation to air pollution regulation. In the context of irrigation induced salinity mitigation, it has been implemented in Australia in the last ten years. This report presented three smaller case studies where salinity offsets are used to prevent and mitigate salinity impacts. The three case studies provide quite different contexts in terms of the nature of the problem, scale of effects, and affected industries. Nevertheless, they have many similarities, in particular in relation to the economic performance, distributional effects, and the effects of transactions costs and uncertainty.

The effects of irrigation are inextricably linked with the natural hydrological and climatic processes. Cycles of droughts and floods, trends in landscape processes, and changes in local climate, all affect the salt dynamics driven by irrigation. The period of introducing offsets for irrigation induced salinity in Australia coincided with one of the worst and most prolonged droughts in history (2002-2008). During this period, the allocation of water to irrigation was severely restricted, leading to drastic reduction in volume of irrigation water applied. As the volume of irrigation water applied is one of the main drivers of salinity, its reduction resulted with dampening of the salinity threat in the areas where offsets were implemented. Consequently, the need for offsets was not great as the environmental conditions did not create situations where they would be required. Nevertheless, the very existence of the offsets, and the institutional capacity that was build around them, ensures that they will be used more when the hydrological and climatic conditions become conducive again to increased salinity pressures.

4.1 Lessons learned

Environmental outcomes: In general, the collected evidence suggests that salinity offsets work well in reducing salinity pressures. In the Australian context of the last ten years it is very difficult to attribute the changes in salinity pressures to the implementation of the offsetting programs, as natural environmental conditions driven by climate contributed to alleviation of the salinity problems. Despite this, the data on salinity specific to the covered case studies of UCML, CIA and SA point to reduction of salinity pressures in the period since the establishment of salinity offsets, which is an indication of the environmental effectiveness of the offsets.

Economic outcomes: Salinity offsets are able to mitigate salinity pressure from irrigated agriculture at very reasonable cost, when compared to alternative salinity mitigation and prevention approaches. Evidence from the three case studies show that the costs of the offsetting programs in some cases were orders of magnitude lower (e.g. UCML) than those of the possible alternative approaches. In other cases (e.g. SA Irrigation zoning) the cost difference is relatively small in absolute terms, but the cost per unit of potential salinity impact reduction is substantially lower under offset than under the alternative policy. In light of this, salinity offsets are at par, and most likely perform better in terms of cost-effectiveness, in comparison to other policy instruments. As offsets can take into account heterogeneity across agents, they are also likely to be more efficient, i.e. result in smaller deadweight loss than other policy instruments, including other economic instruments.

Distributional effects and social equity: Introducing 'property' or 'use' rights in situations when there is open access approach to the environment, as is effectively done with salinity offsets, is widely documented to have positive distributional effects. In this case, offsets are effectively used to transfer the burden of the 'public bad' created by private actions, from the community at large back to the agents that cause the environmental degradation. Offsets offer the possibility that those agents decide among themselves as to who is going to mitigate, and by how much. This is the main source of cost-effectiveness, as it is expected that the agents would be able to determine (perhaps through a market) the least-cost ways to provide the offsets. Consequently, the distribution of regulatory burden, and of mitigation costs is equitable.

For the case studies under current investigation, there was a very different scale of social effects and environmental outcomes from the offsetting actions. For the case of Ulan Coal mine, the social effects are limited to a very small number of people in terms of environmental outcomes, and even smaller in terms of economic outcomes. The other two cases have wider social contexts, but by and large, the offsetting programs have relatively small social impacts, and can be viewed as economic policy instruments that provide equitable solution to environmental problems in the context of irrigation induced salinity.

***Institutions*:** Salinity offsets, along with other economic/market based policy instruments, are a part of the significant institutional innovation in natural resource and environmental management that has taken place in Australia and elsewhere in the course of the last twenty years. A common feature of these instruments is that they rely on economic incentive mechanisms (direct, or opportunity costs and benefits) in dealing with natural resource / environmental problems. Even though sometimes met with resistance, these new institutions are now widely accepted in Australia in various contexts, but interestingly they are probably overrepresented in relation to water management issues: e.g. water markets, salinity trading schemes, salinity levies, salinity offsets, water pollution taxes.

This institutional innovation was paralleled with a significant institutional capacity building within government at federal, state and local level. Governments in Australia have facilitated the implementation of the economic policy instruments, including in areas related to management of water quantity and quality in general, and salinity offsets in particular. This new institutional capacity is crucial for effective management of water related problem, including salinity, in the future.

***Transactions cost*:** The importance of transactions costs in relation to economic policy instruments has often been overlooked in research and policy contexts. Transactions cost are prominently associated with these instruments; they include costs to the government, eg.: establishing the register of agents to which the policy instrument applies, establishing information or trading platform, receiving and processing periodic statements, auditing, monitoring, and costs of enforcement; and costs to the agents, e.g.: monitoring and reporting costs, costs of establishing the instrument, cost of compliance with government regulation and community expectations. Sometimes these costs can be so high that they can prevent the economic policy instruments to be used in practice.

In the context of the cases of salinity offsets presented in this report, transactions costs vary considerably across the case studies. In the case of Ulan Coal Mine, the transactions cost do not appear to be too high, and they only pertain to the government and to the mine itself. For this case, we were able to derive a numerical estimate for a substantial portion of the transactions costs (Table 6). The situation is slightly different in the case of Coleambally Irrigation Area, where the net recharge offsets can potentially affect much larger number of agents, and can therefore result in substantial transactions costs in terms of reporting, monitoring and compliance. An interesting feature of this case is that the government is not directly involved (i.e. the salinity recharge offsets are administered by the irrigation co-operative) and therefore it is not bearing any transactions costs. In addition, a characteristic of this case is that the very implementation of the net recharge offset policy was probably greatly influenced by the high transactions costs identified for the previously considered salinity cap&trade permit scheme. Finally, transactions costs are probably quite high in the case of the salinity offsetting under the Irrigation Zoning Policy in

South Australia. The requirement for the offset is that the proponent of the new irrigation development in the high salinity impact zone needs to find on their own a counterparty that would retire an irrigation activity with commensurate salinity impact. The government does not provide any assistance in this, which presumably creates very high cost of search. These costs can potentially be so high, that can be one of the reasons for the modest uptake of the salinity offsetting under the Irrigation Zoning Policy.

***Policy implementability*:** Implementing the environmental policy instruments is a challenging task for governments, and the cases of salinity offsets in Australia have been no exception. However, given the institutional innovation and capacity building, as mentioned above, the implementation of salinity offsets in practice has went relatively smoothly. In the case of Coleambally Irrigation Area, the implementation is through the irrigation co-operative, and this ensures direct community engagement in implementation and enforcing of the policy. The implementation of the offset in the case of Ulan Coal Mine is through its environmental protection licence, which enables the implementability of the instrument through well established administrative channels. In the case of the Irrigation Zoning Policy in South Australia, the offsets are implemented as a part of the zoning policy, and are monitored and enforced through the process of development application for new irrigation activity.
Uncertainty: In the context of offsets in general, and salinity offsets in particular this is probably the most difficult factor to deal with. Questions like: 'How do we now that offsetting activities actually mitigate the same amount of the effects that are caused by polluting activities?' are widespread and difficult to answer. Advances in bio-physical modelling enable the researchers to quantify this uncertainty, which can then be reflected in the so called trading ratios (e.g. salinity impact of 1 ha in some place will have to be offset by retiring of irrigation on 1.5 ha in another place). The knowledge on uncertainty and its treatment in practice is still very limited, and this is an area that warrants considerable future research efforts.

4.2 Enabling / Disabling Factors

Salinity offsets in Australia have been a relative success story. The main enabling factor for this has been the institutional innovation and changes in public perception towards economic policy instruments / market based instruments. These are now widely known and accepted in Australia, and salinity offsets can therefore be implemented in a straight forward way. Another important enabling factor is the economic efficiency and cost effectiveness of these instruments. It is very clear that these instruments can achieve environmental outcomes at costs that are considerably lower than the alternatives. The relative distributional neutrality and social equity of these instruments can probably also be counted among the enabling factors.

Main disabling factor for salinity offsets is the uncertainty. Offsets are often seen as instruments with fairly uncertain environmental outcomes. For instance, the present report cannot shed much light on the environmental performance of the salinity offsets, as the natural variation in the salinity levels, driven by climatic variability is so large, that the uncertainty about the attribution of the observed effects to particular policies is too great to be able to derive conclusive insights. In addition, transactions costs can be seen as another possible disabling factor because their magnitude can be so high so as to prevent practical use of the offsets.

Overall, the evidence presented in this report suggests that salinity offsets can be an effective way to deal with the problem of irrigation induced salinity. The implementation of offsets in several areas in Australia provides a valuable experience for other countries and regions to draw upon when considering options to address the salinity, that unwanted follower of irrigated agriculture.

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