

# Sustainable Irrigation Management, Technologies and Policies II

**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.

Papers presented at Sustainable Irrigation II are archived in the WIT eLibrary in volume 112 of WIT Transactions on Ecology and the Environment (ISSN 1743-3541).

The WIT eLibrary provides the international scientific community with immediate and permanent access to individual papers presented at WIT conferences.

Visit the WIT eLibrary at [www.witpress.com](http://www.witpress.com).

SECOND INTERNATIONAL CONFERENCE ON  
SUSTAINABLE IRRIGATION MANAGEMENT,  
TECHNOLOGIES AND POLICIES

## Sustainable Irrigation II

### CONFERENCE CHAIRMEN

**Y. Villacampa Esteve**  
*University of Alicante, Spain*

**C.A. Brebbia**  
*Wessex Institute of Technology, UK*

**D. Prats Rico**  
*IWES University of Alicante, Spain*

### INTERNATIONAL SCIENTIFIC ADVISORY COMMITTEE

J.M. Andreu Rodes	D.I. Leskovar
H. Bjornlund	G. Lorenzini
M. da Conceicao Cunha	J. Melgarejo Moreno
D. de Wrachien	P. Melgarejo Moreno
C. Juarez	G. Piccini
A.M. Kassem	I. Smout

### Organised by

*Wessex Institute of Technology, UK*  
*University of Alicante, Spain*

### Sponsored by

*WIT Transactions on Ecology and the Environment*  
*Institute for Water and Environmental Sciences of the University of Alicante*  
*Ministerio de Educación y Ciencia, España (CTM2007-29892-E/TECNO)*  
*Instituto del Agua y de las Ciencias Ambientales*  
*Patronato Municipal de Turismo de Alicante*  
*Grupo de Investigaciones Modelización de Sistemas, University of Alicante*  
*Consolider-Tragua*

# WIT Transactions

## Transactions Editor

**Carlos Brebbia**

Wessex Institute of Technology  
Ashurst Lodge, Ashurst  
Southampton SO40 7AA, UK  
Email: carlos@wessex.ac.uk

---

## Editorial Board

---

- B Abersek** University of Maribor, Slovenia  
**Y N Abousleiman** University of Oklahoma, USA  
**P L Aguilar** University of Extremadura, Spain  
**K S Al Jabri** Sultan Qaboos University, Oman  
**E Alarcon** Universidad Politecnica de Madrid, Spain  
**A Aldama** IMTA, Mexico  
**C Alessandri** Universita di Ferrara, Italy  
**D Almorza Gomar** University of Cadiz, Spain  
**B Alzahabi** Kettering University, USA  
**J A C Ambrosio** IDMEC, Portugal  
**A M Amer** Cairo University, Egypt  
**S A Anagnostopoulos** University of Patras, Greece  
**M Andretta** Montecatini, Italy  
**E Angelino** A.R.P.A. Lombardia, Italy  
**H Antes** Technische Universitat Braunschweig, Germany  
**M A Atherton** South Bank University, UK  
**A G Atkins** University of Reading, UK  
**D Aubry** Ecole Centrale de Paris, France  
**H Azegami** Toyohashi University of Technology, Japan  
**A F M Azevedo** University of Porto, Portugal  
**J Baish** Bucknell University, USA  
**J M Baldasano** Universitat Politecnica de Catalunya, Spain  
**J G Bartzis** Institute of Nuclear Technology, Greece  
**A Bejan** Duke University, USA  
**M P Bekakos** Democritus University of Thrace, Greece  
**G Belingardi** Politecnico di Torino, Italy  
**R Belmans** Katholieke Universiteit Leuven, Belgium  
**C D Bertram** The University of New South Wales, Australia  
**D E Beskos** University of Patras, Greece  
**S K Bhattacharyya** Indian Institute of Technology, India  
**E Blums** Latvian Academy of Sciences, Latvia  
**J Boarder** Cartref Consulting Systems, UK  
**B Bobee** Institut National de la Recherche Scientifique, Canada  
**H Boileau** ESIGEC, France  
**J J Bommer** Imperial College London, UK  
**M Bonnet** Ecole Polytechnique, France  
**C A Borrego** University of Aveiro, Portugal  
**A R Bretones** University of Granada, Spain  
**J A Bryant** University of Exeter, UK  
**F-G Buchholz** Universitat Gesanthschule Paderborn, Germany  
**M B Bush** The University of Western Australia, Australia  
**F Butera** Politecnico di Milano, Italy  
**J Byrne** University of Portsmouth, UK  
**W Cantwell** Liverpool University, UK  
**D J Cartwright** Bucknell University, USA  
**P G Carydis** National Technical University of Athens, Greece  
**J J Casares Long** Universidad de Santiago de Compostela, Spain  
**M A Celia** Princeton University, USA  
**A Chakrabarti** Indian Institute of Science, India

- S K Chakrabarti** Offshore Structure Analysis, USA
- A H-D Cheng** University of Mississippi, USA
- J Chilton** University of Lincoln, UK
- C-L Chiu** University of Pittsburgh, USA
- H Choi** Kangnung National University, Korea
- A Cieslak** Technical University of Lodz, Poland
- S Clement** Transport System Centre, Australia
- M W Collins** Brunel University, UK
- J J Connor** Massachusetts Institute of Technology, USA
- M C Constantinou** State University of New York at Buffalo, USA
- D E Cormack** University of Toronto, Canada
- M Costantino** Royal Bank of Scotland, UK
- D F Cutler** Royal Botanic Gardens, UK
- W Czyczula** Krakow University of Technology, Poland
- M da Conceicao Cunha** University of Coimbra, Portugal
- A Davies** University of Hertfordshire, UK
- M Davis** Temple University, USA
- A B de Almeida** Instituto Superior Tecnico, Portugal
- E R de Arantes e Oliveira** Instituto Superior Tecnico, Portugal
- L De Biase** University of Milan, Italy
- R de Borst** Delft University of Technology, Netherlands
- G De Mey** University of Ghent, Belgium
- A De Montis** Universita di Cagliari, Italy
- A De Naeyer** Universiteit Ghent, Belgium
- W P De Wilde** Vrije Universiteit Brussel, Belgium
- L Debnath** University of Texas-Pan American, USA
- N J Dedios Mimbela** Universidad de Cordoba, Spain
- G Degrande** Katholieke Universiteit Leuven, Belgium
- S del Giudice** University of Udine, Italy
- G Deplano** Universita di Cagliari, Italy
- I Doltsinis** University of Stuttgart, Germany
- M Domaszewski** Universite de Technologie de Belfort-Montbéliard, France
- J Dominguez** University of Seville, Spain
- K Dorow** Pacific Northwest National Laboratory, USA
- W Dover** University College London, UK
- C Dowlen** South Bank University, UK
- J P du Plessis** University of Stellenbosch, South Africa
- R Duffell** University of Hertfordshire, UK
- A Ebel** University of Cologne, Germany
- E E Edoutos** Democritus University of Thrace, Greece
- G K Egan** Monash University, Australia
- K M Elawadly** Alexandria University, Egypt
- K-H Elmer** Universitat Hannover, Germany
- D Elms** University of Canterbury, New Zealand
- M E M El-Sayed** Kettering University, USA
- D M Elsom** Oxford Brookes University, UK
- A El-Zafrany** Cranfield University, UK
- F Erdogan** Lehigh University, USA
- F P Escrig** University of Seville, Spain
- D J Evans** Nottingham Trent University, UK
- J W Everett** Rowan University, USA
- M Faghri** University of Rhode Island, USA
- R A Falconer** Cardiff University, UK
- M N Fardis** University of Patras, Greece
- P Fedelinski** Silesian Technical University, Poland
- H J S Fernando** Arizona State University, USA
- S Finger** Carnegie Mellon University, USA
- J I Frankel** University of Tennessee, USA
- D M Fraser** University of Cape Town, South Africa
- M J Fritzler** University of Calgary, Canada
- U Gabbert** Otto-von-Guericke Universitat Magdeburg, Germany
- G Gambolati** Universita di Padova, Italy
- C J Gantes** National Technical University of Athens, Greece
- L Gaul** Universitat Stuttgart, Germany
- A Genco** University of Palermo, Italy
- N Georgantzis** Universitat Jaume I, Spain
- G S Gipson** Oklahoma State University, USA
- P Giudici** Universita di Pavia, Italy
- F Gomez** Universidad Politecnica de Valencia, Spain

**R Gomez Martin** University of Granada, Spain  
**D Goulias** University of Maryland, USA  
**K G Goulias** Pennsylvania State University, USA  
**F Grandori** Politecnico di Milano, Italy  
**W E Grant** Texas A & M University, USA  
**S Grilli** University of Rhode Island, USA  
**R H J Grimshaw**, Loughborough University, UK  
**D Gross** Technische Hochschule Darmstadt, Germany  
**R Grundmann** Technische Universitat Dresden, Germany  
**A Gualtierotti** IDHEAP, Switzerland  
**R C Gupta** National University of Singapore, Singapore  
**J M Hale** University of Newcastle, UK  
**K Hameyer** Katholieke Universiteit Leuven, Belgium  
**C Hanke** Danish Technical University, Denmark  
**K Hayami** National Institute of Informatics, Japan  
**Y Hayashi** Nagoya University, Japan  
**L Haydock** Newage International Limited, UK  
**A H Hendrickx** Free University of Brussels, Belgium  
**C Herman** John Hopkins University, USA  
**S Heslop** University of Bristol, UK  
**I Hideaki** Nagoya University, Japan  
**D A Hills** University of Oxford, UK  
**W F Huebner** Southwest Research Institute, USA  
**J A C Humphrey** Bucknell University, USA  
**M Y Hussaini** Florida State University, USA  
**W Hutchinson** Edith Cowan University, Australia  
**T H Hyde** University of Nottingham, UK  
**M Iguchi** Science University of Tokyo, Japan  
**D B Ingham** University of Leeds, UK  
**L Int Panis** VITO Expertisecentrum IMS, Belgium  
**N Ishikawa** National Defence Academy, Japan  
**J Jaafar** UiTm, Malaysia  
**W Jager** Technical University of Dresden, Germany  
**Y Jaluria** Rutgers University, USA  
**C M Jefferson** University of the West of England, UK  
**P R Johnston** Griffith University, Australia  
**D R H Jones** University of Cambridge, UK  
**N Jones** University of Liverpool, UK  
**D Kaliampakos** National Technical University of Athens, Greece  
**N Kamiya** Nagoya University, Japan  
**D L Karabalis** University of Patras, Greece  
**M Karlsson** Linkoping University, Sweden  
**T Katayama** Doshisha University, Japan  
**K L Katsifarakis** Aristotle University of Thessaloniki, Greece  
**J T Katsikadelis** National Technical University of Athens, Greece  
**E Kausel** Massachusetts Institute of Technology, USA  
**H Kawashima** The University of Tokyo, Japan  
**B A Kazimee** Washington State University, USA  
**S Kim** University of Wisconsin-Madison, USA  
**D Kirkland** Nicholas Grimshaw & Partners Ltd, UK  
**E Kita** Nagoya University, Japan  
**A S Kobayashi** University of Washington, USA  
**T Kobayashi** University of Tokyo, Japan  
**D Koga** Saga University, Japan  
**A Konrad** University of Toronto, Canada  
**S Kotake** University of Tokyo, Japan  
**A N Kounadis** National Technical University of Athens, Greece  
**W B Kratzig** Ruhr Universitat Bochum, Germany  
**T Krauthammer** Penn State University, USA  
**C-H Lai** University of Greenwich, UK  
**M Langseth** Norwegian University of Science and Technology, Norway  
**B S Larsen** Technical University of Denmark, Denmark  
**F Lattarulo**, Politecnico di Bari, Italy  
**A Lebedev** Moscow State University, Russia  
**L J Leon** University of Montreal, Canada  
**D Lewis** Mississippi State University, USA  
**S Ighobashi** University of California Irvine, USA

- K-C Lin** University of New Brunswick, Canada
- A A Liolios** Democritus University of Thrace, Greece
- S Lomov** Katholieke Universiteit Leuven, Belgium
- J W S Longhurst** University of the West of England, UK
- G Loo** The University of Auckland, New Zealand
- J Lourenco** Universidade do Minho, Portugal
- J E Luco** University of California at San Diego, USA
- H Lui** State Seismological Bureau Harbin, China
- C J Lumsden** University of Toronto, Canada
- L Lundqvist** Division of Transport and Location Analysis, Sweden
- T Lyons** Murdoch University, Australia
- Y-W Mai** University of Sydney, Australia
- M Majowiecki** University of Bologna, Italy
- D Malerba** Università degli Studi di Bari, Italy
- G Manara** University of Pisa, Italy
- B N Mandal** Indian Statistical Institute, India
- Ü Mander** University of Tartu, Estonia
- H A Mang** Technische Universität Wien, Austria,
- G D, Manolis**, Aristotle University of Thessaloniki, Greece
- W J Mansur** COPPE/UF RJ, Brazil
- N Marchettini** University of Siena, Italy
- J D M Marsh** Griffith University, Australia
- J F Martin-Duque** Universidad Complutense, Spain
- T Matsui** Nagoya University, Japan
- G Mattrisch** DaimlerChrysler AG, Germany
- F M Mazzolani** University of Naples "Federico II", Italy
- K McManis** University of New Orleans, USA
- A C Mendes** Universidade de Beira Interior, Portugal,
- R A Meric** Research Institute for Basic Sciences, Turkey
- J Mikielewicz** Polish Academy of Sciences, Poland
- N Milic-Frayling** Microsoft Research Ltd, UK
- R A W Mines** University of Liverpool, UK
- C A Mitchell** University of Sydney, Australia
- K Miura** Kajima Corporation, Japan
- A Miyamoto** Yamaguchi University, Japan
- T Miyoshi** Kobe University, Japan
- G Molinari** University of Genoa, Italy
- T B Moodie** University of Alberta, Canada
- D B Murray** Trinity College Dublin, Ireland
- G Nakhaeizadeh** DaimlerChrysler AG, Germany
- M B Neace** Mercer University, USA
- D Neculescu** University of Ottawa, Canada
- F Neumann** University of Vienna, Austria
- S-I Nishida** Saga University, Japan
- H Nisitani** Kyushu Sangyo University, Japan
- B Notaros** University of Massachusetts, USA
- P O'Donoghue** University College Dublin, Ireland
- R O O'Neill** Oak Ridge National Laboratory, USA
- M Ohkusu** Kyushu University, Japan
- G Oliveto** Università di Catania, Italy
- R Olsen** Camp Dresser & McKee Inc., USA
- E Oñate** Universitat Politècnica de Catalunya, Spain
- K Onishi** Ibaraki University, Japan
- P H Oosthuizen** Queens University, Canada
- E L Ortiz** Imperial College London, UK
- E Outa** Waseda University, Japan
- A S Papageorgiou** Rensselaer Polytechnic Institute, USA
- J Park** Seoul National University, Korea
- G Passerini** Università delle Marche, Italy
- B C Patten**, University of Georgia, USA
- G Pelosi** University of Florence, Italy
- G G Penelis**, Aristotle University of Thessaloniki, Greece
- W Perrie** Bedford Institute of Oceanography, Canada
- R Pietrabissa** Politecnico di Milano, Italy
- H Pina** Instituto Superior Técnico, Portugal
- M F Platzer** Naval Postgraduate School, USA
- D Poljak** University of Split, Croatia

- V Popov** Wessex Institute of Technology, UK
- H Power** University of Nottingham, UK
- D Prandle** Proudman Oceanographic Laboratory, UK
- M Predeleanu** University Paris VI, France
- M R I Purvis** University of Portsmouth, UK
- I S Putra** Institute of Technology Bandung, Indonesia
- Y A Pykh** Russian Academy of Sciences, Russia
- F Rachidi** EMC Group, Switzerland
- M Rahman** Dalhousie University, Canada
- K R Rajagopal** Texas A & M University, USA
- T Rang** Tallinn Technical University, Estonia
- J Rao** Case Western Reserve University, USA
- A M Reinhorn** State University of New York at Buffalo, USA
- A D Rey** McGill University, Canada
- D N Riahi** University of Illinois at Urbana-Champaign, USA
- B Ribas** Spanish National Centre for Environmental Health, Spain
- K Richter** Graz University of Technology, Austria
- S Rinaldi** Politecnico di Milano, Italy
- F Robuste** Universitat Politècnica de Catalunya, Spain
- J Roddick** Flinders University, Australia
- A C Rodrigues** Universidade Nova de Lisboa, Portugal
- F Rodrigues** Poly Institute of Porto, Portugal
- C W Roeder** University of Washington, USA
- J M Roesset** Texas A & M University, USA
- W Roetzel** Universitaet der Bundeswehr Hamburg, Germany
- V Roje** University of Split, Croatia
- R Rosset** Laboratoire d'Aerologie, France
- J L Rubio** Centro de Investigaciones sobre Desertificacion, Spain
- T J Rudolphi** Iowa State University, USA
- S Russenckuck** Magnet Group, Switzerland
- H Ryssel** Fraunhofer Institut Integrierte Schaltungen, Germany
- S G Saad** American University in Cairo, Egypt
- M Saiidi** University of Nevada-Reno, USA
- R San Jose** Technical University of Madrid, Spain
- F J Sanchez-Sesma** Instituto Mexicano del Petroleo, Mexico
- B Sarler** Nova Gorica Polytechnic, Slovenia
- S A Savidis** Technische Universitat Berlin, Germany
- A Savini** Universita de Pavia, Italy
- G Schmid** Ruhr-Universitat Bochum, Germany
- R Schmidt** RWTH Aachen, Germany
- B Scholtes** Universitaet of Kassel, Germany
- W Schreiber** University of Alabama, USA
- A P S Selvadurai** McGill University, Canada
- J J Sendra** University of Seville, Spain
- J J Sharp** Memorial University of Newfoundland, Canada
- Q Shen** Massachusetts Institute of Technology, USA
- X Shixiong** Fudan University, China
- G C Sih** Lehigh University, USA
- L C Simoes** University of Coimbra, Portugal
- A C Singhal** Arizona State University, USA
- P Skerget** University of Maribor, Slovenia
- J Sladek** Slovak Academy of Sciences, Slovakia
- V Sladek** Slovak Academy of Sciences, Slovakia
- A C M Sousa** University of New Brunswick, Canada
- H Sozer** Illinois Institute of Technology, USA
- D B Spalding** CHAM, UK
- P D Spanos** Rice University, USA
- T Speck** Albert-Ludwigs-Universitaet Freiburg, Germany
- C C Spyarakos** National Technical University of Athens, Greece
- I V Stangeeva** St Petersburg University, Russia
- J Stasiak** Technical University of Gdansk, Poland
- G E Swaters** University of Alberta, Canada
- S Syngellakis** University of Southampton, UK
- J Szymd** University of Mining and Metallurgy, Poland
- S T Tadano** Hokkaido University, Japan

**H Takemiya** Okayama University, Japan  
**I Takewaki** Kyoto University, Japan  
**C-L Tan** Carleton University, Canada  
**M Tanaka** Shinshu University, Japan  
**E Taniguchi** Kyoto University, Japan  
**S Tanimura** Aichi University of Technology, Japan  
**J L Tassoulas** University of Texas at Austin, USA  
**M A P Taylor** University of South Australia, Australia  
**A Terranova** Politecnico di Milano, Italy  
**E Tiezzi** University of Siena, Italy  
**A G Tjihuis** Technische Universiteit Eindhoven, Netherlands  
**T Tirabassi** Institute FISBAT-CNR, Italy  
**S Tkachenko** Otto-von-Guericke-University, Germany  
**N Tosaka** Nihon University, Japan  
**T Tran-Cong** University of Southern Queensland, Australia  
**R Tremblay** Ecole Polytechnique, Canada  
**I Tsukrov** University of New Hampshire, USA  
**R Turra** CINECA Interuniversity Computing Centre, Italy  
**S G Tushinski** Moscow State University, Russia  
**J-L Uso** Universitat Jaume I, Spain  
**E Van den Bulck** Katholieke Universiteit Leuven, Belgium  
**D Van den Poel** Ghent University, Belgium  
**R van der Heijden** Radboud University, Netherlands  
**R van Duin** Delft University of Technology, Netherlands  
**P Vas** University of Aberdeen, UK  
**W S Venturini** University of Sao Paulo, Brazil  
**R Verhoeven** Ghent University, Belgium  
**A Viguri** Universitat Jaume I, Spain  
**Y Villacampa Esteve** Universidad de Alicante, Spain  
**F F V Vincent** University of Bath, UK  
**S Walker** Imperial College, UK  
**G Walters** University of Exeter, UK  
**B Weiss** University of Vienna, Austria  
**H Westphal** University of Magdeburg, Germany  
**J R Whiteman** Brunel University, UK  
**Z-Y Yan** Peking University, China  
**S Yanniotis** Agricultural University of Athens, Greece  
**A Yeh** University of Hong Kong, China  
**J Yoon** Old Dominion University, USA  
**K Yoshizato** Hiroshima University, Japan  
**T X Yu** Hong Kong University of Science & Technology, Hong Kong  
**M Zador** Technical University of Budapest, Hungary  
**K Zakrzewski** Politechnika Lodzka, Poland  
**M Zamir** University of Western Ontario, Canada  
**R Zarnic** University of Ljubljana, Slovenia  
**G Zharkova** Institute of Theoretical and Applied Mechanics, Russia  
**N Zhong** Maebashi Institute of Technology, Japan  
**H G Zimmermann** Siemens AG, Germany

# **Sustainable Irrigation Management, Technologies and Policies II**

**Editors**

**Y. Villacampa Esteve**  
*University of Alicante, Spain*

**C.A. Brebbia**  
*Wessex Institute of Technology, UK*

**D. Prats Rico**  
*IWES University of Alicante, Spain*

**WIT**PRESS Southampton, Boston



**Y. Villacampa Esteve**

*University of Alicante, Spain*

**C.A. Brebbia**

*Wessex Institute of Technology, UK*

**D. Prats Rico**

*IWES Unviversity of Alicante, Spain*

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

**Computational Mechanics Inc**

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: 978-1-84564-116-0

ISSN: 1746-448X (print)

ISSN: 1743-3541 (online)

*The texts of the papers in this volume were set individually by the authors or under their supervision. Only minor corrections to the text may have been carried out by the publisher.*

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 2008

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.

## Preface

This book contains most of the papers presented at the Second International Conference on Sustainable Irrigation, Management, Technologies and Policies, held at the University of Alicante in 2008. The meeting follows the success of the first Conference which was organised in Bologna in 2006.

The objective of the Conference is to discuss ways to achieve the most efficient and equitable use of water resources used in irrigation, at the same time as ensuring their sustainability.

Over-exploitation of fresh water resources is leading to damaging long lasting environmental effects with considerable depletion of groundwater and surface water sources. The problem of contamination adds to these effects, effectively reducing the availability of clean water. The Conference also discussed how irrigation ought to be used to avoid deterioration of crops and soils.

The papers presented in this volume have been classified in the following sections: Sustainable Irrigation and Economic Instruments; Irrigation Management; Irrigation Modelling; Irrigation Systems and Planning; Re-use of Water.

The Conference was organised by the University of Alicante and the Wessex Institute of Technology and sponsored by the Institute for Water and Environmental Sciences of the University of Alicante; the Ministerio de Educación y Ciencia, España; the Instituto del Agua y de las Ciencias Ambientales; the Patronato Municipal de Turismo de Alicante; Grupo de Investigaciones Modelización de Sistemas of the University of Alicante; and the company, Consolider-Tragua. The organisers are grateful for their support.

The Editors are indebted to all contributors for their papers and to the members of the International Scientific Advisory Committee and other colleagues who helped in the selection procedure.

The Editors  
Alicante, 2008

# Contents

## **Section 1: Sustainable irrigation and economic instruments Special session organised by Henning Bjornlund**

Economic instruments and irrigation water management – a comparative study of private and district irrigators in Alberta, Canada <i>H. Bjornlund, L. Nicol &amp; K. Klein</i> .....	3
Application of economic instruments, tradable licenses and good governance for sustainable water conservation <i>W. L. Nieuwoudt &amp; G. R. Backeberg</i> .....	15
Sustainable irrigation and the role of economic instruments and their supporting institutions <i>K. W. Easter</i> .....	25
Irrigation and water security: the role of economic instruments and governance <i>R. C. de Loë &amp; H. Bjornlund</i> .....	35
Irrigation to meet growing food demand with climate change, salinity and water trade <i>J. Connor, K. Schwabe &amp; D. King</i> .....	43
Irrigated agriculture in an era of high energy prices <i>K. Schoengold, T. Sproul &amp; D. Zilberman</i> .....	53
Factors influencing water allocation and entitlement prices in the Greater Goulburn area of Australia <i>S. Wheeler, H. Bjornlund, M. Shanahan &amp; A. Zuo</i> .....	63
Sustainability of groundwater resources in India: challenges and scope for economic instruments and policy <i>S. Msangi</i> .....	73

Water options contracts to facilitate intersectoral trade <i>J. Byrnes, L. Crase &amp; B. Dollery</i> .....	83
--	----

**Section 2: Irrigation management**

Why do two-thirds of Australian irrigators use no objective irrigation scheduling methods? <i>K. D. Montagu &amp; R. J. Stirzaker</i> .....	95
--	----

Salt tolerance classification of winter cereal varieties according to grain yield performance and water use efficiency <i>N. Katerji, M. Mastrorilli, M. M. Nachit, J. W. van Hoorn, A. Hamdy, T. Oweis, O. Abdalla &amp; S. Grando</i> .....	105
--	-----

Midsummer deficit irrigation of alfalfa as a strategy for providing water for water-short areas <i>B. Hanson, K. Bali, S. Orloff, H. Carlson, B. Sanden &amp; D. Putnam</i> .....	115
--	-----

Yield and canopy response of chickpea ( <i>Cicer arietinum</i> L.) to different irrigation regimes <i>M. Rinaldi, A. V. Vonella, P. Soldo, G. Debiase &amp; P. Garofalo</i> .....	123
--	-----

Using individual farm management plans to manage land use change effects associated with new irrigation development, Canterbury, New Zealand <i>B. Ellwood, L. Mead, C. Mulcock &amp; S. Dawson</i> .....	133
--	-----

Monitoring irrigation water, analysis and database maintenance for Nahr Ibrahim <i>J. Harb &amp; F. Comair</i> .....	143
---	-----

Groundwater history and trends in Kuwait <i>E. H. AlAli</i> .....	153
--	-----

**Section 3: Irrigation modelling**

Applicability of a 4 inputs ANN model for ETo prediction in coastal and inland locations <i>P. Martí, A. Royuela, J. Manzano &amp; G. Palau</i> .....	167
--	-----

Modelling irrigation strategies to minimize deep drainage for two different climatic regions of Canada <i>G. Parkin &amp; S. Wang</i> .....	177
--	-----

Adaptive scheduling in deficit irrigation – a model-data fusion approach  
*M. M. Holloway-Phillips, W. Peng, D. Smith & A. Terhorst*..... 187

Hydrological water balance modelling for assessing productivity and irrigation planning  
*M. B. Nagdeve, G. K. Ramteke & P. A. Kamble* ..... 201

#### **Section 4: Irrigation systems and planning**

An integrated framework for sustainable agriculture land use and production practices  
*T. Leitão, M. C. Cunha, I. Laranjeira, J. P. Lobo-Ferreira & E. Paralta* ..... 213

Sustainable irrigation in areas with an arid and semi-arid climate in the province of Alicante  
*C. J. Sánchez-Rubio* ..... 223

Predicting environmental sustainability for proposed irrigation schemes  
*N. Norton, S. Dawson, B. Ellwood & L. Mead* ..... 233

A framework for evaluating the consumption patterns and environmental impacts of irrigation methods: a case study from South-Eastern Australia  
*T. M. Jackson, S. Khan & M. M. Hafeez*..... 245

Computer application for optimization of turn assignment on a tree-structured irrigation network  
*A. Almiñana, L. F. Escudero, M. Landete, J. F. Monge, A. Rabasa & J. Sánchez-Soriano* ..... 255

Cost-benefit analysis of different solutions for sustainable irrigation in Fucino Plain (Italy)  
*E. Frank, A. Gallina, M. Baldacci & M. Miolo* ..... 263

Determining the climatologically suitable areas for wheat production using MODIS-NDVI in Mashhad, Iran  
*S. H. Sanaeinejad, S. M. Hasheminiya & S. Khojasteh* ..... 273

Mass mixing approach for assessing effects of irrigation on water quality  
*I. Fraser, S. Douglass, B. Ellwood & N. Norton*..... 281

Designs for the future: the role of sustainable irrigation in northern Australia <i>J. K. Camkin, K. L. Bristow, C. Petheram, Z. Paydar, F. J. Cook &amp; J. Story</i> .....	293
Definition of ecological flows downstream of dams located in the South of Portugal: a new method <i>M. M. Portela</i> .....	303
Study to improve the effective use of water in the Stompdrift-Kamanassie water scheme in the Oudtshoorn area in the Western Cape Province of South Africa <i>A. S. Roux</i> .....	313
 <b>Section 5: Re-use of water</b>	
Economic analysis of water reuse in Spain <i>J. M. Moreno &amp; L. D. Chabalina</i> .....	325
Treated wastewater reuse for green space irrigation in arid and semiarid regions <i>G. Badalians Gholikandi, M. Lashgari &amp; P. Kiumarsi</i> .....	335
Integrating alternative water sources in urbanised environments <i>M. Schwecke, B. Simmons, B. Maheshwari &amp; G. Ramsay</i> .....	351
Filter and emitter performance of micro-irrigation systems using secondary and tertiary effluents <i>M. Duran-Ros, J. Puig-Bargués, J. Barragán, G. Arbat &amp; F. Ramírez de Cartagena</i> .....	361
The use of treated effluent for agricultural irrigation: current status in the Bottelary catchment (South Africa) <i>N. Z. Jovanovic</i> .....	371
 <b>Author Index</b> .....	 381