Institution: Abertay University

Unit of Assessment: 12 - Engineering

Title of case study: Sustainability Assessment and Decision Support for the Scottish Government and Water Industry

Period when the underpinning research was undertaken: 2008 – 2020

Details of staff conducting the underpinning research from the submitting unit:

Names:	Roles (e.g. job title):	Periods employed by submitting HEI:
Dr Daniel Gilmour	Senior Lecturer	1998 – present
Prof. Joseph Akunna	Professor in Water and Environmental Engineering	1993 - present
Prof. David Blackwood	Professor of Sustainable Development	1985 – 2019
Prof. Ruth Falconer	Professor of Complex Systems Modelling	2000 – present

Period when the claimed impact occurred: 2015 – 2020

Is this case study continued from a case study submitted in 2014? No

1. Summary of the impact

Scotland's water environment is a recognised national asset that is essential for healthy living and an important part of Scotland's economy. Scottish Government seeks to: (i) stimulate water sector growth, in terms of turnover, jobs and exports; and (ii) provide rural communities, nationally and internationally, with access to clean drinking water supplies together with affordable treatment and disposal of waste.

We have worked with Scottish Government through a portfolio of commissioned projects to:

1. Implement a new decision-support framework to enable Scottish Government to select appropriate drinking water treatment technologies for sustainable rural communities
2. Provide interactive maps to enhance the way in which Scottish Government targets support for the Scottish Water Sector; we have enabled rapid, visual interrogation of facilities, SMEs, etc. in the Sector to signpost inward investors and has contributed to significant growth
3. Identify and implement specific interventions for Scottish Government to support the sustainable development goals of the Government of Malawi.

2. Underpinning research

Our research group (Urban Water Technology Centre, UWTC) has worked with government and sector stakeholders for over 20 years to help improve water and associated services nationally and internationally. UWTC has focused on water-treatment technology assessment and on developing a holistic approach to support decision making for sustainable outcomes.

We have built a body of research in water-treatment technology assessment, nationally and internationally. We have described the case study application of a methodology to determine environmental, social, economic and technical criteria to support sustainable decision making for water management **[3.1]**. Central to this approach is the involvement of stakeholders and multi-criteria decision analysis (MCDA). Our work evidences the utility of the methodology for strategic planning to enhance existing sewage systems and for assessing the relative sustainability of multiple water treatment options. In our international work, we have investigated the removal of pharmaceutical compounds in hospital wastewater treatment plants in Saudi Arabia **[3.2]**. Using two sites that had on-site treatment capability, we determined through chemical analysis the presence of multiple pharmaceutical compounds in hospital wastewater and profiled compound removal by the onsite wastewater treatment plants. We found that the treatment plants achieved high removal efficiencies from wastewater of the pharmaceutical compounds tested and that temperature and potentially photodegradation were likely drivers of removal efficacy.

Our research into decision support for sustainable outcomes recognises sustainable urban and rural planning must address multiple competing environmental, economic and social factors.

Decisions must inevitably trade some factors off against others. A central challenge in decision-making is communication of system-wide interactions that emerge from combinations of decisions for individual factors. We combined engineering, environmental science, mathematics, and computer games to unpack the complexities in this decision-making process through the Sustainability Assessment, Visualisation and Enhancement (SAVE) framework. SAVE provides interactive visualisations of a range of data-modelled scenarios and their sustainability assessment. SAVE promotes an integrated, iterative approach to inclusive decision-making, founded on our generic approach for participatory selection of sustainability criteria and indicators **[3.3]**. We have demonstrated the use of the approach to derive initial wide-ranging criteria set, drawn from literature spanning environmental, social, economic, and technical concerns, which is systematically reduced for that scenario via expert stakeholder involvement.

The visualisation engine at the heart of SAVE **[3.4]** combines a suite of mathematical models with both 2D (to echo conventional plans) and 3D interactive visualisations of a given development region. The environment can comprise multiple built structures, natural features (e.g. rivers) etc. and users can navigate around the area as per a computer game. Mathematical models embody sustainability indicators and include energy efficiency of any building materials used, noise pollution (e.g. traffic), economic value, social acceptance and housing provision. Visualisations allow comparisons of two alternate scenarios and combine multi-variable visualisation through blending (an aggregate score) or by weaving (where multiple sustainability indicators are shown concurrently) shown in Figure 1.

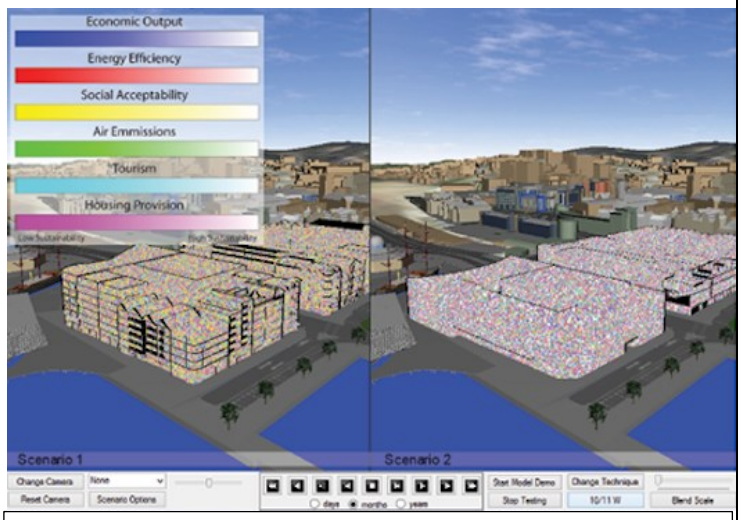

Figure 1: sustainability indicators (colour weaves) for different building materials (left – glass; right – brick) for a waterfront building; control panel enables manipulation of user view, building, parameters, timeline etc. Adapted from Fig 16, in E-*Planning and Collaboration: Concepts, Methodologies, Tools, and Applications,* 2018, Vol 1, Ch 23, IGI Global.

Our SAVE framework of sustainability assessment, visualisation and enhancement **[3.5]** embodies both visualisation **[3.4]** and participatory criteria identification **[3.3]** and includes a case study showing SAVE parameterisation for a waterfront development project. Assessment includes data collation and model parameterisation. Enhancement spans identification of relevant stakeholders, the spectrum of decision options and key intervention points. Enhancement opportunities were determined through stakeholder workshops and the resulting knowledge map and intervention points presented. Finally, and validating the SAVE framework as an effective means of communication of complex information to stakeholders, a series of workshops challenged stakeholders to determine the sustainability of different scenarios and which indicator was driving sustainability. Workshops showed strong stakeholder engagement with the problem space and that stakeholders could interpret the complex visualisations effectively. SAVE is a configurable platform of data inputs and interactive data visualisation engine and has been used in a wide range of contexts in 3D and 2D, including urban planning, coastal erosion, river pollution, landscape mapping for the water sector and solar energy.

3. References to the research

3.1 Ashley R, Blackwood DJ, Butler D, Jowitt P, Davies J, Smith H, Gilmour DJ, Oltean-Dumbrava C (2008). Making asset investment decisions for wastewater systems that include sustainability. *Journal of Environmental Engineering* 134(3), 200-210. https://doi.org/10.1061/(ASCE)0733-9372(2008)134:3(200)

3.2 Al Qarni H, Collier P, O'Keeffe J *et al.* Investigating the removal of some pharmaceutical compounds in hospital wastewater treatment plants operating in Saudi Arabia. *Environ Sci Pollut Res* 23, 13003–13014 (2016). https://doi.org/10.1007/s11356-016-6389-7
3.3 Blackwood DJ & Kurka T (2013). Participatory selection of sustainability criteria and indicators for bioenergy developments. *Renewable and Sustainable Energy Reviews*, *24*, 92-102. https://doi.org/10.1016/j.rser.2013.03.062
3.4 Isaacs JP, Blackwood DJ, Gilmour DJ & Falconer RE (2013). Real-time Visual Simulation of Urban Sustainability. *International Journal of E-Planning Research* 2(1) 20-42. https://doi.org/10.4018/ijepr.2013010102
3.5 Blackwood DJ, Gilmour DJ, Isaacs JP, Kurka T, & Falconer RE (2014). Sustainable urban development in practice: the SAVE concept. *Environment and Planning B: Planning and Design*, *41*(5), 885–906. https://doi.org/10.1068/b39080

4. Details of the impact

4.1 Enabling water technology assessment through a decision support tool

Scottish Government's Hydro Nation Strategy, and Scottish Water's objectives and relevant water policies, include the need to improve the quality and resilience of private water supplies. Key to meeting this need is compliance with the Drinking Water Directive and the performance of septic tanks to help meet Water Framework Directive objectives. Our research underpinned a project commissioned by Scottish Government in which we developed a decision support tool (DST) that has been used by Scottish Water to evaluate technologies for sustainable water treatment. The DST builds on our research experience in water treatment technologies **[3.2]** stakeholder involvement and MCDA **[3.1]**. The DST enables Scottish Water to assess drinking water treatment technologies suitable for small to medium rural communities. We determined candidate technologies to assess, assessment criteria to use, and developed a MCDA tool. Scottish Water then used this tool in their assessment of water treatment technologies.

Head of Research and Innovation at Scottish Water states: "*A Decision Support Tool (DST) developed by Abertay as part of this programme of work examined the drinking water treatment technology landscape on a national and international level, horizon scanning for new and innovative products. Abertay developed a rationale for assessing the technology across a range of operational scenarios through development of assessment criteria. Sustainable Rural Community research undertaken by Abertay improved the decision-making process, making it more inclusive for communities and other stakeholders to explore water innovations. […] The decision support process directly informed the selection of appropriate drinking water treatment for sustainable rural communities. This raised awareness in stakeholders enabling them to make informed decisions and enhanced sustainable water services by including them in the development discussions. The technical assessment of technology provided a wide range of measures that could potentially improve water quality in rural communities.* ***The DST has been used to determine the selection of drinking water technologies suitable for point of use applications in private water supplies in rural communities****. 11 technologies were assessed using the DST which were then tested at Scottish Water's Test Centre in 2018*" **[5.1]**.

Importantly, testing revealed a requirement for a pre-treatment process in order to meet current standards, and this information was shared with local authorities, who regulate private water supplies, and the Drinking Water Quality Regulator. As a result of this finding, and in order to identify a suitable pre-treatment technology, Scottish Water then set up a £450,000 Can Do Innovation Challenge Fund *"The DST developed by Abertay* ***improves the ability of Scottish Water to select potential innovative technologies in a more inclusive way****. This directly supports Scottish Water's aim to create a water and wastewater service that is more affordable, resilient and sustainable to even the most remote of Scotland's communities"* **[5.2].** Additionally, Mr Jon Rathjen, from the Water Industry Team, Scottish Government noted in a CREW (Scotland's Centre of Expertise for Waters) Impact Strategy Report that "*The decision support tool helpfully underpins the work to create both physical testing centres, support mechanisms and innovation culture in the industry. Supports the ongoing HN* [Hydro Nation] *work and links to UK work to support innovation."* **[5.3]**

4.2 Scotland's Water Map

Scotland's water sector is worth an estimated £1.8 billion, with 16,600 direct full-time jobs and 1,000 staff working in R&D and innovation. The Scottish water sector is complex, comprising SMEs providing services, HEIs with RKE expertise, facilities and laboratory services. In a commissioned project, Scottish Government sought our water technology and interactive visualisation expertise to construct a synthesis of Scotland-wide information sets on locations of and interconnections among >400 water sector organisations and assets. In response, we combined our methodology for assessment of sustainable decision making for water management assets **[3.1]** and our SAVE framework **[3.4, 3.5]** to build two complementary interactive visualisations: a 3D landscape map and a 2D information flow graph. The landscape map has zoom and rotate functions and shows the spatial distribution of organisations and assets, which may be filtered by type (renewables, businesses, etc.). The 3D map can transform these data into a density measure of water sector activity per local authority/ activity type. The 2D graph provides an explorable visualisation of information flow amongst organisations, services and facilities. Information flow can be filtered by theme (e.g. R&D, economic) and organisation, to understand the complex stakeholder interaction occurring within the sector.

This Water Map has supported Scottish Government actions to improve Scotland's capacity through an integrated approach to water management. Scottish Government have regularly used our Water Map to target support more effectively for the sector as part of the Scotland's Hydro Nation Strategy Framework which aims to promote Scotland as a Hydro Nation. This Strategy Framework benefits Scotland through the economic development and good stewardship of Scotland's water resources and sharing best practices with the world.

Abertay's integrated analysis of the Scottish water sector via the Map has supported management activities including the Hydro Nation Innovation Service, a bespoke service for the water industry which provides advice, introductions and support to innovators wanting to bring new products and services to market. Since its launch in 2015, Scottish Government has requested two updates to the map to more efficiently identify and target investment in the Hydro Nation. Abertay has added laboratory/ analytical services and then specialist expertise based in both commercial companies and relevant parts of the HEI sector. **The Hydro Nation Team then used this information to identify required facilities and the specialisms from the map and sign post inward investors, nationally and internationally, and collaborators to partner SMEs, laboratories and innovation centres.**

As stated by Mr Barry Greig, Scottish Government Hydro Nation Manager: *"It's no exaggeration to say that the **Water Sector Map is of national importance** and in recognition of that fact the Scottish Government have requested two updates to the data-base since the launch. […] **The water map is a key resource that is used on a weekly basis**. **The map allows me to quickly identify sectoral and geographical synergies in the sector**. The map informs the development and evolution of the Hydro Nation Strategy to help understand the nature and makeup of the water sector business and complex interactions that exist between key actors in the sector to allow water management strategies to exploit inter-sectorial links. As a result of more effective targeted support, there has been significant growth in the water sector in Scotland over the past three years in turnover (29%), jobs (23%) and exports (28%).[…] **Its use** together with Hydro Nation water management strategies **has contributed to economic benefit** through the significant recent growth in the water sector in Scotland.*" Source **[5.4]**.

4.3 Influencing Scottish Government's commitment to support UN SDG6 in Malawi

The United Nations Sustainable Development Goal (SDG)6 is to ensure access to water and sanitation for all. Abertay's research influenced Scottish Government's support to the Government of Malawi to achieve SDG6. We followed the same stakeholder mapping process as in **4.2** using the SAVE framework **[3.5]** to engage stakeholders and identify relevant assessment criteria and sustainability indicators **[3.3]** through interactive visualisation **[3.4]**. We represented the water sector in Malawi showing stakeholders in relation to their contribution to key areas of governance and policy development, regulation, policy implementation and service provision. Our research provided Scottish Government with tools and templates for assessing and developing interventions to address SDG6 needs in sub-Saharan Africa, as reported to

Scottish Government Ministers in the Scottish Hydro Nation Annual Report 2019 **[5.5]**. We also helped to shape the Scottish Government's Water Futures programme (£4.8M, 2017-2020) providing confidence to Scottish Government on the robustness of the approaches that they employed: "[Abertay research] ***helped to shape the forward direction of SG water futures*** *programme keeping it focussed on governance and capacity building and provided confidence and reassurance on pace and direction and the value of continuing interventions in Malawi*" **[5.6]**

Our mapping of water sector stakeholders across the Malawi Government, Regional and District water offices revealed that existing processes and interactions limited the effectiveness of the planning process, which as a result restricted effective operation of the water sector and the implementation of water development projects. This finding allowed us to identify that support was required from Scottish Water International to assist in asset management and governance of existing water assets. Our mapping of policy identified the lack of implementation of the Malawi Water Resources Bill, which required the establishment of the National Water River Authority (NWRA) in Malawi. An implementation plan for the NWRA was required, and we brought in the Scottish Environment Protection Agency (SEPA) with their experience of implementing a regulatory authority in Scotland to act as a support mechanism.

By using the SAVE framework to engage Malawi stakeholders effectively through visualisation of data-driven models **our work identified the Critical Path needed to support Scottish Government to deliver SDG6 in Malawi**. As stated by Mr Jon Rathjen, Water Industry Team, Scottish Government: "*This Critical Path assisted Scottish Government to determine and develop 5 specific interventions actions for Scottish Government to support Malawi. Scottish Government* ***has now implemented support across****:*

- *Scottish Government's role as a Donor - Support coordination efforts at Donor and NGO groups (Donor Group/Sector Working Group/WESNET).*
- *Scottish Government to Malawi Government interaction – Raising the profile of water and improving the governance and regulatory framework*
- *Scottish Government - Support local training provision and capacity building*
- *Scottish Water International - Support asset assessment and management plans*
- *SEPA - Catchment management and water resources management support.*

Abertay University's research has made an impact and positively contributed to the impact of Scottish Government support to the Government of Malawi in the achievement of SDG6." **[5.7]**

As part of Scottish Government's implementation of this critical path, Scottish Environment Protection Agency (SEPA) has been working with Malawi's National Water Resources Authority (NWRA) to support its establishment and operationalisation. The Government of Malawi has recently appointed the board members of the National Water Resources Authority (NWRA). With the establishment of the Malawi Scotland Regulatory Partnership (MSRP), SEPA continues to work with Hydro Nation to support the Government of Malawi to empower key regulatory institutions aiming to protect Malawi's water resources and environment. **[5.8]**

5. Sources to corroborate the impact

5.1 Testimonial from Mr George Ponton, Head of Research and Innovation, Scottish Water
5.2 Testimonial from Dr Richard Allan, Centre of Expertise for Waters (CREW) Manager
5.3 CREW Impact Strategy Survey Response Provision of water and wastewater services project (CRW2016_01). Contact Rachel Helliwell, Centre of Expertise for Waters (CREW)
5.4 Testimonial from Barry Greig, Hydro Nation Manager, Scottish Government.
5.5 Scotland: The Hydro Nation Annual Report 2019 https://www.gov.scot/publications/scotland-hydro-nation-annual-report-2019/
5.6 CREW Impact Strategy Survey Response Malawi project (CRW2016_17). Contact Rachel Helliwell, Scotland's Centre of Expertise for Waters (CREW)
5.7 Testimonial from Mr Jon Rathjen, Head of Water Industry Team, Scottish Government
5.8 Scotland: The Hydro Nation Annual Report 2020 https://www.gov.scot/publications/scotland-hydro-nation-annual-report-2020/