

Institution: 10007822
Unit of Assessment: 6
Title of case study: Improving UK Regulation of Agricultural Irrigation
<p>1. Summary of the impact</p> <p>Research at Cranfield has underpinned national policies for managing and allocating the UK's agricultural water resources over the past 20 years. It has supported major reforms in water policy, abstraction legislation and drought management. It has done this by modelling spatial and temporal variations in demand for irrigation, linking this to the financial impacts of water stress on crop yield and quality, projecting future demand, and assessing climate change impacts and potential adaptations. It has also significantly impacted the agri-food sector, helping agribusinesses assess the viability of irrigation and reservoir investment, encouraging collaboration, and reducing risks in the food supply chain.</p>
<p>2. Underpinning research</p> <p>Weatherhead led the first national comprehensive assessment of current and future water demand for agriculture [1]. Based on multiple linear regressions analysis by crop sector and region, it eliminated distortion from inter-annual weather variation to assess underlying growth rates in areas irrigated and volumes applied. Alternative future agro-economic, policy and technical changes were then modelled, and their influence on growth rates estimated. This work underpinned much research on irrigation water resources in England and Wales for the next two decades.</p> <p>Weatherhead and Knox integrated this research into a (then) novel GIS-based methodology, combining abstraction records, government cropping censuses, irrigation surveys, spatial soils and agroclimatic data, with a crop water-balance model (developed by Hess). This allowed the modelling of spatial variations in irrigation water requirements. This was initially completed for potatoes [2] and then developed for other nationally important irrigated commodity crops.</p> <p>By combining historical records with this novel mapping methodology, Cranfield researchers identified the underlying spatial trends in areas being irrigated, the depths of irrigation water applied and volumetric water use, and predicted future changes in irrigation demand under contrasting socio-economic scenarios [3]. This research fed directly into the Environment Agency's (EA) future water resource planning at catchment, regional and national levels.</p> <p>By combining these spatial analyses with biophysical and econometric models on the effect of water stress on crop yield and price variation with crop quality, the researchers identified the financial costs and benefits of irrigation, the value of water for agriculture, the spatial financial impacts of water shortages and abstraction restrictions on irrigated production, and the economic and societal impacts on the wider rural economy [4].</p> <p>Subsequently, Cranfield researchers incorporated climate change into their demand forecasts and quantified the potential impacts on crop productivity (yield) [5], water use and the viability of rainfed cropping [6]. This allowed them to advise regulators and the agricultural industry on the likely impacts and range of adaptation options available in high-value commodity agriculture.</p> <p>The research also allowed them to identify irrigation water demand "hotspots" to support the formation of farmer-led water abstractor groups and assist the regional development agencies (EEDA, EMDA, SEEDA) in adopting a strategic approach for targeting grant aid (RDPE) funding for investment in reservoir infrastructure in water-stressed catchments.</p>

Key staff	Posts	Dates	Research
Professor K Weatherhead	Lecturer to Professor	1981–present	Water engineering, water resources, technology, climate change
Dr JW Knox	Research Officer to Reader	1993–present	Agricultural systems, water resources, crop science, climate change
Dr TM Hess	Research Officer to Reader	1981–present	Modelling; hydrology; ecosystem services; sustainability assessment

3. References to the research

1. Weatherhead, E K, Place, A J, Morris, J and Burton, M (1993). Demand for irrigation water. R&D Report 14. National Rivers Authority, Bristol.
2. Knox, J.W., Weatherhead, E.K. and Bradley R.I. (1996) Mapping the spatial distribution of volumetric irrigation water requirements for maincrop potatoes in England and Wales. *Agricultural Water Management* 31(1-2): 1-15. doi: 10.1016/0378-3774(96)01238-3.
3. Weatherhead, E.K. and Knox, J.W. (2000). Predicting and mapping the future demand for irrigation water in England and Wales. *Agricultural Water Management* 43(2): 203-218. doi: 10.1016/S0378-3774(99)00058-X.
4. Knox, J.W., Morris J, Weatherhead, E.K. and Turner A.P. (2000). Mapping the financial benefits of sprinkler irrigation and potential financial impact of restrictions on abstraction: a case study in Anglian Region. *Journal of Environmental Management* 58(1): 45-59. doi: 10.1006/jema.1999.0307.
5. Daccache, A., Knox, J.W., Weatherhead, E.K., and Stalham, M.A. (2011). Impacts of climate change on irrigated potato production in a humid climate. *Agricultural and Forest Meteorology* 151(12): 1641-1653. doi: 10.1016/j.agrformet.2011.06.018.
6. Daccache, A., Keay, C., Jones, R.J.A., Weatherhead, E.K, Stalham, M.A., and Knox, J.W (2012). Climate change and land suitability for potato production in England and Wales: impacts and adaptation. *Journal of Agricultural Science* 150: 161-177. doi: 10.1017/S0021859611000839.

4. Details of the impact

Cranfield's research has supported government reforms of the abstraction licensing system and informed regulation and water management strategies during periods of drought, helping minimise financial impacts on agricultural abstractors and economic impacts to the rural economy. It has underpinned improvements in on-farm water management and efficiency. It has enabled farmers, processors and retailers to understand the water-related risks in the fresh produce supply chain. It has also informed farmers and government on the value of water for farming, and supported investment in on-farm water storage, and other adaptations to water scarcity.

The research has been undertaken in close collaboration with key government agencies and departments (MAFF, DETR, Defra, EA, SEPA and Natural England), and the UK agricultural levy boards. Non-governmental collaborators included organisations representing the farming industry such as the National Farmers Union and the UK Irrigation Association, retailers including Marks & Spencer and Sainsbury's, and environmental stakeholders such as the Royal Society for the Protection of Birds and WWF-UK. This broad engagement ensured that the research was suitable for both informing policy development and supporting the rapidly changing food and farming sector.

Water Resources Management and Regulation

In the UK, especially eastern England, water for agricultural irrigation is a critical component of high-value crop production; a major contributor to the rural economy. More than 1000 farming businesses depend on water to supply premium quality produce to food manufacturers and retailers, providing over 30% of potatoes and 25% of all fruit and vegetables produced in the UK. Together the agri-food industry employs over 50,000 people and contributes some £3 billion annually to the economy of eastern England.

Cranfield's research has provided the framework for regional and national actions to improve UK agricultural water management. Our researchers forecast irrigation water demand for the Environment Agency's water resource strategies in 2000 and 2008 [1], and for Defra in 2002 (in

the Climate Change and Demand for Water Revisited study) [2] and in 2013 (in support of Defra abstraction reform). They have informed sector-specific water strategies for the agri-food and horticultural industry (HDC) [3] and regional development programmes for agriculture (EEDA).

Our research forms the basis of the procedure used by the Environment Agency [4] and the Scottish Environment Protection Agency (SEPA) [5] to assess abstraction licence applications; in particular; what constitutes 'reasonable' water allocation for an irrigated farm.

By combining this research with microbiological studies, our work has informed the development of guidelines for the horticultural industry where there are public health risks associated with using low quality river water for irrigation of crops eaten raw [6].

Internationally, Cranfield research has been applied in key studies for the European Commission, including assessments of water saving in agriculture and underpinned the EC's development of a "Blueprint to Safeguard Europe's Water Resources" [7].

Climate change impacts and adaptation

We have advised governments and industry clients on adaptation policy in both the UK and internationally by combining crop growth and irrigation models. This has provided underpinning data for the UK Foresight study on Land Use Futures [8] and to examine the impacts on changes in land suitability for non-irrigated crops, which directly affects irrigation demand. A booklet summarising the climate impacts and adaptation options for the UK potato industry [9] based on our work was disseminated to over 3000 farming businesses by the AHDB levy board (PCL). This research led to Knox being appointed Agriculture Sector champion in the government's first Climate Change Risk Assessment (CCRA).

Improving on-farm water efficiency

The regional development agencies (EEDA, EMDA, SEEDA) have used Cranfield's research on the economics of reservoir investment and benefits of irrigation to assess grant applications for investment in farm reservoirs. Information booklets summarising our research outputs on improving irrigation efficiency, switching technology, coping with droughts and reservoir investment have been disseminated by the water regulator (EA) to over 5000 abstractors in England and Wales, as well as farming businesses, regulatory agencies, government (Defra) and other stakeholders.

Cranfield's approach has been widely commended by both the water regulator and farming community. The impacts of our integrated programme of irrigation research, and strong commitment to knowledge transfer into the food and farming industry, have been recognised internationally. In 2010, Weatherhead and Knox received the WATSAVE Annual Award "for outstanding contribution to water savings and water conservation in agriculture, thereby enhancing the beneficial and sustainable use of this precious resource" from the International Commission on Irrigation and Drainage (ICID) [10].

5. Sources to corroborate the impact

1. EA (2009). *Water Resources in England and Wales - current state and future pressures*. Bristol, England. <http://preview.tinyurl.com/eawaterres2008>
2. Downing, T., Butterfield, R., Edmonds, B., Knox, J.W., Moss, S., Piper, B., and Weatherhead, E K. (2003). *CCDeW: Climate change and demand for water revisited*. Final Research Report to DEFRA. Stockholm Environment Institute, Oxford Office, Oxford. <http://preview.tinyurl.com/ccdew2003>
3. Knox, J.W., Kay, M.G., Weatherhead, E.K., Burgess, C., Rodriguez-Diaz, J.A. (2009) *Development of a water strategy for horticulture*. Project CP 64 Final Report, Horticultural Development Company, Stoneleigh. <http://www.hdc.org.uk/project/hdc-development-water-strategy-horticulture>
4. Rees, B., Cessford, F., Connelly, R., Cowan, J., Bowell, R., Weatherhead, E.K., Knox, J.W., Twite, C.L., and Morris, J. (2003). *Optimum use of water for industry and agriculture; Phase III Best practice manual*. R&D Technical report W6-056/TR2. Environment Agency, Bristol. <http://preview.tinyurl.com/eawateruse2003>
5. SEPA (2013) *Supporting Guidance (WAT-SG-70) Sector-specific Guidance: Agriculture*. Scottish Environmental Protection Agency, Stirling. <http://preview.tinyurl.com/WATSG70>
6. Knox, J.W., Daccache, A., Tyrrel, S.F. and Weatherhead, E.K. (2011). *A geospatial approach*

- to assessing microbiological water quality risks associated with irrigation abstraction. *Water and Environment Journal* 25(2) 282-289. doi: 10.1111/j.1747-6593.2010.00227.x
7. Farmer, A., Dworak, T., Bogaert, S., Berglund, M., Zamparutti, T., Interwies, E., Strosser, P., Stanley, K., Schmidt, G., Cools, J., Hernández, G., Vandenbroucke, D., Cherrier, V., Newman, S. (2012) Service contract to support the impact assessment of the Blueprint to Safeguard Europe's Waters: Assessment of policy options for the blueprint. Final Report. <http://preview.tinyurl.com/BlueprintImpactAssessment>
 8. Weatherhead, E.K., and Howden, N.J.K (2009). The relationship between land use and surface water resources in the UK. Evidence Review 5 for Foresight Land Use Futures Project 2010. <http://www.bis.gov.uk/foresight/our-work/projects/published-projects/land-use-futures/reports-and-publications>.
 9. Knox, J.W., Daccache, A., Weatherhead, E.K., Stalham, M (2011). Climate change and potatoes. An information booklet produced for PCL (AHDB), Cranfield University. <http://www.potato.org.uk/publications/climate-change-and-potatoes>
 10. ICID Awards <http://www.icid.org/awards.html#tech>