

ROUTLEDGE SPECIAL ISSUES ON WATER POLICY AND GOVERNANCE

Global Water Resources

FESTSCHRIFT IN HONOUR OF ASIT K. BISWAS

Edited by
Cecilia Tortajada and Eduardo Araral

 **IWP** INSTITUTE *of* WATER POLICY



Global Water Resources

This is a Festschrift in honour of Professor Asit K. Biswas, for his manifold contributions to water resources policy and management and his extensive efforts over six decades to generate, synthesize, apply, and disseminate knowledge at national and global levels.

Global Water Resources: Festschrift in Honour of Asit K. Biswas includes invited contributions on global water issues from 23 globally renowned leaders in the public and private sectors, as well as academia, who have made significant contributions to the field of water resources policy, management, development, and governance. The vision and expertise of this distinguished group of experts provides a unique focus on unfolding water issues and their bearing on world development.

This book will be of great value to scholars, students, and policymakers interested in water resource governance, sustainable development, and climate change.

The chapters in this book were originally published as a special issue of the *International Journal of Water Resources Development*.

Cecilia Tortajada is Professor at the School of Interdisciplinary Studies, College of Social Sciences, University of Glasgow. She has been an advisor to major international institutions like FAO, UNDP, JICA, ADB, OECD, IDRC and GIZ, and has worked in numerous countries in Africa, Asia, North and South America and Europe on water and natural resources management and environment policies. She is a member of the OECD Initiative on Water Governance and recipient of the prestigious Crystal Drop Award of the International Water Resources Association.

Eduardo Araral is Associate Professor at the Lee Kuan Yew School of Public Policy, National University of Singapore. He is the Co-Director of the Institute of Water Policy, Vice Chairman of the Asia Pacific Water Forum and Associate Editor of the Oxford University Press book series on water governance.

Routledge Special Issues on Water Policy and Governance

Edited by:

Cecilia Tortajada (IJWRD) – Institute of Water Policy, Lee Kuan Yew School of Public Policy, NUS, Singapore

James Nickum (WI) – International Water Resources Association, France

Most of the world's water problems, and their solutions, are directly related to policies and governance, both specific to water and in general. Two of the world's leading journals in this area, the *International Journal of Water Resources Development* and *Water International* (the official journal of the International Water Resources Association), contribute to this special issues series, aimed at disseminating new knowledge on the policy and governance of water resources to a very broad and diverse readership all over the world. The series should be of direct interest to all policy makers, professionals and lay readers concerned with obtaining the latest perspectives on addressing the world's many water issues.

Legal Perspectives on Bridging Science and Policy

Edited by Mara Tignino, Raya Marina Stephan, Renée Martin-Nagle and Owen McIntyre

Virtual Water

Implications for Agriculture and Trade

Edited by Chittaranjan Ray, David McInnes and Matthew R. Sanderson

Flood Resilience of Private Properties

Edited by Thomas Hartmann, Willemijn van Doorn-Hoekveld, Helena F.M.W. van Rijswijk and Tejo Spit

A River Flows Through It

A Comparative Study of Transboundary Water Disputes and Cooperation in Asia

Edited by Selina Ho

Putting Water Security to Work

Addressing Global Sustainable Development Challenges

Edited by Chad Staddon and Christopher A. Scott

Global Water Resources

Festschrift in Honour of Asit K. Biswas

Edited by Cecilia Tortajada and Eduardo Araral

For more information about this series, please visit: <https://www.routledge.com/series/WATER>

Global Water Resources

Festschrift in Honour of Asit K. Biswas

Edited by

Cecilia Tortajada and Eduardo Araral

First published 2022
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN

and by Routledge
605 Third Avenue, New York, NY 10158

Routledge is an imprint of the Taylor & Francis Group, an informa business

Foreword, Introduction, Chapters 1–4, 6–13, 15, 17, 18 and 20–22 © 2022 Taylor & Francis
Chapter 5 © 2019 International Centre for Integrated Mountain Development.

Originally published as Open Access.

Chapter 14 © 2020 Malin Falkenmark. Originally published as Open Access.

Chapter 16 © 2020 Taikan Oki and Rose E. Quirocho. Originally published as Open Access.

Chapter 19 © 2019 R. Quentin Grafton and John Williams. Originally published as Open Access.

With the exception of Chapters 5, 14, 16 and 19, no part of this book may be reprinted or reproduced or utilised in any form or by any electronic, mechanical, or other means, now known or hereafter invented, including photocopying and recording, or in any information storage or retrieval system, without permission in writing from the publishers. For details on the rights for Chapters 5, 14, 16 and 19, please see the chapters' Open Access footnotes.

Trademark notice: Product or corporate names may be trademarks or registered trademarks, and are used only for identification and explanation without intent to infringe.

British Library Cataloguing-in-Publication Data

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

ISBN13: 978-1-032-01662-7 (hbk)

ISBN13: 978-1-032-01664-1 (pbk)

ISBN13: 978-1-003-17949-8 (ebk)

DOI: 10.4324/9781003179498

Typeset in Myriad Pro
by codeMantra

Publisher's Note

The publisher accepts responsibility for any inconsistencies that may have arisen during the conversion of this book from journal articles to book chapters, namely the inclusion of journal terminology.

Disclaimer

Every effort has been made to contact copyright holders for their permission to reprint material in this book. The publishers would be grateful to hear from any copyright holder who is not here acknowledged and will undertake to rectify any errors or omissions in future editions of this book.

Contents

<i>Citation Information</i>	vii
<i>Notes on Contributors</i>	xi
 Foreword <i>Masagos Zulkifli</i>	 1
 Introduction: Festschrift <i>Cecilia Tortajada and Eduardo Araral</i>	 4
1 A decade of work on water governance at the OECD: what have we learnt? <i>Angel Gurría</i>	7
2 The knowledge economy in the twenty-first century: a modest proposal <i>Annie Callanan</i>	13
3 Scotland: a world-leading Hydro Nation <i>Anton Muscatelli, Erin McKee and Sean McGivern</i>	17
4 Nestlé's corporate water strategy over time: a backward- and forward- looking view <i>Paul Bulcke, Samuel Vionnet, Christian Vousvouras and Ghislaine Weder</i>	23
5 Scarcity of water or scarcity of management? <i>David Molden</i>	36
6 Singapore's water challenges past to present <i>Peter Joo Hee Ng and Celine Teo</i>	47
7 Facing the challenge of extreme climate: the case of Metropolitan Sao Paulo <i>Benedito P.F. Braga and J. Kelman</i>	56
8 China's achievements of water governance over the past seven decades <i>Shaofeng Jia and Wenbin Zhu</i>	70
9 Some reflections on water for residential uses in developed countries <i>Francisco González-Gómez, Miguel Á. García-Rubio and Jorge Guardiola</i>	89

10	Can water professionals do more? <i>Michael Rouse</i>	103
11	Reflections on flood control in Japan and recommendations for developing countries <i>Yutaka Takahasi, Kimio Takeya, Miki Inaoka, Wataru Ono and Kaoru Sasaoka</i>	116
12	A retrospective analysis of Laos's Nam Theun 2 Dam <i>Thayer Scudder</i>	129
13	What I learned from Asit Biswas about transboundary water, ethics, mentoring and, in general, how to be a better human being <i>Aaron T. Wolf</i>	149
14	Water resilience and human life support - global outlook for the next half century <i>Malin Falkenmark</i>	155
15	Adaptive and sustainable water management: from improved conceptual foundations to transformative change <i>Claudia Pahl-Wostl</i>	175
16	Economically challenged and water scarce: identification of global populations most vulnerable to water crises <i>Taikan Oki and Rose E. Quiocho</i>	194
17	The status of the UN Watercourses Convention: does it still hold water? <i>Gabriel Eckstein</i>	207
18	Australian water decision making: are politicians performing? <i>James Horne</i>	240
19	Rent-seeking behaviour and regulatory capture in the Murray-Darling Basin, Australia <i>R. Quentin Grafton and John Williams</i>	262
20	Quenching the thirst of rapidly growing and water-insecure cities in sub-Saharan Africa <i>Madiodio Niasse and Olli Varis</i>	283
21	Sustainability of water and energy use for food production based on optimal allocation of agricultural irrigation water <i>Mo Li and Vijay P. Singh</i>	306
22	Rethinking on the methodology for assessing global water and food challenges <i>M. Dinesh Kumar, Nitin Bassi and O. P. Singh</i>	325
	<i>Index</i>	343

Citation Information

The chapters in this book were originally published in the *International Journal of Water Resources Development*, volume 36, issue 2–3 (2020). When citing this material, please use the original page numbering for each article, as follows:

Foreword

Masagos Zulkifli

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 223–225

Introduction

Festschrift

Cecilia Tortajada and Eduardo Araral

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 226–228

Chapter 1

A decade of work on water governance at the OECD: what have we learnt?

Angel Gurría

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 229–234

Chapter 2

The knowledge economy in the twenty-first century: a modest proposal

Annie Callanan

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 235–238

Chapter 3

Scotland: a world-leading Hydro Nation

Anton Muscatelli, Erin McKee and Sean McGivern

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 239–244

Chapter 4

Nestlé's corporate water strategy over time: a backward- and forward-looking view

Paul Bulcke, Samuel Vionnet, Christian Vousvouras and Ghislaine Weder

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 245–257

Chapter 5

Scarcity of water or scarcity of management?

David Molden

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 258–268

Chapter 6

Singapore's water challenges past to present

Peter Joo Hee Ng and Celine Teo

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 269–277

Chapter 7

Facing the challenge of extreme climate: the case of Metropolitan Sao Paulo

Benedito P.F. Braga and J. Kelman

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 278–291

Chapter 8

China's achievements of water governance over the past seven decades

Shaofeng Jia and Wenbin Zhu

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 292–310

Chapter 9

Some reflections on water for residential uses in developed countries

Francisco González-Gómez, Miguel Á. García-Rubio and Jorge Guardiola

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 311–324

Chapter 10

Can water professionals do more?

Michael Rouse

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 325–337

Chapter 11

Reflections on flood control in Japan and recommendations for developing countries

Yutaka Takahashi, Kimio Takeya, Miki Inaoka, Wataru Ono and Kaoru Sasaoka

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 338–350

Chapter 12

A retrospective analysis of Laos's Nam Theun 2 Dam

Thayer Scudder

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 351–370

Chapter 13

What I learned from Asit Biswas about transboundary water, ethics, mentoring and, in general, how to be a better human being

Aaron T. Wolf

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 371–376

Chapter 14

Water resilience and human life support - global outlook for the next half century

Malin Falkenmark

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 377–396

Chapter 15

Adaptive and sustainable water management: from improved conceptual foundations to transformative change

Claudia Pahl-Wostl

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 397–415

Chapter 16

Economically challenged and water scarce: identification of global populations most vulnerable to water crises

Taikan Oki and Rose E. Quiocho

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 416–428

Chapter 17

The status of the UN Watercourses Convention: does it still hold water?

Gabriel Eckstein

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 429–461

Chapter 18

Australian water decision making: are politicians performing?

James Horne

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 462–483

Chapter 19

Rent-seeking behaviour and regulatory capture in the Murray-Darling Basin, Australia

R. Quentin Grafton and John Williams

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 484–504

Chapter 20

Quenching the thirst of rapidly growing and water-insecure cities in sub-Saharan Africa

Madiodio Niasse and Olli Varis

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 505–527

Chapter 21

Sustainability of water and energy use for food production based on optimal allocation of agricultural irrigation water

Mo Li and Vijay P. Singh

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 528–546

Chapter 22

Rethinking on the methodology for assessing global water and food challenges

M. Dinesh Kumar, Nitin Bassi and O. P. Singh

International Journal of Water Resources Development, volume 36, issue 2–3 (March–May 2020, Special issue) pp. 547–564

For any permission-related enquiries please visit:

<http://www.tandfonline.com/page/help/permissions>

Contributors

Eduardo Araral Institute of Water Policy, Lee Kuan Yew School of Public Policy, National University of Singapore, Singapore.

Nitin Bassi Institute for Resource Analysis and Policy Liaison Office, New Delhi, India.

Benedito P.F. Braga Universidade de São Paulo (USP), Escola Politécnica – Departamento de Engenharia Hidráulica e Ambiental, São Paulo, Brazil.

Paul Bulcke Nestlé SA, Vevey, Switzerland.

Annie Callanan Chief Executive, Taylor & Francis Group, Abingdon, UK.

M. Dinesh Kumar Institute for Resource Analysis and Policy, Hyderabad, India.

Gabriel Eckstein Texas A&M University School of Law, Fort Worth, USA.

Malin Falkenmark Stockholm Resilience Centre, Sweden.

Miguel Á. García-Rubio Department of Applied Economics, University of Granada, Spain Water Institute, Granada, Spain.

Francisco González-Gómez Department of Applied Economics, University of Granada, Spain Water Institute, Granada, Spain.

R. Quentin Grafton Crawford School of Public Policy, Australian National University, Canberra.

Jorge Guardiola Department of Applied Economics, University of Granada, Spain.

Angel Gurría Secretary-General, Organisation for Economic Co-operation and Development (OECD), Paris, France.

Peter Joo Hee Ng PUB, Singapore's National Water Agency, Singapore.

James Horne James Horne and Associates, Canberra, Australia.

Miki Inaoka Global Environment Department, Japan International Cooperation Agency, Tokyo.

Shaofeng Jia Key Laboratory of Water Cycle and Related Land Process/Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China.

J. Kelman Universidade Federal do Rio de Janeiro (UFRJ), Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa de Engenharia (Coppe), Rio de Janeiro, Brazil.

Mo Li School of Water Conservancy & Civil Engineering, Northeast Agricultural University, Harbin, China.

Sean McGivern University of Glasgow, UK.

Erin McKee University of Glasgow, UK.

David Molden Director General, International Centre for Integrated Mountain Development (ICIMOD), Lalitpur, Nepal.

Anton Muscatelli Principal, University of Glasgow, UK.

Madiodio Niasse Land, Water and Environmental Governance Expert, Ngaparou, Senegal.

Taikan Oki United Nations University, Tokyo, Japan. Institute for Future Initiatives, University of Tokyo, Japan.

Wataru Ono Global Environment Department, Japan. International Cooperation Agency, Tokyo.

Claudia Pahl-Wostl Institute of Environmental Systems Research, University of Osnabrück, Germany.

Rose E. Quiocho Graduate School of Engineering, University of Tokyo, Japan.

Michael Rouse Department of Geography and Environment, University of Oxford, Oxford, UK and International Advisor.

Kaoru Sasaoka Global Environment Department, Japan. International Cooperation Agency, Tokyo.

Thayer Scudder Department of Humanities and Social Sciences, California Institute of Technology, Pasadena, USA.

O. P. Singh Department of Agricultural Economics, Banaras Hindu University, Varanasi, India.

Vijay P. Singh Department of Biological and Agricultural Engineering & Zachry Department of Civil and Engineering, Texas A&M University, College Station, USA. National Water Center, UAE University, Al Ain, United Arab Emirates.

Yutaka Takahasi Professor Emeritus, Tokyo University, Japan.

Kimio Takeya Distinguished Technical Advisor to the President, Japan International Cooperation Agency, Tokyo, Japan.

Celine Teo PUB, Singapore's National Water Agency, Singapore.

Cecilia Tortajada School of Interdisciplinary Studies, College of Social Sciences, University of Glasgow, UK. Editor-in-Chief, International Journal of Water Resources Development.

Olli Varis Water and Development Group, Aalto University, Espoo, Finland.

Samuel Vionnet Valuing Nature, Antigua, Guatemala.

Christian Vousvouras Nestlé SA, Vevey, Switzerland.

Ghislaine Weder Nestlé SA, Vevey, Switzerland.

John Williams Crawford School of Public Policy, Australian National University, Canberra.

Aaron T. Wolf Oregon State University, Corvallis, USA.

Wenbin Zhu Key Laboratory of Water Cycle and Related Land Process/Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China.

Masagos Zulkifli Minister for the Environment and Water Resources, Government of Singapore, Singapore.



Taylor & Francis

Taylor & Francis Group

<http://taylorandfrancis.com>

Foreword

Masagos Zulkifli

Water is essential for life. Without water, there would be no life on Earth.

Today, one in 10 people – more than 700 million – lack access to a basic drinking water service. One of the Sustainable Development Goals of the United Nations is universal and equitable access to safe and affordable drinking water by 2030.

With expanding global population and agricultural and industrial needs, the demand for clean water is ever increasing. The challenges of water security are compounded by climate change, which will bring more frequent and intense droughts and floods, affecting the availability and distribution of water resources.

To ensure water security in a changing climate, good water management and governance are critical. Good policies need to be backed by effective implementation. Strong support from public agencies, businesses, non-governmental organizations and members of the public is also needed to successfully implement such plans. Everyone needs to work together to tackle our water challenges.

As a small, highly urbanized island state in South-East Asia, Singapore has embraced a holistic approach to water security. One of the most water-stressed countries in the world, Singapore has developed a diversified water supply with its Four National Taps: water from the local catchment, imported water, high-grade reclaimed water (known as NEWater) and desalinated water.

Our water journey began in the early days of independence, over 50 years ago. Our founding Prime Minister, Mr Lee Kuan Yew, recognized that water security was key to Singapore's survival, and famously declared, 'Every other policy had to bend at the knees for our water survival.' He tasked PUB, Singapore's National Water Agency, to collect every drop of water and make it potable.

To realize our first National Tap, Mr Lee called for the clean-up of all rivers and streams in Singapore, including the Singapore River. The massive clean-up operations, which involved resettlement of many homes and businesses, took a decade to transform the Singapore River from an open sewer into a beautiful waterway. These clean-up efforts paved the way for the creation of Marina Reservoir in 2008, an iconic reservoir in the heart of our city. The Marina Reservoir has made Singapore one of the few countries in the world to tap urban stormwater for its water supply. Overall, two-thirds of our island serves as a water catchment.

PUB began researching water reclamation and desalination in the early 1970s. Although the production process was initially expensive and unstable, PUB persisted over several decades and eventually successfully added NEWater and desalinated water as National Taps in 2003 and 2005, when technological breakthroughs made these

economically viable and reliable. With the successful recycling of used water, Singapore is one of the few countries to have closed the entire water loop, embracing a circular economy approach.

These efforts to enhance our water supply must be complemented by good water demand management. Water needs to be priced right to reflect the latest cost of water supply and its scarcity value. At the same time, PUB has consistently promoted water conservation through the years and encouraged homes and industry to use more efficient water fittings, equipment and processes. Household water consumption per capita has fallen from 165 litres per day in 2003 to 141 in 2018, and is targeted to fall further to 130 by 2030.

We are leveraging technology to manage water demand. PUB is rolling out the first phase of its Smart Water Meter Programme, which will see the installation of 300,000 automated water meters by 2023. Customers will be able to monitor their daily water usage and receive high usage notifications, to encourage them to conserve water.

Our water infrastructure must be continuously maintained and upgraded. To reduce water losses during transmission, PUB regularly replaces older pipes and uses the latest resilient materials to increase the durability of pipes. Last year, we completed the upgrading of one of Singapore's oldest water treatment plants, at Choa Chu Kang, with advanced and efficient treatment processes, such as ceramic filtration membrane and ozone-biological activated carbon treatment.

To help us tackle the water challenges arising from climate change, we will continue to invest heavily in research and development. PUB is working with partners on electro-deionization technology and biomimicry, which could halve the energy required for water desalination. PUB is also deploying data analytics and sensors to identify and anticipate issues ranging from transmission losses to flash floods. These investments have catalyzed a thriving water industry, turning Singapore into a major hydro-hub for the testing and implementation of new technologies.

Looking ahead, Singapore will harness synergies across water and other sectors such as waste, energy and food. When completed in 2027, Tuas Nexus will be the world's first greenfield development to integrate a water reclamation plant and an incineration plant. Tuas Nexus will co-digest used water sludge and food waste into biogas, which in turn will help power the plant. By expanding our circular economy approach, we hope to maximize Singapore's resource resilience and contribute to a sustainable future.

This Festschrift or special issue of the *International Journal of Water Resources Development*, prepared by Dr Cecilia Tortajada and Professor Eduardo Araral, commemorates the 80th birthday of Professor Asit Biswas. Professor Biswas is well respected internationally and one of the world's leading water experts. He founded this journal in 1985 and was its Editor-in-Chief for 29 years; currently, he serves as Editor. Professor Biswas is strongly committed to achieving a water-secure world and has advised many policy makers, including those in Singapore. In recognition of his contributions over several decades, he was awarded the prestigious Stockholm Water Prize in 2006.

Professor Biswas is a valued friend of Singapore and has been advising the Singapore International Water Week, a global platform to share and co-create innovative water solutions, since its inception in 2008. Over the years, he has helped garner strong participation in the Water Week to foster productive discussions of our water challenges.

In honour of Professor Biswas's outstanding and inspiring work, more than 20 prominent leaders of water utilities and the public and private sectors, as well as outstanding academics, have contributed to this Festschrift. This issue will be a valuable resource in humanity's journey to achieve water security, and it is a fitting tribute to Professor Biswas on this auspicious occasion.

INTRODUCTION

Festschrift

This Festschrift is a tribute to Professor Asit K. Biswas on his 80th birthday, for his manifold contributions to water resources policy and management and his extensive efforts to synthesize, apply and disseminate knowledge at the global level. His contributions, spanning more than five decades, have had enormous impacts on the lives of millions of people all over the world.

Professor Biswas is considered one of the leading water and environment experts globally. He has worked and taught in universities in Asia, Africa, Europe, North America and South America and lived for prolonged periods in cities on all the continents.

Professor Biswas has been a policy and strategic advisor to 19 governments at prime ministerial and ministerial levels, six heads of UN agencies, two secretaries-general of the OECD, two heads of the World Bank, five CEOs of major multinational corporations on the *Fortune* 500 list, several heads of bilateral and multilateral aid organizations and numerous national and international water, environment and development institutions.

He has been a very successful bridge-builder between the North and the South, scientists and policy makers, governments and NGOs, academics and practitioners, and media and the general public. Through his advisory work to governments, the public sector and businesses, and mentorship of students from all over the world, as well as his technical books and papers in 41 languages, and hundreds of media articles and interviews, his footprint on environmental and water management has been very substantial.

One of his major contributions has been in institution building. He actively participated in the establishment of the Canadian Ministry of the Environment, the United Nations Environment Programme, United Nations University, the Institute for Water, Environment and Health in Canada, the Third World Centre for Water Management in Mexico, the International Centre for Water and Environment in Spain, and the Institute of Water Policy in Singapore. On the professional side, he has been the co-founder of the International Water Resources Association, the International Society for Ecological Modelling, and the World Water Council. He helped with the idea of establishing the Intergovernmental Panel on Climate Change. He is also one of the prime movers behind the Stockholm Water Symposium, which later became Stockholm World Water Week, and Singapore International Water Week.

Professor Biswas has also been directly associated with a large number of universities and research institutions all over the world. Among these institutions are the University of Oxford, University of Loughborough, University of Glasgow and University of Strathclyde in the UK; Queen's University, University of Ottawa and University of Alberta in Canada; the International Institute for Applied Systems Analysis in Austria; the University of Lund and the Royal Institute of Technology in Sweden; Aalto University in Finland; Mexico National Autonomous University, Metropolitan Autonomous University and National Polytechnic Institute in Mexico; University of Tokyo and Shibaura Institute of Technology in Japan; Asian Institute of Technology in Thailand; University of Wuhan, Tsinghua University and

Chinese Academy of Sciences in China; and the Indian Institute of Technology (Bhubaneswar and Kharagpur). In the last 10 years, he has been at the Institute of Water Policy of the Lee Kuan Yew School of Public Policy, National University of Singapore.

Throughout his career, Professor Biswas' work has focused on all four aspects of water and environment-based knowledge: generation, synthesis, application and dissemination. A strong advocate of policy- and practice-oriented research, he has constantly challenged prevailing wisdom with the objective of advancing knowledge and its application. He has encouraged thinkers and practitioners alike to look beyond what is apparent, in the search for broader, creative and multifaceted alternatives. He has eschewed linear alternatives, since, as he would say, they do not work in the real world.

Professor Biswas has been a strong proponent of ideas that result in tangible solutions rather than poor adaptations that would not render the necessary benefits for which they were intended.

'Knowledge does not advance by consensus' is one of the phrases he uses the most. Thus, throughout his life, he has worked only with persons with vision, foresight and broad mindsets. This has allowed him to develop a wide network composed of the brightest minds, many of whom are generously contributing to this Festschrift.

A true visionary, he has championed ideas that have often been 20 or 30 years ahead of their time. For instance, already in the late 1960s, he advocated a new social, economic, political and environmental framework for water management which would enable effective translation of scientific (both natural and social) and technical advances into meaningful policy measures. In 1969, he was one of the pioneers who proposed the use of mathematical models for planning and management of river basins. He applied this concept for the first time to the Saint John River basin in Canada.

He is the 'father' of the concept of the International Water Supply and Sanitation Decade (1981–1990) and worked tirelessly to get it approved unanimously by the UN General Assembly. His contributions to formulating the Decade were explicitly noted by the Assistant Secretary General during the UN Assembly debate. Because of this Decade, hundreds of millions of people in the developing world received access to clean water and adequate sanitation.

Professor Biswas has been a science-driven, fact-based policy advocate. His role for over five decades as a global facilitator of international and regional platforms, where governments, organizations and individuals meet, discuss and take concrete actions on environment and water-related issues, has taken many forms. For instance, as an eminent world expert and firm believer that water is a source of collaboration and not conflict, he was invited to chair the Middle East Water Commission (1993–1997). He successfully involved high-level personalities from the region to discuss water problems face to face in several neutral locations. Because of his work through this commission, some of the actual treaties on water issues between the countries of the region were agreed to.

For his international contributions and reputation, he was awarded the 2006 Stockholm Water Prize. He has also been awarded the Person of the Year Award by the Canadian prime minister, the Walter Huber Award from the American Society of Civil Engineers, the Crystal Drop and the Ven Te Chow and Millennium awards from the International Water Resources Association, and the Aragon Environment Prize from Spain. He holds honorary doctorates from seven of the world's leading universities. Reuters named him one of the top 10 water trailblazers of the world; *Impeller* magazine

identified him as a 'true global hero'; and the readers of *Water & Wastewater International* named him the world's second-most influential industry leader.

He has mentored young scholars and students from many different geographies, opening and many times creating doors for them. Being concerned that potential water leaders of the next generation were not being heard at major international fora, Professor Biswas initiated a one-year programme to select and mentor 15 potential young global water leaders from all over the world. He mentored them regularly over a four-year period, including a meeting every year where he invited very well-established water leaders to interact with the next generation of leaders. All 15 are now leading global water personalities, including the current director of the Postdam Institute for Climate Impact Research.

In Singapore, at both the Institute of Water Policy, Lee Kuan Yew School of Public Policy, and PUB, National Water Agency, Professor Biswas has found a very enabling and stimulating environment for intellectual discussions. This has strongly underpinned his latest work in various aspects of water management from multidisciplinary, multisectoral and multi-issue perspectives.

This Festschrift, sponsored by the Institute of Water Policy at the Lee Kuan Yew School of Public Policy, includes contributions from 23 globally renowned leading personalities from academia, national and international organizations, and businesses, who have had close working relationships with Professor Biswas, in many cases over several decades. At the Institute of Water Policy, we truly appreciate the time and effort that went into these insightful analyses.

Under the umbrella of the Institute of Water Policy, we are confident that this Festschrift will become an important contribution to the literature.

Cecilia Tortajada

 <http://orcid.org/0000-0001-6308-4924>

Eduardo Araral

 <http://orcid.org/0000-0001-7665-616X>

A decade of work on water governance at the OECD: what have we learnt?

Angel Gurría

ABSTRACT

Our societies, economic systems and collective well-being depend on water security and access to water services. Yet, megatrends related to climate change, urbanization and demography are likely to generate more uncertainty about water availability and demand. Responding to these threats will require sharp actions to ensure universal access to drinking water and sanitation. Simultaneous action is also needed to invest in infrastructure and better articulate who does what, how, at which scale, and why. This article explores a decade of work on water governance at the OECD, providing key observations and lessons learnt.

A shared conviction that water security is key to sustainable development

In 2010, in their landmark book *Future water governance: problems and perspectives*, Professor Asit Biswas and co-author Cecilia Tortajada warned:

One development can be predicted with complete certainty; the world in 2030 will be significantly different from what it is in 2010... Water governance may have to change more during the next 20 years compared to the past 2000 years, if societal expectations are to be successfully met.

Fully in line with this statement, when I campaigned to become secretary-general of the OECD in 2006, I proposed water as one of my three priorities (together with migration and health) to support better policies for better lives. At the time, there was a striking lack of awareness of the water challenge world-wide.

From my earlier experience as minister of finance and public credit in Mexico, I was convinced that water was a critical driver for sustainable growth. This is why I set up and chaired the Water Financing Taskforce during the 6th World Water Forum (Mexico, 2006), actively contributed to the Camdessus report (World Panel on Financing Water Infrastructure, 2003) and joined the United Nations Secretary-General's Advisory Board on Water and Sanitation to send a wake-up call to decision makers.

On many occasions, Professor Biswas and I joined forces to insist that greater solidarity and inclusion are essential to water security and climate justice and that public policies should support fair distribution of the socio-economic benefits of water and secure human health, environmental sustainability and income opportunities. We have also



Figure 1. Overview of the OECD principles on water governance. Source: OECD (2015).

repeatedly warned that no country should take current levels of water security or service delivery for granted, and that serious action is needed in *all* countries, be they developed, emerging, or developing.

Today, the economics and governance of water security are finally seen as integral parts of how societies can better achieve and sustain socio-economic development, inclusive growth and environmental sustainability at all levels. The acknowledgement of water as a dedicated goal in the 2030 Agenda for Sustainable Development is a testament to this recognition.

A gloomy outlook that requires urgent action

What on Earth is not driven by water? Our entire society, economic systems, and collective well-being depend on water security and access to water services. We cannot afford to ignore the severity of the crisis any longer.

Today, nearly 200 million people per year are affected or killed by floods, droughts and other water-related disasters. By 2050, water demand will increase by 55%, over 40% of the world's population will live under severe water stress, and the number of people exposed to flood risk will rise from 1.2 billion now to 1.6 billion, 20% of the global population (OECD, 2012). Continued intense groundwater depletion threatens food

security in several regions of the world. And more than 2 billion people do not have access to safe drinking water, while even more lack access to sanitation (WHO/UNICEF, 2017).

Megatrends related to climate change, urbanization and demography will be compounding factors and will continue to exacerbate tensions, generating more uncertainty about water availability and demand. Responding to these threats will require sharp actions and ambitious reforms to concurrently manage the risks of 'too much', 'too little', and 'too polluted' water while ensuring universal access to drinking water and sanitation and reducing the disruption of our freshwater systems.

Designing and implementing such reforms using evidence-based public policies requires acknowledging that the solutions to water challenges cut across sectors (e.g., environment, agriculture, health, land use and spatial planning) and depend on a coordinated approach by governments. They also require significant investment: projections of global financing needs for water infrastructure range from USD 6.7 trillion by 2030 to USD 22.6 trillion by 2050.

Yet, investing in infrastructure is not enough. Simultaneous action is needed to improve governance arrangements: setting the right incentives, managing complexity, and better articulating who does what, how, at which scale, and why. Fundamentally, effective governance is at the heart of finding sustainable solutions to this water crisis.

From vision to action

When I joined the OECD, I set up a multidisciplinary water team tasked to engage different policy communities, including environment, public governance, territorial development, agriculture, financial affairs and development cooperation. By mainstreaming the water challenge into the OECD inclusive growth agenda, we have contributed to improving awareness, providing evidence and supporting ambitious reforms through benchmarks, standards and experience sharing. Our achievements include a wealth of ground-breaking economic analyses, solid policy recommendations and direct support to countries' reforms on the ground. Also, because we firmly believe that 'governance' is not only about 'governments' and that meeting the water challenge is a much broader shared responsibility, we make sure that stakeholders are engaged alongside policy makers.

A decade of OECD work on water governance has taught us that the cross-cutting nature of water policy requires a whole-of-government, multilevel and multi-stakeholder approach to manage trade-offs across siloes and to ensure that decisions made in any related policy area are water-wise. Health, environment, agriculture, energy, spatial planning, regional development, gender equality and poverty alleviation are all directly related to water. This is why governing water is first and foremost about managing a complex system of responsible authorities, scale, stakeholders and priorities.

The OECD's achievements and legacy to improve water policies for better lives were crystallized in the *OECD Council recommendation on water* (2016), a concise legal instrument common to the 36 OECD countries that is a unique source of coherent, evidence-based guidance on water quality, water quantity, water-related risks and disasters, water governance, and water pricing and financing. A cornerstone of its development was the *OECD principles on water governance* (2015), which provide the 12 essential actions in relation to water governance frameworks, institutions and instruments.

Since their adoption, the principles have also been endorsed by non-OECD countries, including China, Brazil, South Africa and Morocco, and over 140 stakeholder groups, who are using them as a tool for dialogue, self-assessment and collective action. The principles are built around three mutually reinforcing blocks of water governance:

- *Effectiveness* is about defining clear, sustainable water policy goals and targets at all levels of government, to implement those policy goals and to meet expected targets.
- *Efficiency* is about maximizing the benefits of sustainable water management and welfare at the least cost to society.
- *Trust and engagement* is about building public confidence and ensuring inclusiveness of stakeholders from across society.

The evidence base from more than a decade advising governments

While supporting water reforms in developed and developing countries, we strived to raise the water profile in local and national agendas with a range of tools and frameworks for action. Actions included:

- Our '3 Ts' called for combining taxes, tariffs and transfers to finance access to water services, changing the conventional wisdom from full to sustainable cost recovery.
- Our Checklist for Private-Sector Participation contributed to dispelling myths about the role of the private sector in water and clarifying how to make the best use of private operators.
- Our Water Security Framework provided a methodology to 'know', 'target' and 'manage' water risks, recalling that related decisions remain essentially political.
- Our work on water governance in cities showed that ageing infrastructure, tighter public budgets and megatrends are generating serious threats for OECD city dwellers.
- Our work on water pollution explored innovative ways to tackle emerging pollutants, which raise emerging concerns globally, although we know little about their harmful effects overall.

What we have learned about governance from supporting water reforms at all levels

Coping with current and future challenges requires robust public policies, targeting measurable objectives at the right time and on the appropriate scale, clear roles and responsibilities for relevant authorities, and regular monitoring and evaluation. Water governance can greatly contribute to the design and implementation of such policies, with shared responsibility across levels of government and the broader range of stakeholders (e.g., civil society, business) who have an important role to play to reap the economic, social and environmental benefits of good water governance.

The water sector has intrinsic characteristics that make it highly sensitive to and dependent on multilevel governance. Water connects across sectors, places and people, as well as across geographic and temporal scales. In most cases, hydrological boundaries and administrative perimeters do not coincide. Freshwater management is both a global

and a local concern, and involves a plethora of public, private and non-profit stakeholders in the decision-making, policy and project cycles. Water is also a highly capital-intensive and monopolistic sector, with important market failures where coordination is essential. To varying degrees, countries have allocated increasingly complex and resource-intensive responsibilities to sub-national governments, resulting in interdependencies across levels of government that require coordination to mitigate fragmentation. Finally, the governance landscape for freshwater management has changed in the last 25 years. Information flows more easily and potentially sheds greater light on malpractices and failures.

OECD evidence shows that there is not a one-size-fits-all solution to water challenges worldwide, but rather a large diversity of situations within and across countries. Governance responses should therefore be adapted to territorial specificities to fit water policies to places. In short, governance is *good* if it can help solve key water challenges using a combination of bottom-up and top-down processes while fostering constructive state–society relations. It is *bad* if it generates undue transaction costs and does not respond to place-based needs. Water governance systems (whether they are more or less formal, complex, or costly) should be designed according to the challenges they are required to address. This problem-solving approach means that the *forms* of water governance should follow the *functions* of water governance. Governance should always remain a means to an end and never become a self-serving goal. Structuring, institutionalizing and/or formalizing institutions should not distract policy makers from the ultimate objective of delivering sufficient water of good quality, while maintaining or improving the ecological integrity of water bodies.

There is now greater recognition that bottom-up and inclusive decision making is key to effective water policies. In addition, a number of legal frameworks have triggered major evolutions in water policy, including the EU Water Framework Directive, the UN General Assembly's resolution on the 'Human Right to Water and Sanitation', and more recently, the Sustainable Development Goals. The Integrated Water Resources Management concept has had uneven results within and across countries; it underwent some rejuvenating calls for operationalization frameworks that consider the issue in a consistent and sustainable way. However, in many places implementation is lagging. Regardless of a country's development level or exposure to water risks, there are common governance challenges: fragmented roles and responsibilities, unclear allocation of tasks, patchy financial management, lack of long-term strategic planning, data and information gaps, corruption, and weak capacity, monitoring and stakeholder engagement.

Despite persistent challenges, many OECD and partner countries have made significant efforts to improve coordination. Better coordination across different policy areas took place in Mexico through action on energy subsidies that exacerbated groundwater depletion. Better engagement across levels of government happened in Brazil, where an ambitious Water Pact set the right political and financial incentives to work together in strengthening state and federal water resources management systems. While the functional autonomy of the regional water boards was preserved in the Netherlands, efforts to use economic incentives more systematically and improve the transparency of information on water costs are currently underway.

In a global context where water resources are already overused or overallocated, we need partnerships between institutions and spatial planners, greater representation of vulnerable groups, and better data and monitoring. Transparency and accountability are

also essential to ensure customers access high-quality services, at the least cost to society. A resilient economy shouldn't focus on crisis management and short-term fixes but seek risk management and prevention through long-term strategies and political commitment.

We live in a world facing striking challenges: from climate change and economic crises to demographic shifts. Our water resources are finite and can be a source of prosperity or distress when water disasters damage goods and harm people. However, each crisis is an opportunity for change. The importance of water has gained increasing prominence on policy agendas globally, but we should all continue to support ambitious and collective action towards better water policies for better lives.¹

Note

1. The opinions expressed and arguments employed herein do not necessarily reflect the official views of the member countries of the OECD.

Disclosure statement

No potential conflict of interest was reported by the author.

References

- OECD. (2012). *OECD environmental outlook to 2050: The consequences of inaction*. Paris: OECD Publishing. Retrieved from <https://doi.org/10.1787/9789264122246-en>
- OECD. (2015). *Principles on water governance*. Retrieved from: <https://www.oecd.org/cfe/regionalpolicy/OECD-Principles-on-Water-Governance.pdf>
- OECD. (2016). *OECD Council recommendation on water*. Retrieved from <https://www.oecd.org/water/recommendation/>
- WHO/UNICEF. (2017). *Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines*. Retrieved from <http://www.who.int/mediacentre/news/releases/2017/water-sanitation-hygiene/en/>
- World Panel on Financing Water Infrastructure. (2003). *Financing water for all*. Retrieved from https://www.worldwatercouncil.org/fileadmin/world_water_council/documents_old/Library/Publications_and_reports/CamdessusReport.pdf

The knowledge economy in the twenty-first century: a modest proposal

Annie Callanan

I was honoured to be invited to contribute to this Festschrift special issue to celebrate the 80th birthday of Professor Asit K. Biswas, editor of the *International Journal of Water Resources Development*. What follows are some reflections based on the 'modest proposal' that, as newly appointed CEO of academic publishing group Taylor & Francis, I presented to a forum of experts in scholarly publishing and communications. Since Professor Biswas is not only a highly respected editor and distinguished expert in water resources but he has also been tireless in extending the reach of scientific research and policy making far beyond their usual audiences, the following remarks focus on how we must harness today's technologies to make knowledge a truly global resource.

I respect expertise and am conscious that the rapid innovations taking place in my own industry must work hand-in-glove with scholars to maximize the potential of their work. The way we use new media to build better platforms to share knowledge more effectively will impact on all our futures.

Sometimes new and different can be insightful. My own world view has been shaped by different dimensions and acronyms, all on a mission to disrupt the competitive advantages and big dreams of others. Here I attempt to share my early observations, first by outlining a modest perspective on the current state of academic publishing, followed by an even more modest proposal formed from an outsider's view looking in.

As an American I consider myself an expert disruptor. It's sort of what we do. Americans respect disruption because it fixes stuff that ultimately breaks and progresses (things) along, even for those whose historical bias favours continuity (or at least used to). In our micro-moment, today's disruption is digital. And if disruption spells progress, lots of progress is coming our way. Long-standing traditional centres of gravity are shifting – rapidly.

English language pre-eminence in knowledge dissemination will soon share a stage with China and any other funding sources serious about solving twenty-first-century problems. By that, I mean not just intellectually stimulating theoretical problems, or 'dead ends', or 'won't be solved for centuries' problems, but today's real-world problems – those perhaps less reputationally rewarding but no less impactful. So how will disruptive forces play out in the current publishing ecosystem? This is one newcomer's view.

Technology will soon dissolve barriers, across languages and cultures. In 2007 it cost \$1 million to translate 1 million English words into Chinese. Today's cost is \$30 for the same translation. Tomorrow's cost will be \$0. Instantaneous translation will soon enable knowledge sharing across diverse borders and cultures. The good news: scholarship that crosses stubborn

boundaries of language, culture and discipline will improve outputs. Crossing boundaries fosters diversity of thought, which ironically is increasingly at risk in the twenty-first century.

Cross-disciplinary collaborations that engineer scientific pursuits, with explicit societal aspirations and impacts, will further amplify the practical applicability and long-term viability of research.

Crude definitions of quality will no longer hold up under the scrutiny and precision of twenty-first-century technology. How we measure will matter. Looking at the total research output for 2016, for example, we know that by 2021, over 40% of that output will remain uncited (Van Noorden, 2017; wizdom.ai, 2017). Does that render 2016 a success or failure in terms of outcomes from the investments made?

Using a twentieth-century artefact to measure quality will not answer that question. Citations can be pragmatic for tracking iterative research, i.e., for those working on small fragments of *big* problems. But a multidisciplinary approach and new success criteria will be required for more practical problems, like this one, where only collaboration across diverse disciplines will drive a solution.

Too many of today's real-world problems don't secure funding due to 'one size fits all' quality benchmarks. But technology will soon enable more impactful funding decisions. Funding has typically rewarded citations and those who have perfected the art of grant writing. To illustrate the current imbalance, look at the funding for Alzheimer's research, one of those 'won't be solved for centuries' problems.

Someone in the world develops dementia every three minutes (Alzheimer's Society, 2019). Between 2014 and 2016, thousands of articles were published in the top journals. But right now, 50 million people are struggling to live with the disease. They, and millions more who serve as their caregivers, need assistive technologies, technologies that might solve many small problems quickly, but which won't accrue citations. Out of the sum total, only 704 articles focused on helping those living with the disease (Web of Science, 2018). Practical value and human impact are attributes of measurement, and important success factors that will advance the higher human purpose science and technology are trying to serve, and not just the science itself.

Many attributes along the continuum of our knowledge endowment seem dated, and very twentieth-century. More and more of our global youth are being left behind – by schools that appear designed to enable nineteenth-century factory work rather than the mitigation of rapid skills obsolescence, and by the growing challenge of accessing critical twenty-first-century knowledge no longer on shelves – critical knowledge and skills that would have otherwise secured a sustainable future. There will be real-world consequences if we fail to educate new generations with the competencies they need to participate and thrive in modern life.

Even ignoring for a moment those not privileged enough to afford a higher education, recent studies from the US indicate that despite four years of academic rigour in leading academic institutions, even privileged graduating students, also known as future researchers, demonstrate little to no improvement in critical thinking and therefore don't become better problem solvers (Belkin, 2017, p. 2).

Moreover, despite a massive investment and years of debt, 50% of employers say graduates, a.k.a. recent consumers of today's corpus of scholarly communication, are not ready for the workplace, mostly due to poor critical reasoning skills, and increasingly the absence of those *very skills* demanded by our modern world (Belkin, 2017, p. 2).

Academic institutions are failing at a time when our collective imperative for learning has never been greater. Human knowledge now doubles every 13 months, soon to be every 12 hours (Schilling, 2013). Ninety per cent of all data in the world was created just in the past two years. The total collective knowledge in circulation by 2020 will be *21 million times* greater than all knowledge currently housed in all academic research libraries combined (Ranking Web of Universities, 2018).

Even in a fully open world, the human brain can absorb only a small fraction of that data set. As the supply of new knowledge accelerates, so does the obsolescence rate of existing knowledge. Fifty per cent of a first year's college curriculum in the US is obsolete by the time a student graduates. In the twenty-first century the need to learn is no longer episodic but continuous. Unless you are living off a trust fund or endowment, knowledge over centuries has served two human imperatives: professional advancement and economic sustainability. Increasingly, these goals are unattainable except for a privileged few. Why? Because academic institutions, with the complicity of publishers, are still largely delivering twentieth-century product to a generation trying to successfully meet twenty-first-century demands.

To those in academia considering the notion of relevancy I humbly say: Professional rewards and recognition for researchers, faculty and the institution *are important*; but of even greater importance right now is impact!

To my fellow publishing colleagues contemplating relevancy in an age of disruption, I say, there *is demand* for designed knowledge artefacts that meet the needs of twenty-first-century learners. And I don't mean young learners, but rather those for whom a 'higher' education will be continuous, not episodic. Learners who will build the twenty-first-century economy. Those committed to addressing real-world problems, not just theories. Those passionate about collective health for both our planet and our people. Those striving for sustainable relevance irrespective of age or credentials. And those in desperate need of an economic lifeline. Learners all over the world are asking for help!

Let's not dismiss the proof or assume libraries will keep up with the fiscal demands of an exponentially growing corpus. The twenty-first is our social century. As publishers, we have the opportunity to be listening directly and *responding* to twenty-first-century knowledge demand, demand which will sound very different from twentieth-century demand.

Academic institutions are not adapting fast enough. Technology will enable publishers to become better digital listeners, and therefore better enablers, developers and amplifiers of the knowledge most relevant to solving twenty-first-century problems.

There are 7.6 billion people in the world. Six billion of them, and counting, have mobile phones, a.k.a. learning devices, a.k.a. no need for global travel or fancy academic settings or mastery of the English language or thousands of dollars in pursuit of too much information from the past, and too little knowledge for the future (Belkin, 2017). Today's generation of learners are tuned in. We just have to bring knowledge *to them*, in the bite-size nodes they are accustomed to.

Whether researching knowledge or learning from it, the pursuit of its bounty is one connected continuum, a continuum that is *collectively* failing. We must all shoulder some blame. 'Open' science feels like a rallying cry, from a generation no longer advancing and not understanding why. But 'open' is also an expression of the *collective failure* of an *entire ecosystem*, so let's not allow ourselves to be casually defined, notwithstanding the importance or intent. Insufficient access to information is hardly our planet's most

pressing collective problem. 'Free' already exists in excess of what learners can practically find, access, comprehend and derive tangible value from.

Seeking relevancy in an age of technological and scientific disruption will necessitate applying a humanities filter to steer wisdom's higher purpose. Only by doing so will we continue to endow far more to the world in terms of meaningful human advancement. By becoming practical and perceptive listeners, technology will enable us to curate knowledge that is precisely the wisdom required for a new generation to advance, find relevancy, and sustain a respectable place in the modern world.

I promised you a 'modest proposal'. Here it is. As the world's pre-eminent knowledge suppliers, let's develop and advance twenty-first-century knowledge artefacts with a better blend of science *and* humanities to solve our most pressing social problems:

- collective health – which should include extending the quality of life and not just its duration;
- sustainability through modern skills and competencies, and not just theoretical knowledge for knowledge's sake;
- and finally, true knowledge democratization, where any child born anywhere in the world in this century has the opportunity to self-serve with small but steady bites from the world's knowledge corpus to lift themselves out of a life of poverty and subjugation.

For this next generation, let's open the on-ramp to every motivated knowledge seeker. Collectively we can do this. Eighty-five per cent of the jobs that will exist in 2030 have not even been invented yet. The pursuit of twenty-first-century knowledge *must not* be for the privileged few.

Disclosure statement

No potential conflict of interest was reported by the author.

References

- Alzheimer's Society. (2019). *Facts for the media*. Retrieved from <https://www.alzheimers.org.uk/about-us/news-and-media/facts-media>
- Belkin, D. (2017, June 5). Exclusive test data: Many colleges fail to improve critical thinking skills. *Wall Street Journal*.
- Clarivate Analytics. (2018). *Web of Science*.
- Ranking Web of Universities. (2018, July). *Countries arranged by number of universities in top ranks*. Author. Retrieved from <https://www.webometrics.info/en>
- Schilling, D. R. (2013, April 13). Knowledge doubling every 12 months. *Industry Tap into News*.
- Van Noorden, R. (2017, December 3). The science that's never been cited. *Nature*, 552, 162–164. doi:10.1038/d41586-017-08404-0
- wizdom.ai. (2017, November). Retrieved from <https://www.wizdom.ai/>

Scotland: a world-leading Hydro Nation

Anton Muscatelli , Erin McKee and Sean McGivern

ABSTRACT

We are facing a global crisis and the status quo must change if we want to preserve our planet for future generations. The University of Glasgow was the first in Scotland to declare a climate emergency and as a progressive Scottish institution, it is our responsibility to lead the way in promoting sustainable practice. This paper looks at some key examples that provide a model for other nations to adapt their own practices for water and wastewater management. It discusses why Scotland has chosen to view water as a major financial resource for the country and how public-sector bodies collaborate effectively with communities to ensure the people of Scotland reap the benefits of green water management.

Clean water is essential to human lives: we bathe in it, drink it, cook with it, cultivate with it, clean with it and use it for sanitation purposes. We often have the luxury in the developed world of forgetting how much we rely on safe, clean and sustainable sources of water.

As sea levels rise and nations are hit by drought, it is more important than ever that we prioritize green water management and work towards a wider goal of sustainability as part of addressing the climate emergency we are faced with today.

The United Nations has declared 2018–2028 the Water Action Decade, with the primary aim to avert a global water crisis and protect our most important natural resource. This will require us to be innovative and research-driven and to learn from those who are spearheading environmental change. My own home country of Scotland is one of these environmental pioneers.

Scotland may only be home to 5.4 million people, but we have around 19,000 km of coastline, which makes up approximately 8% of Europe's coast. Our rivers and lochs hold 90% of the UK's surface freshwater but cover only 2% of our land area. We have some of the world's cleanest drinking water, with 99.1% of public drinking water of a high quality, one of the highest rates in the world.

Not only are we rich in water, but our overall natural capital is worth £273 billion. Our water is not just of great importance to our natural heritage, but also a precious economic resource, and this has not gone unnoticed by the Scottish government.

Scotland was one of the first countries to sign up to the UN's Sustainable Development Global Goals in 2015, and the Scottish government has set its own ambitious, but achievable, sustainability targets. The Climate Change (Scotland) Act 2009 developed

a framework for reducing greenhouse gas emissions by at least 42% by 2020, and at least 80% by 2050.

The Scottish government also oversees the Climate Challenge Fund, a funding programme which supports initiatives tackling climate change, and since its introduction in 2008, 622 communities across Scotland have received grants worth over £85.8 million. Through this community work, around 27,000 tonnes of waste have been recycled. For example, in 2016, a partnership between my institution, the University of Glasgow, and the Scottish government saw the development of a food waste project called Don't Waste Our Future. This initiative raised awareness of food waste and involved schools, students and teachers from across seven European countries.

Whilst the Scottish government has continued to develop its policies on climate change and sustainability over the years, the importance of incorporating water management strategies in these policies has simultaneously increased. There now exists a web of policies on the economy, health, social well-being, culture and the environment which are woven together by an underlying objective to ensure that the most sustainable choices are being made.

Projects, such as Hydro Nation, which seek to use Scotland's expertise and knowledge of water to benefit the economy through innovative management practices, can provide a template for other nations to follow and combine diverse policy areas to achieve sustainability targets.

To see how Scotland does this so effectively, we must look at it nationally, internationally and on a more local level – looking at the work the Scottish government is doing domestically with several organizations and why it is choosing to collaborate; how Scotland is participating internationally and how it has learned from global partners; and finally how individual institutions such as my own, the University of Glasgow, are playing a part in the fight against climate change and contributing to sustainable water management at a local level in Scotland.

To begin, it is important to focus on the key public-sector organizations the Scottish government works with domestically towards its targets for water sustainability. Water management is the responsibility of the cabinet secretary for environment, climate change and land reform, and beneath this level there are several public-sector bodies that answer to the Scottish government and have their priorities set by the cabinet secretary.

First, Scottish Water is the body 'responsible for providing water and waste water services' across Scotland (Audit Scotland, 2005, p. 5, exhibit 1). Scottish Water is tasked with protecting and improving the quality of drinking water in Scotland. It does this through sustainable land and water management practices and by incorporating climate change policy in everything it does. For example, the Scottish government has set targets for reducing carbon emissions, and thus Scottish Water has incorporated this in its water treatment activities. One of the largest solar panel schemes in Scotland was commissioned by Scottish Water in Speyside in north-eastern Scotland, with 80% of the energy generated to be used to take the water from a nearby river to be pumped to water treatment works. Eleven other photovoltaic schemes are now operational across Scotland at different water treatment works.

Moreover, the Scottish government is a signatory to the Ellen MacArthur Foundation's New Plastics Economy, a global commitment to end plastic pollution. To coordinate with this, in 2018 Scottish Water introduced the Your Water, Your Life campaign, which

encourages people to make tapwater their first choice and carry a refillable bottle rather than buy plastic bottles of water. This campaign aimed to highlight the benefits of tapwater not only for the environment but also for health and economic reasons. Scottish Water also works with academic institutions in research on plastics in our wastewater systems and is raising awareness of the inappropriate disposal of plastic products.

In these instances, different sectors of the Scottish government and its policies are being coordinated within Scottish Water's activities to support sustainable water management. This approach is effective because all of these coordinated projects between Scottish Water and Scottish government policies will contribute to the government's overall goals for climate change and sustainability.

Another body which works on Scotland's water management is the Scottish Environment Protection Agency (SEPA). SEPA's overarching goal is to protect the environment, but a major strand of this focuses on sustainable water management.

SEPA's One Planet Prosperity strategy ensures that compliance with environmental regulation is non-negotiable. It works with businesses and communities to deliver projects which tackle climate change, many of which are related to water management. For example, river restoration across Scotland has been a priority for SEPA, as will this not only improve water sustainability but also have economic and social benefits. In the River Garry in Perthshire, SEPA delivered a project in 2017 to improve the ecological quality of the water and get enough water flowing to allow salmon to return. The work included the removal of an old weir, which was a barrier to migrating salmon, and this now allows a sustainable volume of water to flow for the first time in over 60 years. Since the salmon have returned, the number of anglers in the area has increased, making the river a tourist destination, and the natural flow of sediment is improving the ecological health of the river. This illustrates how the coordination of sustainable water management with environmental policies can reap both environmental and economic rewards for communities.

The final public body with a major interest in sustainable water management in Scotland is Scottish Canals. The historic significance of Scotland's canals is immense: they were instrumental in the industrial evolution of Scotland and shaped communities across the country, particularly in Glasgow. Former staff member of the University of Glasgow and inventor of the steam engine, James Watt, assisted in the widening of the River Clyde and the construction of the Forth and Clyde and the Caledonian Canals back in the 1700s, and today these canals are still being reimaged to bring sustainable benefits for the people of Scotland.

Around 332 million litres of water are used each day to run Scotland's canals, but initiatives by Scottish Canals are ensuring that this water is not going to waste. Canal water has a lower carbon footprint than drinking water, as it is gravity fed and is arguably a greener way of providing water for recreational activities, such as the Falkirk Wheel (a major Scottish tourist attraction), and for industry.

Scottish Canals are also exploring the potential for renewable energy generation from canal water and reusing dredged sediments as new materials for road surfaces and bricks. Emphasis has also been placed on the cultural benefits of Scotland's canals. For example, efforts to create nature reserves on the canals, the cultural and musical Glasgow Canal Festival and sporting competitions on canals have seen local communities take ownership of sustainability projects because they now place value on protecting and preserving clean and healthy canals.

There are also redevelopment works happening along canal pathways to encourage more people to walk and cycle rather than use their car. Glasgow's Smart Canal combines 200-year-old canals with modern-day digital surface water technology to make Glasgow a 'sponge city'. The Smart Canal will allow the north of the city to 'passively absorb, clean and use rainfall intelligently. Advanced warning of heavy rainfall will automatically trigger a lowering of the canal water level to create capacity for surface water run-off' (Glasgow City Region, n.d.). This project has significant environmental benefits through the use of green infrastructure and will avoid the need for excavation and subsequent pollution from construction activities. It will also help in flood prevention across Glasgow at a time when water levels are rising and our weather is becoming even more unpredictable.

Thanks to these initiatives, there is a clear public desire to maintain the health and sustainability of our canals. People are keen to preserve the heritage and advantages surrounding their local canals, and consequently the Scottish government's overall goals to reduce emissions and pollution and to tackle climate change are being addressed too.

All of these public bodies work collaboratively on many projects across Scotland, along with the Scottish government as a whole and other public and private-sector organizations. For example, Scottish Water and SEPA signed a sustainable growth agreement to recover value from waste and make Scotland more resistant to climate change. This cooperative and interdisciplinary approach enables complex issues, which are too large for any one organization to tackle effectively, to be more suitably managed.

Ensuring collaboration across the board is undoubtedly a difficult task. Scotland's involvement in projects such as the Hydro Nation Forum is important in bringing together all of the different bodies and factions working on sustainable water management and getting them all on the same page. Scotland is working to become the first Hydro Nation and aims to make Glasgow a global knowledge hub for research, teaching and technological innovation for water-related issues.

Becoming a Hydro Nation and encouraging different bodies to work together is to the greater good of the environment, which should be enough of a prize, considering the climate emergency our planet faces. However, an additional incentive is the economic benefits such an approach can bring.

One of the underpinning themes of Scotland's Economic Strategy is the 'circular economy' approach. In a circular economy, efficiency is increased and waste is reduced because every possible avenue to reuse and recycle an amenity is explored. This is illustrated in the work of Scottish public-sector bodies dealing with water management because Scotland is extracting the maximum value possible from its water through river restoration schemes, renewable energy initiatives, cultural projects, and so on.

Scotland's water sector is worth an estimated £1.8 billion to the economy, thus there is an economic incentive in ensuring the sustainability of the nation's water management systems. Although the driving force for some may be financial gain, the resulting initiatives ultimately have a positive impact on the environment and are helping shape Scotland as a sustainable nation.

And it is not only Scotland's work at home where lessons can be learnt. The work Scotland does abroad and in collaboration with international partners is also an area of real success. The European INTERREG funding stream granted funding to Scottish Water, Scottish Canals and five other partner organizations to establish the SURICATES north-west European network of water and wastewater test facilities. The partnership will

support innovation and encourage cooperation with small and medium-sized enterprises in the recycling of wastewater and flood control measures. The consortium consists of partners from Belgium, Germany, France and beyond, whilst the public bodies in Scotland act as leads for the project.

In its European engagement, Scotland has arguably taken a leading role in sustainable water management measures and has been open and cooperative in sharing knowledge with its European neighbours. Yet, Scotland is not only working with European partners, it also has a variety of international water management projects underway. In fact, sustainable water management has been incorporated in Scotland's own international development policy and in its interactions with developing nations.

For example, the Scottish government funded the Water Futures Project in Malawi, which will help provide an open data resource to evaluate the risks facing water sources and help address water gaps for the Malawian population. The government also signed a memorandum of understanding at the Commonwealth Heads of Government meeting in 2018 on the Indian Mission for Clean Ganga (the River Ganges).

Scotland was also a key player in the 2015 Global Goals for Sustainable Development of the UN, which put sustainable water management at the top of a list of global priorities. Therefore, just as sustainable water management is linked with a number of domestic policies, so too is it linked with the Scottish government's international engagement.

At a local level there are also key lessons for how Scotland is succeeding in water management and sustainability. Specific community projects such as those I have mentioned are contributing to meeting Scotland's environmental goals and targets. However, it is also important to mention the work of researchers and universities in Scotland, as we are helping shape the minds of the future generation, who will inherit these global environmental challenges. We are also playing our part in the discovery of practices and innovation in technology which are improving efficiency and sustainability in Scotland and across the world. To give an insight into some of the work of my own institution, the University of Glasgow, I will mention two projects which are benefitting not only Scotland but the global community too.

The University of Glasgow took part in the Eurolakes project with several other EU academic institutions. It focussed on water resource management for important deep European lakes and their catchment areas. The project was successful in producing affordable and integrated water management strategies to control pollution and advise EU policymakers.

An ongoing cross-border project known as Aquasense has seen the University of Glasgow receive over €900,000 to help support an innovative network for training in water monitoring using sensors, big data and artificial intelligence. These projects are benefitting local communities in Scotland whilst also helping to form the global approach to sustainable water management. It is this synergy between local activity and wider national and international objectives which puts Scotland at the forefront of green water management and the sustainability agenda as a whole.

Scotland's water is a huge part of our geography but also our economy and our everyday lives, and if we did not put such great emphasis on incorporating water management in policies and activities across the country then we would arguably not be as successful at achieving our climate change goals as we are currently.

There are undeniably lessons which Scotland must learn too, from our own domestic experts and from the general public, but also from other international leaders in water management. These lessons will only be learnt from the sharing of best practices and from the prioritization of water in future discussions and policies at the global level.

Yet, overall, Scotland is still making real headway as a global leader in green water management and sustainability. By viewing water as a major financial resource which can be reused and repurposed for economic, health and cultural benefits, Scotland is reaping environmental benefits.

The circular economy approach sees less waste and more efficiency in Scotland's water management systems, which is helpful for the Scottish government's environmental and financial goals. Moreover, a joint approach to water sustainability practices sees Scottish public-sector bodies collaborate together and with communities. It also sees Scotland collaborating with international partners, and local Scottish institutions cooperating with their counterparts across borders. Scotland is taking a globalized approach to sustainable water management, and in an increasingly isolationist climate, this should be commended.

Glasgow's and Scotland's commitment to sustainability was highlighted recently with the announcement that we would host the major climate change conference, COP26, in 2020. This will be a fascinating opportunity to highlight some of the successes we have had in our efforts to tackle climate change, water management and sustainability.

Water is a human right; indeed it is one of key building blocks of human life. By taking this seriously and putting it front and centre in our policy agenda, Scotland has reaped many benefits and is working to leave a cleaner, more sustainable world for future generations.

If we are serious about achieving global development goals, reversing some of the damage we have already done to our planet and tackling the climate emergency, it is vital not only that Scotland build on its existing progress but also that other nations follow Scotland's lead.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Anton Muscatelli  <http://orcid.org/0000-0003-3001-0640>

References

- Audit Scotland. (2005). Overview of the water industry in Scotland. Retrieved from https://www.audit-scotland.gov.uk/docs/central/2005/nr_051013_water_overview.pdf
- Glasgow City Region. (n.d.). Pioneering new digital surface water drainage system. Retrieved from <http://www.glasgowcityregion.co.uk/article/9857/Pioneering-new-digital-surface-water-drainage-system>