Benefits to Australia from ACIAR-funded research

David Pearce, Michael Monck, Kevin Chadwick and James Corbishley
Centre for International Economics

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Australian Government
Australian Centre for International Agricultural Research

Appendix A Tree growing on salt-affected soils

Background

The project 'Tree growing on salt-affected soils in Pakistan, Thailand and Australia' (FST/1993/016) aimed at:

- providing an increased range of tree and shrub species for planting on salt-affected sites in Pakistan, Thailand and Australia to provide fuel wood and other wood products
- defining appropriate establishment techniques for different species under a range of environmental conditions.

Salt-affected land is a major problem in many parts of the world. In particular, soil salinity, sodicity, water-logging and combinations of these have rendered large tracts of land, particularly across Pakistan and Thailand, largely unproductive for agricultural purposes. Australia also suffers from salt-affected land.

- In Australia, dryland salinity adversely affects agricultural or pastoral yields on approximately 3.3 million hectares, while another 5.7 million hectares are considered to be at risk of salinisation.
- The economic impact of salinity and soil-health problems in Australian agriculture has been estimated at approximately $200 million per year in 2000, increasing to $300 million by 2020. This measure considers only the yield gap—the difference between agricultural profits with and without soil health. The off-farm impacts have been estimated to be as high as $90 million a year, increasing to $150 million per year by 2020. In present-value terms, the on-farm and off-farm affects are estimated to cost Australia around $2.5 billion and $1.3 billion, respectively (NHT 2002).

One of a number of related projects

FST/1993/016 is one of a number of ACIAR-funded projects looking at the interaction between land use, ground water and trees, and aspects of the land, including salinity (there are, of course, many other ACIAR-funded projects related to forestry in general, but those listed here all have a soil–water–tree interaction component):

- 'Forage shrub production from saline and/or sodic soils in Pakistan' (FOG/1986/019), which evaluated halophytic (salt-tolerant) forage species, especially *Atriplex* (saltbush) species, for use in revegetating salt-affected land in Pakistan
- 'Australian woody species for saline sites in Asia' (FST/1986/033), which undertook research into extending the range of salt-tolerant trees and shrubs, and to identify nutritional constraints that limit establishment and early growth on these soils
- 'Improving and sustaining productivity of eucalypts in South-East Asia' (FST/1991/015) aimed to increase the yield of Thai eucalypt plantations while maintaining long-term productivity of forest land
- 'Improved tree establishment for tropical dryland conditions in East Africa' (FST/1991/026), which investigated some of the problems associated with tree establishment in dryland regions, by subjecting promising lines of dryland species to a range of variables under glasshouse and field conditions

- 'Multipurpose tree and sandalwood silviculture in eastern Indonesia' (FST/1990/043) developed a management regime for those species selected for the West Timor environment, with other trials in the drier environment of East Sumba
- 'Predicting tree growth for general regions and specific sites in China, Thailand and Australia' (FST/1991/027) addressed the problem of insufficient information during reforestation programs using a variety of computer-based programs to monitor climatic and soil conditions;
- 'Groundwater control measures for salinity management and agriculture in the Khon Kaen area, north-east Thailand' (LWR1/1992/022) investigated groundwater flows and the salt loads they carry, and tested methods for reducing salt levels in the landscape.

Budgets

Table A1 presents the budget for Project FST/1993/016. Project funding was from a range of sources, with roughly half made up from ACIAR funds.

Intended outputs

The intended outputs of 'Tree growing on salt-affected soils in Pakistan, Thailand and Australia' were to:

- improve the productivity of key tree species on salt-affected land, through
  - identification superior genetic materials in species, provenances and progeny trials and establish seed orchards for dominant strains
  - further evaluation of the impact of salt on the imbalance of plant growth
  - evaluation of the impact of improved rhizobia strains on the growth of acacias
  - determination of the impact of size and age of seedlings on the response to salt under controlled conditions
- determine the water use of key species on salt-affected land
  - determine daily and annual water use by single trees and plantations of a variety of species, and validate models for predicting water use from tree size, soil and climate variables
  - determine seasonal variation in root zone soil moisture, salinity and watertable depth beneath plots of key species irrigated with saline water
- develop a tree and shrub performance database for salt-affected land and provide predictions of growth
  - collect, collate and enter trial data from salt-affected sites in Pakistan, Thailand, Australia and other countries into a PC tree-performance database
  - predict site suitability and potential growth of key species for specific regions in Pakistan, Thailand and Australia using simulation modelling
  - update the publication *A bibliography of forage halophytes and trees for salt-affect land: their use, culture and physiology* produced by projects FOG/1986/019 and FST/1986/033.

Table A1. Project budget FST/1993/016

	1993–94 ($)	1994–95 ($)	1995–96 ($)	1996–97 ($)	Total ($)
Total ACIAR expenditure	121,032	256,520	182,954	89,891	650,397
Other support (cash and in-kind)					
Commissioned organisations	58,782	120,698	123,242	62,843	365,565
Australian collaborators	26,500	15,000	15,000	7,500	64,000
Developing-country partners	20,200	37,100	34,800	17,500	109,600
Other support total	105,482	172,798	173,042	87,843	539,165
Grand total	226,514	429,318	355,996	177,734	1,189,562

Source: ACIAR (1994).

Key outcomes

The overall outcome of the project is an enhanced ability for researchers, particularly in Pakistan but also in Australia and Thailand, to better manage salt-affected land through improved knowledge of appropriate tree and shrub species able to withstand salinity.

Specifically, the project component outcomes were:

- identification of the most productive germplasm of proven tree species for a variety of salt-affected soils
- refining key cultural techniques for optimising tree survival and growth on salt land
- evaluation of the water use of trees in saline conditions and their likely impact on shallow, saline watertables
- evaluation of the correct water-management procedures for sustainable tree growing on a variety of salt-affected soils
- development of a greater ability to predict how well a range of tree species and provenances will grow on salt-affected sites in specific regions of Pakistan, Thailand and Australia.

ACIAR's project review

The project's completion report determined that the project met the stated objectives. It found that the overall outcome was an enhanced ability for researches, particularly in Pakistan, but also in Australia and Thailand, to better manage salt-affected land.

That is, the results of the project have enabled researchers to advise farmers on species to plant, planting techniques and the environmental benefits, particularly with regard to water use and watertable control by trees. The research trials have clearly demonstrated the potential for increasing agricultural productivity on salt-affected wastelands.

Furthermore, the project has demonstrated the ability to grow trees and shrubs on salt-affected land that was previously considered wasteland. The project has provided scientists in Pakistan, Thailand and other developing countries with the most recent techniques when determining plant suitability, particularly in water-use measurement, and how to apply these techniques to research on reclaiming salt-affected land using trees and shrubs. The research in Thailand usefully contributed to the data already in place on salt-affected land in the tropics.

In Pakistan, the project review found that the project has been a catalyst, increasing the existing knowledge and awareness of overseas scientists to such an extent that salt-land research in Pakistan is now established and advancing. In Thailand, the impact is less clear. The fight against salinity still appears to be of little interest outside of academic circles. In order for the research to have a broad impact, the demand for solutions to salinity problems would have to increase.

Outcomes mostly academic

However, while the project has had positive impacts at an academic level, the project reviewers determined that the application of the research from the project has had only a limited impact on farmers in Pakistan and Thailand, the eventual end users of the research products. This significantly attenuates the impacts of the project.

Potential benefits to Australia

Currently, Australia faces significant economic and social costs from salinisation of agricultural and rural land, particularly within the Murray–Darling Basin in south-eastern Australia and in the south-west of Western Australia. It is estimated that 2.5 million hectares of land are affected by salinity, with the potential for this to increase to 15 million hectares. Much of this is Australia's most productive agricultural land.

Within Australia, the project has had a range of potential benefits, but it is not possible to quantify these as there is yet no evidence that the results of the research have been adopted.

The primary potential positive impact of the project on Australia is that the amount of salt-affected land would be reduced. A second impact relates to the potential for a productivity boost due to agricultural yields improving through crop diversification. Additionally, Australian researches benefit directly through the collation of relevant research findings.

Potential for land rehabilitation through lowering watertables

In Australia, over 7,000 broadacre and dairy farms (9.0%) have signs of surface waterlogging which has led to some negative impact in almost all (6,300) of these. Of these 6,300 properties, roughly a quarter (1,600) have experienced significant problems due to waterlogging (see Table A2).

The strategic planting of trees in water recharge and discharge locations is considered by researchers to be one approach to halting the spread of salinity.

Water use per unit of land area by trees is an important determinant of the capacity of trees to lower watertables. There are several examples within Australia of significant lowering of saline watertables under or near plantations and agro-forests, particularly in Western Australia and Victoria, where a 2 metre lowering of the watertable was achieved under an 8-year-old eucalypt plantation.

The degree of effectiveness of tree species and plantations depends on the tree density, the proportion of area planted, crown cover, root architecture, soil hydraulic characteristics and groundwater dynamics. Furthermore, individual tree water use is closely linked with leaf and stem cross-sectional area.

By undertaking the research, the data acquired allow researchers to make predictions on likely tree species performance. Combined with other information, researchers and land managers would have a broad spectrum of tree species data that could be used to help determine the optimum species to plant on salt-affected ground, as well as the optimal planting locations.

Potential for income generation through alternative crops

The ACIAR project has undertaken valuable research into determining tree water use and long-term salinity of root zones of a broad range of native Australian tree species. Being able to identify the most appropriate and productive tree species on salt land, and ensure their

Table A2. Australian broadacre and dairy farms impacted by salt-affected land

	Number of properties affected	Per cent of all properties
Dryland salinity		
Showing signs of	10,932	14.0
Impacting upon business	8,855	11.3
Significant problems from	3,608	4.6
Irrigation salinity		
Showing signs of	2,343	3.0
Impacting upon business	2,343	3.0
Significant problems from	609	0.8
Soil sodicity		
Showing signs of	5,466	7.0
Impacting upon business	5,193	6.7
Significant problems from	929	1.2
Surface waterlogging		
Showing signs of	7,028	9.0
Impacting upon business	6,325	8.1
Significant problems from	1,616	2.1

Source: ABARE (2006).

survival through land and water-management practices has real potential to improve agricultural incomes and productivity. The end result, once implemented, would be to make large areas of marginal land in Australia available for income-earning activities. Potential sources of revenue include:

- growing trees for construction timber
- growing native Australian shrubs digestible for fodder production.

In addition to growing trees and shrubs for use on their own land, farmers may benefit from the research by the establishment of a domestic market for useful tree species; that is, there may be scope for expanding the supply and demand for plant nurseries.

Contributing to and collating relevant research findings

The final potential benefit to Australia relates to the collection of research findings. Assembling all available knowledge may markedly assist academics and government and forestry officials in applying and distributing the research findings from this project, as well as other related projects.

Related to the benefits associated with positive research findings, the project may also benefit other researchers and land managers by identifying potentially fruitless research avenues.

Costs of implementation

In order to lower watertables using techniques developed as part of this project, agricultural firms would be required to plant significant areas of land. While the opportunity cost of the land can be assumed to be zero given its degraded state, there is still a direct financial cost and opportunity cost associated with planting trees. Furthermore, there are costs associated with accessing the research findings and determining the appropriate tree species to use.

Conclusion

If the outputs of the project are implemented into widespread land-management practices, there is potential that land management within salt-affected areas of Pakistan, Thailand and Australia will sufficiently change so as to reduce the impact of salinity. Clearly, however, this is conditional on the research findings being widely disseminated and applied and being integrated with the variety of other research efforts in this area.