Book of abstracts of the INTERNATIONAL WORKSHOP on Nonconventional Water for Irrigation and Environment Protection

Date: 5th September 2024 (AEST 10:30 – 14:30H)

At the 9th Asian Regional Conference on Irrigation & Drainage and the ICID 75th IEC Meeting, 1-7 September 2024, ICC Sydney, Darling Harbour, NSW, Australia

Workshop overview:

Water quantity and quality have been identified by the World Economic Forum as the biggest threat facing the world over the next few decades. Climate change and the ever-growing global need is making this essential natural resource increasingly scarce. Water is critical to everyone on this planet, whether for personal use, growing crops, animal husbandry, manufacturing products, and/or washing clothes. United Nation's SDG-6 aims to deliver clean and safe water to all by 2030. Recent estimates warn that this is not on track. At the same time, there is a large volume of nonconventional water being generated every day, which can only grow with increasing urbanization and economic growth. Nonconventional water includes - treated sewage water, drainage water and non-fresh water (i.e., with a relatively high salt, nutrients, organic matter content and other contaminants). There are many international guidelines outlining safe use of nonconventional water demonstrating its acceptance as irrigation water for wider food production including greenfield development. For achieving global food security, there is a greater need for resiliency, efficiency, and smart management of irrigated agriculture with no harm to our environment.

High-value horticultural crops, including fruits, vegetables, flowers, aromatic plants, and herbs, are key components of agricultural development and economic progress in many countries. For example, in Australia the horticulture sector alone generates over $15 billion in value and employs over 60,000 people.

This workshop is to bring end users, researchers, academicians, students and policy makers together on a global platform to exchange knowledge and networking on how to best use nonconventional water for irrigation to achieve a closed loop future for water, food security and a healthy environment.

Workshop Themes:

Nonconventional irrigation's role in delivering economically viable food security and sustainable urban spaces in an increasingly unpredictable climate condition.

Governance – identifying and addressing structural and policy impediments to the adoption of nonconventional irrigation practices.

Artificial Intelligence (AI) and Machine Learning (ML) for better decision making in wastewater irrigated agriculture.

Environmental, economic, social and cultural aspects of nonconventional irrigation.

Workshop Program:

Session 1	**Dr. Tapas Biswas, ANU, Australia (Workshop Chair)**
10:30 – 10:35	Welcome and introduction (Chair)
10:35 – 10:45	Michael Cutting, Landscape SA, Australia – Setting the workshop scene
10:45 – 11:00	Dr Wenyoung Wu, China Inst of Water Res & Hydropower Res, Beijing - Distribution, transport and health risks of nonylphenol and bisphenol-a in the soil-corn systems with reclaimed water irrigation
11:00 – 11:15	Dr Michael Williams, CSIRO Adelaide, Australia - Crop uptake of contaminants from wastewater reuse
11:15 – 11:30	Prof. Tasuku Kato, Tokyo Univ of Agril & Tech, Japan - Circulate irrigation scheme for paddy fields to conserve water environment and to increase water use efficiency – a case study in Japan
11:30 – 11:45	Dr Shalini Tandon, CSIR-NEERI, India - Use of Municipal Wastewater for Irrigation Purpose in India– Health perspective
11:45 – 12:00	Dr Tapas Biswas & Klaus Joehnk, ANU & CSIRO Australia - AquaWatch EO tools for nonconventional water resources
12:00 – 13:00	Lunch Break
Session 2	**Dr Gouranga Kar, CRIJAF, India (Co-chair)**
13:00 – 13:15	Dr Gouranga Kar, Director, CRIJAF, India - Nonconventional water use for enhancing agricultural productivity: A case study in India
13:15 –13:30	Dr Mohammed Mainuddin, CSIRO Canberra, Australia - Saline water agriculture in coastal Bangladesh
13:30 – 13:45	Peter Reeve, One Basin CRC /Adelaide Uni– Opportunities and challenges identifying, sourcing and treating brackish groundwater
13:45 – 14:00	Michael Cutting & Tapas Biswas, Australia - Transition of saline water irrigated vineyard to freshwater irrigation in South Australia
14:00 – 14:15	Open floor discussion (Prof. Tasuku Kato, Lead)
14:15 – 14:30	Concluding remarks, thanks and close (Chair)

Setting the scene: Nonconventional Water for Irrigation and Environment Protection

Michael Cutting*

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Murraylands and Riverland Landscape Board, Australia

Key words: water, irrigation, salinity, alternative, climate

Abstract:
Water is critical to everyone on this planet, whether for personal use, growing crops, manufacturing products and day-to-day hygiene. United Nation's SDG-6 aims to deliver clean and safe water to all by 2030. Recent estimates warn that this is not on track. At the same time, there is a large volume of non-conventional water being generated every day, which can only grow with increasing urbanization and economic growth.

Climate variability and climate change will continue to place significant pressure on the availability and quality of traditional surface water sources and therefore strong drivers will persist to pursue opportunities to adopt non-conventional and climate independent water sources.

To highlight the potential opportunities in the Murray-Darling Basin region of Australia it is estimated that the sum of the sustainable brackish groundwater yield in NSW, SA, QLD and VIC is over 2,000 GL/year yet only a small fraction of this water is currently utilised. We will hear more about how this very opportunity is being investigated further in this workshop. Likewise significant volumes of municipal wastewater are generated daily, and the volumes will only continue to grow with increasing levels of urbanization. The workshop will address some of the key challenges and opportunities to ensure that we can deliver economically viable food security and sustainable urban spaces in an increasingly unpredictable climate.

Presenter biography:
Michael Cutting is the Team Leader – Land and Water Management with the Murraylands and Riverland Landscape Board based at Murray Bridge, South Australia. In this role, Michael has oversight of the management and delivery of natural resource management programs and projects, with a particular focus on sustainable water use across the region. Michael has been actively involved in the implementation of on-farm projects in the Lower Murray region of South Australia that seek to address current and future water quality and availability challenges and opportunities which he will provide an overview of today.

Distribution, transport and health risks of nonylphenol and bisphenol-a in the soil-corn systems with reclaimed water irrigation

Tingting JIANG [1], Yaqi HU[2], Meng MA[2], Wenyong WU*[1,2]

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Key words: Reclaimed water, corn, nonylphenol, bisphenol-a, health risks

Abstract:
The objectives of this experiment were to study the accumulation and transport patterns of nonylphenol and bisphenol-a in the soil-maize system, and to evaluate the effects of nonylphenol and bisphenol-a on root traits and maize yield, as well as the health risks. A field pot trial was conducted with different moisture treatments at 60 FC%, 70 FC%, and 80 FC%, respectively. The effects of varying irrigation years on bisphenol-a and nonylphenol accumulation were simulated by adding different series of bisphenol-a and nonylphenol into the soil. The concentration of bisphenol-a were 0.0450-0.1575, 0.0325-0.1175, and 0.0196-0.0289 mg/kg in roots, stems, and leaves of maize, respectively, and the concentration ranges of nonylphenol in roots, stems, and leaves of maize were 0.3344-1.1344 mg/kg, 0.1974-0.7127 mg/kg, and 0.2081-0.3793 mg/kg. The presence of bisphenol-a and nonylphenol was not detected in seeds. The concentration of bisphenol-a was higher in roots than in stems and leaves and in stems than in leaves. The accumulation of bisphenol-a and nonylphenol in roots and stems was more pronounced with increasing initial concentration. However, the highest non-cancer risk quotients for bisphenol-a and bisphenol exposure via both soil pathways were in the order of 10^{-5}-10^{-4}, which is below acceptable and safe levels. Human exposure pathways to contaminants are diverse, and thus require more data on the potential risks of cumulative phenomena though multiple pathways.

Presenter biography:
Dr Wenyong Wu is a senior researcher with the China Institute of Water Resources and Hydropower Research, Beijing, China. He is also the chair of the NCWREP-WG of the ICID.

Crop uptake of contaminants from wastewater reuse

Michael Williams*

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Senio Research Scientist, CSIRO Environment, Adelaide, SA, Australia

Key words: Wastewater, contaminants, PFAS, antimicrobial resistance, crop uptake

Abstract:
This aims of this project were to detect and quantify a broad range of potential organic, inorganic and biological contaminants in two classes (A and B) of recycled wastewater in Victoria used for crop irrigation and their contribution to accumulation in soils and plant tissues, relative to sites not using recycled wastewater for irrigation. Of the more than 1000 organic chemicals targeted for quantitative analysis (including pesticides, pharmaceuticals and personal care products, industrial chemicals and PFAS) more than 65 were measured in water, 160 in soil and 100 in plant tissues. Also, genes related to antimicrobial resistance (AMR) were detected in water (7), soil (6) and plant tissue (2). With the exception of PPCPs and EDCs, the majority of organic chemicals measured were found in both recycled wastewater and irrigation water collected from references sites. There were no measurable impacts on plant condition and there were no apparent trends that would indicate a greater contribution of contaminants from recycled wastewater are available for uptake by irrigated crops.

Presenter biography:
Dr Mike Williams is a senior research scientist in the CSIRO Environment (Industrial Environments) research program. His research experience involves assessment of the fate and effects of trace organic contaminants, including microplastics, in aquatic and terrestrial environments. He has the ability to integrate assessment of fate and effects to determine the potential ecological impacts of trace organic contaminants. Dr Williams has a demonstrated capacity to work and interact with others across a range of disciplinary backgrounds and has recently been focussed on working with regulators and industry in understanding the potential impacts of chemical contaminants in waste.

Circulate irrigation scheme for paddy fields to conserve water environment and to increase water use efficiency – a case Study in Japan

Tasuku KATO*[1] and Fumi Okura[2]

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Key words: Circulation Irrigation, Water quality, Paddy fields,

Abstract:

Recycling use of paddy fields drainage is expected to contribute to improve water use efficiency through reduction of blue water consumption. At same time, highly repeated drainage water use would accumulate pollution in irrigation water. It means that recycling of drainage water use has trade-off between water use efficiency and environmental conservation. We would like to review Japanese case studies on recycling use of paddy fields drainage toward sustainable water use as water saving technology.

Three case studies are collected, Biwa Lake paddy fields block, Kasumigaura lake block and Inbanuma block. In those blocks, the priority target of recycling use of paddy fields drainage is water environment. Because these blocks are located with neighbor of enclosed water bodies and eutrophication of the water bodies is a quite serious issue. Especially, high nutrients concentration is observed in these case studies, some counter measures were taken to reduce nitrogen loads. At same time, in paddy fields, denitrification process is well known, so, inundated condition is preferred to reduce nitrogen. However, in water saving aspect, over irrigation could be expected through the activities. Then, further research is expected to harmonize water use efficiency and water quality control through recycling use of drainage water.

Presenter biography:

Professor Kato is with the Tokyo University of Agriculture and Technology (TUAT), and vice dean of Ph.D course in United Graduate School of Agricultural Science in TUAT. Graduated from the University of Tokyo in 1998. The research topic is irrigation & drainage from paddy fields, water environment and international agricultural development.

Use of Municipal Wastewater for Irrigation Purpose – Health perspective

Shalini A Tandon*

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Key words: Untreated waste water, Antimicrobial resistance, Public health, Global policy

Abstract:
In the given scenario of climate change, one possible step that can be adopted to counter shortage of water for agricultural purpose could be the diversion of used domestic water after its proper treatment. Approximately, 80 % of water which is consumed at the domestic level is discharged as waste water and the waste water treatment facilities (WWTF) should ideally provide for its complete treatment. This ideal situation may not exist in developing countries leading to discharge of partially treated or untreated waste water. There are discharge standards (of selected parameters) which should be met before waste water is discharged into the environment including land application. Besides these selected parameters, there are biological components which could do serious harm to public health. The biological components include a plethora of pathogenic microbes which include those which are resistant to antimicrobials. Already the agricultural use of water from fresh water sources having resistant microbes and genes from WWTF is a route to the spread of antimicrobial resistance. Hence, the direct use of untreated or improperly treated municipal waste water for irrigation purposes could have adverse public health implications.
Study on antibiotic resistance in waste water: Indian Scenario envisaged surveillance of sewage carrying drains in four major cities in India and demonstrated the presence of antibiotic-resistant bacteria (ARB) exhibiting resistance to 7 classes of antibiotics. High Antibiotic Resistance Index (ARI) was observed in major cities. Such a situation could be prevalent in other parts of the world as well and remain unnoticed. Before using municipal waste water for the purpose of food production, proper treatment of waste water is needed to avoid adverse implications on human health and at the global policy level, stringent standards including these biological parameters needs to be adopted.

Presenter biography:
Dr Shalini Tandon is a Principal Scientist with CSIR-NEERI, India (Council of Scientific and Industrial Research -National Environmental Engineering Research Institute) under the Ministry of Science and Technology. She has published 45 papers in refereed journals and several technical reports on research/consultancy conducted for government agencies and private industries.

AquaWatch EO tools for nonconventional water resources quality monitoring and forecasting

Tapas K Biswas*[1,2] and Klaus D Joehnk*[2]

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Key words: Poor quality water, climate change, AquaWatch, monitoring, forecasting, environment protection

Abstract:
Water quantity and quality have been identified by the World Economic Forum as the biggest threat humanity is facing over the next few decades. Climate change and the ever-growing global demand for freshwater is making this vital resource increasingly scarce and fiercely competitive. Water is critical to everyone but today, 2.2 billion people lack access to safely managed drinking water. United Nation's SDG-6 aims to deliver clean and safe water to all by 2030. Recent estimates warn that this is not on track. At the same time, there is a large volume of nonconventional water being generated every day, which can only grow bigger with increasing urbanization and economic growth. Currently, 80 per cent of global wastewater flows back into the ecosystem before treatment or reused.

Sustainable management of water resources is essential for unlocking economic growth and productivity. Water shortages destabilize food security and the incomes of marginal farmers. Sustainable use of nonconventional water will not only strengthen national economies, but also make the agriculture and food sectors more resilient to rainfall variability (droughts) and able to fulfil the needs of growing population. Now more than ever the world needs to transform the way it manages its nonconventional water resources and delivers benefit to people, agriculture and environment and industries.

This presentation will discuss the importance of 3M (measure, monitor and manage) with special reference to the AquaWatch earth observation and artificial intelligence system in monitoring and managing nonconventional water resources sustainably while complying stringent environmental protection requirement. Traditional grab sampling and local water quality sensors provide valuable data, but they are limited to a specific area/water body. By integrating satellite sensor data, AquaWatch's data analytics and visualisation system will provide accurate monitoring and forecasting of water quality to support water management in a larger spatial context.

Bio of presenters:
Dr. Tapas Biswas is a Senior Fellow with the Australian National University and a Senior Scientist in the CSIRO Aquatic Remote Sensing Team with 35 years of experience in research, teaching, and consultancy in water resources management. He has conducted research and taught in several countries, earning national and international awards and delivering significant societal and environmental outcomes. Dr Biswas's current research focuses on river basin water quality risk assessment, inland water quality remote sensing, forecasting and management, water quality impacts from climate change and bushfires. Dr. Biswas is an associate editor of the Irrigation & Drainage journal (Wiley).

Dr Klaus Joehnk is a lead scientist in the field of water quality modelling and holds the position of Principal Research Scientist at CSIRO Environment business unit. With over 25 years of experience in Europe and Australia, he specialises in hydrodynamic and water quality modelling of lakes and rivers. Dr. Joehnk is the work package lead for Modelling and Forecasting of Water Quality within CSIRO AquaWatch Australia. He has over 50 publications in International Journals and Conference Proceedings. He is a committee member of the Australian Water Association/ACT branch.

Nonconventional water use for enhancing agricultural water productivity-A case study in India

Gouranga Kar*

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Key words: Farming system, water productivity, conjunctive use, micro-irrigation

Abstract:
Agricultural water management is a prime challenge for enhancing agricultural production in India. The most important task is to improve water productivity at basin, farm and individual field level under both rainfed and irrigated conditions and now major challenges would be to increase the marketable produce from each unit of water used, to reduce all outflows viz., runoff, seepage and percolation, including evaporative outflows, and to increase the effective use of rainfall, stored water, and through use of non-conventional water of marginal quality.

According to a study, India receives 400 million hectare meters (mham) of rain and snowfall. There are opportunities for rainwater harvesting interventions in regions where rainfall is higher than 600 mm. The effectiveness of rainwater harvesting on a watershed basis has been studied based on several on-site factors, such as landscape topography, soil surface texture and structure, soil nutrient availability status, and the depth of the cultivated area.

In order to address the twin difficulties of a lack of water and increase crop output, micro-irrigation techniques like drip and sprinkler irrigation, drip-fertigation have been standardized which becomes now very popular, especially among progressive farmers. Considerable work has been done for livelihood improvement of tribal farmers through water management intervention. In saline groundwater areas, conjunctive use practices can ensure judicious use of canal water, which is available in limited quantities along with saline groundwater. Dilution or mixing of available poor-quality water with good water in such proportions that the result safe limit of water quality. Attempt was also made to reclaim seasonal flood affected areas through on-dyke agro-forestry based integrated farming system after land modification.

To undertake challenges relating to water scarcity and to develop appropriate strategies for the efficient use of non-conventional water resources, it requires further international collaboration in this sector.

Presenter biography:
Dr. Gouranga Kar is presently the Director of ICAR-Central Research Institute for Jute and Allied Fibres (ICAR-CRIJAF), Kolkata, India. He has done pioneering contribution in quantification of on-farm water footprint in India and implemented many national/international projects in different agro-climatic regions of the country. Dr Kar's research areas include use of remote sensing in water and watershed management, crop growth modelling, climate change research, mitigation and adaptation, land use planning and crop diversification, natural fibre based self-reliant farming, on-dyke agro-forestry for coastal agro-ecosystem and groundwater recharge structures. Presently he also serves as a Hub Director of the IARI-Kolkata Education Hub offering graduate, post graduate, PhD program in agricultural sciences. He has published more than 250 research papers, review paper and book chapters of immense academic as well as practical importance.

Growing dry season crops with limited irrigation in the salt-affected coastal zone of the Ganges delta

Mohammed Mainuddin*

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Principal Research Scientist, CSIRO Environment, Canberra, ACT, Australia.

Key words: Salinity, cropping, dry season, Bangladesh, West Bengal

Abstract:
The salt-affected coastal zone of the Ganges Delta in Bangladesh and West Bengal, India is home to 20 million people who depend on agriculture for their livelihoods. There is a high incidence of poverty and poor food security in the region. Traditionally, farms produce low-yielding local rice under rainfed conditions in the wet season. In the dry season, most agricultural land remains fallow due to a late rice harvest, prolonged waterlogging and the perceived lack of fresh water for irrigation.

CSIRO along with partner organizations from Australia, Bangladesh and India has been working since 2015 to sustainably increase cropping intensity and productivity in that region particularly in the dry season through integrated soil, water and crop management.

The trans-disciplinary project focused on analyzing climate patterns to assess agroclimatic potential and developed models to understand salt and water dynamics. Field experiments and crop production modeling were conducted to study soil, plant, waterlogging, and salinity interactions. The project identified salt-tolerant crop varieties, optimal sowing times, and best agronomic and water management practices along with their socio-economic impacts.

To cultivate crops during the dry season several strategies such as drip irrigation, conjunctive use of saline and non-saline water, and pitcher and bottle irrigation for high-value vegetables were evaluated. We also used straw mulch to conserve moisture, sow crops early to take advantage of post-monsoon residual soil moisture, practice zero-tillage cultivation, and organize communities to store fresh water in canals and ponds for dry season irrigation.

The project has identified suitable and profitable cropping patterns that enhance cropping intensification. Crops like sunflower, maize, zero-tillage potato, garlic, onion, pumpkin, watermelon, and spinach have proven well-suited for dry season cultivation which are increasingly being taken up by the farmers. There is evidence of increasing crop productivity and intensity, enabling farmers to boost their incomes and livelihoods.

Presenter biography:
Dr Mohammed Mainuddin is a Principal Research Scientist and Leader of the 'Water and Society Team' with the Water Security Program of CSIRO Environment in Canberra, Australia. Prior to that he worked with International Water Management Institute (IWMI), Sri Lanka and Asian Institute of Technology (AIT), Thailand. He has over 32 years of research experience in integrated water resources management and modelling for river basins, coastal water and salinity management, irrigation systems performance analysis, agricultural productivity and food security analysis, socio-economic and livelihood issues related to water use, and impact of climate change on water availability, agricultural productivity, and food security.

Opportunities and challenges identifying, sourcing and treating brackish groundwater

Peter Reeve*[1], Julien Anese[2], Ben Mullins[3], Ilka Wallis[3], Okke Batelaan[3], Howard Fallowfield[3], Holger Maier[1], Seth Westra[1], Kym Walton[4], Enys Watt[5], Darren Graetz[6] and Michael Leonard[1]

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Key words: desalination; brackish groundwater; Murray-Darling Basin; agriculture.

Abstract:
The Murray-Darling Basin (MDB), Australia's largest agricultural region, faces significant water management challenges, particularly during droughts when surface water becomes scarce and reliance on groundwater increases. This project explores the potential of desalination technologies, particularly reverse osmosis, to convert brackish groundwater into usable water for agriculture. While costs can be high, desalination could enhance water resilience in the MDB, particularly for high-value crops and controlled environments.

A demonstration site at Century Orchards in South Australia's Riverland is central to this project, assessing the feasibility of desalination under MDB-relevant conditions. The site uses aquifer discharge for brine disposal, a novel method for the region. Alongside practical trials, economic modelling and stakeholder engagement will assist in the identification of barriers and opportunities for broader adoption. Key outcomes include developing an online cost calculator to assist potential users, raising awareness of brine management techniques, and exploring where desalination could be utilised in the MDB.

The project will examine desalination's potential role in enhancing productivity, providing drought resilience, and serving as an alternative water source for MDB communities, including First Nations groups. Additionally, it will explore how renewable technologies can support the environmental sustainability of desalination.

Barriers such as high brine management costs, regulatory complexities, and limited access to information and expertise are explored. For instance, aquifer injection, though cheaper than evaporation ponds, requires detailed hydrogeological data and careful planning. Despite these challenges, there is significant potential to expand the use of desalinated brackish groundwater in the MDB. By addressing these barriers through improved data, technological advancements, and targeted case studies, the project aims to enhance the sustainable management of water resources, contributing to greater agricultural resilience in a changing climate.

Presenter biography:
Peter is an environmental scientist who aims to use applied research to better understand interactions between water, health, and the environment. He is currently working as a Postdoctoral Research Fellow for the One Basin CRC at the University of Adelaide on the project entitled 'opportunities and risks associated with identifying, sourcing and treating brackish groundwater.

Transition of a saline water irrigated vineyard to freshwater irrigation in South Australia

Michael D. Cutting*[1], Tony Hoare[2], Tapas K. Biswas[3]

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Key words: Rootzone salinity, vineyards, saline water, millennium drought, SoluSampler, leaching

Abstract:

Water quality and quantity deteriorated rapidly in the Lower Murray/Lakes region of South Australia with the onset of millennium drought in early 2000's. During this period, significant investment occurred to better understand and manage rootzone salinity within high value horticultural crops in South Australia. Vineyard operators in the Finniss/Currency Creek region had always been conscious of the need to manage rootzone salinity accumulation however have traditionally relied on reactive monitoring techniques that didn't necessarily encourage adaptive management solutions to be implemented. This study summarises the key findings generated through a vineyard study pre-, during and post-the millennium drought in South Australia and highlights how deteriorating water quantity and quality impacted rootzone salinity build up and the adaptation of farm practices to manage the salinity threat.

During Phase 1 of the study when active irrigation was applied rootzone salinity levels exceeding 10dS/m were observed and on-going monitoring has shown that several seasons of winter rainfall was required to 'leach' the high levels of residual salt from the rootzone. The ability to extract solution and monitor rootzone salinity in the field allowed decisions to be made with far greater confidence. The study has also highlighted the value of winter rainfall in leaching accumulated salts from the rootzone and the ability to maximise the effectiveness of leaching programs.

Post the millennium drought significant investment in new water supply infrastructure to service key irrigation areas in this region eased the pressures. However, valuable lessons were learned and that can be used to inform the future use of more brackish water sources as an alternative to traditional freshwater water used for irrigation. This study reinforced the importance of implementing an active monitoring program to support informed decision making and encourage adaptive management solutions to support the adoption of long-term sustainable practices.

Presenter biography:

See page 3.