

## **Incentives and Instruments for Sustainable Irrigation**

**WIT***PRESS*

WIT Press publishes leading books in Science and Technology.

Visit our website for the current list of titles.

[www.witpress.com](http://www.witpress.com)

**WIT***eLibrary*

Home of the Transactions of the Wessex Institute, the WIT electronic-library provides the international scientific community with immediate and permanent access to individual papers presented at WIT conferences. Visit the WIT eLibrary at

<http://library.witpress.com>

# Incentives and Instruments for Sustainable Irrigation

Edited by

**H. Bjornlund**

*University of South Australia, Australia  
and  
University of Lethbridge, Canada*

**WIT**PRESS Southampton, Boston



**Editor:**

**H. Bjornlund**

*University of South Australia, Australia and University of Lethbridge, Canada*

Published by

**WIT Press**

Ashurst Lodge, Ashurst, Southampton, SO40 7AA, UK

Tel: 44 (0) 238 029 3223; Fax: 44 (0) 238 029 2853

E-Mail: [witpress@witpress.com](mailto:witpress@witpress.com)

<http://www.witpress.com>

For USA, Canada and Mexico

**WIT Press**

25 Bridge Street, Billerica, MA 01821, USA

Tel: 978 667 5841; Fax: 978 667 7582

E-Mail: [infousa@witpress.com](mailto:infousa@witpress.com)

<http://www.witpress.com>

British Library Cataloguing-in-Publication Data

A Catalogue record for this book is available  
from the British Library

ISBN: 978-1-84564-406-2

Library of Congress Catalog Card Number: 2009930794

*The texts of the papers in this volume were set  
individually by the authors or under their supervision.*

No responsibility is assumed by the Publisher, the Editors and Authors for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions or ideas contained in the material herein. The Publisher does not necessarily endorse the ideas held, or views expressed by the Editors or Authors of the material contained in its publications.

© WIT Press 2010

Printed in Great Britain by Athenaeum Press, Ltd.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the Publisher.

# Contents

<b>Part I Concepts and Background</b>	<b>1</b>
<b>Chapter 1 Sustainable irrigation: Setting the scene</b>	<b>3</b>
1 Introduction	3
2 Sustainable irrigation in the context of this book	5
3 An outline of the book	7
<b>Chapter 2 Sustainable irrigation: A historical perspective</b>	<b>13</b>
1 Introduction	13
2 Examples of early irrigation systems/societies	14
2.1 Mesopotamia	15
2.2 Egypt—The Nile	16
2.3 The qanat system	17
2.4 Bali—Rice growing	18
2.5 India—A diversity of systems	20
3 Conclusions	22
<b>Chapter 3 Sustainable water projects: The task of economic instruments and supporting institutions</b>	<b>25</b>
1 Introduction	25
2 Institutional setting	26
3 Financial failures in public irrigation	28
4 Economic instruments	30
5 Institutions to improve cost recovery	32
6 Supporting institutions	36
7 Conclusion	38
<b>Chapter 4 Governance and the challenges of water and food security</b>	<b>41</b>
1 Introduction	41
2 Water security and irrigation	43
3 Governance and water security	44
4 Case study: Irrigation, water security, and governance in the Murray–Darling Basin	48
5 Discussion and conclusions	52

<b>Chapter 5</b>	<b>A robust framework for the allocation of water in an ever-changing world</b>	<b>59</b>
1	Introduction	59
2	Outcomes, principles and concepts	61
3	Defining a robust allocation regime for a regulated river system	62
4	System bulk allocations	64
5	Individual interests	65
6	Water accounting	66
7	Interception	66
8	Allocation management	67
9	Facilitating adjustment in an ever-changing world	67
10	Managing environmental water	70
11	Concluding comment	71
<b>Part II</b>	<b>Case Studies</b>	<b>73</b>
<b>Chapter 6</b>	<b>Non-profit-maximising values and attitudes influencing irrigators' management response to new policy instruments</b>	<b>75</b>
1	Introduction	75
2	Policy problem	76
3	The study region—The Namoi Valley of New South Wales	77
4	Methods	78
5	Findings	79
6	Strengths and limitations	83
7	Policy implications	84
8	Recommendations for future research	86
9	Conclusion	87
<b>Chapter 7</b>	<b>Towards more sustainable irrigation: Factors influencing allocation and entitlement prices and demand in the Goulburn Murray Irrigation District of Australia</b>	<b>91</b>
1	Introduction	91
2	The study region and water trading background	92
3	Influences on allocation and entitlement prices	97
4	Influences on the elasticity of water demand and supply	98
4.1	Water allocations	98
4.2	Water entitlements	100
5	Conclusion	103
<b>Chapter 8</b>	<b>Incorporating the environment into the market: The case of water trusts and environmental water transfers in the western United States</b>	<b>107</b>
1	Introduction	107
2	Institutional framework for environmental water transfers	109

2.1	Prior appropriations doctrine and beneficial use	109
2.2	Endangered Species Act	110
3	The environmental water market for in-stream flows	111
3.1	Federal and state provision of in-stream flows	112
3.1.1	Idaho	112
3.1.2	Utah	112
3.1.3	Wyoming	113
3.1.4	Colorado	114
3.1.5	Southwestern states	114
3.1.6	California	114
3.1.7	Nevada	115
3.2	Water trusts	115
3.2.1	Oregon Water Trust	116
3.2.2	Washington Water Trust	117
3.2.3	Montana Water Trust	119
3.2.4	Columbia Basin Water Transactions Program	119
4	Conclusion	119

## **Chapter 9 Water options contracts to facilitate intersectoral trade 123**

1	Introduction	123
2	Potential for intersectoral trade in the Murrumbidgee Valley	124
3	The nature of options contracts and their applicability to water markets	125
3.1	Valuing water options contracts	127
3.2	Previous efforts at exploring water options in Australia	127
4	Methodology, data and results	129
4.1	Estimation of the PVOB from holding a water option	129
4.1.1	Data	129
4.1.2	PVOB from holding water option contract	130
4.2	Estimation of premium payable to writer of option contract	131
4.2.1	Data	131
4.3	Results	133
5	Policy implications	133
6	Conclusions	134

## **Chapter 10 Assessing alternative models for farmers' ability to pay for irrigation water 137**

1	Introduction	137
2	Background and conceptual framework	138
2.1	Policy background	138
2.2	General economic framework	139
2.3	General definition of ATP	140
2.4	Conceptual model of ATP	140

2.4.1	Basic model	140
2.4.2	Alternative ATP models	142
2.5	Some additional issues	144
2.6	Further remarks	145
2.7	Previous literature	145
3	Case study from the Kyrgyz Republic	146
3.1	Background: Description of study area	146
3.2	Some preliminaries in the application of alternative models	147
3.3	Application of alternative models	147
4	Conclusions	150
 <b>Chapter 11 Energy prices, biofuels, and irrigated agriculture</b>		<b>153</b>
1	Introduction	153
2	Model of irrigation water demand	154
2.1	Optimal water use and output levels	155
3	Impact of changing energy prices	156
3.1	Impacts of energy prices on optimal water prices	158
4	Choice of irrigation and conveyance technology	160
4.1	Impacts of technology adoption on water use and output	162
5	Impact of changing energy prices on technology choice	167
6	Conclusion	169
 <b>Chapter 12 Toward sustainable irrigation: Would subsidizing improve technologies result in water conservation in Alberta, Canada?</b>		<b>173</b>
1	Introduction	173
2	Policy and legislative framework	175
3	Irrigation in Alberta and Canada	177
4	Survey design and methods	179
5	Survey results	180
5.1	Property and farmer characteristics	180
5.2	Adoption of improved technologies	182
5.3	Reasons for and against adoption	183
6	Subsidizing new technologies	185
7	Conclusions	186
 <b>Chapter 13 Application of economic instruments, tradable licences and good governance for sustainable irrigation water conservation in South Africa</b>		<b>189</b>
1	Introduction	190
2	Some theoretical and practical considerations	190
3	Economic instruments for water conservation	191

3.1	Charges for water resource development and use	191
3.2	Costing of water use	192
4	Hydrological issues	193
4.1	Metering and complete description of water use entitlements	193
4.2	Water quality impacts	193
5	Empirical results of water marketing studies	194
5.1	Efficiency of water use	194
5.2	Risk in water marketing	195
6	Equity with water allocation	196
7	Governance in water management	197
8	Separation of water and land rents	199
9	Conclusion	199

**Chapter 14 Sustainability of groundwater resources in India:  
Challenges and scope for economic instruments  
and policy** **203**

1	Introduction	203
2	Overview of groundwater issues in India	204
3	Linkages between land, energy and water usage	206
3.1	The economics of water usage and the role of land	207
3.2	The energy dimension of groundwater usage	209
4	Alternative economic instruments for Indian groundwater	209
4.1	Demand-side management through quotas	209
4.2	Market-based instruments for demand allocation	211
4.3	Payment for environmental services	212
5	Synthesis and conclusions	215