Institution: Cranfield University

Unit of Assessment: UoA 6

Title of case study: Water for food - setting the agenda for sustainable agricultural water management

Period when the underpinning research was undertaken: 2000-2020

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

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Professor Tim M Hess	Research Officer to Professor	1981–present.
Professor Jerry W Knox	Research Officer to Professor	1993–present.
Professor Ian P Holman	Research Officer to Professor	1994–present.
Dr Dolores Rey Vicario	Lecturer	2014–present.

Period when the claimed impact occurred: 2013 to 2020

Is this case study continued from a case study submitted in 2014? Y/N Yes

1. Summary of the impact (indicative maximum 100 words)

A new framework for understanding current and future water demands in agriculture has directly informed policy and management reforms by the Department for Environment, Food and Rural Affairs (Defra) and the Environment Agency.

Cranfield research has been used across the agri-food sector - including horticultural and fresh produce retail businesses - to develop sustainable water plans and build resilience.

Policy changes and industry engagement around planning and catchment management are critical to protecting fresh produce supply chains from climate change both domestically and globally; and meeting growing global demand for fresh fruit and vegetables (with the associated benefits to public health).

2. Underpinning research (indicative maximum 500 words)

Cranfield staff developed a combination methodology to provide the first national-scale assessment of water demands and the economic value of irrigated agriculture. This involved using hydrological and biophysical models to estimate water requirements for a range of crops, incorporating spatial variations in soils, land use, agronomic management practices and agro-climate. More reliable estimates of water demand were produced by incorporating algorithms to eliminate distortions arising from weather variation and integrating high-resolution geospatial data. Using horizon scanning techniques with input from stakeholder groups, scenarios were constructed to reflect plausible changes in future agro-economic policy, environmental regulation and socio-economic development. The combined impacts on future agricultural water demands were then modelled as part of a national initiative to provide robust and methodologically consistent demand forecasts across competing sectors (public water supply, agriculture, power generation and environment) [R1]. Our research has provided the evidence for all national strategic water demand forecasts for agriculture by Defra, the Environment Agency, Scottish Environment Protection Agency and Natural Resources Wales over the last two decades.

Capitalising on high-resolution climatology from the UK Climate Impacts Programme, the researchers had previously developed simulation models to integrate climate change into the modelling and mapping of impacts on crop yields, and the potential risks and opportunities that

might arise from predicted changes in land suitability [R2]. For selected high-value crops, experimental data were used to validate biophysical models to assess the impacts of climate variability and abiotic stress (drought) on productivity, water use and crop quality, under both conventional and precision management regimes [R3]. Econometric analyses assessed the impacts of water stress on price due to reductions in crop quality. By combining outputs, the researchers quantified the financial benefits of irrigation and economic consequences of restrictions on irrigation abstraction [R4]. In parallel, and drawing extensively on the outputs from this research, new methodologies were developed to conduct post farm-gate assessments of water footprints, and to assess the impacts of dietary choices on water use and greenhouse gas emissions [R5].

Cranfield led the agricultural drought impacts and modelling research (within the Historic Droughts and MaRIUS projects) and agricultural stakeholder engagement in the five-year NERC Droughts and Water Scarcity Programme (2015 to 2019). Building on our earlier research, this critically evaluated farm-scale strategies to improve drought resilience in agriculture under conditions of increasing water scarcity [R6]. Our expertise in modelling climate and drought risks has also been applied to support business level decision-making. This has involved the development of a webtool to help farming enterprises understand emergent drought and abstraction risks. This tool has supported decision-making for a range of business sectors on how future changes in abstraction licensing (resource availability and licensed 'headroom') might impact on their investment plans for new irrigation and water resources infrastructure.

3. References to the research (indicative maximum of six references)

R1 Knox, JW, Haro-Monteagudo, D, Hess, TM, Morris, J (2018) Identifying trade-offs and reconciling competing demands for water: Integrating agriculture into a robust decision-making framework. *Earth's Future* 6(10): 1457-1470. https://doi.org/10.1002/2017EF000741

R2 Daccache, A, Weatherhead, EK, Stalham, MA, Knox, JW (2011) Impacts of climate change on irrigated potato production in a humid climate. *Agricultural and Forest Meteorology* 151: 1641-1653. https://doi.org/10.1016/j.agrformet.2011.06.018

R3 González Perea, R, Daccache, A, Rodríguez Díaz, JA, Camacho Poyato, E, Knox, JW (2017) Modelling impacts of precision irrigation on crop yield and in-field water management. *Precision Agriculture* 19(5): 1-16. https://doi.org/10.1007/s11119-017-9535-4

R4 Salmoral G, Rey D, Rudd A, de Margon P, Holman IP (2019) A probabilistic risk assessment of the national economic impacts of regulatory drought management on irrigated agriculture *Earth's Future* 7(2) 178-196. https://doi.org/10.1029/2018EF001092

R5 Hess, TM, Chatterton, J, Daccache, A, Williams, A (2016) The impact of changing food choices on the blue water scarcity footprint and greenhouse gas emissions of the British diet: The example of potato, pasta and rice. *Journal of Cleaner Production*, 112(5) 4558-4568. https://doi.org/10.1016/j.jclepro.2015.08.098

R6 Rey, D, Holman, IP, Knox, JW (2017) Developing drought resilience in irrigated agriculture in the face of increasing water scarcity. *Regional Environmental Change* 17(5): 1527-1540. https://doi.org/10.1007/s10113-017-1116-6

4. Details of the impact (indicative maximum 750 words)

Cranfield has delivered research impact through close collaboration: with key government agencies and departments (Defra, Environment Agency (EA), Natural England, Scottish Environment Protection Agency, National Resources Wales); with the private sector and agricultural levy board (AHDB); non-governmental collaborators (National Farmers Union (NFU), UK Irrigation Association, Royal Horticultural Society); retailers (Marks & Spencer and Sainsbury's); and, environmental stakeholders (Rivers Trusts, Royal Society for the Protection of Birds and WWF-UK).

This level of engagement has ensured our research has directly informed strategic responses at national and regional levels by the agri-food industry to profound water resources policy reforms. It has also supported industry initiatives to raise awareness of the future climate and water-related risks facing their sector [S1].

Our socio-economic, policy and environmental impacts are evident within three key areas:

(i) Abstraction regulation and agricultural water resources planning

Research has underpinned national (Defra and EA) water regulation and policy formulation, as well as water resource planning at catchment, regional and national levels.

"The EA have relied extensively on the research by Cranfield staff to support its national strategic planning of water resources" (Senior Advisor, EA) [S2]

This has included strategies such as "The Case for Change: current and future water availability" (2013) providing core evidence to underpin the UK Government's Water White Paper, and latest national water policy "Meeting our future water needs: a national framework for water resources" (2020) [S2]. Three strategically important areas of EA water resources regulation have been supported by our research, including (a) understanding future water demands and climate uncertainty in the agricultural and horticultural sectors, (b) supporting the UK Government national framework for water resources, and (c) supporting abstraction management reforms including licence renewal [S2].

Our modelling approaches and outputs have also been used in regional integrated water resources management planning frameworks to support robust decision-making, and in multi-sector collaboration among stakeholders involved with public water supply, agriculture, power generation and the environment [S3].

(ii) Retailer water risks and sustaining sourcing

Our work on water accounting, footprinting and water risk mapping has been used by 12 food and drink businesses (including importers, manufacturers, and retailers) to support company policies for more sustainable production and sourcing, and in support of sustainability reporting and supply chain engagement (contributing to reduced water risks and environmental impacts) [S4].

"As a result of the work that Cranfield have delivered, we have been able to share best practice and learnings with our growers globally. The work on potatoes has been of particular benefit….to optimise marketable yield, ultimately making them more efficient and sustainable" (Category Technical Manager, Sainsbury's Plc) [S4].

An Agricultural Water Use Efficiency Toolkit, a bespoke package of training materials was developed by Cranfield for PepsiCo. The Toolkit is now being used to improve on-farm water management and build resilience to climate and water risks right across its global operations, including the USA, Latin America, Europe, Middle East, Asia, China, and Australia. The core content is being used to deliver water use efficiency, improve resilience, create quality, and cost benefits, and improve farming livelihoods. The direct agricultural supply chain involved sources 25 crops across 60 countries and supports more than 100,000 jobs [S5].

"(Cranfield are) critical partners in PepsiCo's efforts to build a more resilient and sustainable agricultural supply chain, including a program of ongoing engagement." (Senior Director, PepsiCo Global Sustainability) [S5].

(iii) Improving drought risk management and climate adaptation

The D-Risk webtool has been actively promoted by the UK Irrigation Association in its Irrigation Handbook. There are more than 175 business users of D-Risk, including major agribusinesses and high-profile sports and amenity businesses, who use the tool to support their decision-making, risk management and strategies regarding investment in new water infrastructure. Our risk-based assessments have formed the basis of expert advice to the regulatory agencies (Environment Agency, Natural England) and agri-food industry (NFU, AHDB) on the likely impacts of future climate and policy reforms on high-value commodity agriculture [S1].

Through a Knowledge Transfer Partnership (KTP), Cranfield researchers have been supporting Royal Horticultural Society (RHS) initiatives to improve water management across its own estates as well as members' gardens in order to increase recognition of the value of water. This has been achieved by co-provision of water management training to curatorial staff within the gardens; the press office delivering messaging on water management to 500,000 members and a national audience of gardeners; co-production of an RHS Water Policy for the RHS Senior Leadership Team; selection of 'water' as a Theme for the RHS flagship shows at Chelsea and Hampton Court in 2021, and the re-organisation and updating of the water management pages on its website. Cranfield provided improved information within their 'water use in gardens' and 'watering' advice profiles, which saw a 680% increase in web traffic in 2020 (versus 2018), impacting on new membership conversions [S6].

5. Sources to corroborate the impact (indicative maximum of 10 references)

[S1] National Water Resources Specialist, National Farmers Union (NFU): the importance of water for food and the value of the food and agricultural sector to the economy; CU role in supporting and advising the agrifood industry.

[S2] Senior Advisor, (E&B Water Resources), Environment Agency: evidence of our research impact on national water resources regulation and abstraction management.

[S3] Managing Director, Water Resources East (WRE): essential contribution of Cranfield to the innovative holistic approach to integrated water resources management. Cranfield support for agricultural components in WRE as an exemplar for water resources planning now being adopted in other regions nationally.

[S4] Category Technical Manager, Sainsbury's Plc: Cranfield's identification and mapping of water risks in their fruit and vegetable supply chain has underpinned their responsible sourcing strategy.

[S5] Senior Director, PepsiCo Global Sustainability: how our irrigation efficiency toolkit is helping the business build resilience to climate and water risks across their global grower base and supply chains to reduce environmental impacts (including Walkers in the UK).

[S6] Director of Science & Collections, Royal Horticultural Society (RHS): the value of the UK landscape and amenity, horticulture and gardening sector to the economy and wellbeing; the central role of water; Cranfield's support in developing an organisational water strategy that underpins improved efficiency; Cranfield impacts on RHS membership growth and shows.