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INTRODUCTION TO CHAPTER 3: SUSTAINABILITY AND ENVIRONMENTAL IMPACT

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The Sustainability concept and its application in practice provide humanity with many challenges and opportunities at different geographical scales. At a global scale, those challenges and opportunities are embodied in the 17 United Nations Sustainable Development Goals and the numerous targets behind them. At the other end of the scale, improving the efficiency of a pump in a wastewater treatment plant, or enhancing the environment around such works – whether for wildlife or to reduce the plant's visual impact on the local community – is making an important contribution.

In between these scales, any project team can improve their project's sustainability credentials by making use of one of the three infrastructure sustainability assessment tools (UK's CEEQUAL, Infrastructure Sustainability from Australia, and Envision from the USA) [see details at the end of this introduction]. These are not only formal assessment and rating systems but can also be important informal tools for project teams in decision-making, by enabling exploration of opportunities to reduce adverse impacts and/or improve performance across a wide range of sustainability-related criteria.

This chapter contains seven interesting papers connecting to the sustainability agenda in a range of ways, from striking better balances between the three legs of sustainability – environmental impacts & benefits, social impacts & benefits, and economic costs & benefits – to improvements at a system or project scale.

The first two papers deal with issues related to the sustainability of desalination and possible measures to reduce its significant environmental impacts and to enhance its sustainability credentials. The following paper focuses on water footprint analysis to identify the quantities of water used in the production of aggregates and related industrial activities. The fourth and fifth papers in this chapter introduce interesting ideas of recovering water from domestic and industrial activities where the output wastewater has never been reused. Staying with the re-use and recycling theme, the following paper shows that construction waste and other by-products could be recycled into the construction of infrastructure facilities to support a more sustainable approach for the management of storm-water. The last paper in this unique collection of papers presents a comparative performance evaluation of two wastewater treatment technologies, as

contributors to sustainable water management. In the rest of this introduction, we provide a brief outline of the important topics and issues addressed in each paper.

It is also worth noting that El-Naser's paper in Chapter 2 on the political and economic consequences of groundwater depletion is also highly pertinent to consideration of the sustainability of water supplies.

The chapter starts with a paper that is meant to start a constructive debate on the sustainability of the water industry as a whole and, in particular, desalination processes. Dr Badr, in his paper on the sustainability of desalination, makes it clear that a technique or technology that brings social and economic benefits to communities or even countries cannot be regarded as sustainable if it is accompanied by serious environmental impacts. The paper examines those serious and significant impacts, and concludes with a list of research and development pathways towards significant improvements. It also stresses that there are some technologies that should only be adopted when the benefits of other, environmentally-beneficial techniques, such as waste minimisation, have been adopted as much as they can be in a socially and economically appropriate way.

Staying with desalination, the paper by Kharraz *et al.* addresses a serious environmental impact – the impact of used reverse osmosis membranes. The authors explore the options for an important sustainability-driven operational improvement in many areas of infrastructure, namely extending the lifecycle of a key system component. They conclude that, whilst some work on extending the useable life of the membranes and into recycling options are under way, further research is particularly needed on alternatives to landfill – on the direct and indirect reuse of membranes including energy recovery.

The paper by Wayman *et al.* concerns an important environmental impact at the upstream end of the construction and use of infrastructure, namely the use of water in the creation of aggregates and aggregate-derived products. It uses water footprint analysis to identify the quantities of water used in Qatar on these activities, and to explore ways in which that consumption can be reduced and/or how the use of potable water can be replaced by using treated sewage effluent. It seems certain that this paper can benefit many other construction organisations in the Gulf Cooperation Council region and further afield. It needs to be remembered that water supply stress is very common around the world – even the south-east of the UK is semi-arid in relation to the size of population living there – so such analysis as a route to reducing water consumption in industrial processes has worldwide application.

Next are two papers addressing another challenge for water-supply-stressed areas – recovering water from activities where the water has previously been considered to be inevitable waste. Alhinai describes the characterisation of domestic and commercial laundry wastewaters in the capital of Oman, Muscat, and explores options for onsite or local treatment to a standard that would enable re-use locally for non-potable uses. Khan et al address the potential for capturing and recycling – also for non-potable uses – the large amounts of condensate water generated through cooling coils of air conditioning

units, which is typically wasted to municipal sewerage systems. Both conclude that these options have a high potential for success, with the condensate collection and recycling being available now, with substantial quantities of water available and typical payback periods of the necessary works being less than a year.

The penultimate paper shows an important aspect of sustainability-driven improvements, that the source of an improvement in one area – in this case attenuation of rainfall run-off from roads – needs development in another – in this case a better pervious concrete (PC). Tijani et al also demonstrate that the developers of a better pervious concrete needed to look to a new material component to provide the properties they required, in this case Sorghum Husk Ash (SHA), alongside a more-widely used, but for some still-new material of recycled concrete aggregate (RCA). They conclude that, at the right proportions, SHA and RCA are suitable for the enhancement of the properties of PC.

The final paper here takes us one more step up the 'supply chain' of new ideas, techniques and new technologies needed for sustainability-driven improvements to infrastructure – better data. The paper by Alwahaibi et al describes a study of absolute and comparative performance evaluation of conventional activated sludge and membrane bioreactor wastewater treatment technologies, as contributors to sustainable water management. The pros and cons of both technologies are identified and further work on MBR is suggested as necessary as a step towards more-sustainable management of wastewater treatment than is currently possible.

In summary, these papers provide a timely discussion of fundamental aspects of the sustainability credentials of water-related activities and how they could be improved. Applying learning from them could yield significant improvements to the sustainability of processes related to the production of freshwater and treatment of wastewater. Some papers provide valuable recommendations and insights for engineers and organisations on improving the sustainability of activities related to the water industry.

Finally, in order to enrich the brief description given in this introduction and to capture the excitement of the persistently evolving debate on sustainability and in particular on what *is* a sustainable water future and how can it be delivered, we encourage you to read thoroughly all papers in this chapter and to pursue the further reading included in the following links to UN SDGs and sustainability rating systems for infrastructure.

- For the United Nations work on sustainability, go to https://sdgs.un.org/goals.
- CEEQUAL, the sustainability assessment, rating and awards scheme for civil engineering, infrastructure, landscaping, and works in public spaces is based in the UK but available internationally. Details are at https://www.ceequal.com/.
- The IS Rating Scheme is operated by the Infrastructure Sustainability Council of Australia. Details are at https://www.isca.org.au/is_ratings.
- Envision operated in the USA by the Institute for Sustainable Infrastructure is detailed at https://sustainableinfrastructure.org/envision/overview-of-envision/.