Final report

CP 64

Development of a water strategy for horticulture

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Grower Summary

Headline

This project produced a water strategy for the HDC to identify future research and communications requirements for growers in water application, scheduling and resource management.

Background and expected deliverables

(i) Context and project rationale

Water is an essential component of most horticultural production systems, and serves to deliver continuous supplies of premium quality produce to the major multiples. Horticultural irrigation represents only a small component of total water abstraction nationally, but is concentrated in the driest parts of the country at the driest times of the year when resources are scarcest. However, the demand for water is rising and yet many catchments in England are over-abstracted. The Environment Agency is addressing this through its Restoring Sustainable Abstraction Programme (RSAP) and Review of Consents (RoC) under the Habitats Directive. However, these actions represent only the tip of a growing conflict between water for horticulture, the environment and other users. The longer term threat of climate change, with hotter, drier summers, will exacerbate the problem. Growers will also need to deal with greater variability and magnitude of extreme events, including both water shortage (increased likelihood of droughts) and water excess (localised flooding, and crop damage associated with intense, short heavy rainfall events).

(ii) Expected project outputs

The expected deliverable from this study was a water strategy for horticulture that would define the key priorities and actions at both grower and industry levels, and the actions required (i.e. research, communication, and knowledge transfer) over the next 5 years to ensure horticulture receives a fair share of available water resources and uses it in a more efficient and sustainable manner.

Summary of the project and main conclusions

(i) Project objectives and approaches

The project combined desk-based research, structured interviews with key informants, farm visits, computer modelling and GIS mapping. The specific objectives of the project were:

Objective 1: To identify the key 'grower' water related priorities and actions, and to review and assess the extent to which each priority was relevant to each crop sector panel.

The **grower focus** concentrated on three questions relevant at farm and field levels:

1. What are the main application equipment and technology issues?
2. What are the in-field soil and water management (scheduling) issues?
3. What are the water resource (quality and quantity) issues?

A matrix was produced for each crop sector identifying the key priorities and actions. The individual matrices were then combined and used to rank the relative importance of each priority across the sectors, to identify opportunities for cross-sector collaboration.

Objective 2: To identify the key 'industry' issues, focussing on initiatives to improve water management, raise the profile of horticultural water resources to external stakeholders, promote collaboration and develop a knowledge base for water.

The **industry focus** concentrated on three different questions:

1. What specific actions should the HDC undertake to promote water efficiency (e.g. communication and knowledge transfer activities)? These actions focus on 'looking downwards' towards the grower base;

2. What specific actions should the HDC undertake to raise the profile of water for horticulture outside the industry, helping inform government, the public, regulatory agencies, and others (stakeholder engagement, public relations, profile raising)? These actions focus on 'looking upwards' beyond the horticultural industry;

3. What specific actions should the HDC undertake to develop a more extensive industry knowledge base on water management (e.g. professional development, training, technology transfer, education needs)? These actions help businesses improve resource efficiency and maintain competitiveness by raising the level of skills, knowledge and understanding of water and water management within the industry.

This involved a review of initiatives taken by other organisations and consultation with industry experts, particularly those involved in water-related research on how best the HDC could engage with the relevant stakeholders to promote better water management within horticulture.

(ii) Project conclusions

Key issues at grower level

A detailed review and assessment of the key priorities and research actions needed for each of the seven HDC sector panels has been completed. A summary matrix of R&D priorities has been produced (Table 1). All sectors, except mushrooms, registered significant water research needs of varying priority. As expected, the matrix shows some R&D priorities are common to several crop sectors creating opportunities for cross-panel collaborative work and economies of scale for the HDC. The most common priorities include addressing concerns about diffuse pollution, water harvesting and re-use, scheduling, and understanding the impacts of water regulation. The mushroom sector, although not a major water user, also registered diffuse pollution and water harvesting as important areas for further research. The role of benchmarking water use within key crop sectors (e.g. soft fruit) should also be considered as a highly beneficial tool for improving water efficiency and productivity.

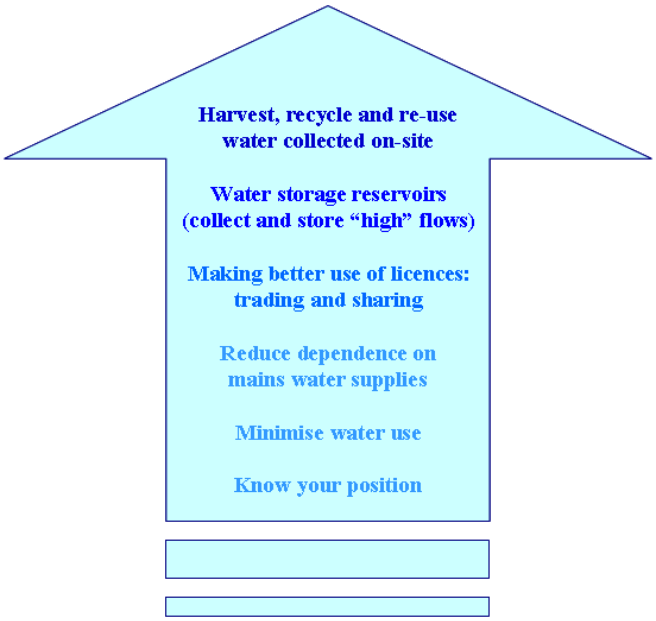
It is also vital that holdings make best use of all the water resources available to them. This reduces water needs, minimises the impacts of water abstraction on others, and helps retain existing licences and justify new applications. The ideal is that businesses should become "self sufficient" in their water consumption. Growers should base their best management practices for irrigation on a 'hierarchy of water resource actions' (Figure 1). Further details on each of the 6 key actions that relate to this hierarchy is given in the Science section.

Key issues at industry level

At an industry level, the HDC needs to ensure that all horticultural holdings in England and Wales have access to adequate, reliable water supplies, which cause minimal environmental impact, and which are used efficiently and effectively. To achieve this, the HDC needs to broaden its traditional "downward look" towards its grower base and begin to "look upwards" to better represent the horticulture industry in the ongoing debate over how limited water resources will be allocated in the future.

Looking 'downwards' requires focusing on three themes of which R&D is a part. The first is '*making best use of available water'* – following the 'hierarchy of water resource actions' to reduce water needs, minimise impacts of water abstraction on others, and working to retain existing licences and justify new applications (Figure 1).

Figure 1 Hierarchy of water resource actions for horticultural growers.



The second theme is '*developing a knowledge base'*. Growers need access to the latest information to remain competitive, not just R&D developed in the UK but also the wealth of knowledge available internationally. Growers should not reinvent the wheel unnecessarily. The final theme is '*working together'*. Some growers in water short catchments have already formed Water Abstractors Groups (WAGs) to protect their water rights and improve dialogue with the Environment Agency and other regulatory agencies. Others are being encouraged to do so. As competition for resources increases the need for more WAGs to form will become more obvious, and the HDC should help facilitate this process.

Looking 'upwards' beyond the horticultural industry cannot be ignored. The HDC, on behalf of its growers, will need to fight its corner to make a strong, coordinated case for a fair share of the nation's water resource for horticulture. It will need to raise the profile of water for horticulture outside the industry – informing government, the public, regulatory agencies, and other stakeholders of how important and valuable water is for horticultural production. This is a substantial task as the 'voice' of water for agriculture and horticulture is barely audible above those of water companies and environmental organisations. The public perception of food and farming is of an industry that typically wastes water. There seems to be little public

appreciation of how water underpins this high value industry, how well it is regulated, how efficiently it uses water, and how important it is to securing food production and rural livelihoods in England and Wales. The HDC therefore needs to take a more pro-active stance in protecting the water interests of the horticultural industry working with other levy bodies.

Although looking 'upwards' will be relatively new territory for the HDC, it is not something that it needs to do alone. Other organisations that support agriculture face a similar challenge – the Potato Council, NFU, CLA, UK Irrigation Association and others. At the moment each organisation pursues its own water agenda which, although laudable, tends to be disconnected. So at best they are patchy and at worst lead to unnecessary duplication of effort, inefficient use of limited resources and a fragmented and potentially weak lobby for the critical resource on which each organisation depends. The obvious answer is for all these organisations with a vested interest in water to work together. This may be easier said than done but if there is the political will it can be done and it would produce a "win-win" situation with many benefits. Since the formation of the AHDB, the HDC and Potato Council are now institutionally much closer and together represent the majority of irrigation interests in England and Wales. The NFU and CLA could provide the political drive and the UKIA brings a range of technical expertise and industry support to the table. With growing concerns over water availability, this new water strategy could be the catalyst that brings together these key organisations to create a 'champion' for water for agriculture and horticulture that can drive the water agenda at the highest levels and provide increased water security for all farmers and growers.

Financial benefits and action points for growers

There are no direct financial benefits or action points for growers associated with this work, as it was intended to provide a strategic framework for implementing a set of water actions, including promoting cross-panel collaboration by the HDC. However, the strategy does highlight a number of key options at farm level including the 'hierarchy of water resource actions' which growers should implement, to improve security of their on-farm water supplies.

Table 1 Summary of key water priorities and their relative importance (* = low; ** = medium; *** = high) within each HDC crop sector.

Key priorities	BOF	FV	HNS	M	PC	SF	TF
Understand/quantify links between poor irrigation uniformity, crop production and profitability (yield & quality)	*	***	**	*	**	***	*
Improve efficiency of irrigation application equipment (energy, labour and water)	**	***	**	*	**	**	*
Evaluate new equipment and technologies and options for switching systems	**	**	*	*	*	*	*
Improve understanding of water harvesting and water reuse options for horticultural irrigation	**	*	***	*	**	**	*
Improve irrigation schedules for specific crop types and production systems (including monitoring/auditing)	*	**	**	*	***	**	*
Improve soil management to understand the links between soil variability, soil water and crop production	*	**	*	*	*	*	*
Support the development of improved scheduling technologies (wireless etc)	*	**	***	*	**	***	**
Improve knowledge of the impacts of new water regulation on water availability and reliability	**	**	**	*	**	**	**
Improve knowledge of the impacts of irrigation on diffuse pollution including nitrate leaching, phosphate and pesticides	***	***	*	**	***	***	**
Improve knowledge of the risks associated with low irrigation water quality on crop production	*	**	*	*	*	***	**
Improve knowledge on alternative water sources (e.g. grey) and impacts on water quality and suitability for production	*	*	**	**	*	**	*

BOF = Bulbs & Outdoor Flowers
FV = Field Vegetables
HNS = Hardy Nursery Stock
M = Mushrooms
PC = Protected Crops
SF = Soft Fruit
TF = Tree Fruit

Science section

Introduction

Water management is an essential component of most high quality horticultural production systems. As with agriculture, horticultural irrigation represents only a small component of total water abstraction nationally, but is concentrated in the driest parts of the country at the driest times of the year when resources are scarcest. Its availability and reliability are also under increasing pressure and scrutiny. For example, in the Environment Agency (EA) Anglian Region, three quarters of all spray irrigation abstractions (78%) are within catchments defined as either being either over-licensed and/or over-abstracted (Knox *et al*., 2009). The EA is addressing these abstractions through its Restoring Sustainable Abstraction Programme (RSAP) and Review of Consents (RoC) under the Habitats Directive. However, this represents only the tip of a growing conflict between water for horticulture, the environment and other users. The longer term threat of climate change, with hotter, drier summers and greater frequency of droughts predicted, will only exacerbate the problem. This situation is not unique to the UK - internationally, abstraction of water for irrigation is considered by many to be one of the sectors that will be most influenced by climate change. As well as the underlying increases in temperature, probably of greater risk to UK horticulture will be in dealing with the greater variability and magnitude of extreme events; these relate to both water shortage (increased likelihood of droughts) and water excess (localised flooding, and crop damage associated with intense, short heavy rainfall events).

A water strategy for the industry was needed to define the key priorities and actions at both grower and industry levels to ensure that horticulture receives a fair share of available water resources and then uses it in a more efficient and sustainable manner. This study focused on the short to medium term (5 year) strategic planning horizon; however, it is important that the HDC does not lose sight of preparing the industry for adapting to longer-term issues associated with climatic change. The project was undertaken by Cranfield University working with independent water and horticultural specialists including RTCS Ltd (water management consultants), Chris Burgess (Horticultural Consultant) and extensive industry consultation.

Aim and objectives

The aim was to develop a medium term (5 year) water strategy for the horticultural industry. This strategy will inform the development and implementation of the HDC Corporate Plan, and provide a framework for identifying the key water priorities at grower and industry levels, the research and other strategic actions required, and timescales for implementation. The specific objectives were:

1. To identify the key ‘grower’ water related priorities and actions, and to review and assess the extent to which each priority is relevant to each crop sector panel;

2. To identify the key ‘industry’ issues, focussing on initiatives that would improve water management, raise the profile of horticultural water resources to external stakeholders, promote collaboration and develop a knowledge base for water;

3. To combine the ‘grower’ and ‘industry’ themes into a coherent strategy, with key actions that can be delivered (implementation plan) in the medium term.

Methodology and approaches

The project included a detailed review and assessment of the key priorities and research requirements across the seven sector panels (field vegetables, protected crops, bulbs and outdoor flowers, hardy nursery stock, mushrooms, tree fruit, soft fruit). The importance of water resources and research needs vary significantly between and within each sector panel. Potential synergies between the sectors in terms of R&D priorities were investigated to identify which actions would be sector specific and which could be addressed collaboratively.

The methodology combined desk-based research, structured interviews with key informants, farm visits, computer modelling and GIS mapping. A brief summary of the work undertaken as part of each objective is outlined below.

Objective 1: *To identify the key 'grower' water related priorities and actions, and to review and assess the extent to which each priority was relevant to each crop sector panel.*

The grower focus focussed on three questions relevant at farm and field levels:

1. What are the main application equipment and technology issues?

2. What are the in-field soil and water management (scheduling) issues?

3. What are the water resource (quality and quantity) issues?

This objective first involved extensive desk-based analyses of the current use and underlying trends in water use in horticulture. This provides the context for the strategy, quantifying the importance of irrigation to each sector, and assessing the spatial extent of the water problem in terms of abstraction and water resource stress. This was followed by an assessment of the key priorities for growers in each crop sector panel and the main industry issues, including reference to relevant examples from overseas where similar problems are evident. There was also a need to review and assess the extent to which existing and ongoing HDC R&D activities and other R&D have addressed each of the specific grower and industry themes. This work was supported by structured telephone interviews with key informants within each sector (usually two selected growers and two consultants) to assess their opinions and sentiment on the proposed research priorities.

A matrix was then produced for each sector identifying the key priorities and actions. The individual sector matrices were then combined and used to rank the relative importance of each priority across the sectors, to identify opportunities for cross-sector collaboration.

Objective 2: *To identify the key 'industry' issues, focussing on initiatives to improve water management, raise the profile horticultural water resources to external stakeholders, promote collaboration and develop a knowledge base for water.*

The industry focus focussed on three different questions:

1. What specific actions should the levy board be doing to promote and encourage greater water efficiency (e.g. communication and knowledge transfer activities)? These are actions that focus on 'looking downwards' towards the grower base;

2. What specific actions should the levy board be doing to raise the profile of water for horticulture outside the industry, helping inform government, the public, regulatory agencies, and others (stakeholder engagement, public relations, profile raising)? These are actions that focus on 'looking upwards' beyond the horticultural industry;

3. What specific actions should the levy board undertake to develop a more extensive industry knowledge base on water management (e.g. professional development, training, technology transfer, education needs)? These are actions that help businesses to improve resource efficiency and maintain competitiveness by raising the level of skills, knowledge and understanding of water and water management within the industry.

This involved a review of initiatives taken by other organisations and consultation with industry experts, particularly those involved in water-related research on how best the HDC could engage with the relevant stakeholders to promote better water management within horticulture.

Objective 3. *To combine the 'grower' and 'industry' themes into a coherent strategy, with key actions that can be delivered (implementation plan) in the medium term.*

The findings from Objectives 1 and 2 were combined into an over-arching water strategy for the horticultural industry. The strategy does not set out detailed specifications for each of the proposed research projects and initiatives that are needed, but rather defines the key priorities and actions which need to be implemented, under both the 'grower' and 'industry' themes.

It should be recognised that new priorities will emerge during the 5 year planning horizon; the strategy must therefore remain sufficiently flexible to incorporate new issues, and/or remove actions that might become less urgent.

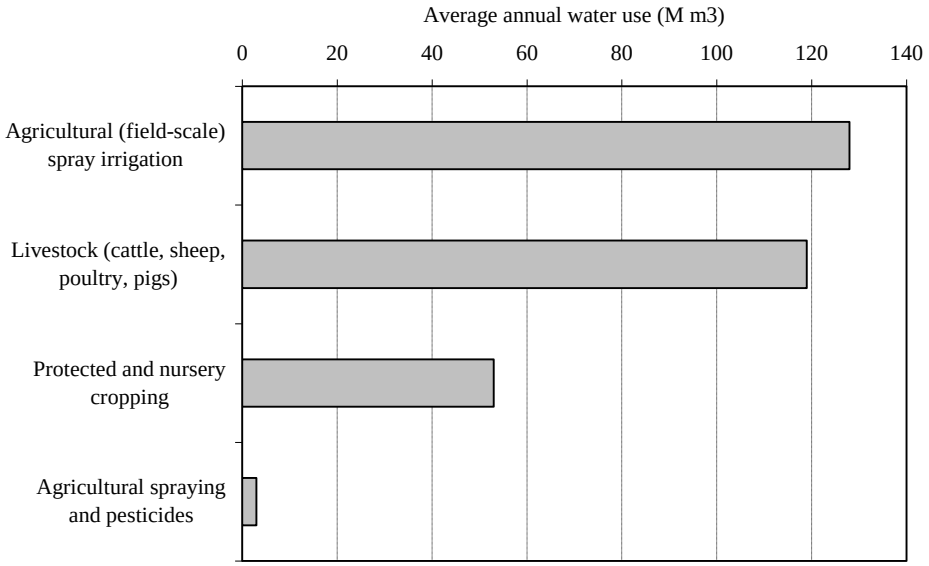
Water for horticulture – current use and underlying trends

A significant proportion of horticultural holdings, both large and small scale, traditional and organic, are dependent on water to provide the high quality continuous supplies of premium quality produce demanded by the major multiples (supermarkets), processors, and retailers. However, during times of drought, irrigated production can be last in line when it comes to water allocation, with for example Section 57 restrictions applied only to this sector. This chapter provides an overview of current use and underlying trends in irrigation within the horticultural sector, including data on cropped and irrigated areas (ha), volumetric irrigation water demand (m^3), underlying growth rates in horticultural water use compared against field-scale potatoes, and a regional assessment of resource availability and water stress.

Water use in farming

King *et al* (2006) conducted a baseline assessment of agricultural water use in England and Wales and estimated total on-farm water abstraction to be in excess of 300 million m^3 $year^{-1}$. Almost half (128 M m^3) was used for field-scale agricultural (and horticultural) spray irrigation. Livestock rearing accounted for a further 119 M m^3, mainly for consumption (drinking), but also for cleaning housing and yard assembly areas. The third largest sector was for protected and nursery cropping, which accounted for 53 M m^3. A minor but significant use was for spraying pesticides on field crops, which accounts for nearly 3 M m^3 (Figure 2).

Figure 2 Estimated water use in farming, by sector in 2006 (derived from King *et al*., 2006).



Cropped and irrigated areas

Even in a dry year such as 2003, less than 2% of the total water abstracted in England and Wales is used for irrigation of outdoor crops. However, it is a consumptive use, concentrated in the drier catchments in the driest months, and it can be the largest abstractor in some catchments during dry summers. Over the last 20 years, there have been significant changes in the types of crops irrigated. The proportion of irrigation on grass, sugar beet, and cereals has declined steadily. In contrast there has been a marked increase in irrigation of

high value crops, particularly potatoes and vegetables for human consumption. In 2005, irrigated potatoes and horticultural crops together accounted for 74% of the total irrigated area, and 86% of the total volume of irrigation water applied (Weatherhead, 2006). This trend is at least partly driven by the major supermarkets' demand for quality, consistency, and continuity of supply, which can only be guaranteed by irrigation.

In 2003 Tyrrel *et al* (2006) surveyed the nature and composition of irrigation practices within the UK ready to eat (RTE) horticultural salads sector. They collated information on the salad crops grown, areas irrigated, water sources, irrigation methods, minimum harvest intervals, on-farm water storage, and scheduling practices via a survey of HDC holdings. The total UK irrigated salad area in 2003 was estimated to be 5141 ha. Lettuces accounted for half this total, while spinach and salad onions together accounted for a further third (32%). A national Survey of Irrigation of Outdoor Crops is undertaken periodically by Defra, typically every three years, most recently for 2005. Information on the irrigated areas and volumes of water applied, by crop category, are given by Weatherhead (2006). By combining data from the annual Defra June cropping census with data from this latest irrigation survey, and from other industry sources, the total cropped and irrigated areas for each HDC crop sector have been estimated (Table 2).

Table 2 Estimated cropped areas (ha), irrigated areas (ha), and proportions irrigated (%) in 2005, by HDC crop sector, in England and Wales**.**

HDC Crop sector	Cropped area (ha)	Irrigated area (ha)	Proportion irrigated (%)
Bulbs & outdoor Flowers	5300	2500*	47
Field vegetables	107600	32202	30
Hardy nursery stock	6200	5000*	81
Mushrooms	125	125	100
Protected crops	1875	1875	100
Soft fruit	7700	7700*	100
Tree fruit	21000	1468	7
Total	**149800**	**50870**	**-**

* estimated from grey literature, and from key informants

The total irrigated area is estimated to be over 50000 ha, with field vegetables accounting for nearly three-quarters (63%). Within this sector, the most important irrigated crops include carrots, onions, lettuces and baby leaf salads. For each of these individually, the proportion irrigated would probably be close to 100%. For many other field vegetables, such as brassicas, irrigation is still important but not so extensive, since these crops are grown on more moisture retentive soils, are less prone to drought stress, and have quality criteria that are not as sensitive to water stress. Overall, the proportion irrigated is estimated to be 34%, but the data shows wide variation between individual crop sectors. For example, only a very small proportion of the tree fruit sector is irrigated, but the very high value drought sensitive crops such as soft fruit, hardy nursery stock and protected cropping are almost entirely dependent on irrigation.

Irrigation Water Use

Similarly, by combining information from the 2005 survey of irrigation of outdoor crops (Weatherhead, 2006) with other published and grey literature, and feedback from key informants in each crop sector, the total volumes of irrigation water applied, by HDC sector panel in 2005, have been estimated (Table 3).

Table 3 Estimated irrigated areas (ha), volumes of irrigation water (m^3) applied and average depths applied in 2005, by HDC crop sector, in England and Wales**.**

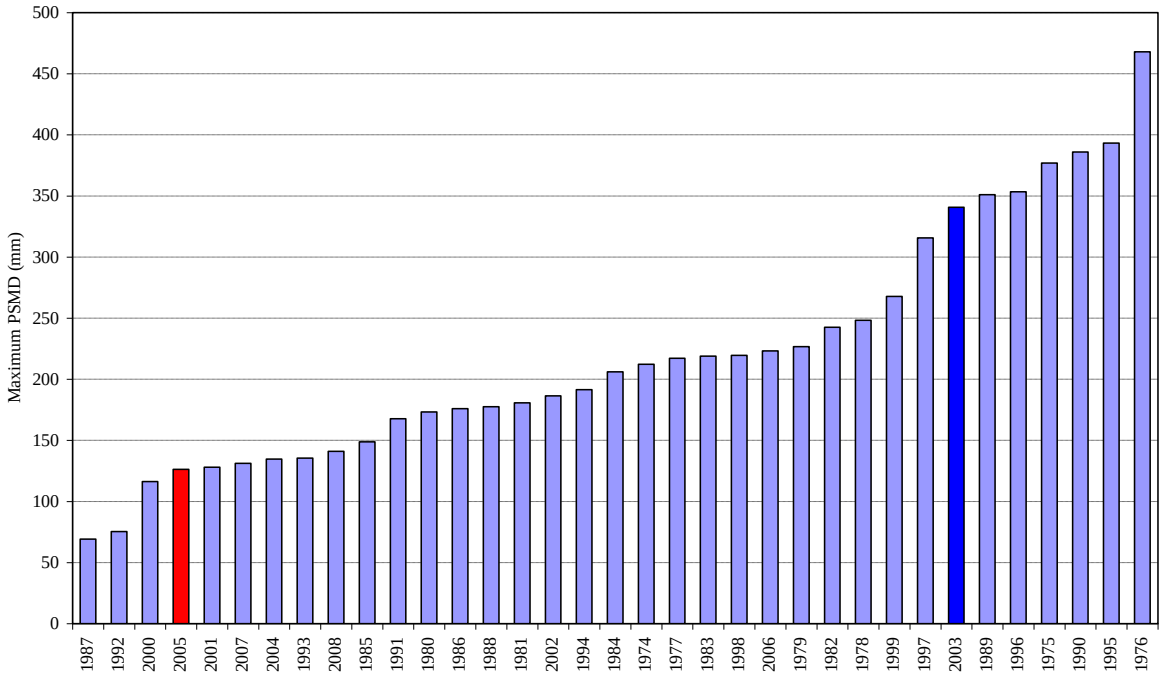
HDC Crop sector	Irrigated area (ha)	Volume applied (000 m^3)	Average depth applied (mm)
Bulbs and outdoor flowers	*2500	*1875	75
Field vegetables	32202	24740	77
Hardy nursery stock	*5000	*25000	500
Mushrooms	125	n/a	n/a
Protected crops	1875	*14063	750
Soft fruit	*7000	*7000	100
Tree fruit	1468	731	50
Total	**50870**	**73409**	**-**

*estimated

Field vegetables and HNS account for the greatest proportion of water used (36%) by volume, respectively, although the highest average depths of water applied were on protected crops (~750 mm) and HNS (500 mm), due to production being under cover (glasshouses or polytunnels) or sheltered from rainfall (plastic mulched). For field-scale cropping, it should be noted that the average depths are calculated by allocating the total volume over the gross area reported, and that in 2005 the weather (and hence irrigated areas and volumes) was considerably wetter than even an average year. Indeed, in irrigation terms, 2005 was considered to be one of the wettest in the last 35 years using an aridity index developed by Knox *et al* (2006) for assessing agroclimate variability (Figure 3) and hence reported figures for 2005 should be considered within the context of the weather in that year.

In a more typical ‘dry’ year such as 2003 (Figure 3) the irrigation depths applied, and hence volumes used, would be much higher; for field vegetables average depths of 200-300 mm in a dry year would be more normal.

Figure 3 Ranked annual agroclimate (aridity index) for Silsoe (Bedfordshire) based on daily climate data for 1974-2008. Recent wet (2005) and dry (2003) years are shown in red and dark blue, respectively.



Horticultural irrigation trends

The figures above relate specifically to individual sectors within horticulture. However, it is useful to consider how water use for horticulture compares against other field-scale irrigated crops. In England, potatoes are the most important crop in terms of irrigated area and water use. The equivalent figures for 2005 for maincrop potatoes are presented in Table 4.

Table 4 Comparison of total cropped area (ha), irrigated area (ha), and proportion irrigated (%) for horticulture and potatoes (based on 2005 data) for England and Wales.

Crop sector	Cropped area (ha)	Irrigated area (ha)	Proportion irrigated (%)	Irrigated volume (Ml)
Horticulture*	149800	50870	34	73409
Maincrop potatoes	102400	49555	48	43140

*comprising here vegetables grown in the open, soft fruit and orchard fruit.

The data shows the parity that exists between horticulture and maincrop potatoes in terms of irrigated areas, and the greater relative use of water (volumetrically) for horticulture. This has implications when considering future water research priorities, and the opportunities that could be derived from collaboration between these two levy boards. Many growers involved in potato production are also involved in field vegetable production, and therefore scope for addressing common water issues should be actively pursued. These are discussed in greater detail in the final section “Key issues at industry level”.

The comparison between field horticulture (vegetables) and potatoes (Table 4)) relates to 2005, but the areas irrigated and volumes of water applied vary significantly each year depending on the summer weather. In order to assess underlying trends, it is therefore important to separate out the impacts of any annual weather variation from underlying changes. Using irrigation survey data for the period 1982 to 2005, Weatherhead (2006) analysed the underlying growth rates in the areas irrigated, volumes and depths applied of various horticultural crops as linear functions over time after allowing for the annual weather variation, using multiple regression techniques (

Table **5**).

Table 5 Underlying linear growth rates (% per annum) in irrigated areas, volumes applied and average depths, for main horticultural crops and potatoes (for comparison), between 1982-2005, after allowing for annual weather variation (Derived from Weatherhead, 2006).

Crop sector	Area	Volume	Depth
Vegetables	3.0%	3.9%	2.0%
Orchard (tree) fruit	-2.5%	-2.7%	-0.5%
Small (soft) fruit	0.3%	2.6%	2.4%
Maincrop potatoes	3.0%	3.5%	1.6%

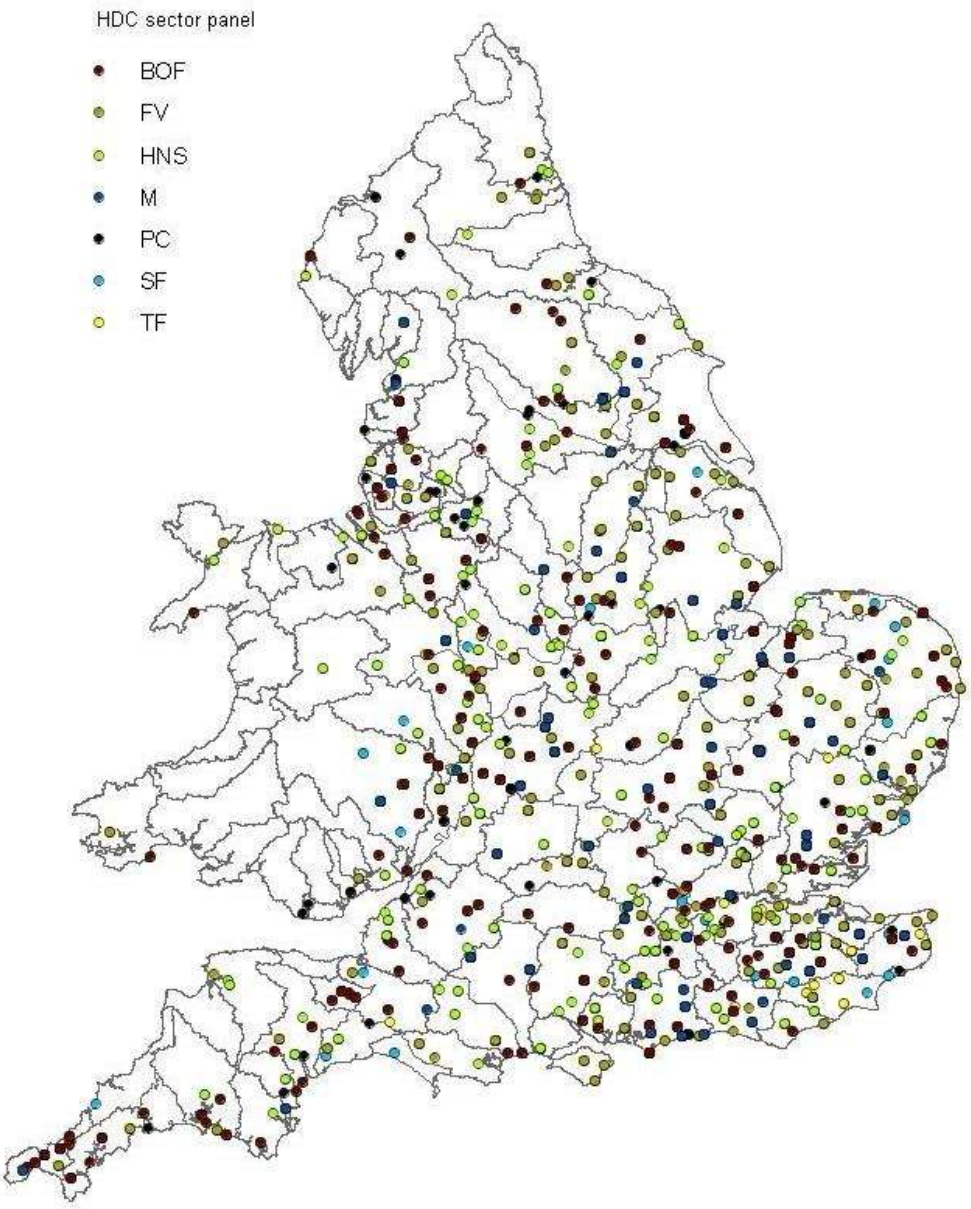
The data from 1982 to 2005, assuming linear growth, suggests that the total irrigated area of vegetables has been growing strongly at 3% per annum, in contrast to orchard (tree) fruit which has been declining steadily and soft fruit which has remained relatively stable. However, the volumes of water used on vegetables and soft fruit have been rising quite rapidly (3.9% and 2.6% pa), reflecting the increased depths of water being applied to obtain higher crop quality.

The figures for potatoes are also shown for comparison, and suggest similar trends to those observed for vegetables, although the depths applied have been growing more slowly. However, Weatherhead (2006) reported that these latest underlying growth rates are sensitive to the time series used for the analyses, and that the latest estimates could mask a significant recent downturn in irrigation growth rates for maincrop potatoes.

Resource availability and water stress

In 1999 the government published “Taking Water Responsibly” which outlined the proposed changes to the abstraction licensing system, including the development of Catchment Abstraction Management Strategies (CAMS) in England and Wales. The objective of the CAMS process was to (i) provide a mechanism for assessing water supply and demand at a catchment level, (ii) inform the public on water resources and licensing practice, (iii) provide a consistent approach to local water resources management, and (iv) to encourage local engage stakeholder engagement in water resources management. In England and Wales, 126 CAMS were subsequently defined, based on existing hydrological boundaries. Using a GIS and HDC data, the spatial distribution of registered holdings in 2008 by crop sector were mapped, by Environment Agency (EA) CAMS catchment (Figure 4). Individual maps for each crop sector are given in Appendix 1.

Figure 4 Spatial distribution of horticultural holdings, by sector, by EA CAMS catchment.



The map shows concentrations of horticultural holdings in eastern and south eastern England, including parts of Norfolk, Suffolk, Essex, Kent, south coast (Hampshire and West Sussex) in Nottinghamshire and the West Midlands (Welsh borders, Herefordshire and Worcester), and North West (Merseyside). There are also pockets in Cornwall.

The data from Figure 4 have been aggregated by EA Region (Table 6) and sector panel (Table 7). The results show that half of all HDC holdings are located within EA Anglian (29%) and Southern Regions (22%). These regions correspond to known areas of high irrigation water demand, with Weatherhead (2006) reporting that 67% of all irrigation water abstraction in 2005 occurred within these two regions. The data in Table 7 demonstrates that field vegetables and bulbs and outdoor flowers are predominantly located in EA Anglian Region.

Similarly, between a third and half of all soft fruit and tree fruit holdings are located in EA Southern Region.

Table 6 Number of HDC holdings, by EA Region, in 2008.

EA_Region	HDC holdings (number)	HDC holdings (%)
Anglian	1173	29
EA Wales	129	4
Midlands	574	14
North East	266	7
North West	305	8
South West	347	9
Southern	860	22
Thames	345	9
Total	**3999**	**100**

Table 7 HDC holdings (expressed as % of total) by HDC crop sector and EA Region, in 2008.

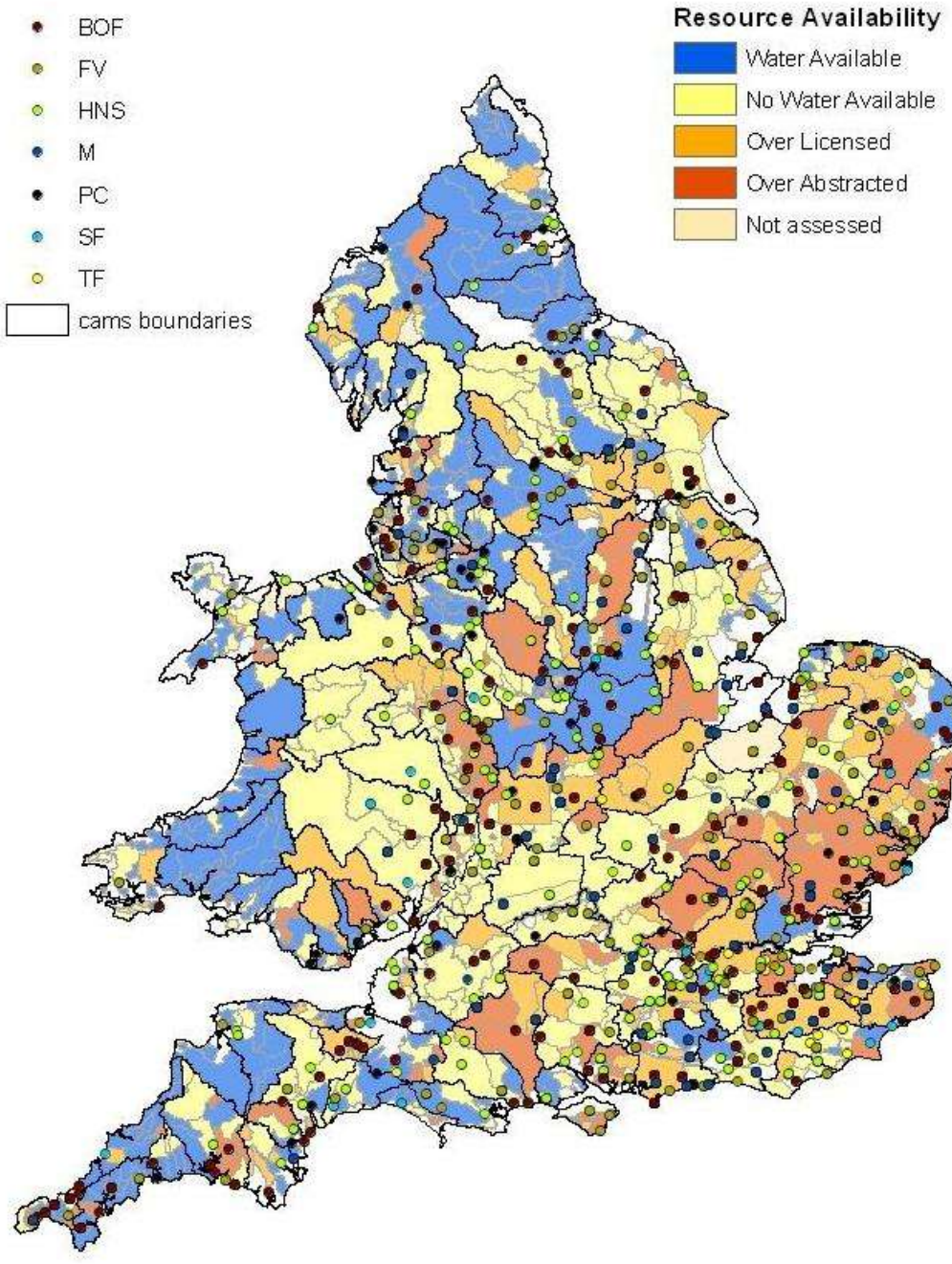
EA_Region	BOF	FV	HNS	M	PC	SF	TF
Anglian	37	40	25	24	26	24	23
EA Wales	2	2	4	2	3	6	4
Midlands	12	15	16	18	14	15	12
North East	7	6	8	11	9	5	3
North West	7	9	8	5	12	3	2
South West	13	9	11	7	7	10	3
Southern	14	13	17	20	17	30	48
Thames	9	6	11	13	12	7	4
Total	100	100	100	100	100	100	100

Water resource availability for horticulture

In England and Wales water resources are under pressure, due to rising demands, increasing competition between sectors (public water supply, industry, agriculture) and demands for greater environmental protection. Other industries (e.g. golf) have responded to the potential threats by developing strategies to cope with future changes in water availability (Knox *et al*., 2007). It is important that horticulture also recognises the risks and acts accordingly, particularly since the majority of its growers are dependent on surface water abstractions for irrigation (rather than storage or groundwater). It is these sources which are particularly susceptible to seasonal restrictions in irrigation water abstraction, sometimes with very little advance warning.

For each catchment, the EA have assessed the water resource availability and defined the catchment according to one of four categories, namely 'water available', 'no water available', 'over-licensed', and 'over-abstracted', in order of increasing stress. A description of their derivation and application for water resource management is given in EA (2004). Using computer mapping techniques (GIS), the location of HDC holdings in 2008 were mapped and compared against EA defined water resource availability (Figure 5). The GIS data were then analysed to assess the number and proportion of HDC holdings located within catchments with each defined resource availability (Table 8), by crop sector.

Figure 5 Spatial distribution of HDC holdings in relation to EA CAMS resource availability, based on HDC and EA data for 2008**.**



The data in Table 8 shows that only 16% of all HDC holdings are located within catchments where additional water abstraction licences would be available during summer low-flow periods ("water available"). Over half of all HDC holdings (59%) are located within catchments defined as having 'no (more) water available' or already being 'over- licensed'. Nearly a fifth of all holdings are in areas defined as being 'over- abstracted'. These figures clearly demonstrate the potential risks of water supplies to horticultural production, and the critical importance of developing an appropriate water strategy for dealing with future changes in the reliability and availability of water for horticulture. Similarly, the analysis of HDC holdings against water resource availability demonstrates the risks to particular crop sectors (Figure 7). Typically between 30-40% of holdings are within catchments defined as having 'no water available' and a further fifth in catchments that are 'over-abstracted'.

Table 8 Number and proportion of HDC holdings located within catchments with each defined water resource availability, in 2008.

Resource availability	Number HDC holdings	Proportion (%)
Water available	658	16
No water available	1429	36
Over-licensed	900	23
Over-abstracted	751	19
Not assessed	261	7
Total	**3999**	**100**

The severity of the likely impact on HDC holdings is largely dependent on the course of action chosen by the EA to redress the situation in each catchment. For example, in some catchments the EA decision to maintain the 'status quo' may not impact on a horticultural holding unless they are wishing to obtain additional water resources which would not be possible without considering a high flow (winter) storage reservoir. In other catchments, the EA may take steps to move the catchment from "over-abstracted" to one of "over-licensed" or "no water available" when abstractors wish to vary the conditions of their licence or when time-limited licenses are renewed – in this case, licence holders may be asked to consider reductions in their licensed volume which would have an immediate impact on a business.

A similar situation exists with respect to HDC holdings dependent on mains water abstraction. The government has published information on public mains water stress, delimiting areas using utility water resource zones (WRZ). Using a GIS, the location of HDC holdings have been mapped (Figure 5) and aggregated according these defined levels of mains water stress (Table 9). The analysis shows that about a third (35%) of all HDC holdings are located within areas currently being defined as having a 'serious' level of mains water stress.

Table 9 Number of HDC holdings in relation to defined categories of mains water stress.

Level of mains water stress	Number of HDC holdings	Total (%)
Serious	1414	35
Moderate	1588	40
Low	734	18
Not assessed	263	7
Total	**3999**	**100**

Figure 6 Distribution of HDC holdings in relation to public mains water stress.

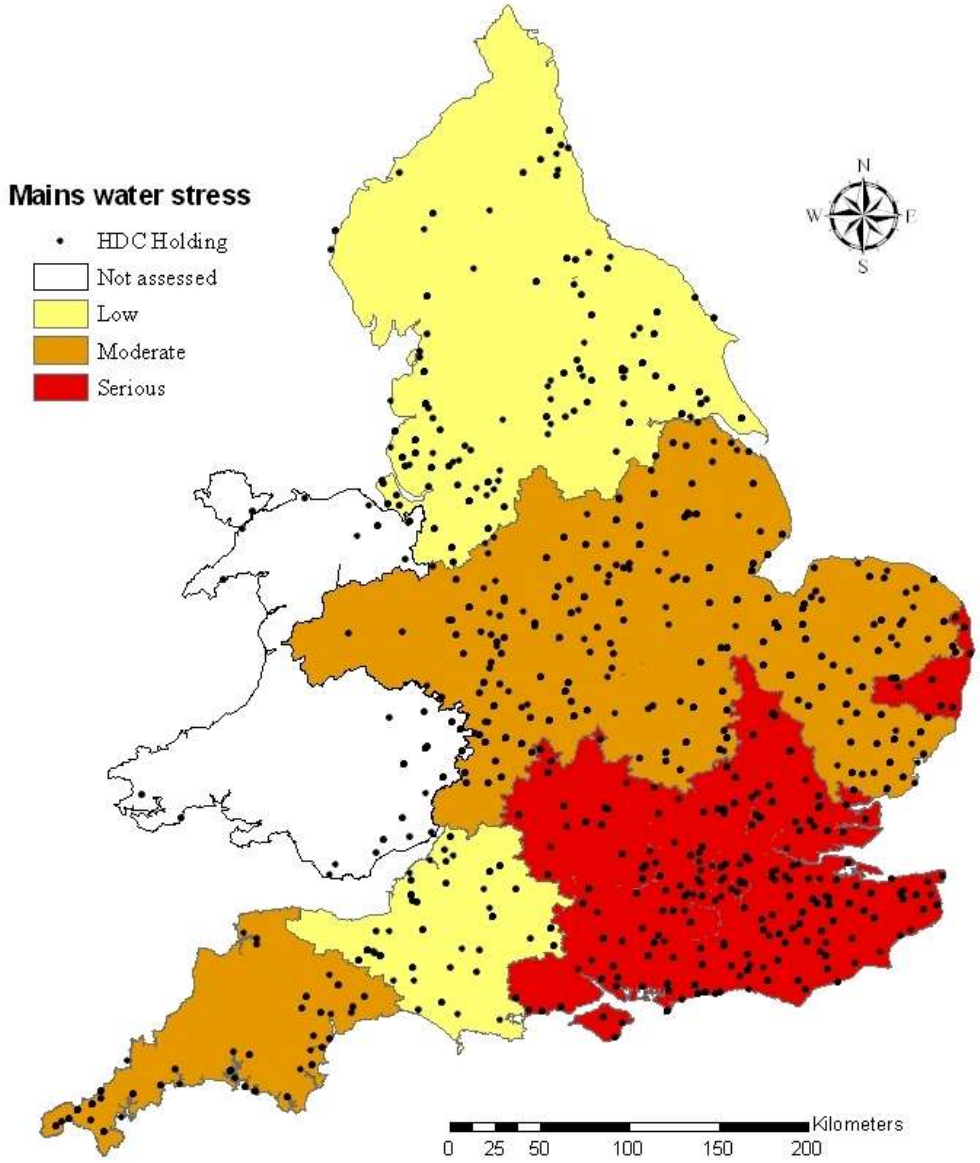
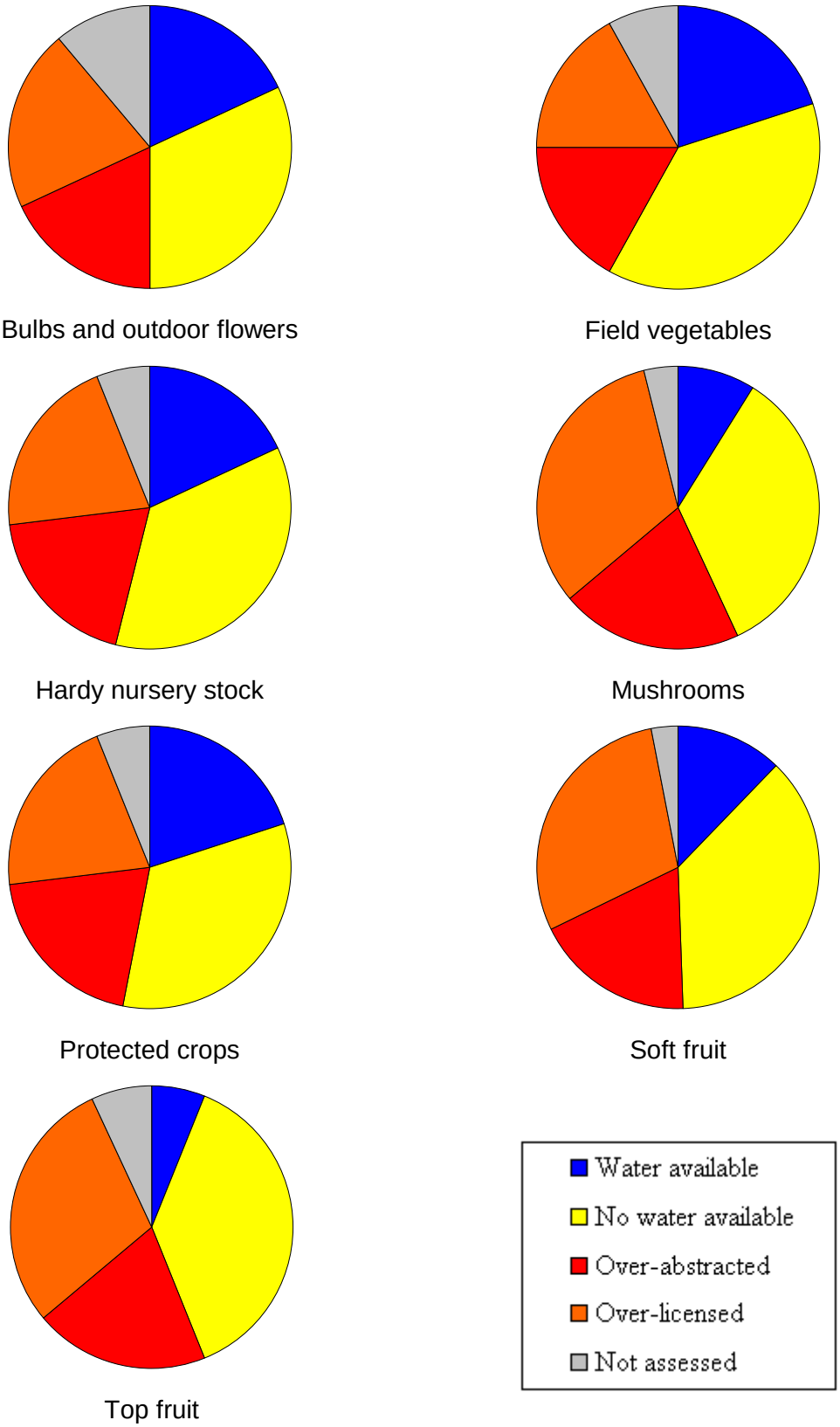


Figure 7 Assessment of water resource availability (for direct abstraction), by HDC crop sector, in 2008**.**



Time-limited abstraction licences are subject to a presumption of renewal provided three tests are satisfied at the time of renewal (Table 10). Test 1 (continued environmental sustainability) is largely undertaken by the EA through their Catchment Abstraction Management Strategies (CAMS) and other water regulation processes, although licence applicants may be required to provide data and/or other information The availability status and the EA policy for that catchment can therefore also be critical for renewing existing licences. Test 2 (continued justification of need) requires the licence holder to submit a case for renewal, addressing a range of factors that impact on the requirement for irrigation (justifying 'reasonable' need). The methodologies already in place for justifying reasonable need for a new abstraction licence provide the basis for judging whether the need is likely to be reasonable, though the use the applicant has made of the licence in previous years can provide additional supporting information. Test 3 (efficient use of water) will require the licence holder to demonstrate that 'efficient use' is being made, largely based on evidence on irrigation practices.

Table 10 Tests for abstraction licence renewal.

Test		**Definition**
1	Continued environmental sustainability	To assess whether the abstraction can be sustained without significant impact on water resources, other water users or the environment
2	Continued justification of need	To assess whether the abstraction is still required and to check that the maximum levels of abstraction are still reasonable
3	Efficient use of water	To assess whether the right amount of water is being used in the right place at the right time

Although these criteria do not apply to public mains water abstractions (which account for 5% of horticultural abstractions) HDC member holdings should nevertheless be aware of the increasing risks of future mains water supplies, not just in terms of rising costs but also the likelihood of restrictions and requests for additional volumes, due to other pressures on demands (e.g. for housing development). The water companies face many of the same issues in obtaining additional water as direct abstractors.

The most important point for the HDC is to ensure that all horticultural holdings are (i) aware of the water resource availability status of their catchment and (ii) considering developing alternative water sources where future summer supplies are likely to be reduced.

Key issues at grower level

Defining the criteria

For most growers irrigation is about optimising soil-water management practices to improve crop yield and more importantly quality. This will also improve 'irrigation efficiency', a criteria now required by the EA as part of abstraction licence renewal. Demonstrating efficiency is also important to the supermarkets through their grower protocols to ensure environmental sustainability. Optimising soil and water management practices is all about applying the right amount of water at the right place and at the right time. It involves balancing soil and water management (scheduling) decisions, whilst ensuring that the irrigation equipment is applying the water as uniformly as possible. In turn, achieving uniformity in water application and getting the irrigation scheduling right relies on having adequate water resources available (in both quality and quantity) to deal with variations in daily, seasonal and peak irrigation water demands.

These three criteria (equipment, management, and water resources) are the fundamental elements of the 'pathway to efficiency' defined by Knox (2006) and are common to any irrigated business, whether involved in large field-scale vegetable production or small-scale specialist horticulture (e.g. nurseries or protected crops). From this, three fundamental questions relevant to growers at the farm and field levels, across all crop sectors were defined:

Question 1 What are the main application equipment and technology issues?

Question 2 What are the main in-field soil and water management (scheduling) issues?

Question 3 What are the main water resource (quality & quantity) and environment issues?

For each question a set of research priorities were identified using a combination of literature review, expert opinion, and discussion with key informants from each sector panel. These are summarised below. The relevance of each priority within each sector panel varies depending on the importance of water for production in that particular sector. However, when trying to identify common issues across which sector panels could work collaboratively, it is sensible first to identify a common set of research priorities and then to assess the extent to which each priority is relevant to each sector.

Application equipment and technology

Four key priorities were defined in terms of application equipment:

1. Understand and quantify the links between poor irrigation uniformity, crop production and profitability (yield and quality);

2. Improve efficiency of irrigation application equipment (energy, labour and water);

3. Evaluate new equipment / technologies and options for switching systems;

4. Improve understanding of water harvesting and water reuse options for horticultural irrigation.

Soil and water management

Three key priorities were defined in terms of soil and water management:

1. Improve information on irrigation schedules for specific crop types and production systems (including monitoring and auditing);

2. Improve soil management to understand the links between soil heterogeneity, soil water availability and crop production;

3. Support the development of improved scheduling technologies.

Water resources and environment

Four key priorities were defined in terms water resources and environment:

1. Improve knowledge of the impacts of new water regulation on water availability and reliability;

2. Improve knowledge of the impacts of horticultural irrigation on diffuse pollution including nitrate leaching, phosphate and pesticides;

3. Improve knowledge of the risks associated with low irrigation water quality on crop production;

4. Improve knowledge on alternative water sources (e.g. grey / waste water) its impacts on water quality and suitability for irrigated production.

Using a combination of expert opinion, literature review and telephone interviews with key informants, the relative importance of each priority in each crop sector has been assessed. One of the objectives of the water strategy was also to identify potential synergies between crop sector panels where shared R&D actions could be developed. A matrix of the key priorities and their relative importance to each crop sector is presented in Table 11. This highlights areas where specific priorities have equal relative importance across the different crop sectors, and provides the basis for defining potential cross-panel collaboration. The proposed mechanisms and opportunities for collaboration are discussed in more detail under “Key Issues at Industry Level”.

Table 11 Summary of key water priorities and their relative importance (* = low; ** = medium; *** = high) within each HDC crop sector.

Key priorities	BOF	FV	HNS	M	PC	SF	TF
Understand/quantify links between poor irrigation uniformity, crop production and profitability (yield & quality)	*	***	**	*	**	***	*
Improve efficiency of irrigation application equipment (energy, labour and water)	**	***	**	*	**	**	*
Evaluate new equipment and technologies and options for switching systems	**	**	*	*	*	*	*
Improve understanding of water harvesting and water reuse options for horticultural irrigation	**	*	***	*	**	**	*
Improve irrigation schedules for specific crop types and production systems (including monitoring/auditing)	*	**	**	*	***	**	*
Improve soil management to understand the links between soil variability, soil water and crop production	*	**	*	*	*	*	*
Support the development of improved scheduling technologies (wireless etc)	*	**	***	*	**	***	**
Improve knowledge of the impacts of new water regulation on water availability and reliability	**	**	**	*	**	**	**
Improve knowledge of the impacts of irrigation on diffuse pollution including nitrate leaching, phosphate and pesticides	***	***	*	**	***	***	**
Improve knowledge of the risks associated with low irrigation water quality on crop production	*	**	*	*	*	***	**
Improve knowledge on alternative water sources (e.g. grey) and impacts on water quality and suitability for production	*	*	**	**	*	**	*

Bulbs and outdoor flower production

This sector encompasses narcissus bulb and flower production, forced bulbs, tulips and gladioli, as well as outdoor cut flowers and foliage. Most BOF growers (37%) are located within EA Anglian region (Table 6), and in catchments where water resources are 'over-licensed' and/or 'over-abstracted'. However, although irrigation is important particularly in dry years, it is not a major component of production. A summary of the key water research priorities and actions identified for this sector is given in Table 12.

Table 12 Key water research priorities and actions for bulb and outdoor flower production.

Theme	Key priorities	Key actions
Equipment and technology	Understand and quantify the links between poor irrigation uniformity, crop production and profitability (yield and quality)	Update knowledge of irrigation and crop production for selected BOF crops
	Improve efficiency of irrigation application equipment (energy, labour and water)	Develop best practice guidelines for optimising performance and management of irrigation application equipment
	Evaluate new equipment / technologies and options for switching systems	Research to compare performance of new technologies and equipment (grower field trials)
	Improve understanding of water harvesting and water reuse options for horticultural irrigation	Research to assess technologies available for water harvesting and re-use, and economic benefits
Soil and water management	Improve information on irrigation schedules for specific crop and production systems (incl monitoring and auditing)	Research to develop revised/updated schedules for specific crop types to ensure maximum yield and premium quality
	Improve soil management to understand the links between soil heterogeneity, soil water availability and crop production	Study to collate information and case studies on optimising soil management for BOF irrigation
	Develop improved scheduling technologies	Technology transfer from other crop sectors

Theme	Key priorities	Key actions
Water resources and environment	Improve knowledge of the impacts of new water regulation on water availability and reliability	Study to collate information relating to water regulation and impacts on horticultural BOF industry
	Improve knowledge of the impacts of horticultural irrigation on diffuse pollution including nitrate leaching, phosphate and pesticides	Research to quantify impacts of BOF irrigation on nitrate and phosphate leaching
	Improve knowledge of risks associated with low irrigation water quality on crop production	Not relevant
	Improve knowledge on alternative water sources (grey / waste water) its impacts on water quality and suitability for production	Technology transfer from other crop sectors

Field vegetable production

This is the largest of the sector panels by cropped area, including carrots, onions, parsnips, herbs, brassicas, and leafy salads. It is also largest in terms of irrigated area and water use, accounting for 71% and 62% respectively. Half of all production is located in eastern and southern England, in areas of severe water stress (

Figure **5**) it is thus one of the sectors most at risk from future water scarcity. Optimising resource use to improve farm efficiency through increased automation, precision agronomy, water, soil and waste management is one of its priorities. For many water is an essential component of production, driven by demands for quality. Many of the key water research priorities and actions have direct relevance to this sector (

Table 13) although there are major opportunities for research collaboration, both cross-sector within HDC and with the broader industry (notably the Potato Council).

Table 13 Key water research priorities and actions for field vegetable production.

Theme	Key priorities	Key actions
Equipment and technology	Understand and quantify the links between poor irrigation uniformity, crop production and profitability (yield and quality)	Research to assess links between irrigation and crop production on FV crops
	Improve efficiency of irrigation application equipment (energy, labour and water)	Develop best practice guidelines for optimising management and performance of irrigation application equipment
	Evaluate new equipment / technologies and options for switching systems	Research to compare performance of new technologies and equipment (grower field trials)
	Improve understanding of water harvesting and water reuse options for horticultural irrigation	Research to assess technologies available for water harvesting and re-use, and economic benefits
Soil and water management	Improve information on irrigation schedules for specific crop and production systems (incl monitoring and auditing)	Research to develop updated schedules for specific crop types to ensure maximum yield and premium quality
	Improve soil management to understand the links between soil heterogeneity, soil water availability and crop production	Study to collate information and case studies on optimising soil management for FV irrigation

Theme	Key priorities	Key actions
	Develop improved scheduling technologies	Research to develop new scheduling technologies (e.g. wireless) that link soil water status with crop water stress and precision irrigation application
Water resource and environment	Improve knowledge of the impacts of new water regulation on water availability and reliability	Study to collate information relating to water regulation and impacts on horticultural industry
	Improve knowledge of the impacts of irrigation on diffuse pollution including nitrate leaching, phosphate and pesticides	Research to quantify impacts of FV irrigation on N and P leaching
	Improve knowledge of risks associated with low irrigation water quality on crop production	Research to improve understanding of links between water quality, microbiological contamination and RTE food risk
	Improve knowledge on alternative water sources (grey / waste water) its impacts on water quality and suitability for production	Develop grower guidelines for highlighting the alternatives and their cost/benefit implications for FV production

Hardy Nursery Stock

This is most diverse crop sector, encompassing all HNS species produced both outdoors (field or container), or under protection (glasshouses or tunnels). The businesses operating in this sector vary considerably in size, with some specialist nurseries concentrating on only a few lines while others may supply well over a thousand. Although the cropped areas on individual holdings are relatively small, the value and importance of irrigation for production is extremely high. This sector has the potential to become almost self sufficient in water use by reducing its dependence on mains supplies and moving more towards water harvesting and re-use. A summary of the key water research priorities and actions identified for this sector is given in

Table 14.

- HNS as a commodity covers the production of a very wide range of crop types including trees, shrubs, herbaceous perennials, - i.e. many ornamentals but excluding 'houseplants', bedding plants, cut flowers (PC & BOF sectors). Some overlap here though. Also includes some specialities such as aquatics, pot-grown herbs, wild flowers, and includes nursery production of fruit plants (trees, bushes, canes and strawberry plants), but not their fruit.

- HNS both outdoor and protected. Increasing proportion of crop spends at least some time under protection during cropping cycle. Many issues thus common to the PC sector.

- HNS both soil grown and container grown or both i.e. containerised from field for growing on or marketing. Soil grown HNS will use similar range of irrigation technology as FV from rain-guns through portable sprinklers to drip and trickle. Dynamics of water gain and loss by containers, and differences between organic based growing media and soil has big implications for water application and scheduling. Uniformity of irrigation can be more critical, and frequency of irrigation typically higher with container crops. Soil 'water balance' approach to scheduling less easy to apply. Rainfall has less direct effect on reducing irrigation frequency (little storage in containers), though can greatly reduce abstraction / mains consumption where water harvesting / drainage recapture is used.

- Containers susceptible to 'run-through' losses. Application rates often exceed rate of absorption by growing media. Opportunities for improved water use efficiency by more careful use of pulsed irrigation. Also managing growing media (structure, wettability, mulches) can improve this.

- Most growers on HNS nurseries (as with PC) traditionally do not think in terms of 'mm irrigation' and would not express their water consumption in this way, thinking more in terms of 'minutes of irrigation' for an area, and probably weekly / monthly / annual m^3 consumption from their borehole or mains meter for the nursery as a whole. This is due to the complexity of cropping and irrigation systems used compared to field production, and that a simple water balance approach to scheduling using soil moisture deficit is less easy to apply to container cropping. This makes it difficult to collect reliable detailed statistics on water consumption for HNS and PC crops. However, 'mm irrigation' (litres per cropped or irrigated m^2) is still the best way of defining water consumption and it is important growers understand the concept. Greater use of water meters on nurseries to monitor consumption from different cropping systems can be a beneficial management and auditing tool.

- The huge range of crop size, woody vs herbaceous, perennial vs annual, soil or container grown, container size, production and irrigation system has a large effect on water need and 'efficiency' of water use and cannot be generalised or easily benchmarked without specifying these factors.

- Very diverse range of application technologies used (as with PC). Best choice often linked with production system and crop type, e.g. capillary, drip or sub-irrigation good if important to keep foliage dry. Efford sand beds – extremely efficient but high capital cost. Despite sophistication of some systems, still large opportunities for improving uniformity and efficiency of application and scheduling.

- Wide range of crop types and sizes, and regular turnover creates significant problems for effective irrigation scheduling. Best growers group crops according to water need, but always some compromise. Production scheduling, timing and marketing considerations usually have bigger influence on where crops placed than water need. Limit to sub-divisions of 'irrigated zones' possible with infrastructure. However, as with PC sector, some opportunities for addressing this when upgrading systems. More smaller irrigated zones = more flexibility for scheduling, but adds control complexity. Gantry irrigation allows variable irrigation down runs, but currently few gantries in UK HNS.

- Labour for water management issues represents higher % of costs than in e.g. FV, SF, M, and even PC where more automation. Less automation of scheduling and application in HNS due to complexity of crop species, different systems etc. However, recent R&D making progress towards improving scheduling and automated irrigation.

- As with some PC production (especially ornamentals) much HNS irrigation relies on timer systems applying water cyclically around irrigation zones. Necessary to maintain system pressures and make efficient use of water delivery infrastructure. This may result in excessive water being applied 'by default' as it is easier to keep to a regular schedule than apply it exactly when needed. Containers typically need more frequent irrigation than field crops – they may only get a single or two 'irrigation opportunity slots' per day so unless automatic systems are used, water is often applied 'just in case' rather than risk plants going short. Staff often working in HNS crops during the day so crops often watered after hours. Early morning (5 – 7 am) preferable for some species where wet leaves overnight encourage disease.

- Irrigation in HNS linked more to crop quality than yield *per se*. More plants lost or damaged due to over irrigation than under irrigation.

- As with PC, there are good opportunities for water recapture and recycling on container nurseries. Mains still very important water source for many HNS – some rely on it exclusively, while others use partial surface or borehole extraction. Small reservoirs and above ground tanks increasingly being installed to ensure continuity of supply, although economics of reservoirs will depend on nursery's reliance on and cost of mains water, and availability of other sources. Less opportunity for creating water abstraction groups or sharing reservoirs in HNS than agriculture / FV due to dispersal of many nurseries, though maybe some opportunities worth exploring.

- Nutrition of container HNS predominantly with controlled release fertilisers, although some liquid feeding used, particularly under protection. The risks of high conductivity of runoff water, risks of high levels of pesticides, and therefore pollution, are generally very low, but there are occasional risks from point-sources at some times of year. As with PC, work is ongoing to develop protocols for sampling and testing runoff from nurseries, and record-keeping, so that environmental responsibility can be demonstrated. There is general acceptance that the industry needs to be pro-active in helping develop standards for compliance and encourage self-regulation rather than have possibly inappropriate measures imposed upon them.

- Water quality issues – chemical and biological water quality for crop safety and health much more important than microbial risks (*E. coli etc*) to humans because ornamental crops not eaten. Exception would be eliminating Legionnaire's disease risk for fog and mist systems used in plant propagation for example. Control of potential water-borne diseases, weed seed, algae, moss and liverwort spores is important where non-mains water sources used or runoff recycled. Nurseries may drain to 'dirty water' reservoir at bottom of site and then treat with chlorination, UV, slow sand filtration etc., then pump and store clean water in above ground tanks or covered clean reservoir at top of site.

- Acidification of hard water or treatment for high iron levels often used for irrigation of propagation, young plants, or those where lime etc deposits affect quality, but too expensive for routine acidification of general irrigation water. Dilution of hard water or bed runoff by harvested rainwater can reduce the problem.

Table 14 Key water research priorities and actions for hardy nursery stock production.

Theme	Key priorities	Key actions
Equipment and technology	Understand and quantify the links between poor irrigation uniformity, crop production and profitability	Research to identify how far non-uniformity in irrigation affects quality and growth uniformity in HNS subjects.
	Improve efficiency of irrigation application equipment (energy, labour and water)	Develop best practice guidelines for optimising management and performance of all irrigation application equipment. Design, monitoring and system maintenance.
	Evaluate new equipment / technologies and options for switching systems	Research to compare performance of new technologies and equipment. Decision support tree for choosing appropriate technology linked to auditing.
	Improve understanding of water harvesting and water reuse options for horticultural irrigation	Promote wider adoption of harvesting / reuse from roofs / hard-surfaces, incl production beds. Options to upgrade/replace existing facilities. Research underground storage options.
Soil and water management	Improve information on irrigation schedules for specific crop types and production systems (including monitoring and auditing)	Research to develop practical methods for quantifying water needs on complex mixed crop / production system nurseries (e.g. monitoring / auditing benchmarking). Identify crops with high 'lean regime' potential. Crop quality and shelf-life impacts.
	Improve soil management to understand the links between soil heterogeneity, soil water availability and crop production	Link water requirements with ranges of growing media. Develop and promote appropriate media water management technologies.
	Develop improved scheduling technologies	Research to develop/implement new scheduling technologies (e.g. probes, ET estimation, wireless communication, thermal imaging) that link soil water status with crop water stress and precision irrigation. Also integration with or upgrading existing nursery equipment.

Theme	Key priorities	Key actions
Water resources and environment	Improve knowledge of impacts of new water regulation on water availability and reliability	Study to collate information relating to water regulation and impacts on horticultural industry. Each nursery needs to know technical / legislative water availability & costs from each source. Explore water abstraction / collaboration groups.
	Improve knowledge of the impacts of horticultural irrigation on diffuse pollution including nitrate leaching, phosphate and pesticides	Research to quantify impacts of HNS irrigation on nitrate and phosphate leaching and pesticide runoff. Develop protocols for sampling and testing nursery runoff for audits.
	Improve knowledge of risks associated with low irrigation water quality on crop production	Not relevant
	Improve knowledge on alternative water sources (grey / waste water) its impacts on water quality and suitability for production	Research leading to decision tree for water cleaning and treatment options (biological vs chemical / physical) for plant pathogens, or pH and chemical imbalance issues.

Mushrooms

This is one of the smallest crop sectors. It faces a number of challenges including dealing with the issue of odours from mushroom compost and the introduction of revised Waste Regulations. Access to water is not a major constraint to production. The main challenges for the industry are to reduce its operating costs through reducing its dependence on mains water, and addressing environmental concerns regarding the extent to which mushroom production and compost production are contributing to diffuse pollution. A summary of the key water research priorities and actions identified for this sector is given in Table 15.

Table 15 Key water research priorities and actions for mushroom production.

Theme	Key priorities	Key actions
Equipment and technology	Understand and quantify the links between poor irrigation uniformity, crop production and profitability (yield and quality)	Not relevant
	Improve efficiency of irrigation application equipment (energy, labour and water)	Technology transfer from other crop sectors
	Evaluate new equipment / technologies and options for switching systems	Technology transfer from other crop sectors
	Improve understanding of water harvesting and water reuse options for horticultural irrigation	Review and assess options for reducing dependence on mains water without increasing risks associated with recycling
Soil and water management	Improve information on irrigation schedules for specific crop types and production systems (including monitoring and auditing)	Not relevant
	Improve soil management to understand the links between soil heterogeneity, soil water availability and crop production	Not relevant
	Develop improved scheduling technologies	Not relevant

Theme	Key priorities	Key actions
Water resources and environment	Improve knowledge of impacts of new water regulation on water availability and reliability	Not relevant
	Improve knowledge of the impacts of horticultural irrigation on diffuse pollution including nitrate leaching, phosphate and pesticides	Clarify extent to which mushroom production and compost production are contributing to diffuse pollution
	Improve knowledge of risks associated with low irrigation water quality on crop production	Technology transfer from other crop sectors
	Improve knowledge on alternative water sources (grey / waste water) its impacts on water quality and suitability for production	Investigate options for UV treatment and sand filtration

Protected crops

This large sector encompasses protected salad crops (e.g. tomatoes, cucumbers, lettuce, peppers, herbs, celery) and protected ornamental crops (e.g. cut flowers, pot plants and bedding plants). It excludes nursery stock and soft fruit grown under protection, including polythene tunnel strawberries. The crops are grown in a variety of media including soil, pots, cell trays (pack bedding), and hydroponics – especially rockwool and some NFT. Irrigation is essential as rainfall is excluded. Much of the nutrition is applied via fertigation. Chemical and biological water quality are important, with acidification of both mains and groundwater supplies usually necessary in hard water areas. Slow-sand filtration, chlorination, and UV water treatment are widely used. Many growers still rely on mains water supply. However, rainwater harvesting, from glasshouse roofs and hard surfaces, is increasingly being adopted, and there are opportunities for further uptake.

A very wide range of application technologies is used, depending on the cropping system, including overhead sprinkler and spray-lines, trickle (drip), ebb & flow, trough-track, gantry, capillary matting, and some sand beds. Despite the apparent sophistication, there is still big opportunity for improving uniformity and efficiency of application and scheduling. In 'open' systems, the surplus irrigation and feed runs to waste, often after some treatment. In 'closed' systems, the drainage is treated and re-circulated. There is an impetus to develop more closed or partially closed systems. In practice it is difficult to run a totally 'closed' system and occasionally 'flushing through' or partial replenishment with fresh solution is necessary.

- The pollution threat from nutrient runoff from protected cropping is small compared to field scale agriculture, but local and point source pollution threat might be significant. More work is needed to trace the fate of runoff to identify whether and what treatment is necessary. There is an opportunity to develop best practice, including protocols for sampling and testing runoff (frequency and methods) and record-keeping to demonstrate responsible compliance. There is historical and ongoing work on monitoring both nutrient and pesticide runoff from PC and HNS, and treatment options. This needs extending and implementing. As with HNS, quite a lot of the 'Key Actions' in the strategy matrix have already been or are being addressed, at least in part. The priority is frequently to get existing knowledge and best practices into operation, although this can then reveal new problems needing further work. A summary of the key water research priorities and actions identified for this sector is given overleaf in

Table 16.

Table 16 Key water research priorities and actions for protected crop production.

Theme	Key priorities	Key actions
Equipment and technology	Understand and quantify the links between poor irrigation uniformity, crop production and profitability (yield and quality)	Research to identify how far non-uniformity in irrigation affects yield, quality and growth uniformity in PC subjects.
	Improve efficiency of irrigation application equipment (energy, labour and water)	Develop best practice guidelines for optimising management and performance of all irrigation application equipment. Design, monitoring and system maintenance for open and closed systems.
	Evaluate new equipment / technologies and options for switching systems	Research to integrate appropriate irrigation, fertigation and scheduling technology into new automated and mechanised crop production systems. Decision support tree for choosing appropriate technology linked to auditing.
	Improve understanding of water harvesting and water reuse options for horticultural irrigation	Promote wider uptake of technology by protected crop nurseries.
Soil and water management	Improve information on irrigation schedules for specific crop types and production systems (including monitoring and auditing)	Research to develop practical methods for quantifying water needs on complex mixed crop / production system nurseries (monitoring/auditing - benchmarking). Identify crops with good potential for 'lean regimes'. Crop quality and shelf-life impacts.
	Improve soil management to understand the links between soil heterogeneity, soil water availability and crop production	Link water reqt. with ranges of growing media. Develop and promote appropriate media water management technologies (e.g. wetters). Wider adoption of leachate monitoring for improved irrigation/fertigation management for some crops.
	Develop improved scheduling technologies	Research to develop and implement new scheduling technologies (e.g. media water and EC probes, gravimetric techniques, ET estimation, wireless communication, thermal imaging) that link growing medium water / EC status or environment with crop water stress and precision irrigation application. Also integration with, or upgrading existing, nursery equipment.

Theme	Key priorities	Key actions
Water resources and environment	Improve knowledge of impacts of new water regulation on water availability and reliability	Study to collate information relating to water regulation and impacts on horticultural industry. Each nursery needs to know technical/legislative water availability and costs from each source including roof water. Explore water abstraction / storage collaboration groups. Reduce reliance on mains water.
	Improve knowledge of the impacts of horticultural irrigation on diffuse pollution including nitrate leaching, phosphate and pesticides	Research to quantify environ. impacts of PC irrigation on nutrient leaching and runoff and options for treatment if required. Develop protocols for sampling, testing and interpretation of nursery runoff for audits.
	Improve knowledge of risks associated with low irrigation water quality on crop production	Research to improve understanding of links between irrigation water quality, microbiological contamination and RTE food risk.
	Improve knowledge on alternative water sources (grey / waste water) its impacts on water quality and suitability for production	Research leading to decision tree for water cleaning and treatment options (biological versus chemical / physical) for plant pathogens, or pH & chemical imbalance issues. Include alternative acidification technologies for hard water sources.

Soft fruit production

Soft fruit is a small sector, mainly comprising strawberries, raspberries and blackcurrants. Between 2007 and 2008, there was a small increase in the total area in England, with around 8000 hectares grown. Strawberries are the dominant crop (41% area) representing just over 3000 ha, with raspberries and blackcurrants accounting for 13% and 26%, respectively. There were decreases in raspberry (-7.7%) and other small fruit (-7.9%) areas over the same period, including gooseberries and blackberries. Wine grapes account for 11% of the total area. Soft fruit production represents a small proportion of the total irrigated area and volume of water used in horticulture nationally, but its returns (£/m^3 applied) are one of the highest. Almost all soft fruit is irrigated, with most growers using trickle irrigation and a high degree of automation for control. Mains water is used by a significant proportion of growers notably in the south east to minimise risks associated with low water quality. The sector has a number of major water challenges, including the need for appropriate schedules to maximise fruit quality, addressing concerns regarding pathogen risks from low quality water and managing soil and water to limit diffuse pollution. A summary of the key water research priorities and actions for the soft fruit sector is given in Table 17.

Table 17 Key water research priorities and actions for soft fruit production.

Theme	Key priorities	Key actions
Equipment and technology	Understand and quantify the links between poor irrigation uniformity, crop production and profitability (yield and quality)	Research using benchmarking to assess the links between SF irrigation water use, crop productivity and value
	Improve efficiency of irrigation application equipment (energy, labour and water)	Ongoing research to improve management of irrigation equipment
	Evaluate new equipment / technologies and options for switching systems	Research to compare performance of new technologies and equipment (field trials)
	Improve understanding of water harvesting and water reuse options for horticultural irrigation	Research to assess technologies available for water harvesting and re-use, and economic benefits
Soil and water management	Improve information on irrigation schedules for specific crop types and production systems (including monitoring and auditing)	Research to develop revised schedules for specific SF crops to ensure maximum yield and premium quality
	Improve soil management to understand the links between soil heterogeneity, soil water availability and crop production	Study to collate information and case studies on optimising soil management for SF irrigation
	Develop improved scheduling technologies	Research to develop new SF scheduling technologies (e.g. partial root drying PRD)

Theme	Key priorities	Key actions
Water resources and environment	Improve knowledge of impacts of new water regulation on water availability and reliability	Study to collate information relating to water regulation and impacts on SF industry
	Improve knowledge of impacts of horticultural irrigation on diffuse pollution including nitrate leaching, phosphate and pesticides	Research to quantify impacts of irrigated SF production on nitrate leaching, and best practice to minimise N losses
	Improve knowledge of risks associated with low irrigation water quality on crop production	Research to improve understanding of links between water quality, microbiological contamination and SF food risk
	Improve knowledge on alternative water sources (grey / waste water) its impacts on water quality and suitability for production	Research to improve understanding of links between irrigation water quality, microbiological contamination and RTE soft fruit food risk (notably strawberries)

Tree fruit production

This is one of the smaller HDC sector panels, covering apples, pears, plums, cherries and nuts. There has been significant rationalisation in the industry, resulting in a steady decline in cropped area. In terms of irrigation, it constitutes a very minor but nevertheless important use of water. Expansion of tree fruit production internationally provides opportunities for technology transfer on water aspects including the latest irrigation scheduling technologies to maximise quality (e.g. deficit irrigation, partial root drying) A summary of the key water research priorities and actions identified for this sector is given in Table 18.

Table 18 Key water research priorities and actions for tree fruit production.

Theme	Key priorities	Key actions
Equipment and technology	Understand and quantify the links between poor irrigation uniformity, crop production and profitability (yield and quality)	Not relevant at present
	Improve efficiency of irrigation application equipment (energy, labour and water)	Technology transfer from other crop sectors
	Evaluate new equipment / technologies and options for switching systems	Technology transfer from other crop sectors
	Improve understanding of water harvesting and water reuse options for horticultural irrigation	Technology transfer from other crop sectors
Soil and water management	Improve information on irrigation schedules for specific crop types and production systems (including monitoring and auditing)	Updated information on TF scheduling from international review of BMP to ensure maximum yield and premium quality
	Improve soil management to understand the links between soil heterogeneity, soil water availability and crop production	Not relevant
	Develop improved scheduling technologies	Updated international information on latest scheduling technologies (e.g. deficit irrigation, PRD) in tree fruit production

Theme	Key priorities	Key actions
Water resources and environment	Improve knowledge of impacts of new water regulation on water availability and reliability	Study to collate information relating to water regulation and impacts on TF industry
	Improve knowledge of the impacts of horticultural irrigation on diffuse pollution including nitrate leaching, phosphate and pesticides	Research to quantify impacts of irrigated TF production on nitrate leaching, and best practice to minimise N losses
	Improve knowledge of risks associated with low irrigation water quality on crop production	Research to improve understanding of links between irrigation water quality, microbiological contamination and TF food risks
	Improve knowledge on alternative water sources (grey / waste water) its impacts on water quality and suitability for production	Research to improve understanding of links between irrigation water quality, microbiological contamination and top fruit food risk

Key issues at industry level

At an industry level, the HDC need to ensure that all horticultural holdings maintain access to adequate, reliable water supplies, which cause minimal environmental impact, and are used more efficiently and effectively. There are steps that individual growers can take to secure water and improve water productivity on-farm (e.g. building on-farm storage, adopting scientific approaches to scheduling) and there are actions that the HDC can take to support them – these are actions that focus on looking 'downwards' towards the grower base. But in order to help the horticultural industry to secure water resources in the medium-term, the HDC needs to make the case for a fair share of the nation's water resource. To do this, it needs to raise the profile of water for horticulture outside the industry – helping to inform government, the public, regulatory agencies, and other stakeholders. These are actions that focus on looking 'upwards' and outwards beyond the horticultural industry.

Looking 'downwards' towards the grower base

Looking downwards, the HDC should focus their activities on three themes:

Theme 1 Making best use of available water – researching and promoting technologies and practices that will help to secure adequate and reliable water resources;

Theme 2 Developing a knowledge base – an agricultural water management information gateway to enable growers to continually improve their knowledge and skills, and;

Theme 3 Working together – encouraging growers to form water abstractors groups (WAGs).

Theme 1: Making best use of available water

It is vital that all irrigated holdings make best use of all the water resources made available to them. This reduces water needs, minimises the impacts of water abstraction on others, and helps retain existing licences and justify new applications. The ideal is that businesses should become "self sufficient" in their water consumption. The HDC should promote irrigation technologies and practices based on a 'hierarchy of water resource actions' (Figure 8). From this, a set of key actions are identified.

(i) Know your position

Growers need to fully understanding their current position as this is the critical starting point on the "pathway to efficiency". A useful starting point for growers is to do the "5 minute Irrigation Performance Assessment" (Appendix 2). Although subjective, it will help growers assess how well they are irrigating and identify ways to improve water efficiency.

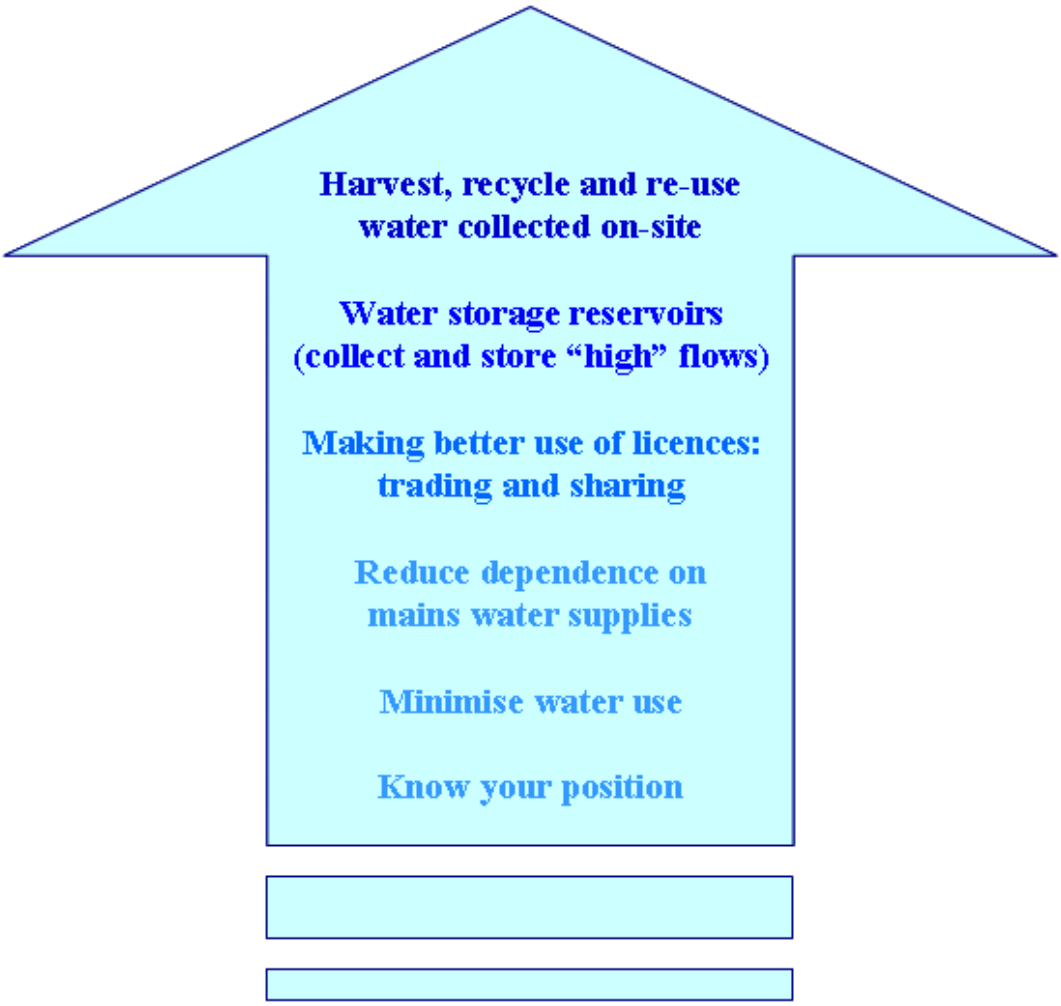
(ii) Minimise water use

Minimising the water required avoids conflict and potentially saves money. However this must be achieved without excessively impacting on crop production or quality. A vital first step is therefore to know how much water is really required (as compared to how much is currently being applied) and by how much can the efficiency be raised. This requires a good understanding of the external factors that impact on crop water demand (climatic and agronomic) and then matching water requirements to the availability of equipment and management (irrigation scheduling). Crop water use modelling can be helpful at this stage.

Irrigation water auditing will then play an important role in understanding where water is actually being used. A water audit is a short-term operational tool used to monitor and compare patterns of water use. Using water audits to assess efficiency is currently the subject of an Environment Agency consultation on renewal of time-limited licences. Water audits would have an important role to play in meeting Tests 2 and 3 in Table 10, and the data collected may also be useful for Test 1. However, the audit should be of much wider use to the business by identifying potential savings and priority actions.

Efficient use of water also requires the adoption of best irrigation practice using appropriate equipment with accurate scheduling. As technology advances, it is important for growers to keep abreast of international developments as well those taking place in the UK, whether in the horticulture sector or elsewhere.

Figure 8 Hierarchy of water resource actions for horticultural growers.



(iii) Reduce dependence on mains water supplies

Using mains water for irrigation is likely to become less acceptable unless the financial and other benefits (e.g. rural sustainability and employment) are more clearly explained to the general public and regulators. This is evidenced by a recent response to a Defra

consultation on the proposed changes to powers to restrict non-essential uses (Defra, 2007) by WaterUK, an organization which represents the water companies.

Mains water use is confined mainly to nurseries and protected cropping but is extremely important for those who rely upon it. Due to the pressures on water supply, the prioritization of users is under discussion. Changes in legislation that, for example, classifies certain kinds of irrigation as a "non-essential use" would have very serious consequences for growers. In 2006 in south-east England, irrigation of sports grounds was restricted for many months under the non-essential use category, causing severe difficulties to many commercial businesses. The horticultural industry urgently needs to raise awareness of the value of water to horticulture to water undertakers, the regulatory agencies and general public, and fight to retain it as a reasonable and justifiable use in the "essential" use category.

However, where this is not possible, a robust case will be needed to support continued use of mains water.

(iv) Making better use of licences – trading and sharing

In many catchments, it is no longer possible to obtain additional licences for direct (summer) abstraction. However, many existing licences held are unused or under-used. Subject to hydrological and environmental constraints, there are opportunities to obtain water by either trading or sharing licences. Sharing also enhances opportunities for conjunctive use of surface water, groundwater and reservoirs, thus increasing reliability.

(v) Water storage reservoirs – collecting and storing high flows

Environmental pressures are forcing all surface water abstractors to move from summer to winter abstraction (or more correctly from low to high flow abstraction). Even in water-short catchments, there are often periods when rivers are in flood. Storage tanks and reservoirs can provide growers with an opportunity to benefit from these peak flows, as well as being essential for rainwater harvesting. However, they require a major investments in fixed assets. Reservoirs come in a wide range of sizes and specifications.

(vi) Harvest, re-cycle and re-use water collected on-site

Restrictions from the mains water companies and the abstraction licence regulators can be avoided by making better use of water resources already on the farm. Harvesting water from hard surfaces, buildings and glasshouses can provide a resource as well as minimising disposal costs. Most growers will have roofed areas and hard surfaces suitable for rainwater harvesting, though water quality will depend on the surfaces used.

Re-use of "grey" water from operations such as vegetable washing can also provide a useful water source, as well as reducing disposal costs.

Theme 2: Developing a knowledge base

All growers need to stay informed and have access to the latest information to remain competitive. Beyond the research and development undertaken in the UK, there is a wealth of knowledge and experience available internationally that can avoid 're-inventing the wheel'. However, this would need tailoring to UK conditions. Experience in other countries where irrigation is important, particularly Australia, Spain, USA, and Israel, demonstrates the benefits of providing information on water management in a form that is readily accessible by growers. They use a range of media to provide practical advice. Handbooks, factsheets and videos on water efficiency enable growers to learn about innovative approaches and implement improvements to their production systems. UK growers would similarly benefit

from better information on water management, water policy and licensing, guidelines on the best use of equipment, implementing best water management practices, identifying water savings and conducting water audits.

Most growers are now familiar with internet services and so the web is an ideal vehicle to deliver this information. A web-based information gateway would provide a 'one-stop-shop' for information and advice on water issues and contribute to the skills development within the horticultural sector by supporting the delivery of professional development training. The gateway would be of major interest to other organisation involved in promoting good water management practices and so there are opportunities for collaborative work with organisations such as the Potato Council, Environment Agency, and the UKIA.

Professional development training is needed for growers to continually update their knowledge and skills through workshops, technical meetings and conferences. Some training needs may be specific to horticulture but many training needs are common across horticulture and agriculture.

Demonstration sites

Experience with LEAF (Linking Environment and Farming) Marque demonstration farms in the UK has shown that on-farm commercially operated demonstrations can be particularly effective for highlighting and transferring new knowledge and experience between farmers. A similar scheme could prove beneficial for horticultural growers. Demonstration sites would promote good land and stewardship, help to identify innovative approaches to water scarcity, and showcase new irrigation technologies and practices. They would also provide a focal point for problem solving, networking and training.

Benchmarking water use

Experience in Australia and Spain suggests that irrigation efficiency can be significantly improved by comparing how individual businesses perform with industry best practice. A web based gateway would provide an ideal opportunity to set up a web-based benchmarking scheme (Malano and Burton, 2001). Growers could, in confidence, enter basic information about water use and production on the own sites and see how their business is performing against others in the same sector. The role of benchmarking should be considered for a key crop sector panel (e.g. soft fruit) where irrigation water productivity and value is extremely high.

Theme 3: Working together

As in many countries, the 'voice' of water for agriculture and horticulture in the UK is relatively weak and fragmented and many growers are disadvantaged when negotiating water rights with the regulator and influencing future water policy towards agricultural use. So developing farmers' institutional capacity by forming Water Abstractor Groups (WAGs) to defend their existing water rights and build communication channels with the water regulator is considered essential to any future horticultural water strategy. WAGs exist worldwide, for example in Spain, Mexico, Peru, the Middle East, India, Nepal, Indonesia and the Philippines, many with a long and successful history. In most, growers have faced water scarcity and decided to work together to minimise and share that scarcity in an equitable and sustainable manner. Despite the different cultures, their operating principles have been shown to be very similar (Trawick, 2003), and recent studies suggest that WAGs in England should be no different in this regard.

The concept of promoting WAGs is also supported by the EA who view them as a mechanism for better communications with its licensed abstractors. For example, in eastern

England there are 3000 licensed irrigators – here the EA would prefer to deal with local groups of abstractors rather than 3000 individuals during times of water stress (drought). Although six WAGs already operate in England – four in East Anglia, one in Lincoln, and another in Northumberland, there has been a lack of urgency among farmers to initiate new groups, due to other more immediate commercial pressures, including regulation and uncertainties associated with EU CAP reform (Rickard *et al*., 2005). However, forming new WAGs is not straightforward, as both technical and social conditions must be right (Leathes *et al*., 2007). Dry years have highlighted the risks of water security to crop production, but similarly wet summers (2007 and 2008) have lessened the requirement to collaborate with neighbouring farmers. Another drought may well provide the catalyst for new groups but waiting for that to happen is not necessarily the most rational way forward.

A fundamental question therefore is whether there is a way of assisting growers to form new WAGs when there is no immediate crisis, and where to concentrate efforts. New groups are most likely to form where irrigation demand is high, where water resources are most constrained and where farmers are most willing to address the problem in a collective manner. The HDC could help promote the establishment of WAGs, working with other organisations to identify appropriate 'hotspot' catchments where demand for horticultural irrigation is high, where resources are constrained and where there is a willingness between growers to collaborate. The HDC could facilitate the establishment of new pilot WAGs in key areas (e.g. Kent) and benefit from the experiences of other established WAGs in Norfolk and Lincolnshire.

Looking 'upwards' beyond the horticulture industry

The importance of HDC "looking upwards" beyond the horticultural industry is growing as the competition for water resources increases. In this climate of change the HDC will need to fight its corner among the many competing water users and make a strong case for a fair share of the nation's water resource. The HDC will need to raise the profile of water for horticulture outside the industry – informing government, the public, regulatory agencies, and other stakeholders. This is a substantial task as the "voice" of water for agriculture and horticulture is barely audible above those of the water companies and environmental organisations. The public perception is of an industry that wastes water. There seems to be little public appreciation of how water underpins this high value industry, how well it is regulated, how efficiently it uses water, and how important it is to securing food production and rural livelihoods in England.

Horticultural water use is only 1% but…

Over the past decade most individuals in the UK together with those organisations that rely on water for their future sustainability, have developed a heightened awareness of the fact that water is often in short supply and that it is desirable to use it efficiently and sustainably. They are increasingly aware that the demand for water is increasing while at the same time the supplies in some parts of the country are limited and likely to reduce as the climate begins to change. The recent increases in energy costs have also helped to increase this awareness. In most cases energy is needed to pump and to treat water and so it is evident that profligate use of water not only wastes water and fuel, but also contributes to global warming.

Some argue that as agriculture uses less than 1% of available water resources it is not important. Indeed this is much less than the total amount of water lost through leakage in the domestic supply system. So what is the concern? The problem is that this is just an average figure for the whole country. Irrigation is concentrated in the drier areas of East Anglia, the Midlands and southern England and delivers the proverbial "double-whammy". Peak irrigation demand is concentrated over very short periods at times when water is least available in areas of scarcity. In Eastern England on a dry summer day, irrigation can be as

much as 40% of total abstraction. Irrigation also *consumes* water while others just *use* it and then put it back in the system for others to use again. For these reasons irrigation abstraction takes on a more important strategic dimension in some regions.

A barely audible voice on water matters

However, in the ongoing debate over the future of water resources in the UK (e.g. House of Lords, 2007) the voice of water for agriculture and horticulture is barely audible. There is a public perception of an industry that wastes water by throwing it around the countryside from rain guns, but there is little appreciation of the importance of water to grow the high quality crops that the market demands. There is little knowledge of the high value the industry places on water, its importance to the future of the rural economy, or indeed to the rural environment.

Current water legislation also reflects the level of importance attached to agriculture. It prioritises domestic and industrial supply and the environment leaving agriculture last in line. So in times of shortage, agriculture tends to take the brunt, through Section 57 restrictions – the pain is not shared proportionally. There are political reasons why this is so. But there are serious questions to be asked of the other users about the inefficiency of domestic water use (e.g. leakage, toilet flushing) and environmental restrictions that rely on the 'precautionary principle' – this means that if the amount of water needed to maintain the environment is not known then the 'environment' can take what is necessary to make sure that it is not harmed.

The main water users in the UK – domestic water users, industry, and the environment – have well established commercial (e.g. WaterUK), governmental (e.g. Natural England), and non-governmental organisations (e.g. RSPB), that look after their various water interests. They employ full-time water professionals who meet with the regulator, lobby government and the European Union, publicise the importance of water to their mission, and make sure that their interests are fully represented at every level of water policy development and decision-making. Their main aim is to make sure that their sector gets a fair share of the available water resource. This is not the case for agriculture and horticulture.

A strong institutional focus on water

Most agricultural organisations, including the HDC, are commodity or business focused rather than resource focused. This stems from their early beginnings when the need to focus on specific crops was identified and water was not so important and was considered as just another input into the production process. They were set up to support and promote various sectors of agriculture. Cereals, potatoes, sugar beet and horticulture are serviced by levy boards while organisations like the CBI, CLA, and NFU represent agri-business and land ownership interests. These organisations have served the industry well. They provide support and advice to farmers and growers about such issues as what crops to grow, how to improve and conserve soils, how to use land and water, and the energy inputs needed.

Over the past decade each organisation, including the HDC, has come to recognise the importance of water for producing the quality of produce now demanded by the UK markets. But the crop focus of the various institutions means that they tend to concentrate on water use in their particular sector – water use for vegetables, water use for potatoes etc. Each pursues its own water agenda and although the efforts to reduce water wastage and maximise the value of water are laudable, they are disconnected. They are best patchy but at worst they lead to unnecessary duplication of effort, inefficient use of limited resources, and most importantly from an industry point of view, a fragmented and potentially weak lobby for the critical resource on which they all depend. So when government is looking for a view on the importance of water for agriculture to whom does it turn? Water UK very ably takes this role for domestic and industrial users, Natural England picks up the baton for the environment, but who is there for agriculture and horticulture? There are several to choose

from and they each approach the issue under discussion from their own perspective. A good example of this was the House of Lords enquiry into water management in the UK in 2007. Comprehensive written and oral evidence was forthcoming from the Environment Agency, English Nature (now Natural England), various water companies, and Water UK. The only representations on agriculture and horticulture were written and oral evidence presented by the NFU, Defra, UK Irrigation Association, and the Broadland Agricultural Water Abstractors Group (BAWAG). Without taking anything from the efforts made by these organisations, there was no attempt to coordinate responses and there was silence from the other agricultural organisations. This is not acceptable from an industry that considers water vital to its future sustainability. So how can we improve this situation?

A "champion" for water in agriculture and horticulture

The EA EEDA study (Knox *et al*., 2007, 2007) also recognised the importance of "looking upwards" and those stakeholders consulted during the preparation of the EEDA water strategy recommended that the best way to do this was through a greater degree of collective effort rather than as individual organisations, each working in isolation. One widely held view was the need for a 'Water Champion' who would bring together various stakeholder organisations to coordinate research and development, and extension activities and provide a "one-stop-shop" for promoting the views of agriculture in the water sector. So the champion's role would concentrate on both looking 'downwards' towards the farmer and grower base and looking 'upwards' outside the industry. To provide a focus for these activities it was proposed that the champion would reside in an Agricultural Water Saving Centre. This would not necessarily mean setting up a new organisation. Rather it would exist within an existing stakeholder organisation. The concept of this centre is still valid but as yet it does not have a champion nor a "home". Although HDC is not a 'political' organisation it could play a pivotal role in establishing this centre as part of its water strategy development. The HDC alone supports growers on about 40% of the irrigated area in England, albeit in providing technical support and research – looking 'downwards'. However, there are others with similar and complementary interests who may be interested in 'getting together' over water. The Potato Council for example, represents potato growers and promotes technical issues in much the same way that HDC does for horticulture. As both HDC and PCL have recently been brought under 'one roof' – the Agricultural and Horticulture Development Board (AHDB) this presents an unique opportunity to bring together the majority of irrigation interests in the country for the benefit of all irrigators. As many of the nation's potato growers now rely on irrigation, many of the Potato Council's objectives in the water sector (both looking down and upwards) will be identical to those of HDC – a 'win-win' situation for HDC, PCL and the farmers and growers they serve.

The NFU and the CLA are much more politically active and have strong influences across and outside the industry – they look 'upwards' on behalf of their members. The UK Irrigation Association looks both ways and has a broad church membership of growers, consultants, suppliers, researchers and government agency staff.

Communication and knowledge transfer - key actions

In addition to the priority R&D actions described within the "Key Issues at Grower Level" section for each crop sector panel, this study has identified a raft of related communications and knowledge transfer (KT) actions that the HDC also need to implement as part of this water strategy. These are summarised below:

- The HDC should ensure that all growers who depend on direct irrigation abstraction are aware of the EA licensing requirements and collecting adequate data to demonstrate efficient and reasonable use of water (in support of licence renewal).

- HDC should promote awareness of water auditing as a tool for improving understanding of water use on the farm and in relation to abstraction licence renewal.

- HDC should promote actions to alert members to developments elsewhere across a range of topics including wireless sensors systems, infra-red scheduling, improved sprinklers and system control.

- Where alternatives exist, the HDC should support members to move away from dependence on public mains water irrigation. The initial emphasis should be on avoiding mains water use in water stressed zones and when the public are facing "hose-pipe" restrictions.

- The HDC should promote actions to clarify the opportunities and issues involved in trading and sharing licences.

- The HDC should help growers to cope with pressures to reduce abstractions and avoid total licence revocations by supporting them to establish the need for and value of the water for horticulture, by ensuring efficient use and by investigating alternative water sources and storage for at least some of the water requirement.

- The HDC should encourage the use of water storage reservoirs, support actions to help growers learn from others' experiences, identify legal, contractual and other issues that might not be apparent, investigate funding options, and suggest the best ways forward.

- The HDC should support research and information exchange between growers and with other organisations to identify and resolve issues related to rainwater harvesting.

- The HDC should work to ensure changes to regulations and build acceptance among growers for the re-use of grey water.

- The HDC should develop a web-based knowledge base – a horticultural water management information gateway to enable growers to continually improve their knowledge and skills. As this gateway is a requirement across the horticultural and agricultural sectors HDC should work with other stakeholders with similar water interests (Potato Council, Environment Agency, UKIA) to develop the gateway.

- The HDC should promote the 'water hierarchy' through training initiatives and identify opportunities for collaborative training with other stakeholders with similar water interests (Potato Council, Environment Agency, UKIA) to develop the gateway.

- The HDC should promote a LEAF-type approach to establishing demonstration sites in each of the horticultural sub-sectors to showcase new irrigation water technologies and practices and provide a focal point for problem solving, networking and training.

↳ The HDC should introduce benchmarking as a means of promoting improved water use efficiency across the horticultural industry. A web-based service would be most appropriate and this would complement the web-based irrigation gateway.

↳ The HDC should help promote the establishment of WAGs, working with other organisations to identify appropriate 'hotspot' catchments where demand for horticultural irrigation is high, where resources are constrained and where there is a willingness between growers to collaborate.

↳ The HDC should ensure that all horticultural holdings are (i) aware of the water resource availability status of their catchment and (ii) aware of the options for considering developing alternative water sources where future summer supplies are likely to be reduced.

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Appendix 1: Spatial distribution of growers by sector panel

Figure 9 Spatial distribution of growers involved in bulb and outdoor flower production (BOF) in England and Wales, based on HDC membership database (2008).

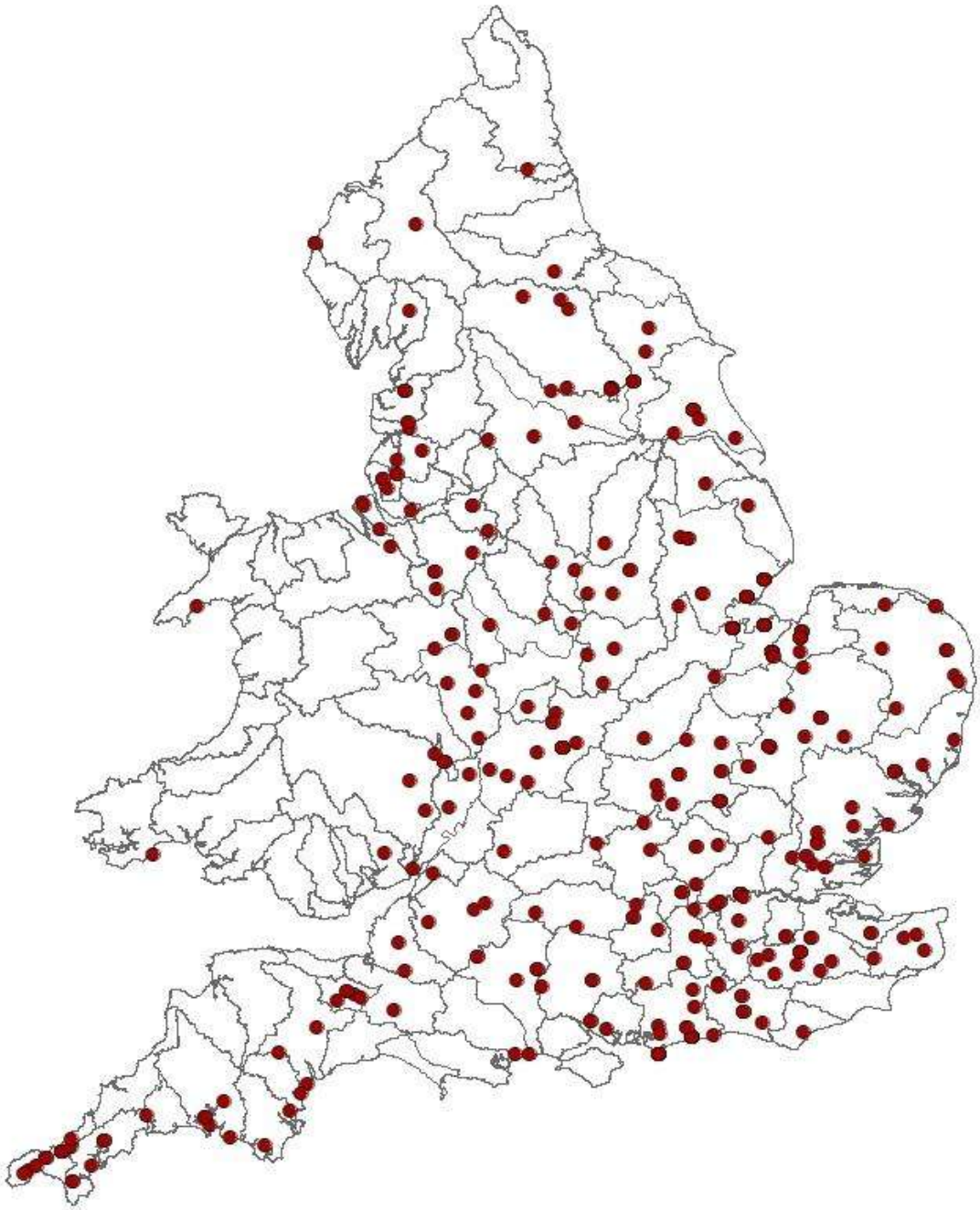


Figure 10 Spatial distribution of growers involved in field vegetable production (FV) in England and Wales, based on HDC membership database (2008).

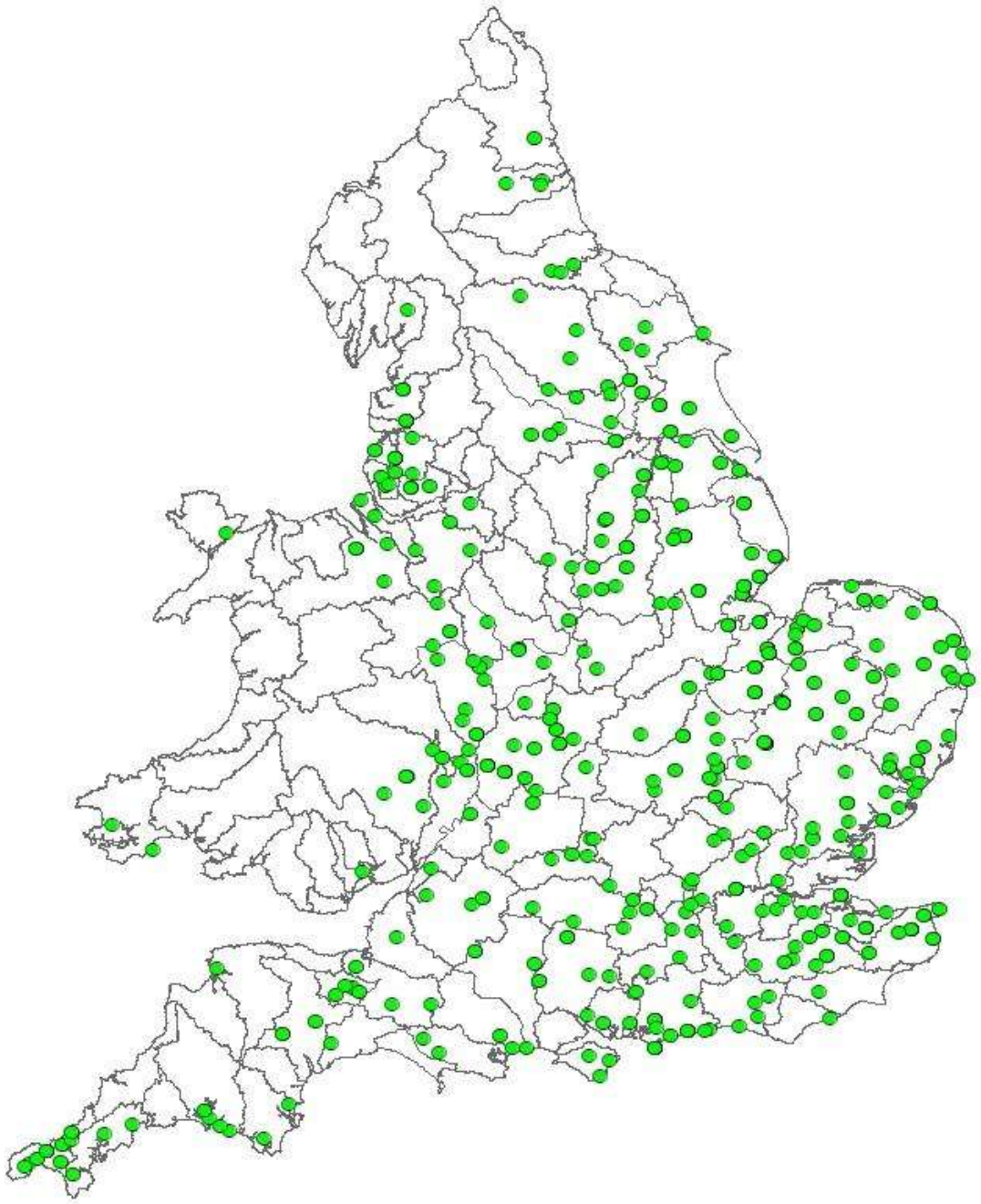


Figure 11 Spatial distribution of growers involved in hardy nursery stock production (HNS) in England and Wales, based on HDC membership database (2008).

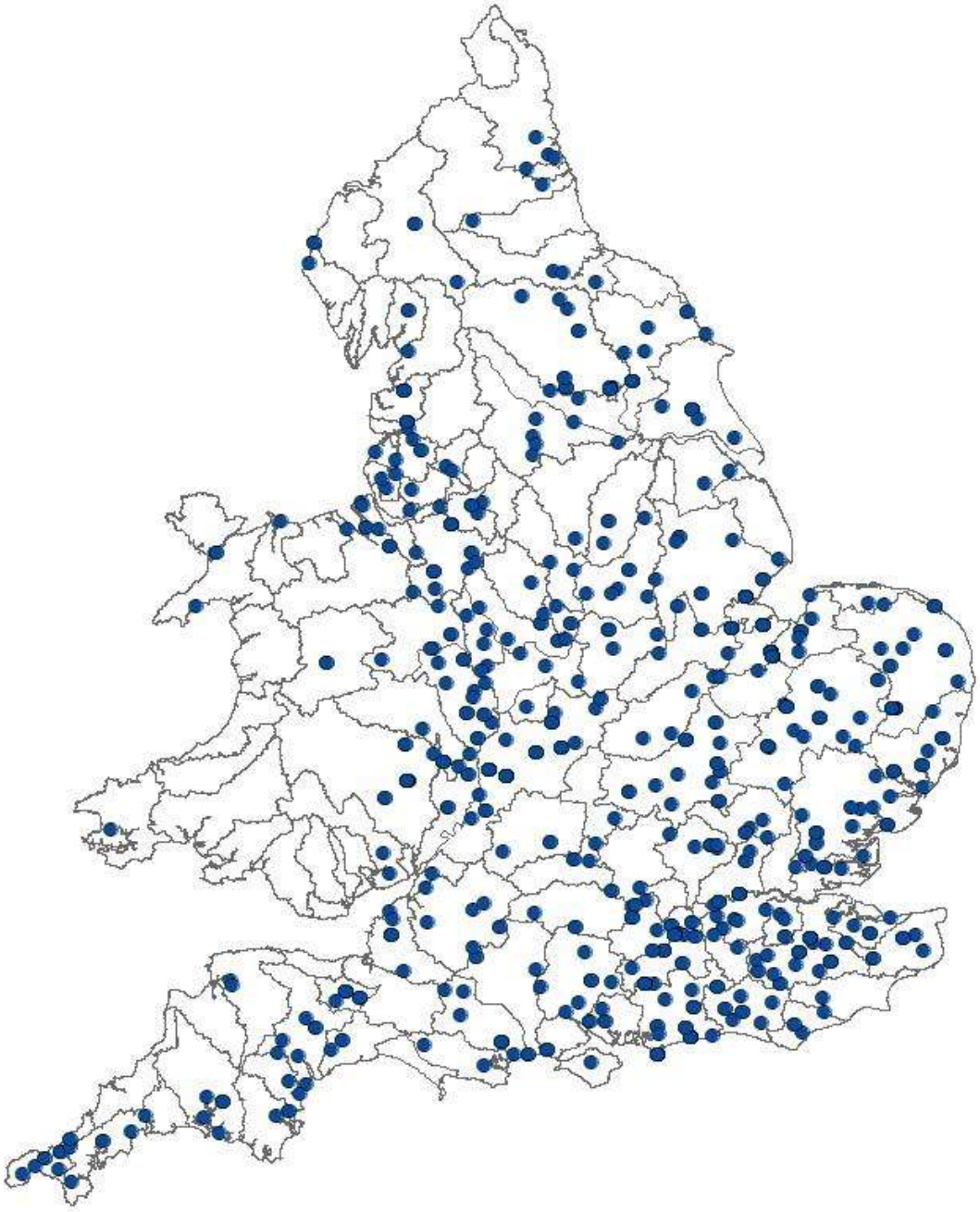


Figure 12 Spatial distribution of growers involved in mushroom production (M) in England and Wales, based on HDC membership database (2008).

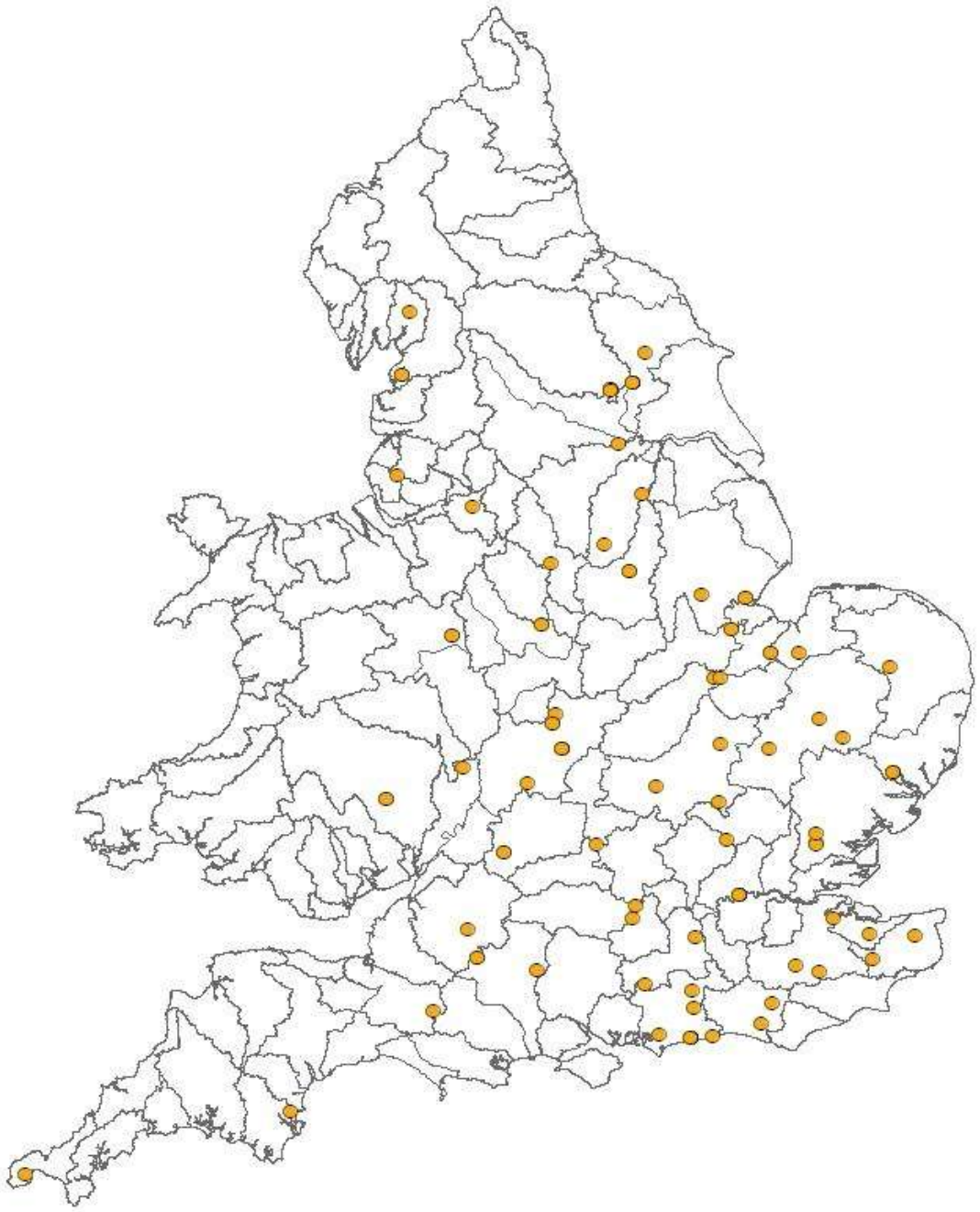


Figure 13 Spatial distribution of growers involved in protected crops production (PC) in England and Wales, based on HDC membership database (2008).

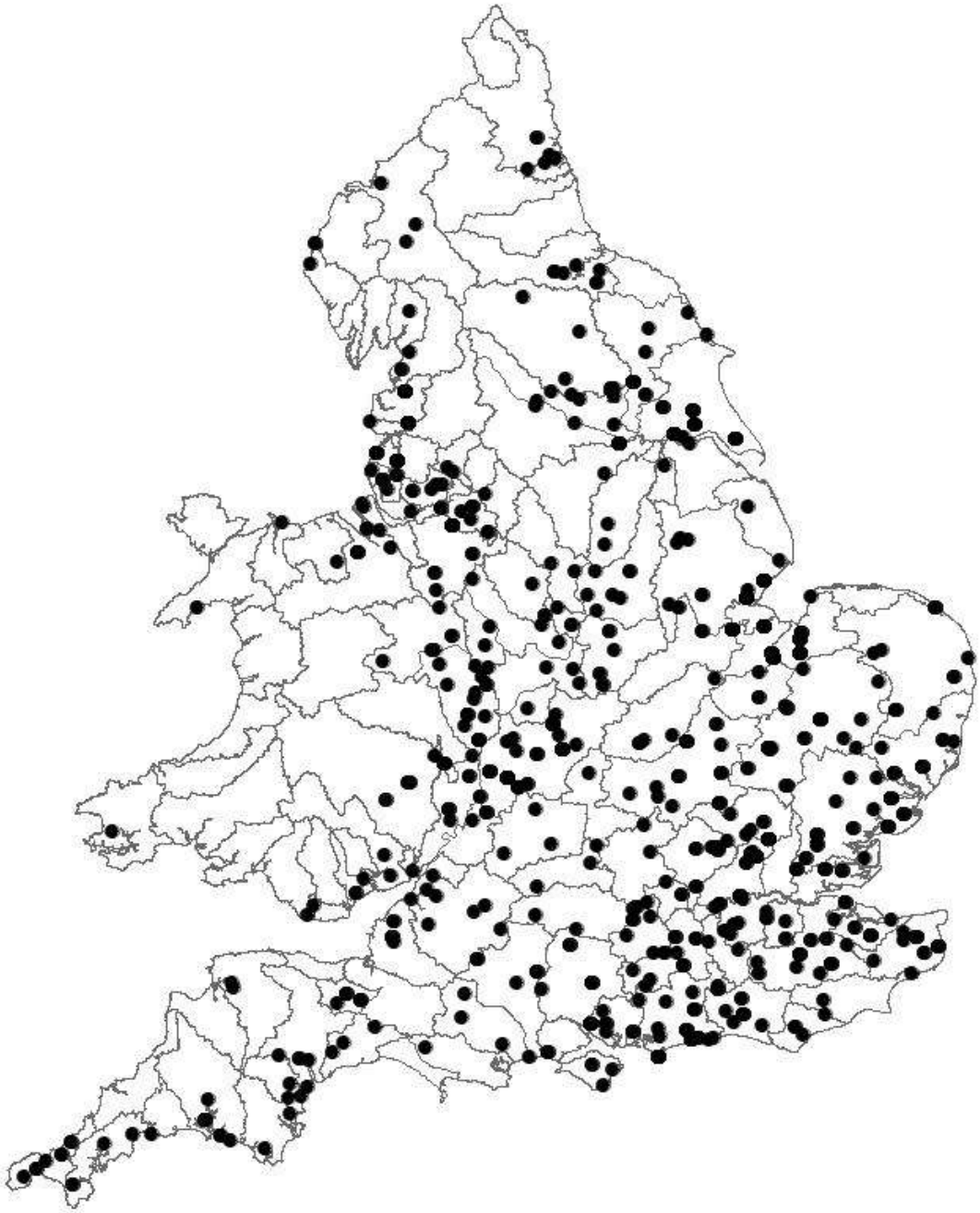


Figure 14 Spatial distribution of growers involved in soft fruit production (SF) in England and Wales, based on HDC membership database (2008).

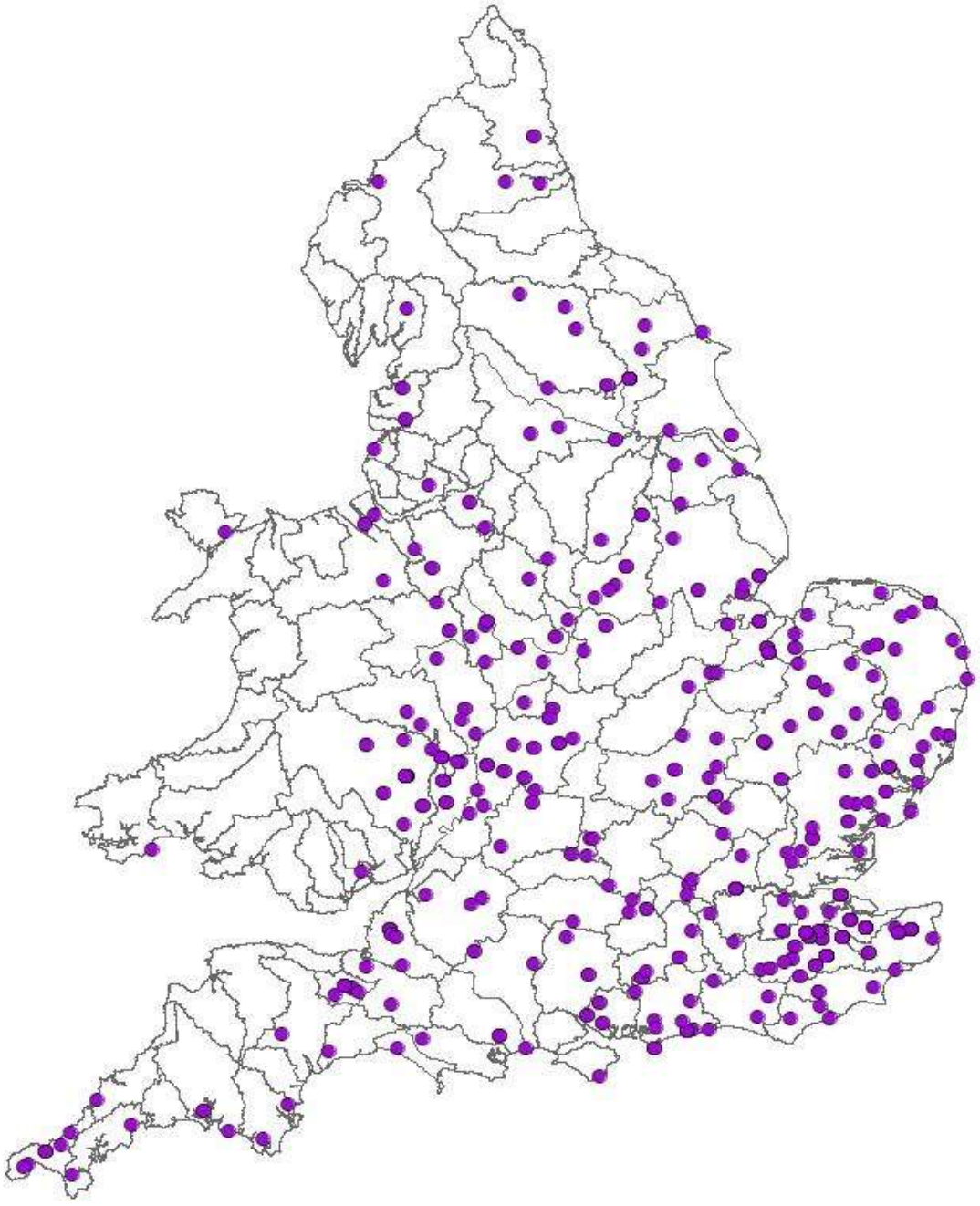
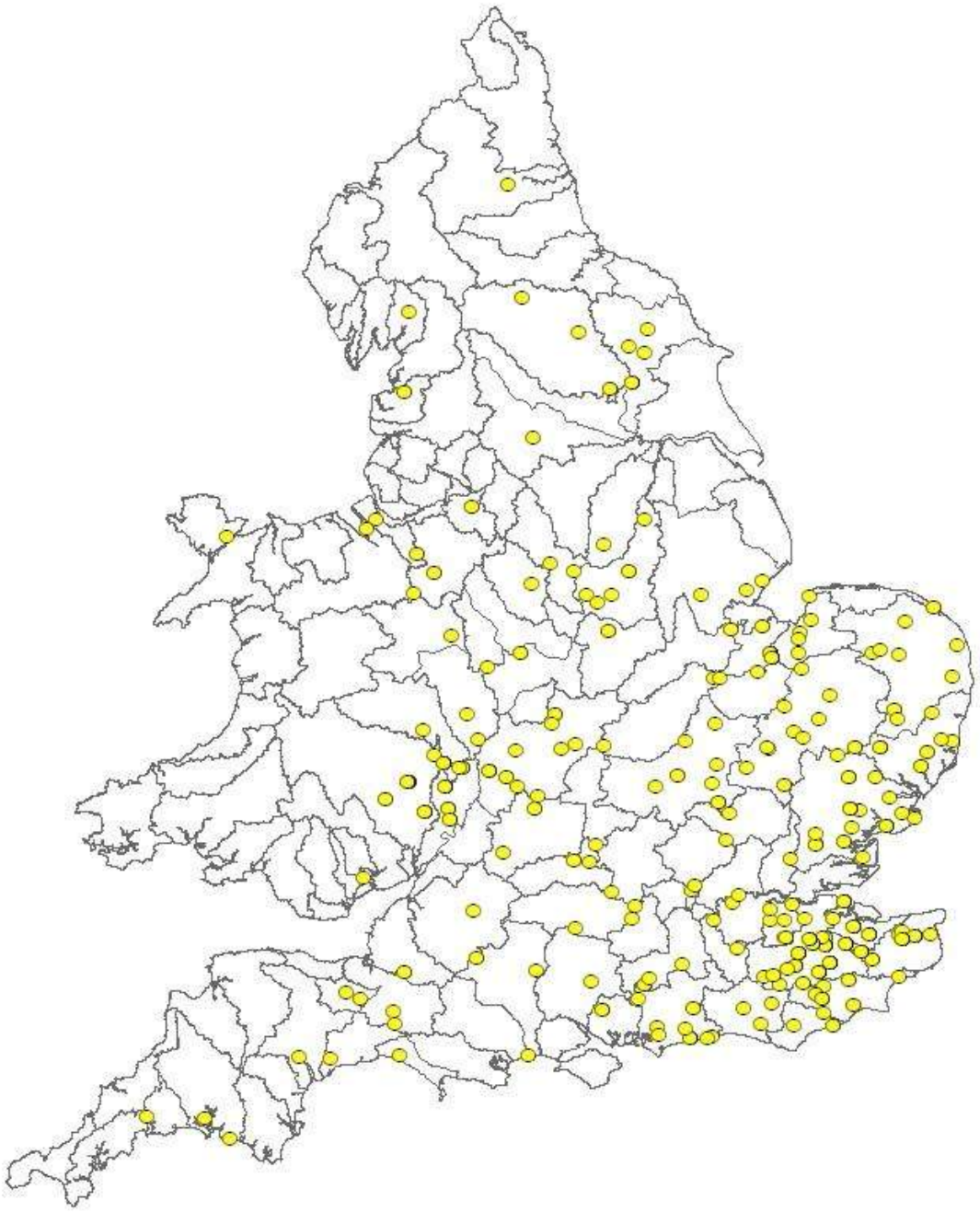


Figure 15 Spatial distribution of growers involved in tree fruit production (TF) in England and Wales, based on HDC membership database (2008).



Appendix 2: Five minute irrigation performance checklist

Cranfield UNIVERSITY
Silsoe

Improving irrigation efficiency

The 5 minute irrigation performance checklist

Irrigation is an essential component of production for many high value crops. In a dry year, getting it right pays real dividends. But how well is your irrigation system performing? Circle one answer for each question.

Q1. Do you have enough water in a season to meet your total crop irrigation demand?

1 Don't know
2 Inadequate volume
3 Adequate in an average year
4 Adequate in all years

Q2. Can you abstract enough water to meet your crop water requirements in a peak month?

1 Don't know
2 Inadequate volume
3 Adequate in average year
4 Adequate in all years

Q3. Do you have a strategy for managing periods of limited water availability/restriction?

1 No plan
2 Limited consideration
3 Some consideration
4 Detailed strategy

Q4. How efficient is your on-farm storage and distribution system?

1 Don't know
2 OK
3 Good
4 Excellent

Q5. Does your irrigation system (e.g. gun, boom) operate at its design pressure in each field?

1 Don't know
2 No
3 Yes, in most fields
4 Yes, in all fields

Q6. How uniformly does your system apply irrigation water within the field?

1 Don't know
2 Large variations
3 Some variation
4 Only minor variations

Q7. Do you know the rate of water applied (e.g. m^3/ hr) by your system?

1 Don't know
2 Based on manufacturer's information only
3 Measured some time ago
4 Measured routinely

Q8. What is the current physical condition of your pumping, storage, distribution and application system?

1 Don't know
2 Major repairs required
3 Minor repairs required
4 No repairs required

Q9. Do you measure and compare your crop returns (yield and quality) against the volume of water applied?

1 Not measured
2 At farm level only
3 Sometimes at field level
4 Routinely at field level

Q10. Do you use a scientific tool (e.g. neutron probe, water balance computer model etc) to schedule your irrigation applications?

1 No, visual inspection only
2 Scientific tool on some crops
3 Scientific tool on all crops

Q11. Do you modify your irrigation applications in response to changing weather conditions?

1 No
2 Sometimes
3 Usually
4 Always

Q12. What is the quality of the water you use for irrigation?

1 Don't know
2 Marginal
3 Satisfactory
4 Good

Q13. Do you think you would save water by becoming more efficient?

1 Don't know
2 No
3 Maybe
4 Yes, definitely

Thank you for taking part in this exercise.

Assessing your current practices will help you to identify opportunities for improving the operation and management of your irrigation system. This is the first step in improving the efficiency of your water use.