WRE: Assessing future changes in agricultural water demand

Summary findings from key informant workshop

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Introduction

In the WRE project, Task 2 “Agricultural water demand forecasts” involves developing a series of algorithms to estimate spatial changes in agricultural water demand taking into account future agronomic, agroclimatic, technical and socio-economic uncertainty. These algorithms will subsequently be embedded into the Anglian Water WRE regional water resource simulator, currently being developed by the University of Manchester and Atkins. This model represents all water resource zones in the WRE region, including sources of supply and centres of demand, as well as proposed new supply schemes. The simulator will be capable of evaluating multiple alternate system designs under a range of future scenario following a robust decision-making (RDM) approach. The model includes, among others, agricultural nodes and demands for irrigated agriculture operating under a range of contrasting agroclimatic and socio-economic scenarios.

In Task 2 (Part I)” (Knox et al. 2017), a methodology was developed to calculate the baseline agricultural water demand for each EA CAMS catchment, with demand varying as a function of agroclimate. The methodology to estimate future irrigation demand builds on this approach by incorporating a set of ‘change factors’ that are intended to capture the effects of different socio-economic drivers on future agricultural production. These ‘change factors’ represent the combination of various micro-components of demand which themselves vary depending on each contrasting socio-economic scenario, and are in addition to the effects of climate change on crop productivity (yield) and water use.

Estimating these ‘change factors’ for each agricultural sub-sector and socio-economic scenario is a complex exercise with a high degree of uncertainty. For this task, a qualitative approach was used to first develop a series of scenario narratives describing how agriculture might be impacted. From this, as set of qualitative estimates of change in the direction and magnitude of key micro-components that would shape future agricultural water demand were then developed. These will be used in the agricultural demand forecasting modelling. In order to inform the derivation of these ‘change factors’, a workshop involving key informants from the UK agricultural sector were invited to contribute their views and expert opinion on the drivers of change likely to impact on future agricultural water demand. The workshop was held on 15th February 2017 at Cranfield University. The participants included representatives from the AHDB levy board, growers, abstractor groups, AW, and researchers with interests in agricultural water resources (Table 1).

Table 1 Participants attending the “WRE – Future agricultural water demand” workshop held at Cranfield University on 15th Feb 2017.

Name	**Affiliation**
Tim Darby	ESWAG
Paul Hammett	NFU
David Matthews	G&D Matthews
Stuart Smith	Atkins
Hannah Stanley-Jones	Anglian Water
Mike Storey	AHDB
Keith Weatherhead	Independent
Joe Morris	Cranfield University
Jerry Knox	Cranfield University
Tim Hess	Cranfield University
David Haro	Cranfield University

The workshop involved a series of structured discussions around a number of fundamental questions to determine the high-level drivers that might shape future agricultural production in the UK and thus how these might then translate into impacts within the irrigated sector. Aspects of the workshop also focused on the extent to which drivers had a national focus and where there might be regional dimensions. Five key questions were posed:

Q1. What are the key drivers affecting UK agriculture over the next 50 years? Is there an Anglian region dimension?

Q2. How do these drivers affect the main irrigation sub-sectors in the UK and Anglian region?

Q3. For two contrasting future scenario (Global Sustainability and Uncontrolled demand), what are the likely directions and magnitude of change in the micro-components of irrigation water demand?

What are the major differences in drivers between the two scenarios and likely expected differences in irrigation water demand?

Q4. What are the main gaps and uncertainties in our knowledge and understanding of Q1-3?

Q5. Brexit. What are the implications for irrigated agriculture and irrigation water demand in the UK and Anglian Region?

This report summarises the discussions and key findings from the workshop.

Q1: What are the key drivers affecting UK agriculture over the next 50 years? Is there and Anglian region dimension?

The WRE project has adopted and developed four contrasting socio-economic scenario to assess future uncertainties in water demand. These scenarios are based in the combination of two main dimensions of change, governance and societal values. The first dimension ranges from a regional/local approach of governance to globalisation. In the first case, protection of local economies and self-sufficiency would be fostered as opposed to an open global market situation with free circulation of goods and commodities between countries. The second dimension ranges from a society adopting attitudes of sustainable behaviour to a society in which demand is uncontrolled (i.e. ranging from conservationism to consumerism). Appendix 3 includes key slides from a presentation given to the workshop participants to illustrate these concepts. The combination of two dimensions of change allows the development of four possible future socio-economic scenarios with different effects on UK agriculture, namely:

Scenario 1 (Sustainable, regionalisation)

Scenario 2 (Sustainable, globalisation)

Scenario 3 (Uncontrolled demand, regionalisation)

Scenario 4 (Uncontrolled demand, globalisation)

For each scenario, a series of detailed narratives were then produced in order to reflect the possible effects on different drivers on society including water consumption, economy and industry, at both the national level (Table 10) and more specifically for the agricultural sector (Table 11). These narratives are given in Appendix 2 and were sent to participants prior to attending the workshop.

After an introduction to the socio-economic scenario and their narratives, participants were asked to identify 3 key drivers they believed would exert a critical influence on the UK agricultural sector over the next *c*30 years (Table 2). Each participant was then invited to comment on the rationale for the drivers had they chosen.

Table 2 Participant feedback to Question 1 on key drivers affecting UK agriculture over the next 30 years.

Participant	**Driver**
1	Diet+Food choices (inc. population growth). What we eat and how much of it
	Standards and regulation: Food safety, environment, animal welfare,GM, pesticides
	Brexit! Exchange rates and tariffs
2	Restrictions on imports (tariffs, regulations, etc)
	Crop yield changes (tonnes/ha & tonnes/m3 water)
	Food demand (population growth & diet changes)
3	Climate Change
	Population growth
	(Need for) Cheap food
4	Global markets and competition
	Government policy – subsidies,
	Consumer preferences and trends
5	Climate uncertainty, greater variability in rainfall patterns plus reliability
	Impact of Brexit on UK agricultural policy plus tariffs trade agreements
	Competition for and access to water for agriculture (in Anglian region)
6	Weather/Climate
	Food security/Access to international trade
	Food prices/viability of production

Participant	Driver
7	Need for viable agricultural production businesses
	Political influence/Public opinion
	Global security
8	Availability/Acceptability of crop protection products (where does GM fit/ acceptance)
	Need for sustainable food supply affected by population and climate
	Relative value of pound vs other currencies., National/International
9	Land price and availability
	International commercial relationships (exchange rates)
	Changes in dietary changes
10	Population growth (effects on land and on food demand)
	Genetic Modification
	Environmental regulation (payments for stewardship, failure of environmental systems)

This introductory question was useful to prompt some initial thoughts and discussion with informed insights that confirmed the complexity of the challenge in understanding the high level drivers on agriculture. All the drivers identified for the agricultural sector cascade directly down into specific irrigation sub-sectors (horticulture, potatoes). The drivers identified by the participants could also be broadly grouped into general topics relating to policy/politics, population growth and associated food demand, future climate/weather, and commercial/economic relationships of the UK with the rest of the world. Of these four groups, policy drivers were identified bu the group as being the most dominant overall.

Regarding the Anglian region dimension, there was some consensus on the likely increase in competition for water resources, mainly because the projected changing population dynamics within the region are different to other parts of England (highest population increase rates and highest productive agricultural land). However, participants also agreed that there are several important drivers such as total food demand that are nationally determined and independent from any regional dimension.

The possibility of moving agricultural production out from Anglian region to other parts of the country was also discussed. The overall feeling was that Anglian region contains a unique series of production characteristics (fertile soils, favourable weather and established irrigation infrastructure) that give it a competitive advantage, which would constrain any attempts to move large-scale agricultural production (especially arable and some horticulture) to other parts of the country. Conversely, despite livestock production (notably pigs and poultry) also benefitting from some unique attributes within Anglian region, it was felt this sub-sector of agriculture could move more easily to other regions if necessary.

Finally, the following quotes reflect some of areas of discussion during this exercise:

> *"We need to have a viable agricultural industry within the UK if we wish to supply food locally. We will have to rely on external sources if we cannot achieve that. Currently, there is too much political uncertainty locally and worldwide now to be absolutely sure which way all may fall."*
>
> *"Politics and food security as a political objective are the most important drivers of agriculture."*
>
> *"Producing cheap food is a key driver for farmers now and I do not see that changing."*
>
> *"UK is very food secure at the moment but it is not self-sufficient."*
>
> *"We may be able to absorb population increase than weather shocks."*

Q2: How do these drivers impact on the main irrigation sub-sectors in the UK, and Anglian region?

Building on participant feedback from the previous question, the scope of the discussion then focused to the irrigation sub-sector. For this, a PESTE (political, economic, social, technical and environmental) analysis framework was used. PESTE is a framework of macro-environmental factors used in the environmental scanning component of strategic management. It is part of an external analysis when conducting a strategic analysis or doing market research, and gives an overview of the different macro-environmental factors to be taken into consideration. It is a strategic tool for understanding market growth or decline, business position, potential and direction for operations. The approach was explained to participants (Appendix 2).

Workshop participants were asked to write down (on post-it stickers), three 'change factors' linked to each component of the PESTE framework (Figure 1). Table 3 to Table 7 summarise the factors reported in this exercise, aggregated by PESTE sector. Overall, the PESTE analysis exercise seemed to work reasonably well. Participants were initially concerned about potential duplication with the previous question, although they were encouraged to repeat their responses if they considered them relevant for the irrigation sub sector. Despite some of the factors identified being applicable to the general agricultural sector, the approach did provide an opportunity to drill down deeper into the irrigation sub-sector.

Figure 1 Posters produced from the PESTE analysis for the UK Irrigation sector.

'Change factors' were clustered into common themes for each PESTE component. Political and related policy factors, apart from having the largest number of responses (33), also had the largest variety of cluster themes. Abstraction reform, income support, immigration policy and competition for water resources were the most common themes initially identified during the workshop.

Subsequent analysis of the responses resulted in identifying 'environmental policy', 'population policy' and 'imports/exports policies' as additional political factors. With regard to economic factors, the responses were broadly aggregated under 'cost of water' and 'world prices' themes. Social factors included the 'value of environment', 'diet', 'preference of locally produced food' and 'labour'. Technological factors focused on either crop science with special importance of attributed to developing new climate-change-adapted varieties, and water technologies, especially oriented towards increasing efficiency of supply. Finally, the environmental factors were mainly focused on 'measures for environmental protection', 'climate change', and 'water availability for the environment'.

There were a number of identified factors that clearly overlapped across topics, with water being the most common denominator. This highlights the importance that access to and availability of water, and the policies regulating this resource, have on UK agriculture, particularly for the irrigated sub-sector. Another overlapping factor was policy. Policies regulating all the different factors included in the PESTE analysis were reported to be crucial within the UK irrigation sector. Most of discussions captured during this exercise often included the importance that future policies would have on any factor being considered.

Table 3 Summary of 'political' drivers affecting irrigation water demand in the UK and Anglian region.

Political drivers	**Cluster topic**
Legislation: pesticides, stewardship	Agric policy
Importance of self-sufficiency	Agric policy
Support for food self-sufficiency, employment, farming	Agric policy
Domestic agricultural policy	Agric policy
Government support to build agriculture food export opportunities	Agric policy
Farm /Food support mechanism availability of more level???	Agric policy
Avoidance (or imposition) of constraints on (food) imports	Agric policy
Brexit impacts on agriculture policy – whether food self-sufficiency needs to increase to counter market change	Agric policy
Sustainable abstraction and licence changes	Abstraction policy
Length of permit timeline	Abstraction policy
License format	Abstraction policy
Abstraction reform and allocation to agriculture	Abstraction policy
Increased environmental policies and regulation post-Brexit	Env policy
Government regulation	Env policy
Housing development policies – Loss of land for agriculture	Env policy
Strength of environmental regulation	Env policy
Export driver	Env policy
Planning policies	Env policy
Visas for migrant workers	Immigration policy
Employment, migrant workers availability	Immigration policy
Labour availability plus costs for agriculture	Immigration policy
Migrant labour	Immigration policy
Farm support RPA?	Income support
Commitment to support agriculture as a social policy	Income support
Removal of farm income support	Income support
Defra and its conflicting functions	Income support
Subsidies to agriculture	Income support
Water availability	Competition for water

Agriculture's ranking in water resource table of need/use	Competition for water
Competition for water from domestic/industry	Competition for water
Investment in water resource infrastructures to support agriculture	Competition for water

Table 4 Summary of 'economic' drivers affecting irrigation water demand in the UK and Anglian region.

Economic drivers	**Cluster topic**
Quantify risk to make decision regarding investment for farming (evidence/uncertainty)	Agric economics
Confidence or uncertainty in future direction	UK macro economy
GDP growth (ability to pay)	UK macro economy
Price of water	Irrigation benefits and costs
Cost of irrigation	Irrigation benefits and costs
Cost of water	Irrigation benefits and costs
Cost of water and farming	Irrigation benefits and costs
Cost of water as % of production costs	Irrigation benefits and costs
Incentives for reservoirs	Irrigation benefits and costs
Payments for ecosystems services	Irrigation benefits and costs
Economies of scale	Irrigation benefits and costs
Viable farming business model	Irrigation benefits and costs
Land values linked with water availability 'value of water'	Irrigation benefits and costs
Energy Input costs	Irrigation benefits and costs
Value of water and funding/cost of future (multi-sector?) irrigation schemes	Irrigation benefits and costs
Availability of capital funds/support for infrastructure development	Irrigation benefits and costs
Generating data to support the 'irrigators position' what data and how much cost?	Irrigation benefits and costs
World market conditions – free trade	International economic factors
Foreign exchange rates affecting	International economic factors
Comparative prices of imported food (exchange rate, tariffs)	International economic factors
World food prices	International economic factors
Prices for fresh produce	International economic factors
Food prices/stability of supply	UK agric and food sector economics
Food prices and role of supermarkets	UK agric and food sector economics
Supply chain (local, national, international) perspectives	UK agric and food sector economics
Links between Anglian food + "???" Med production	UK agric and food sector economics
Profitability of rainfed farming	UK agric and food sector economics
Loss of imports due to competition from other countries, eg China	UK agric and food sector economics
Cheap food imports reducing economic viability of irrigated production in Anglian Region	UK agric and food sector economics

Table 5 Summary of 'social' drivers affecting irrigation water demand in the UK and Anglian region.

Social drivers	**Cluster topic**
Dietary choice (exotics, out of season food)	Dietary preference and behaviour
Food habits, healthier eating	Dietary preference and behaviour
Quality of food required (cosmetic)	Dietary preference and behaviour
Consumer preferences and trends	Dietary preference and behaviour
Consumer tastes. Subject to economic constraints	Dietary preference and behaviour
Health	Dietary preference and behaviour
Changing consumer food choice and acceptability and quality and price	Dietary preference and behaviour
Effect of wider economy on consumer preference (??? To org veg boxes which were supported until 2008 crash in financial markets)	Dietary preference and behaviour
Food affordability	Dietary preference and behaviour
% of income to spend on food	Dietary preference and behaviour
Consumer awareness/food provenance	Dietary preference and behaviour
Water competition for manufacturing + PWS. Who has to pay?	Dietary preference and behaviour
Quality of food required (cosmetic	Dietary preference and behaviour
Population growth	Population and demographics
Population and population structure and composition	Population and demographics
Demography and population change. Impacting supply (labour) and demand (consumption)	Population and demographics
Availability of Easter Central EU labour for harvesting irrigated produce	Population and demographics
Expectations for the world around us	Value of environment
Environmental importance	Value of environment
Leisure expectation	Value of environment
Support for conserving landscape	Value of environment
Competition for water for social purposes by an increased population in region – wildlife areas, recreation	Value of environment
Generational replacement of farmers. Willingness to work in agriculture	Social motivation
Attitudes to sustainability	Social motivation
Housing development on agricultural land. Changing rural communities + attitudes to food production	Social motivation
Demand for local food	Local food
Change in demand for locally grown/organic crops	Local food
Consumer 'local foods'	Local food

Table 6 Summary of 'technology' drivers affecting irrigation water demand in the UK and Anglian region.

Technology drivers	**Cluster topic**
GM and other agricultural technologies. Lower water per unit of production	Crop related
Breeding drought resistance	Crop related
Chemical use	Crop related
Plant breeding for drought tolerance	Crop related
New crops (GM or climate adapted)	Crop related
Improved water use by new varieties – across all sector	Crop related
GM	Crop related
Varietal development: drought tolerance, shorter seasons, scab resistance	Crop related
Automation of harvesting	Crop related
GM will be introduced but adoption and impact in this time frame will be limited	Crop related
Reservoirs	Water related
Availability of technical expertise and support (R&D funding)	Water related
Cheap affordable control of water use. Targeted application, automated.	Water related
New sources of water	Water related
Desalination	Water related
Technology development in precision applications	Water related
GM drought resistance crops	Water related
Use of soil water management systems	Water related
Irrigation efficiency (drip irrigation – lower system losses)	Water related
Availability of smart technologies and extension services for precision agriculture expansion/uptake	Water related
Advances in water treatment technology (is desalination really a feasible option?)	Water related
Improved soil management and water holding capacity allied with adoption of wider/more accurate assessment of crop water demand and application will improve	Water related
Development in protected cropping (eg indoor production of all salad crops)	Integrated systems
Increase in yield (reducing area needed and water needed)	Integrated systems
Feasibility of sustainable intensive irrigated food	Integrated systems
Integration of Big Data → informatics into agriculture	Integrated systems

Table 7 Summary of 'environmental' drivers affecting irrigation water demand in the UK and Anglian region.

Environmental drivers	**Cluster topic**
Climate variability (weather extremes)	Climate
Climate change	Climate
Climate change impacts	Climate
Drought risk and increased water scarcity	Climate
CC/ increase drought frequency outside UK pushing production towards us	Climate
Increased EA weather variability (affects risk+investment decision)	Climate
Agricultural sectors response to and planning for future droughts (worse than historic)	Climate
Regulation and standards. Env protection, GM, pesticides	Environmental protection
Rest of industry cleaned up its act, therefore WQ, flow and	Environmental

hydromorphology problem in aquatic environments focus on diffuse/catchment/landscape effects	protection
RSPB/WWF (interests and activities)	Environmental protection
Support mechanism for environmental stewardship	Environmental protection
Working in partnership	Environmental protection
Catchment focus on rules and management	Environmental protection
Loss of multifunctional benefits of agriculture. Reducing environmental connection between land management and environment	Environmental protection
Need for adaptation measures to protect biodiversity. Pressure to reduce agricultural demands in water and increase of water dependent habitats	Environmental protection
Public perception of a good environment	Environmental protection
Standards and regulation / environmental protection	Environmental protection
Environmental importance	Environmental protection
Volume of environment/concept of natural capital	Environmental protection
(Need for) Clean water (means cheaper water??)	Water management
Minimal headroom in abstraction licensing. Inability to increase water use when need arises	Water management
Reduced water allocation for agriculture to support environmental needs/ecosystems	Water management
Availability of water	Water management
Water licensing	Water management
Acceptability/constraints on chemicals	Water management

Q3: For two contrasting future scenario, what are the likely directions and magnitude of change in the components of irrigation water demand?

In this third exercise, participants were split into two groups to discuss two contrasting future socio-economic scenario - “Global Sustainability” and “Uncontrolled Demand Regionalisation”. Each group was asked to discuss the potential direction and magnitude of change relative to the underlying baseline situation for a number of defined micro-components of demand within three main irrigation sub-sectors (arable, horticulture and potatoes) over the next c30 years. Participants used stickers to indicate their perceptions of the direction and magnitude of change on posters. For each scenario, the key findings are summarised in Table 8 and Table 9.

Table 8 Direction and magnitude of change for irrigation micro-components under the "Sustainable Globalisation" scenario relative to the baseline situation.

Sector	Consumption per head	Proportion UK-grown	Yield	Proportion irrigated	Agro/Eco Optimum	Irrigation efficiency
Arable	↔	↔	↑	↔	↔	↔
Potatoes	↓	↑	↑	↑	↔	↑
Horticulture	↑	↑	↑↑	↑↑	↔	↑↑

Table 9 Direction and magnitude of change for irrigation micro-components under the "Uncontrolled Demand Regionalisation" scenario.

Sector	Consumption per head	Proportion UK-grown	Yield	Proportion irrigated	Agro/Eco Optimum*	Irrigation efficiency
Arable	↑↑	↑↑	↑	↑↑↑	→ ←	↓↓
Potatoes	↑	↑	↔	↑	→ ←	↓
Horticulture	↔	↑	↑	↑	→ ←	↓

Note: *Thus group felt that the agronomic and economic optimum for irrigation would converge.

For “Sustainable, globalisation”, the group agreed that horticultural products would increase their presence in the typical UK resident’s diet to the detriment of starchy products. In a globalised world with open markets, but with society caring for sustainability of the products consumed, there would be a slight tendency towards producing more in the UK. Slightly better yields would be achieved relative to the baseline following sustainable practices with the exception of horticulture. The proportion irrigated would have to increase in order to produce more food for the country in order to reduce imports that might be harmful to exporting countries. Efficiency of irrigation would increase in the same proportion as the irrigated land in order to make a sustainable use of water resources. The group considered that nowadays farmers irrigate to reach the economic optimum and this would not change in the scenario.

For “Uncontrolled demand, regionalisation”, the protectiveness of the situation would mean that only crops currently produced in the UK increased their rates of consumption. In addition, the same reason would apply for the need to increase the proportion grown within the UK. Yields would likely stay the same or increase slightly mostly due to the increase in the proportion of the land irrigated. Efficiency would fall due to the lack of incentives for promoting efficiency.

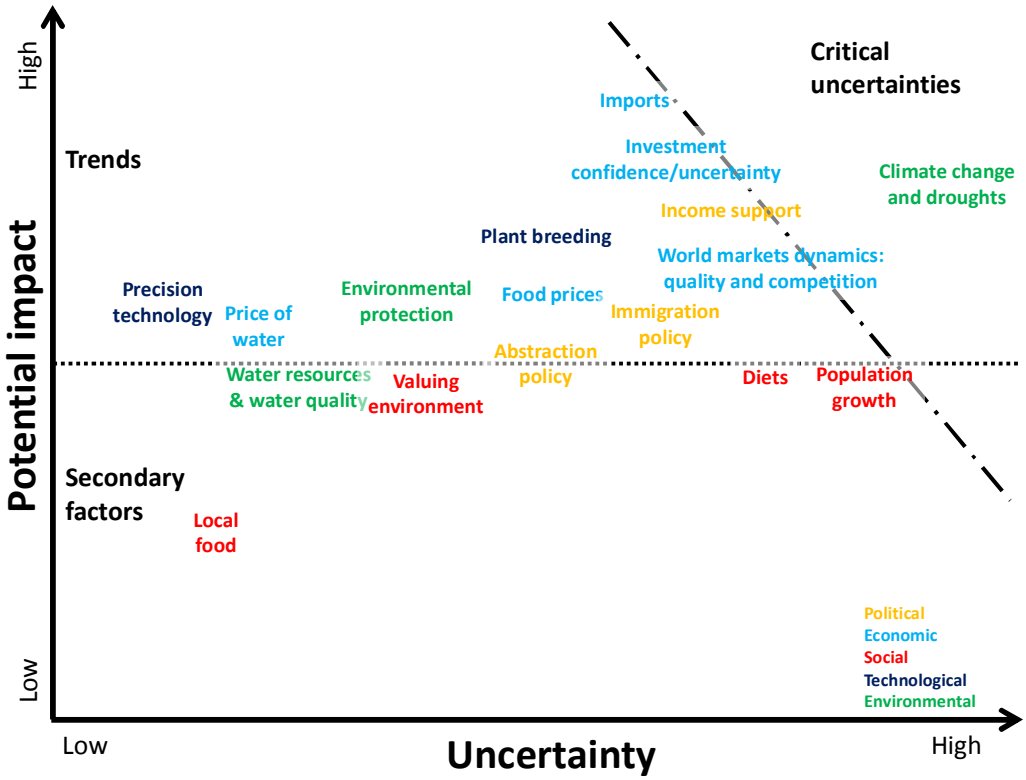
Broadly, this exercise worked and continued through a working lunch. The participant feedback on the two scenario were broadly consistent with the narratives that had been drafted previously and circulated before the workshop. However, in hindsight instead of providing each group with a single scenario and then determining any changes or differences relative to a baseline, it would perhaps have been better to present each group with two diametrically opposing scenario. This would have led to greater differences between the outcomes for the two scenario considered here. However, this would have required significantly more time dedicated to micro-component analysis and scenario comparison.

Q5: What are the main gaps and uncertainties in our knowledge and understanding of Q1-4?

The preceding exercises identified a wide range of contrasting factors within the PESTE framework that could influence the future direction and composition of UK agriculture. These were broadly classified under the five individual PESTE categories. For each factor (e.g. income support; water pricing) there is of course imperfect knowledge on its consequences and uncertainty regarding the its potential impact on UK agriculture. The purpose of this exercise was therefore to identify which factors had the greatest uncertainty and which could lead to the highest impact on future agricultural water demand. Each participant was asked to identify two factors (high-level constructs) from the PESTE analysis which they considered potentially to have a medium to high impact, and to position them on an impact-uncertainty matrix (Figure 2).

The impact-uncertainty matrix divides factors between those that may have a low potential impact, irrespective of their uncertainty, and those that may have a high potential impact. The former are termed 'secondary factors' and the latter are 'trends'. The focus of this exercise was on the latter, with special attention paid to those factors that had both a high potential impact and a high degree of uncertainty, so-called critical uncertainties (Figure 2).

Figure 2 Uncertainty matrix derived from the PESTE analysis of irrigation water demand (Question 2).



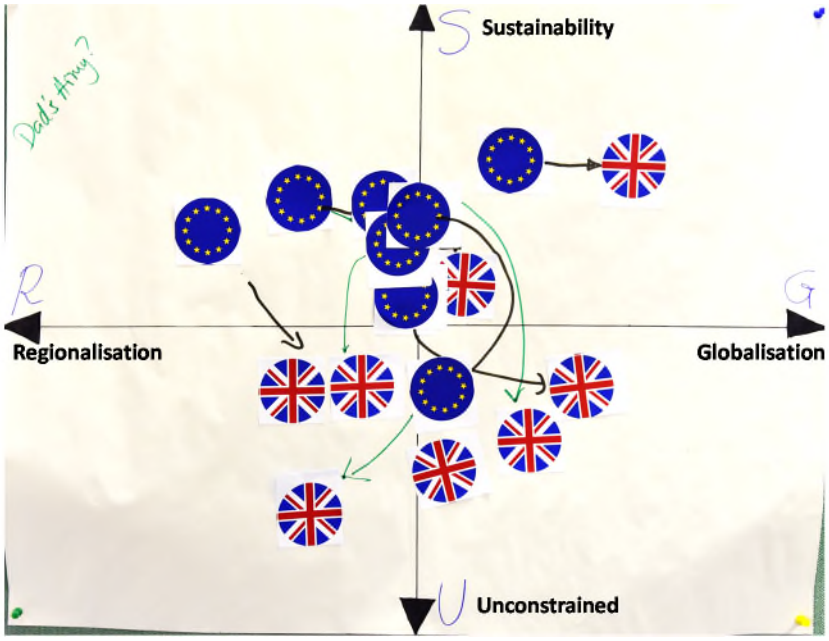
Climate change and droughts were identified as being the most uncertain high potential impact factor, followed by population growth. A number of key economic and political driven factors including income support imports and world market dynamics were also selected as being close to the critical uncertainty threshold.

In general, there was a tendency to place the factors around the medium impact line but with different levels of uncertainty. There was also some reluctance to place factors within the critical uncertainties area, with some of accumulating along the boundary.

Q6: Brexit: What are the implications for irrigated agriculture and irrigation demand in the UK and Anglian region?

In addition to the socio-economic scenarios being considered within WRE that generally have a longer time frame for potential realisation, there is currently significant additional uncertainty in relation to future relationships between the UK and European Union due to Brexit. This may have strongly impact on future socio-economic and agro-economic policy and thus directly influence the irrigated agriculture sector in numerous ways (positive and negative). In this final exercise, through facilitated discussion, participants considered viewpoints on the Brexit effect on agriculture and irrigation both in the UK and more regionally. Following open discussion, participants were asked to position a sticker corresponding to pre-Brexit and post-Brexit on a socio-economic scenario matrix and to indicate the direction of change (Figure 3).

Figure 3 Participant's estimation of the current socio-economic scenario and evolution after Brexit.



The discussion was predominantly on where the UK is currently with respect to agricultural trade and policy and how that might change in future. There was greater consensus on the former (with an intermediate point between globalisation and regionalisation in terms of governance and some sustainability driven social values) than on the latter (which split into a world market and localised protectionist future). The general feeling was perhaps towards uncontrolled globalisation (world market) with UK agriculture left to fend for itself. Brexit could result in less environmental and agricultural regulation. However, it was recognised that some regulations had their origins in Britain. Some sectors will not want environmental protection regulations withdrawn and it will depend on agreements the UK signs with different countries with looser and or tighter regulations.

There was also discussion regarding the positive aspects that Brexit might bring to UK irrigated agriculture and horticulture. There was general agreement that irrigated agriculture could benefit from Brexit, especially for crop sectors that are currently less dependent on agricultural policy support. The point was raised that In recent decades there has been some levelling off in the productivity of UK agriculture relative to its international competitors, partly associated with the retention of smaller, less efficient production (although it was noted these provide other services). It was pointed out that a reduction of income support due to Brexit could lead to significant structural change in the agricultural sector. This could also expose the UK food sector to global supply risks associated with global drought and water scarcity. At the same time, however, there could be opportunities for consolidation and further specialisation in the irrigation sector. The latter could be associated with efficiency gains, and opportunities for the import substitution of high value produce affected by changes in trading arrangements due to Brexit.

Appendix 1: Workshop agenda

WRE: assessing future changes in agricultural water demand in Anglian region: Key informant workshop

Weds 15th February 2017, 09:30 to 14:00

Hardwicke Room, 2nd floor, Building 62, Cranfield University, Cranfield MK43 0AL

Time	**Description**	
09:15	Arrival, coffee and refreshments	All
09:30	Welcome and introduction; workshop objectives	Jerry
09.35	Participant introduction	All
09:45	Introduction to the 4 future socio-economic scenario and agricultural narratives	Joe
10:00	**Q1** what are the key drivers affecting UK agriculture over the next 30 years; what are the Anglian region dimensions? Post-it and talk session	Joe lead All
10:15	**Q2** How do these drivers impact on the main irrigation sub-sectors in the UK, and Anglian region? Participant PESTE exercise and group discussion	Joe/Jerry All
11:00	**Q3** For two contrasting future scenario (Global Sustainability and Uncontrolled demand), what are the likely directions and magnitude of change in the components of irrigation water demand? Exercise with participants in 2 groups, followed by group feedback	Joe lead All
11.40	**Q4** With respect to Q3, what are the major differences in drivers between the two scenario, and likely expected differences in irrigation water demand? Facilitated discussion	Joe/Jerry All
12:00	**Q5** What are the main gaps and uncertainties in our knowledge and understanding of Q1-4? Uncertainty mapping	Joe All
12:30	**Q6: Brexit**: What are the implications for irrigated agriculture and irrigation water demand in the UK and Anglian region Facilitated discussion	Joe
13.00	Buffet lunch and continued open discussion around Q6	All
13.45	Workshop close and depart	

Appendix 2: Socio-economic narratives

Table 10 General UK overview by socio-economic scenario.

Drivers/selected key metrics	Scenario 1 (sustainable, regionalisation)	Scenario 2 (sustainable, globalisation)	Scenario 3 (uncontrolled demand, regionalisation)	Scenario 4 (uncontrolled demand, globalisation)
Parallel Foresight type Scenario	Local Stewardship (increased innovation at local scale)	Global Sustainability	National Economy	World Markets
Value placed on water and wastewater resources	Broad based value based on water as a natural resource, including provision of public goods, Explicit values for non-market goods	Broad based value based on water as a natural resource, including provision of public goods, Explicit values for non-market goods	Local Economic Imperative: water value based on willingness/ability to pay by dominant public regional water supply and industrial sectors	Economic imperative: water value based on market value added and ability to pay Virtual markets in water through commodity trading
Water consumption	Prudent – minimum waste, inherent water value	Prudent: wise water use encouraged by campaigns and pricing	Imprudent, limited incentive for using (cheap and accessible) water wisely	Imprudent – flush and forget, but water pricing gives incentives to adopt water saving
Society's response to climate change	Proactive response resulting in local adaptation and mitigation solutions	Proactive response resulting in national adaptation and mitigation solutions	Customers unlikely to change behaviours but expect organisations to be resilient	Focus on technical solutions rather than behavioural change
Competition between sectors	Strong focus on the environment	Balanced	Strong focus on agriculture and energy	PWS main draw on water
Regulatory environment	Catchment-based, through local political systems; any regional or national investments occur only through local cooperation	Strict national – sustainability focused (international environmental legislation key)	Strict, national regulation – consumer (including industrial) protection and price focussed	Economically and environmentally market driven (limited regulation)
Likely energy sources	Low carbon – renewable; local power generation	Low carbon – renewable and nuclear; national grids	Fossil fuels – UK shale gas and coal	Fossil fuels – foreign sources
UK industry	Service based, with some low-tech R&D Balanced national economy, reflecting regional comparative advantage	Resurgent, high-tech engineering, design and manufacture, supported by international R&D and exchange	Resurgent, traditional manufacturing and heavy industry Protected and introspective. Internal regional trade	Driven by international comparative advantage with 'free trade' agreements. Service and knowledge based
State of the economy	Growth: Low GDP Low geni factor Stable; diminished national	Growth: High GDP Low geni factor Buoyant, based on green	Growth: Moderate GDP, Moderate geni factor. 'Closed' markets, high self-sufficiency;	Growth: High GDP High geni factor Open economy, unbalanced

Drivers/selected key metrics	Scenario 1 (sustainable, regionalisation)	Scenario 2 (sustainable, globalisation)	Scenario 3 (uncontrolled demand, regionalisation)	Scenario 4 (uncontrolled demand, globalisation)
	public sector, increased self-sufficiency in bulk commodities	growth	based on manufacturing (however growth more limited than Scenario 4), protectionist	sectoral and regional development, vulnerable to shocks
Investment and access to capital	Constrained; some local, private finance is available. Cooperative ventures	Investment in high-tech, green industry, International funding, green bank Joint PP partnerships	Low investment; limited access to capital Government funding sources, including subsidies	International investment in services and infrastructure, driven by financial returns. PFI options
Competition in the water sector	Local water companies. River basin solutions ?Competition from new entrants – local suppliers, technology innovators	Competition between existing companies and new entrants: international market in 'sustainable' water services	Competition between existing companies. National/regional water companies: Government funded regional transfers	Strong competition; attractive to existing and new entrants (and investors) Global water
Innovation	Variable: actively promoted in some sectors but constrained by funds and capabilities. Strong focus on small scale, low tech appropriate solutions to improve resource efficiency and self-sufficiency solutions.	Actively promoted and funded. Visionary approach. Strong focus on high tech-green solutions to reduce environmental and resource footprints. Growth information technology and artificial intelligence employed to balance economic, social and environmental objectives	Driven by short term needs and vision. 'Make do and mend' approach: focus is on infrastructure life extension. Fragmented and somewhat isolationist approach to innovation, mainly remedial driven	Responsive to market needs Focus on building technical solutions to relieving resource constraints and environmental problems High automation and robotics. IT and AI growth sectors in response to market drivers
GDP % growth	0.5%	1.7%	1.5%	2%
Pop % growth national	Very Low 0.1%	Moderate0.5%	Low 0.35%	High 0.7%
Pop (East regional)	Very Low 0.1%	Moderate0.5%	Low 0.35%	High 0.7%
Income distribution Geni coeff:	Low 0.3	Moderate 0.35	Moderate 0.35	High Geni 0.4
Agric self-sufficiency	High 75%	Moderate 65%	High 75%	Low 55%
Agric as % of GDP	High (1.5 - 2%)	Low (0.6%)	High (1.2%)	Low 0.5%
Currency exchange? $US/£S	Low 1.2 Import substitution. Food and fossil energy imports expensive	Moderate 1.4 Neutral currency effects: Some trade in niche products	Low 1.3 Import substitution. Food and energy imports expensive: High value exports	High 1.6 Relatively cheap imports. Increased import orientation. Exports expensive

Drivers/selected key metrics	Scenario 1 (sustainable, regionalisation)	Scenario 2 (sustainable, globalisation)	Scenario 3 (uncontrolled demand, regionalisation)	Scenario 4 (uncontrolled demand, globalisation)
Diets	High healthiness: Healthier eating promoted by combination of awareness and necessity. Low disparities. Fresh produce important	High healthiness. Greater awareness and scope for healthier diets. Medium disparities. Varied diets. Fresh produce & organics important	Low healthiness, limited awareness and dietary options. Consumption is price rather than health sensitive. High consumption of processed foods	Low healthiness, high disparities. Polarisation of diets according to disposable income. High priced fresh and niche foods, Low priced processed foods .Diets of poorest deteriorate

Table 11 Key agricultural drivers of change, by scenario.

Agricultural sector drivers	Scenario 1 (sustainable, regionalisation) (SR)	Scenario 2 (sustainable, globalisation) (SG)	Scenario 3 (uncontrolled demand, regionalisation) (UR)	Scenario 4 (uncontrolled demand, globalisation) (UG)
Agricultural and rural policy	Nationally and locally determined rural support regimes in accordance with local needs and priorities reflecting self reliance, social and environmental objectives. Support for small family farms urban agriculture and allotments. Development defined in terms of conservation and community: a living/working countryside.	Reformed CAP. WTO promoted liberalisation. Decoupled agric support. Promotion of sustainable agriculture, including agri-environment and animal welfare regimes. Separation of support for sustainable farming and for environmental (ecosystem) services in the public interest. Global rules seek ethical rural development. Multi-functional agriculture produces public goods.	Protectionist agricultural policies promoting 'food from our own resources', involving input and commodity subsidies, 'deficiency' type payments and marketing/intervention regimes. Limited environmental and social concerns. Rural economy is based primarily on agriculture and food. Farming is the main agent of development	Abandonment of CAP (or equivalent national regime). WTO led 'free' trade in agricultural commodities. Limited interventions for social or environmental purposes. Increased global trade in agricultural commodities. Rural diversification opportunities based on market potential.
Food markets and prices	Greater connectivity between consumer and producer. Local area produce and market. Local 'brands' emphasise environmental and social attributes. Farmers join co-operative production and marketing schemes to add value and raise prices. Low market risk, associated with diverse production and marketing systems	Food supply chain accepts responsibility for promoting and responding to consumer concerns about safe, healthy and ethical foods. Consumer food prices rise due to quality assurance and compliance costs, providing incentives to producers. Moderate market risk due to global commitment to securing global food	Supply driven food chain. Food industry, especially producers and processors , define product offering and criteria for food quality. Government sponsored supply side interventions maintain high producer prices, but relatively low consumer food prices. Moderate market risk due self-sufficiency ,	Market led, consumer driven, with increased domination of major food retailers. International procurement and market integration, with limited reference to environmental issues in food trades. Real producer and consumer food prices fall for global bulk products, with premia for niche products. High level of

		and climate change mitigation/adaptation	requiring national 'buffer stocks' to managed periods of shortage.	market risk associated with supply demand : imbalance and vulnerability to climate change
Environmental policy	Generally lower environmental risk but fragmented and selective regulation and control. Sustainable soil and water management embedded in farming culture, with policies, including regulation, to promote and support. Tacit understanding of responsible land management	Comprehensive, integrated approach to the prevention /minimisation of diffuse pollution from agriculture. Policy mix includes regulation, voluntary measures and economic instruments reflecting a commitment to 'stewardship', biodiversity and 'nature's contribution to people' Agreed international protocols require compliance with environmental and ethical standards. Land tenure covenants contain sustainability criteria. High energy prices, including carbon taxes	Input-intensive farming, limited controls on agro-chemicals and farming practices on environmental grounds. Regulation for controlling high risks which prejudice commercial interests. Emphasis on correction/mitigation remediation rather than prevention of environmental risk. Land tenure agreements emphasise production purposes, including management of strategic agricultural assets	Limited restrictions on chemical use, other than market imposed. Limited interest in soil and water conservation unless affecting production. Environmental risk managed through economic instruments. Few constraints on land ownership and use. Energy prices determined by international markets, with limited environment an intervention
Farmer attitudes/ motivation	Farmers are welfare maximising custodians, embracing commitment to sustainable livelihoods. Strong conservation and community ethic. Varied income sources, on and off-farm	Production oriented farmers tempered by increasing personal and societal interest in conservation, actively seeking to balance agriculture, wildlife and natural resource management. Conservationists find expression in agri-environment schemes.	Commercially driven production focus, emphasis on output and production. Farmers respond to clear productionist policies that reinforce 'the right to farm'. Environmental motivations mainly commercially based and remedial.	Polarisation into commercial and lifestyle farmers: 'real' and 'hobby' farmers. Biodiversity in farmed areas to suit commercial farming, or as a commercial activity in itself.
Agricultural production and farming systems	Decreased productivity but total agricultural area increases, including retention (and extension) of marginal farm areas, including uplands. Commitment to sustainable rural livelihoods reflecting community priorities. Mix of intensive and extensive and greatly diversified systems. Retention of small scale, family based farming units. Low input systems an important part of sustainable farming. Widespread	Moderate to high increases in agricultural productivity linked to 'sustainable intensive farming'. Agri-environment contributes to global and local (eco-system) services. Diversification/multi-functionality is important. Strong 'compliance' requirements for 'predominantly agricultural areas and units'. Mainly large scale farms with targeted policies to retain family farms. Relatively high migrant labour force with strong employee protection,	Broad based, relatively high input: high output farming to provide self-sufficiency. Vegetables, and agro-industrial raw materials are growth sectors. Re-establishment of orchard and soft fruit sectors. Mixed arable and livestock farming systems, intensive lowland dairy and cattle, with beef and sheep maintained in disadvantaged areas. Moderate trend towards large farms but	Global competition leads to highly intensive, high technology, commercially driven large scale production by specialists, industrialised and global in scope, emphasis on efficiency through reduced unit costs for bulk commodity crops in face of relatively low global prices, with focused high quality production to gain price advantage where possible. High dependency on migrant workers across all farming

	adoption of Integrated Farming Systems. GMOs rejected. Relatively labour intensive, low wage systems, with high participation of non- migrant seasonal workers, with variable employee protection. Relatively extensive livestock systems, part of mixed farming systems. Emphasis on environment and welfare, Undifferentiated organic produce widespread	High labour cost encourages mechanisation /automation. Growth of 'multifunctional' farms providing range of non-agric public goods supported by payments, including designated nature conservation areas. Selected adoption of GMOs, driven by environmental benefits. Limits on stocking rates, extensification incentives, strong welfare controls. High quality assurance. Some differentiated organic produce.	family farms remain viable, given relatively strong commodity prices and technical support. Low dependency on migrant workers , except for seasonal tasks. Patchy adoption of GMOs, given limited (relative) economic incentives and little concern about side effects. Limited by investment. Organics limited, given low incentives	sectors, with high level of mechanisation and automation, and contract /contractor-based farming. Agriculture consolidates in areas with comparative production advantage. Marginal land 'abandoned', especially in uplands. GMOs widely promoted and adopted. Differentiated organic produce are important niche market. Intensive feedlot livestock systems, with some extensive grazing on abandoned cropland.

Appendix 3: Workshop presentation (Joe Morris)

Slide 1

Irrigation Water Futures

- Context: water demand and supply
- Dimension of change
- Key Drivers
- Future Scenarios
- Uncertainties

Slide 2

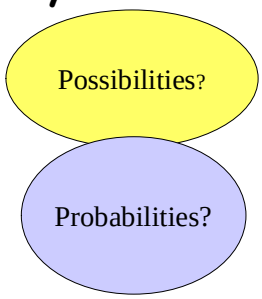
Q1: Agricultural Futures

- 1(a) What are the key drivers affecting the future of UK agriculture over the next 30 to 50 years?
- 1(b) Is there an Anglian Region dimension?

Slide 3

Looking Ahead : why bother?

- **Positivist approach**: what 'will' be : what do we do about it?
- **Normative approach**: what 'should' be : how do we make it happen?
- **Strategic resource management**



Slide 4

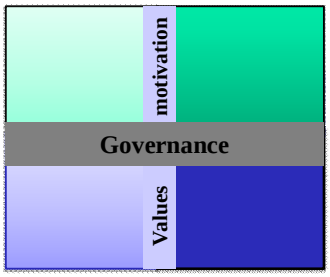
Future Scenarios

- Possible futures/prospects/propositions
- Dimensions of change
  - demography
  - economic growth
  - technology change
  - social values
  - governance

Slide 5

Possible Futures

Sustainable behaviour/ Conservationism



Regionalisation/ localisation

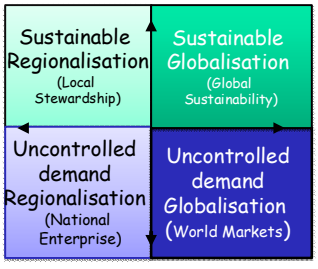
Globalisation

Uncontrolled demand/ Consumerism

Slide 6

Possible Futures

Sustainable behaviour/ Conservationism



Regionalisation/ localisation

Globalisation

Uncontrolled demand/ Consumerism

Slide 7

Possible Futures: Agriculture

Sustainable behaviour/ Conservationism

SR
Soc and Env Priorities

SG
Targetted compliance

Regionalisation/ localisation

Globalisation

UR
Production oriented self sufficiency

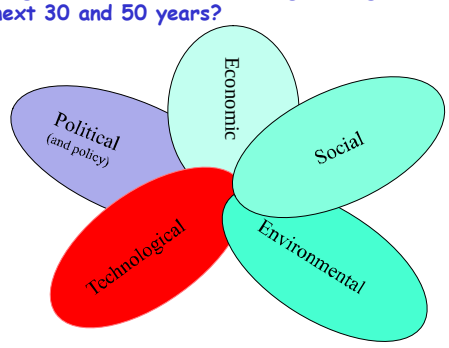
UG
Agric free trade

Uncontrolled demand/ Consumerism

Slide 8

Q2: Irrigation Futures

What are the key drivers affecting the future of the irrigation subsector in the Anglian Region over the next 30 and 50 years?



Slide 9

Q3: Irrigation Drivers and Scenarios

- What are the direction and magnitude of the drivers of irrigation water demand in the Anglian region for TWO scenarios
  - SG:Sustainable Globalisation
  - UR: Uncontrolled Demand Regionalisation

Slide 10

Q4 : Differences in Drivers and Outcomes

- What are the big differences in drivers between the two scenarios, and what are the expected differences in water demand?

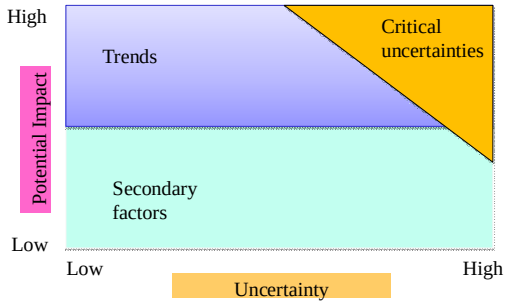
Slide 11

Q5: Uncertainity Analysis

What does the PESTE and scenario analyses tell us about the main uncertainties and gaps in knowledge required to estimate future irrigation water demand?

Slide 12

Irrigation Futures: Uncertainty mapping



Appendix 5: Selected photos from workshop