Cranfield UNIVERSITY

A water strategy for UK horticulture

Technical Report

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The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could

produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

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Executive Summary

Context

Despite operating in a humid climate, UK horticulture is increasingly dependent on supplemental irrigation. For many crops, it is an essential component of production, not only to maximise yield but also for quality assurance, helping to deliver continuous supplies of premium produce to processors and retailers. It is also critical for many non-food crops including hardy nursery stock (HNS) and for outdoor bulb and flower production. In some protected crop sectors, such as soft fruit, modern methods of production are entirely dependent on irrigation. Whilst irrigation helps alleviate drought stress during critical crop growth periods, it is also important for seedbed preparation, transplanting, nutrient (fertiliser) management and for helping provide optimal harvest conditions.

In 2009, the HDC produced its first water strategy (Knox *et al*., 2009), including a review and assessment of water priorities and research needs. Some of those priorities are still relevant today, but other issues have emerged. The HDC has since relocated and has a much closer association with levy boards in the AHDB family. The agro-economic and environmental policy landscape has changed significantly too, with new water regulations coupled with increasing scrutiny from processors and retailers adding pressure on growers to demonstrate greater awareness of water in relation to environmental sustainability.

The aim of this study was to produce an updated water strategy drawing on evidence from growers and the industry. It included identifying the latest water related R&D priorities, assessing opportunities for more strategic R&D collaboration on water between the AHDB levy boards, and reviewing other sources of funding to help underpin HDC water R&D, including dissemination and knowledge transfer.

This revised strategy provides a framework for coping with current and emerging water risks arising from regulatory, economic and environmental change and is intended to secure a fair share of water for UK horticulture. The study was undertaken between October 2013 and April 2014 by water specialists from Cranfield Water Science Institute. The key findings are summarised below.

Identifying gaps in knowledge

The initial stage involved reviewing the 2009 HDC Water Strategy and identifying gaps in knowledge. This process was based on three grower workshops held in key areas of horticultural production (Kent, Norfolk, and Worcestershire) to identify grower priorities, and then an internet based survey of HDC growers to rank the identified priorities. The workshops were used to assess the extent to which water priorities in the existing strategy were still relevant to individual grower businesses, what other gaps in knowledge had emerged, what 'excess' water (waterlogging/flooding) issues needed to be incorporated, and what 'other' factors were important in developing an industry level water strategy.

The three workshops attracted a very low turnout (11 participants from *c*70 invitees). The reason for such a low level of engagement is unclear; the previous very wet summer and winter may be contributory factors, but also pressure on grower's time with other

stakeholder workshops being run during the winter may explain reduced levels for interest. In all, 9 research priority themes were identified, spanning water resources and regulatory impacts, water harvesting/reuse and water quality issues, impacts of irrigation on diffuse pollution (nitrate and phosphate leaching), developing irrigation schedules to maximise crop quality, improving soil management and role of mulches, and quantifying the links between irrigation performance, crop production and profitability. A summary table was produced ranking the 9 priorities and showing their relative importance as viewed by the growers attending the workshop and from the larger sample of growers who provided feedback via an internet based survey. The data highlights a high degree of consensus between sectors for some priorities and discrepancy between sectors for others. It should be stressed that the survey sample size (27) is very small given the current HDC grower membership (*c*1700) and low/no participation from some sector panels could skew the results presented.

An important addition to the list included the need for a position statement on the importance of water and contribution it makes to UK horticulture. This was in support of developing an evidence base for horticulture given pending changes in abstraction licensing reform and likely pressure on growers to justify water need.

Surprisingly, despite the recent spate of very wet years, research to understand the impacts of increased climate variability on crop production and ways to manage impacts of excess water on crops including drainage, were discussed but not ranked as a high priority.

The highest ranked priority was to “improve grower awareness of potential impacts of new water regulation on business”. This is not surprising given the ongoing consultation on abstraction licensing reform which will have important impacts on access to and cost of water for irrigation abstraction.

Barriers and enablers to collaboration on water

The HDC recognise that wider industry and research collaboration will be key to sustaining a thriving horticultural industry. Funds for R&D and KT are shared across the eight HDC sector panels, but there is a real need for greater emphasis on additionality to maximise the impact and benefit of research funded from levy income. One obvious mechanism by which it can achieve this is through increased emphasis on cross-panel research (within HDC) focussing on strategic issues, such as water, as well as promoting greater cross levy board (AHDB) collaboration. In order to assess scope for collaboration, a series of semi-structured interviews (telephone and face to face) were conducted with selected key informants from the HDC, PCL and the HGCA.

In the past, a perceived uniqueness prevented water R&D and KT cross-sector work but the AHDB increasingly recognises that water is a shared resource where many problems relating to regulation, access, quality, monitoring and discharge are common across sector panels. Wherever possible, water R&D priorities within the HDC should to be addressed collectively, recognising that specific issues do arise for particular sector panels. Diversity in crop sector should not be seen as an unsurmountable barrier to collaboration. Linking the R&D priorities for improving soil management with water management would also be sensible and cost effective to help tackle soil and water challenges at the HDC sector panel level.

The main enablers to collaboration include maximising training opportunities for the HDC to benefit from recent research via the BBSRC ATP scheme. This could help increase knowledge and understanding of water for both HDC staff and levy payers on various water issues, including for example, on-farm water management, water recycling, water resources and abstraction regulation, water quality, and system evaluation. The approach adopted by PCL for utilising ATP funds for industry training should be investigated and a similar training programme proposed for selected HDC sector panels.

The recently formed BBSRC/NERC Sustainable Agriculture Research and Innovation Club (SARIC) should also provide a useful mechanism for greater AHDB levy board collaboration on water. The findings from this water strategy should inform the research agenda in the forthcoming SARIC research programme. Similarly, the TSB AgriTech could provide many opportunities and industry benefits for fostering greater cross-levy board collaboration and HDC involvement in funded research, although the challenge will be in reconciling the 'near market' demands for TSB outputs against more conventional HDC 'active research' outputs, but nevertheless the TSB should be investigated as a major opportunity for support funding and developing new collaborations.

Finally, a number of strategic water R&D areas were identified for potential cross levy board collaboration, including:

- Dealing with diffuse pollution and environmental water quality impacts arising from intensive production;
- Water and nutrient management on farm, including nitrate and phosphate and sediment loss associated with field-scale production;
- Dealing with pesticide risks to groundwater and risks associated with loss of active ingredients used by growers (e.g. granular nematacides);
- Adapting to changes in abstraction regulation and water resources availability, both for supplemental irrigation and for livestock production;
- Understanding links between improving soil and water management (including drainage) to maximise use of rainfall and deal with greater climate variability.

Opportunities for collaborative funding

Continued innovation and development within the UK horticulture industry will need to be underpinned by significant investment in ongoing research. However, to achieve this, the HDC will need to investigate opportunities to align with and benefit from other alternative funding streams to support its own internal levy funded R&D budget.

A synthesis of possible funding sources of relevance to the HDC to support its water-related R&D research was completed. For each, a brief summary of the funding body scheme/s, the funds available and how the HDC might collaborate or benefit from funding has been provided. Whilst many of these schemes may already be familiar to the HDC, it will be critical that a proactive approach is taken to integrate with consortia bidding into these schemes, and where possible to influence research proposals to help address the water R&D priorities

identified in this strategy. There is a major opportunity to benefit but proactive engagement by the HDC will be required.

1. Study aim and objectives

In 2009, the HDC produced its first water strategy for horticulture, a medium term (<5 year) assessment of water priorities and research needs to inform implementation of the HDC Corporate Plan. It reviewed the key water priorities for growers and the industry, defined the research and strategic actions and suggested timescales for implementation. Many of the priorities identified in 2009 are still relevant today, but other issues have emerged. Since 2009, the HDC has relocated and developed a closer association with the other levy boards within the AHDB and the agro-economic and environmental policy landscape has changed significantly too – for example, the Water White Paper and ongoing government review of the abstraction licensing regime will have major implications for UK horticulture in terms of water allocation, abstraction management and water cost. Environmental regulations and increasing scrutiny from processors and the retailers are also likely to add further pressure on growers to demonstrate greater responsibility in water management in relation to environmental sustainability.

The 2009 HDC Water Strategy (Knox *et al*., 2009) also focused on grower research priorities to cope with having 'too little' water, and particularly the challenges of supplemental irrigation to improve efficiency via uptake of technology and management. However, recent very wet summers have highlighted the production risks associated with having 'too much' water or indeed a combination of drought and excess water conditions in the same season. The impacts of a changing climate and managing the risks associated with greater climate uncertainty and variability also present a major challenge to the horticulture sector, so identifying appropriate adaptation options to increase resilience and business sustainability are also likely to become more relevant.

Given these environmental, policy and regulatory 'drivers of change' it is timely to review the 2009 HDC Water Strategy and assess the extent to which it is still fit for purpose. This includes assessing whether the priorities set out in 2009 have been addressed; which ones are still relevant; what new challenges have emerged; and how best the HDC could work with its industry and research partners to build knowledge and capacity to manage emerging water-related risks. Some challenges will inevitably need to be tackled by the HDC, but others will benefit from a more collaborative approach. New funding streams for agricultural and horticultural research have also emerged and new opportunities exist to leverage additional funding to support to HDC water-related R&D.

The aim of this study was therefore to provide an updated water strategy for UK horticulture. This would include identifying and ranking the water R&D priorities, assessing opportunities for closer R&D collaboration across the AHDB, and reviewing opportunities for securing additional funding from other sources to support HDC water R&D. Collectively these will provide a medium term framework for assessing the water risks and impacts arising from regulatory, economic and environmental change and help to secure a fair share of water for UK horticulture.

2. Water use in horticulture

Between April 2014 and March 2014, the HDC allocated £4.2 million to R&D and knowledge transfer (KT) across its eight sector panels. However, given increasing pressure on an increasingly constrained R&D budget, the HDC will need to place greater emphasis on additionality - improving the efficiency, outreach and impact of the research it funds from levy income. One of the obvious mechanisms by which it can achieve this will be through increased emphasis being put on cross-panel research which focuses on common core issues; this is not only the case for HDC, but also between different AHDB levy boards.

Within the HDC's strategic development framework, water is viewed as one of the key 'inputs' to crop production, although it also has bearing within other areas including soil and substrates (soil water content influences crop growth), cropping systems (need to be managed according to water resource availability) and post-harvest (water stress during growing of fresh produce can directly impact on storability and shelf life). The critical element here is that water has a wide, integrated multi-functional role in horticulture, with water quality and quantity impacting on the productivity of horticulture as well as horticulture impacting on the local water environment.

2.1 Water entry points in horticulture

Before opportunities for cross-panel collaboration can be promoted, it is first necessary to identify the different 'entry points' where water-use in horticulture is involved. These are summarised in Figure 1 highlighting where and how water can impact on horticultural crop production and the opportunities these might present for promoting greater cross-panel collaboration.

Figure 1 Understanding the water 'entry points' in UK horticulture.

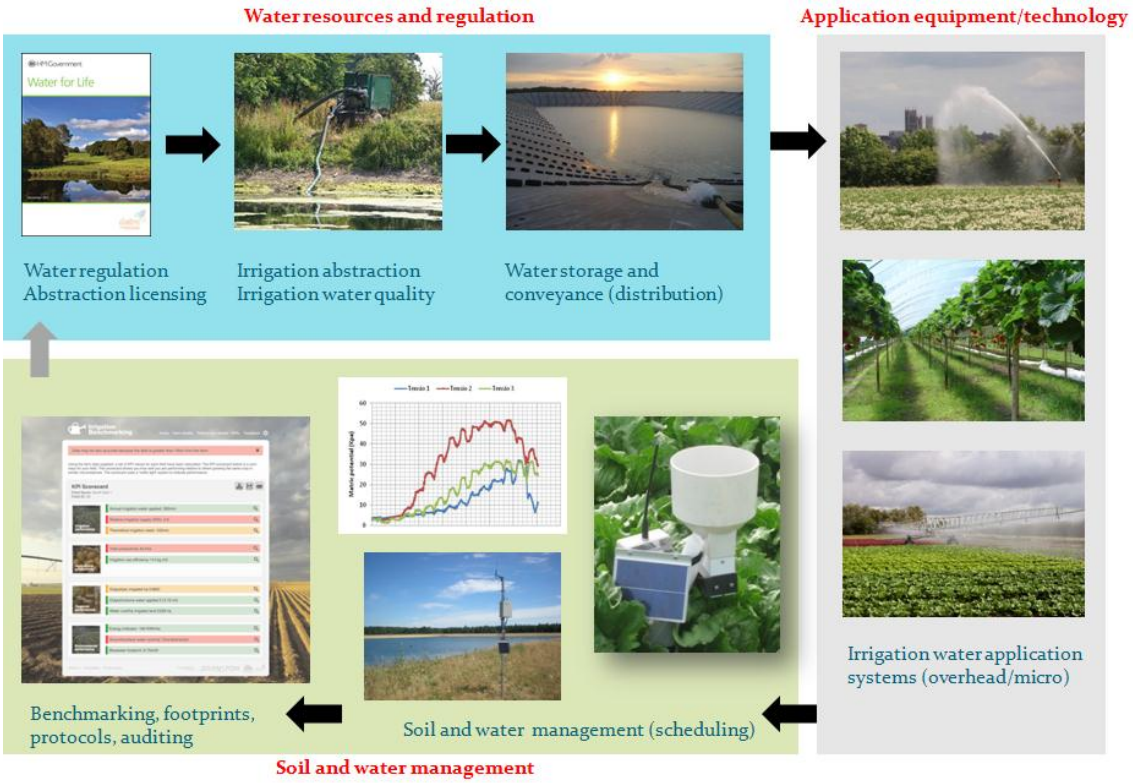


Figure 1 highlights six major areas where water use in horticulture is important and where production could be impacted unless managed carefully.

The regulatory processes responsible for abstraction licensing and water regulation are undergoing major reform (Defra, 2013) and are likely to present an ongoing medium-term risk to UK horticulture, given increasing pressure and competing demands on water resources (EA, 2008). Increased variability in both summer and winter water availability and hence reliability are impacting on growers' allowable abstraction limits with many investing in water storage to provide a more reliable source for supplemental summer irrigation. For some sectors, such as soft fruit or HNS production, a large proportion of growers rely on mains water, which itself is also subject to rising cost and can be constrained during drought periods due to its definition as 'non-essential' use. These have been grouped under '*water resources and regulation*' category.

Once access to water has been secured (either direct or via storage), horticulture relies on a range of different overhead (sprinklers, booms, centre pivots, raingun), micro (trickle) and other (e.g. sandbed) methods for irrigation water application, each suited to specific crop type(s) and production systems. Collectively, these have been grouped under the '*application equipment/technology*' category.

In-field water management then comprises of different methods for irrigation scheduling; monitoring tools and technologies to help growers demonstrate efficient use of water (for abstraction licensing renewal and/or for crop assurance protocols); and other management techniques (such as benchmarking or water foot printing) to appraise levels of water and environmental sustainability at the industry level. Collectively, these aspects have all been grouped under the '*soil and water management*' category.

2.2 Water resources for horticulture

Irrigated horticulture is known to be a significant abstractor in some catchments and concerns have been raised regarding its potential impacts on the environment, particularly in catchments where water resources are under pressure (Hess *et al*., 2010). In many catchments, summer water resources are reported to be over-committed and licences for additional summer surface and groundwater abstraction are unobtainable. Information on the spatial distribution of horticultural holdings in England and Wales is collected annually by the HDC, and can be used to map the spatial distribution of growers relative to water resource stress. In England and Wales, the Environment Agency (EA) has assessed the availability of water resources for abstraction at local level, with each catchment defined according to its resource status and allocated to one of four categories; either 'water available', 'no water available', 'over-licensed' and 'over-abstracted', in order of increasing water stress (EA, 2010). The spatial distribution of HDC holdings has been mapped and compared with water resource availability using a GIS. The spatial data and aggregated by sector panel are summarised in Figures 2 and 3.

The analysis shows that on average only 10-15% of horticultural holdings are located in catchments where additional water abstraction would be available during summer ("water available"). About half of all holdings are located in catchments defined as either having 'no (more) water available' or are already 'over- licensed'. Nearly a fifth of holdings are in catchments defined as being 'over-abstracted'.

Figure 2 Distribution of HDC holdings, by sector, by catchment in England and Wales relative to EA water resource availability (2009).

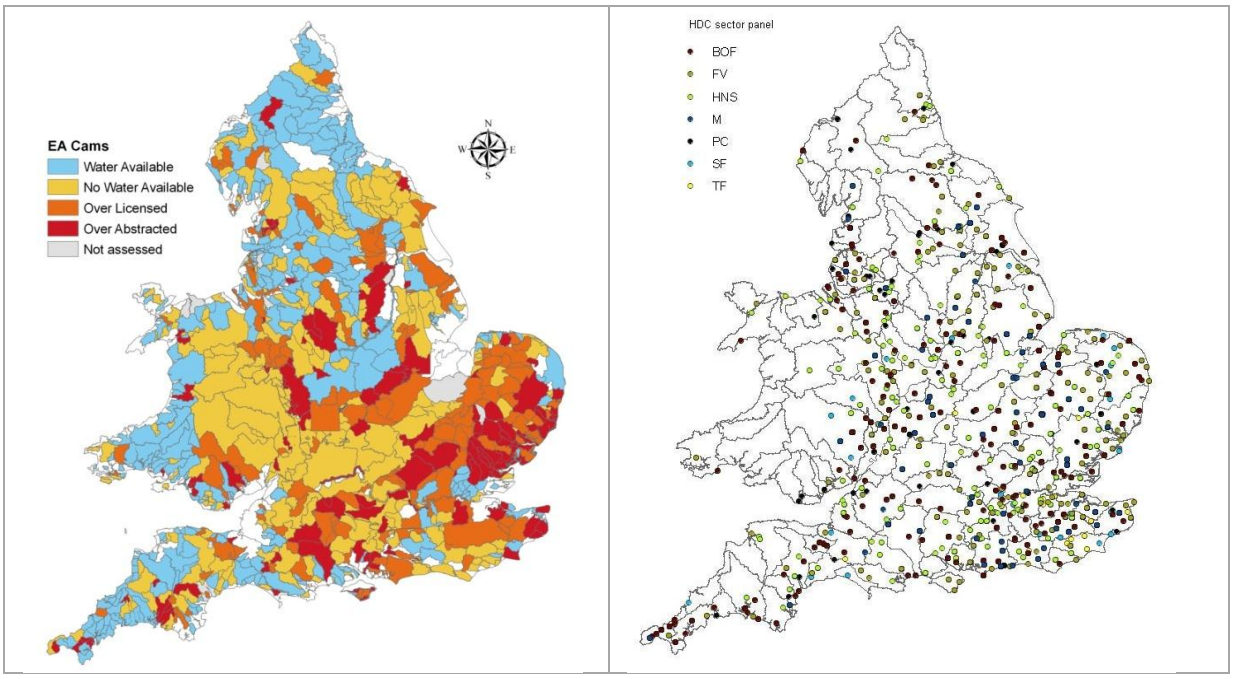
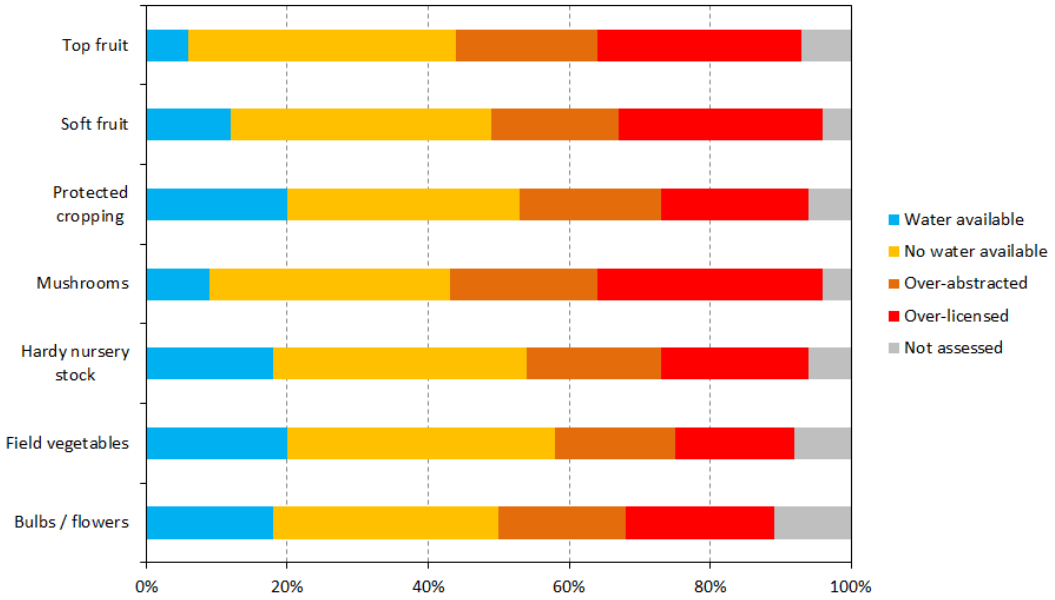


Figure 3 Proportion (%) of HDC holdings in each EA water resource assessment category.



The analysis shows that on average a third (35%) of all HDC holdings are within catchments defined as having 'no water available' and a fifth (19%) are in 'over-abstracted' catchments. Many HDC growers are also located within 'irrigation hotspots' - areas defined as having a high proportion of irrigation abstraction within water stressed catchments (Knox *et al*., 2014). For comparison, a similar analysis using PCL (2010) data showed that half (50%) of potato fields in 2010 were located in either over abstracted and /or over-licensed catchments.

3. Identifying gaps in knowledge

This chapter focusses on reviewing and assessing the 2009 HDC Water Strategy and identifying gaps in knowledge. The 2009 HDC Water Strategy provides a good starting point for evaluating current water-related risks. Its technical content and priorities were critically reviewed through structured discussions with HDC staff and key informants in each HDC crop sector panel. Any gaps in knowledge were identified and the scope was broadened to include risks relating to water excess (flooding).

The research prioritisation process had two stages;

1. Face-to-face workshops to identify key grower priorities, and;
2. An internet based survey of HDC growers to rank the identified priorities.

3.1 Grower workshops

Three workshops were organised to engage with the HDC grower membership to elicit their sentiment and opinion on:

1. The extent to which the water priorities and key actions in the 2009 HDC Water Strategy are still current and relevant to their businesses;

2. What other gaps in knowledge or water priorities might have emerged recently;
3. What excess water issues (waterlogging/flooding) also need to be incorporated, and;
4. What other factors are important in developing a sector level/industry water strategy.

Originally, it was planned to run two workshops on the same day, repeated at three locations, in order to provide wide coverage of sectors and regions; one focussing mainly on *outdoor/large scale* horticultural production - broadly encompassing field vegetables (FV), bulbs and outdoor flowers (BOF) and tree fruit (TF) grower panels - and another on *small scale, intensive*, covered horticultural production - encompassing the hardy nursery stock (HNS), mushroom (M), soft fruit (SF), and protected edibles (PE)/ornamentals (PO) grower panels. Sixty-eight HDC grower members and consultants were identified and HDC coordinated invitations to the workshops. In the event, response was poor and so a single workshop was organised at each location (Table 1).

The HDC growers and advisors that attended represented the field vegetables, protected edibles, HNS, protected ornamentals, tree fruit and soft fruit sectors. No growers from the bulbs and outdoor flowers or mushrooms HDC panel sectors were present.

Table 1 Details of grower water workshops.

Date	Location	No. Invitees	No. Attendees
14th Jan 2014	East Malling, Kent	25	3
20th Jan 2014	PGRO, Peterborough	25	3
30th Jan 2014	Droitwich, Worcs	18	5
-	**-**	**68**	**11**

Participants were sent a briefing-pack in advance of the workshop, containing the meeting programme, a summary of the key priorities/actions for that sector based on the 2009 HDC Water Strategy, and a set of questions that were to be asked by the meeting facilitator. Each workshop commenced with a brief overview presentation of the key areas of water management that defined the scope of the workshops. Open discussions were held to address the following topics:

1. To identify water shortage risks and priorities (relating to irrigated horticultural production);
    a. Water resources / regulation;
    b. Irrigation application technology, and
    c. Soil and water management
2. To identify water-excess risks and priorities (relating to waterlogging/flooding), and;
3. To identify 'other' water issues that the HDC should address with other levy boards or organisations.

The collated list of issues identified by the workshop participants is given in Appendix I. These were then grouped by the workshop participants into priority research areas. As a

result, 9 research priority themes were identified. Some of these were consistent with the priorities identified in the previous HDC water strategy (Knox *et al*., 2009), although new priorities were also identified:

1. To improve grower awareness of potential impacts of new water regulation on business.
2. To improve grower understanding of water harvesting/reuse options for horticultural irrigation.
3. To improve knowledge of alternative water sources and impacts of water quality on production.
4. To improve knowledge of impacts of irrigation on diffuse pollution (nitrate leaching, phosphate, etc.).
5. To improve knowledge of risks associated with low quality irrigation and options to minimize risk.
6. To prepare a position statement on importance of water and contribution it makes to horticulture.
7. To quantify links between poor irrigation performance, crop production and profitability.
8. To develop understanding of how soil management and mulches can make more effective use of rainfall.
9. To update guidance on irrigation scheduling technologies to maximize yield and quality.

Issues relating to excess water (localised flooding or waterlogging) were discussed, but not deemed to be an R&D priority that individual growers or the HDC could easily define. A better approach would be to actively engage with government (Defra) research on the topic to provide case studies or evidence of agronomic and economic impact.

3.2 Online survey of HDC grower opinion

Although the workshops had identified the key research issues, the low number of participants (11) meant that some of these priorities may have been specific to particular growers, locations or sectors. In order to test the wider relevance of these priorities, an online survey link (using Survey Monkey) was set up and disseminated via HDC communication channels to all HDC levy payers, asking them to prioritise the research issues and to identify any key issues that they felt had not been covered.

3.2.1 Response

In all, 25 people responded. These were predominantly from the field vegetable and hardy nursery stock sectors (Table 2). Only two respondents were from the protected edibles sector. Due to the low numbers from some sectors, those from Mushroom and Protected Edibles were combined, as were soft fruit and tree fruit, for subsequent analysis.

Table 2 Please select the main HDC sector your business is associated with.

Main HDC sector	Response count
Field Vegetables	7
Hardy Nursery Stock	7

Soft Fruit	4
Tree Fruit	3
Protected Edibles	2
Mushrooms	1
Bulbs & Outdoor Flowers	0
Protected Ornamentals	0
No response	1
Total	**25**

3.2.2 Priorities

The grower workshops identified nine R&D priorities. For each, respondents were asked to rate the relative importance (in terms of 'low', 'medium' or 'high' priority) and to identify if they felt the priority should be tackled by the HDC or addressed by the levy board (AHDB) as a more strategic issue (Table 3).

Table 3 Ranked priorities across all respondents.

R&D priorities	Low	Med	High	Priority for…
1. Improve grower awareness of potential impacts of new water regulation on business	2	2	18	AHDB
2. Update guidance on irrigation scheduling technologies to maximize yield and quality	2	9	14	HDC
3. Quantify links between poor irrigation performance, crop production and profitability	3	9	13	HDC
4. Position statement on importance of water and contribution it makes to horticulture	3	8	13	AHDB
5. Improve knowledge of alternative water sources and impacts of water quality on production	5	7	13	AHDB
6. Improve knowledge of risks associated with low quality irrigation and options to minimize risk	4	13	8	HDC
7. Improve grower understanding of water harvesting/reuse options for horticultural irrigation	2	17	6	HDC
8. Improve knowledge of impacts of irrigation on diffuse pollution (nitrate leaching, phosphate, etc.)	2	19	4	
9. Understand how soil management and mulches can make more effective use of rainfall	6	11	8	HDC

For those priorities in **bold** in Table 3 there was a high degree of consensus between sectors. For those in *italics*, there was a high discrepancy between sectors.

Table 4 Ranking of priorities by sector from High (red) to Medium (green).

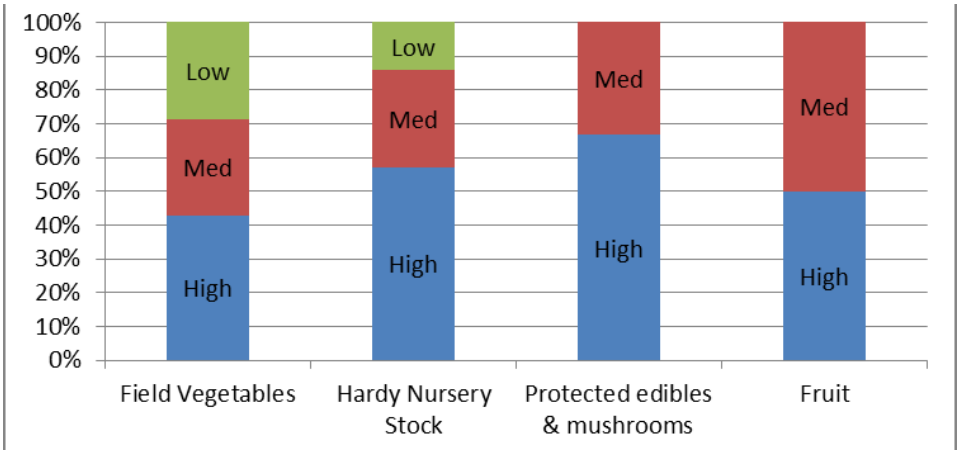
Issue	FV (7)	HNS (7)	PE & M (3)	SF and TF (7)	Total (25)
1. Improve grower awareness of potential impacts of new water	2.9	2.9	2.3	2.3	**High**

regulation on business					**2.6**
2. Update guidance on irrigation scheduling technologies to maximize yield and quality	2.4	2.6	2.3	2.4	**↓2.5**
3. Quantify links between poor irrigation performance, crop production and profitability	2.4	2.3	2.3	2.6	**↓2.4**
4. Position statement on importance of water and contribution it makes to horticulture	2.1	2.4	2.7	2.3	**↓2.3**
5. Improve knowledge of alternative water sources and impacts of water quality on production	2.6	1.9	2.3	2.4	**↓2.3**
6. Improve knowledge of risks associated with low quality irrigation and options minimize risk	2.6	2.3	1.7	1.9	**↓2.2**
7. Improve grower understanding of water harvesting/reuse options for horticultural irrigation	2.1	2.0	2.3	2.1	**↓2.1**
8. Improve knowledge of impacts of irrigation on diffuse pollution (nitrate leaching, phosphate etc)	2.3	2.1	2.0	1.9	**↓2.1**
9. Understand how soil management and mulches can make more effective use of rainfall	2.4	1.7	2.0	2.0	**Med 2.0**

3.2.3 Highest priority

The overall highest ranking priority was to “Improve grower awareness of potential impacts of new water regulation on business”, which was generally felt to be an AHDB (92%) issue rather than HDC (8%). This was the highest ranked priority for those in the Field Vegetables (FV) and Hardy Nursery Stock (HNS) sectors. There was no obvious difference between individual sectors (Figure 4).

Figure 4 Improve grower awareness of potential impacts of new water regulation on business.



3.2.4 High priority for all sectors

Three further research issues were identified as high priority for all sectors:

- Update guidance on irrigation scheduling technologies to maximize yield and quality;
- Quantify links between poor irrigation performance, crop production and profitability;
- Position statement on importance of water and contribution it makes to horticulture.

There was a high degree of consensus among sectors on "Update guidance on irrigation scheduling technologies to maximize yield and quality" and "Quantify links between poor irrigation performance, crop production and profitability". These were identified as issues for the HDC. There was moderate consensus on "Position statement on importance of water and contribution it makes to horticulture" which was identified as an AHDB issue.

Figure 5 Update guidance on irrigation scheduling technologies to maximize yield and quality.

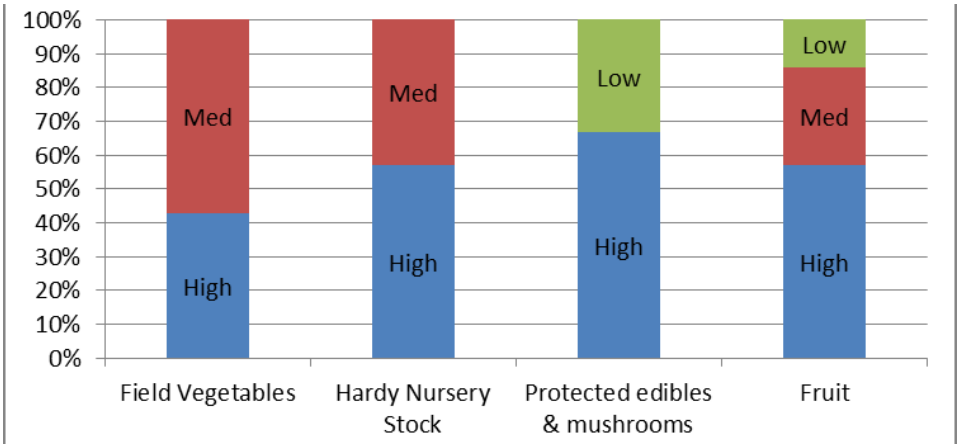


Figure 6 Quantify links between poor irrigation performance, crop production and profitability.

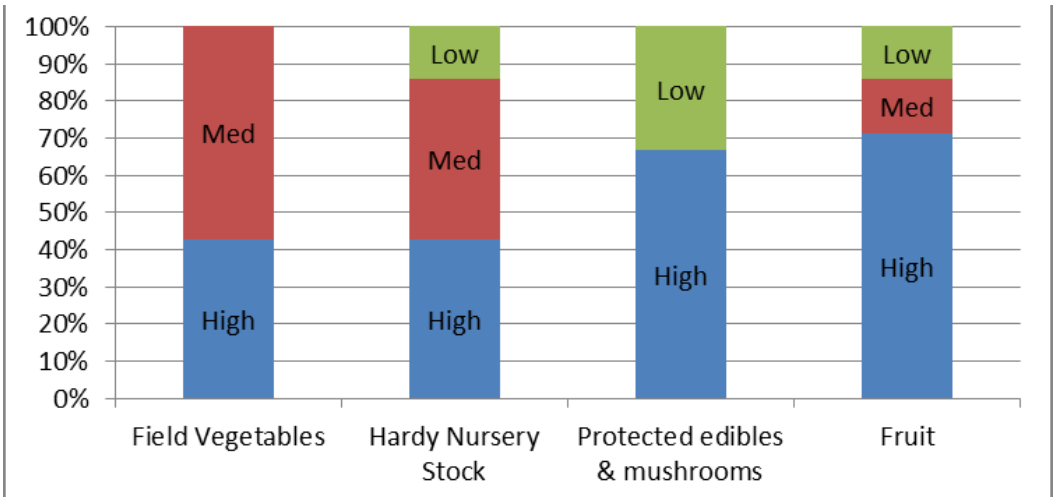
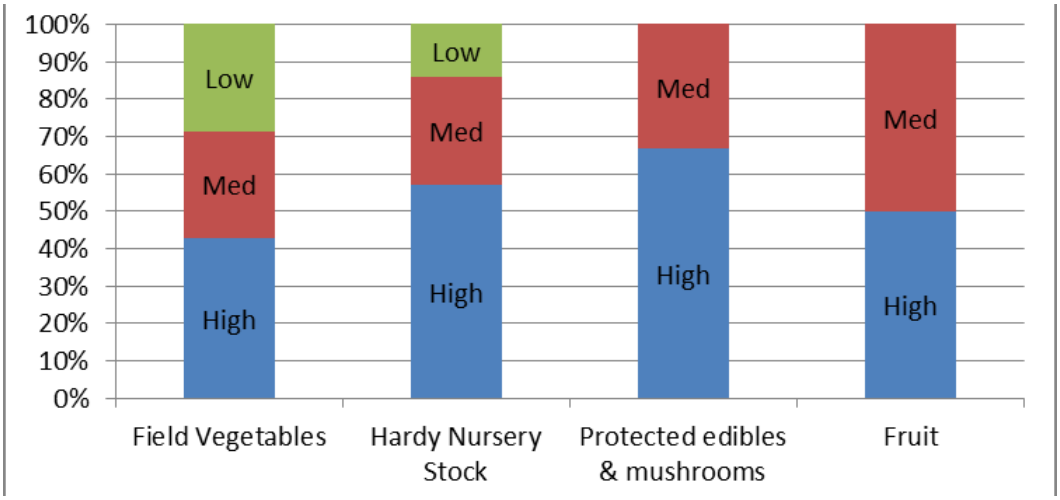


Figure 7 Position statement on importance of water and contribution it makes to horticulture.

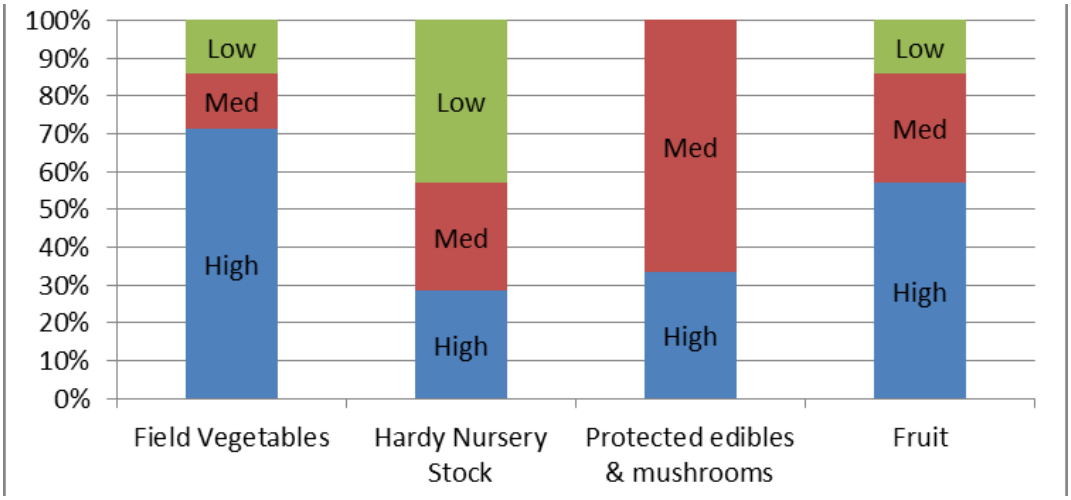


3.2.5 High priority for outdoor edible crops

There was a discrepancy in the response to "Improve knowledge of alternative water sources and impacts of water quality on production" and "Improve knowledge of risks associated with low quality irrigation and options to minimize risk" among sectors.

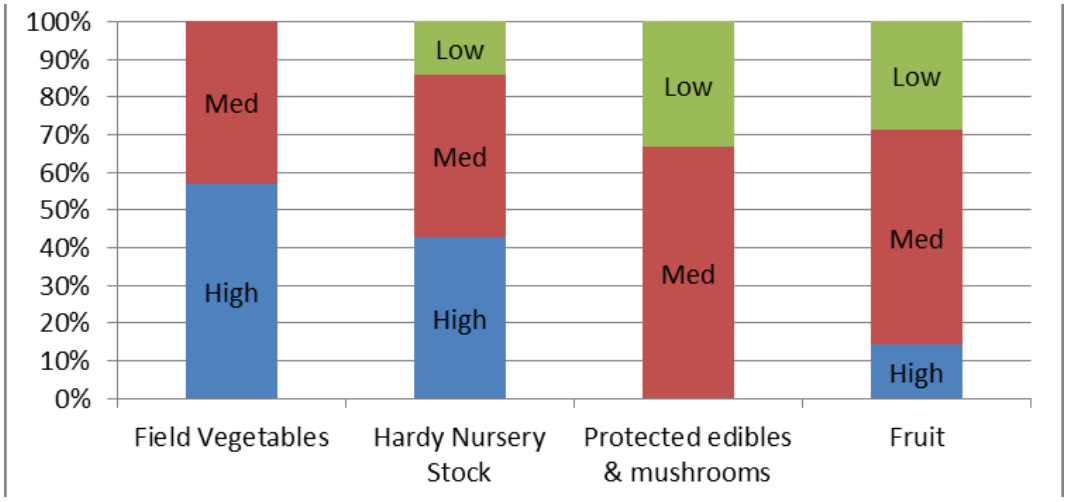
No surprisingly, "Improve knowledge of alternative water sources and impacts of water quality on production" was a higher priority for the Field Vegetable and Fruit sectors and was identified as an issue for AHDB. This was not a high priority for non-edible crops and protected cropping, possibly because of their greater dependence on public mains water (potable) supplies used for production.

Figure 8 Improve knowledge of alternative water sources and impacts of water quality on production.



"Improve knowledge of risks associated with low quality irrigation and options to minimize risk" was a lower priority for protected edibles, mushrooms and fruit sectors.

Figure 9 Improve knowledge of the risks associated with low quality irrigation and options to minimize risk.



3.2.6 High priority for protected cropping

"Improve grower understanding of water harvesting/reuse options for horticultural irrigation" was a higher priority for protected cropping, but a medium priority for the other sectors.

3.2.7 Medium priority

The remaining issues were seen as a medium priority.

- "Improve knowledge of risks associated with low quality irrigation and options to minimize risk" was a medium priority for all sectors;

- "Understand how soil management and mulches can make more effective use of rainfall" was a medium priority for all sectors;
- "Improve knowledge of impacts of irrigation on diffuse pollution (nitrate leaching, phosphate, etc.)" was a medium priority but higher for the Field Vegetables sector than the others.

3.2.8 Other issues

It is possible that Priorities 1 and 2 (Improve grower awareness of potential impacts of new water regulation on business, (ii) update guidance on irrigation scheduling technologies to maximize yield and quality) could be addressed through KT activities within the AHDB, via the newly formed soils and water group. Workshops or technical meetings involving key stakeholders (NFU, UKIA, EA) could be used to help disseminate information on the proposed water regulatory impacts on horticulture. Systematic reviews of the international literature could be used to develop baseline evidence on emerging and novel irrigation scheduling technologies.

The Potato Council 'Have Your Say' Survey (2011) identified 'water use' as the 4th most important priority of relevance to potato farming business. When asked about the main challenges for their business in the next 5 years (unprompted), a fifth (20%) identified water, including issues regarding water availability/supply, water management, variability in rainfall, Water Framework Directive/legislation, moisture probes, and pesticides in water.

4. Opportunities for R&D collaboration

The 2009 HDC Water Strategy provided no insight on the potential for wider collaboration between the HDC and other organisations on water issues including, for example, establishing closer strategic water links with the AHDB (Potato Council and HGCA) or even more broadly across the UK agrifood sector (POs, UK Irrigation Association, NFU). Given the restructuring of the AHDB and raft of recent government and industry initiatives to encourage and financially support innovation and economic development across the food and farming sector, it is sensible to:

(i) Identify any existing barriers and enablers that would foster greater collaboration between HDC grower panels on water issues, and between different levy boards (e.g. PCL, HGCA);

(ii) Identify funding organizations from which HDC could leverage additional financial support or develop closer links to support its R&D water related research, and;

(iii) Match the water R&D priorities identified in Section 3 against these funding sources.

The HDC allocate their R&D funds from levy payer income across eight crop sector panels. However, given rising pressure on an increasingly constrained R&D budget, the HDC need to place much greater emphasis on additionality, improving efficiency, outreach and impact of the research it funds from its levy income. One obvious mechanism by which it can achieve this will be through increased emphasis on cross-panel research focussing on common core issues, such as water, which is integral to production in most of the HDC crop panels. Given

pressure on resources, there will inevitably also be a need to promote much greater collaboration across the different AHDB levy boards.

In order to assess scope for promoting collaboration between different HDC panels and between the different levy boards, semi-structured interviews (telephone and face-to-face) were conducted with selected key informants from the HDC, PCL and HGCA. The interviews focussed on identifying current activities where collaboration on water issues was already evident, where barriers might exist, and what enablers were needed to foster stronger levy board integration on water in future. The key findings are summarised below.

4.1 Barriers and enablers for collaboration on water between HDC sector panels

- *Whilst a mechanism to conduct HDC cross-panel research exists, there is only a limited number of examples where collaborative research on 'inputs' such as water has been or is currently being undertaken*. These include CP 108 AHDB Farm scale resource use efficiency calculator (2013 to 2015), CP 054 Rhizobacteria to reduce water use and enhance crop quality (2007 to 2010) and HNS/PO 188 Baiting and diagnosis techniques for monitoring *Phytophthora* spp and *Pythium* spp in irrigation water on ornamental nurseries (2012 to 2014). These types of projects where multiple panels are engaged should be encouraged and the benefits of cross panel collaboration widely promoted.

  Many of the R&D priorities identified in Section 3.2 were ranked at a similar level by different sector panels offering HDC a good opportunity to develop further collaborative water-related projects. Some topics (e.g. understanding new water regulation impacts on crop production) are of common and important relevance across all sector panels, whilst other topics (e.g. developing irrigation schedules to maximise yield and quality) are a higher priority for particular crops/sectors.

- *The 'uniqueness' of particular sector panel should not be viewed as a barrier to collaboration on water issues, even if the nature of water use and its management by that panel is considered specialised.* Useful generic advice can be formulated at the levy board/industry level, and then tailored to specific sector panel needs. This would avoid duplication of effort and cost at the individual HDC sector panel level. For example, the provision of good quality, safe water for production is relevant to most HDC sectors, but more stringent standards for microbiological quality or pathogen levels are required for ready to eat (RTE) salad crops; in contrast, most field vegetables are processed prior to consumption so the acceptable water quality standard would lower for that sector.

- *In the past, a major barrier was the numerous and diverse sector panels that exist within the HDC*. This differentiation is of course essential for identifying and coordinating crop specific research and KT activities, but multiple panels each with individual budgets also restricts the ability of the HDC to deal with major cross-cutting strategic issues, particularly if one or more sectors did not recognise it as being of 'high importance'. Funds are now taken from all panels to support cross cutting strategic work to address this previous barrier.

- *Each year a proportion of the HDC R&D budget is allocated to knowledge transfer (KT), research dissemination and training*. Training opportunities for the HDC via the ATP

scheme could be increased and targeted to HDC staff and its levy payers to support knowledge transfer and build capacity linked to selected water R&D priorities. For example, a course on water management in horticulture could help address key areas such as improving on-farm water management, understanding water resources regulation and its impacts and crop production, water quality, or irrigation system performance. The HDC could adopt a similar approach to that developed by the PCL by offering a programme of ATP training short courses for key crop sectors (e.g. field vegetables, soft fruit, HNS). Refer to Section 4.2 for further details on the ATP scheme.

- *A recent study to develop an HDC soil strategy (Rickson et al., 2013) identified the importance of understanding the links between soil and water management*. Identifying R&D priorities for improving soil management and combining these with R&D water priorities (where relevant) would make sense and would be a very cost effective way to tackle the soil and water challenges facing many of the HDC sector panels.

4.2 Barriers and enablers for AHDB cross levy board collaboration on water

- *In recent years (since relocation to Stoneleigh) there has been a greater willingness and appetite for cross levy board collaboration, particularly for issues of strategic importance to both arable and horticultural production*. Improving soil and water management, dealing with environmental regulation and minimising the environmental impacts arising from sustainable intensification of agriculture all seem obvious choices as key strategic areas where AHDB cross-levy board collaboration make business and R&D funding sense. But there are other areas too where collaboration should be encouraged. The challenge is finding a practical mechanism – a willingness to collaborate is insufficient; there needs to be a framework which will bring the AHDB organisations closer together on strategic R&D issues including water.
- *The BBSRC/NERC Sustainable Agriculture Research and Innovation Club (SARIC) could a useful mechanism through which AHDB crop levy board collaboration should be fostered*. Working in partnership, the BBSRC, NERC and industry partners are exploring opportunities for a collaborative research and knowledge translation activity to address key challenges surrounding sustainable agriculture. This industry-led initiative will be structured around three interlinked themes (i) driving predictive capability and modelling for food production, (ii) developing resilient food production systems, and (iii) management and best practice to protect the environment while maintaining a profitable agricultural system. Given Research Council involvement, the importance of water for crop production (resource use efficiency), and the impacts of horticulture on the water environment, including impacts of water quality and quantity should all be viewed as high priority R&D areas. This water strategy could inform the SARIC research programme.
- *The TSB Agri-Tech call could also provide useful opportunities and industry benefits from AHDB cross-levy board collaboration.* However, the challenge will be in reconciling the near market demands for TSB outputs against the types of research typically requested by HDC sector panels. Current types of output are more 'active research' rather than

'near market' research, but nevertheless the TSB should be viewed as a major opportunity.

- *A number of strategic R&D areas have been identified for AHDB cross levy board collaboration, including*:
    - Dealing with diffuse pollution and environmental water quality impacts arising from intensive production;
    - Nutrient management on farm, including nitrate and phosphate and sediment loss associated with field-scale production;
    - Dealing with the consequences of pesticides in groundwater and the risks associated with the loss of active ingredients used by growers due to pesticide mobility (e.g. granular nematacides);
    - Adapting to changing water resources availability and abstraction regulation, both for supplemental irrigation and for livestock and pig production;
    - Understanding links between improving soil and water management (including drainage) in the context of maximising effective use of rainfall and dealing with greater climate uncertainty;

The HDC and other levy boards should consider a joint workshop to discuss common water issues and to identify options for promoting greater common engagement and discussion, including strategic outputs from SARIC, TSB and other funding streams.

- *Each levy board generally operates as an autonomous entity with its own distinct customer base, which makes it very difficult to foster collaboration.* The methods used internally by each levy board for project short-listing, review, assessment and contract management all differ markedly too, as well as the number and size of projects that are then funded. For example, the HDC tend to fund many small short-term consultancy type projects; in contrast, the HGCA tend to prefer fewer, much larger research projects. These differences are understandable given the different scales at which each levy board operates, reflecting the industry size and levy income generated. However, the concept of ring fencing a fixed proportion of funds each year from each levy board for R&D on common strategic issues could help develop the sense of shared strategic vision on key resource issues (water, energy, land). Without dedicated resources, it is very difficult to take a strategic view on key issues such as water.

4.3 Sources of funding to support HDC water related R&D

The HDC recognise that wider industry and research collaboration will be key to sustaining a thriving horticultural industry. It also recognises that innovation and development will need to be underpinned by applied research. But to realise this, it will need to actively manage existing links and develop new ones to maximise returns on levy investment. An internet based search of possible funding bodies of relevance to the HDC to support its water related R&D research was therefore undertaken to identify alternative sources of funding support. A brief summary of the funding body, scheme/s, funds available, and importantly how the HDC might collaborate or benefit from the funding is provided (Table 5). The funding opportunities span both UK and international funding sources.

Table 5 Summary of funding sources available to support water-related HDC R&D research.

Funding organization	**Funding scheme**	**Funding period**
European Commission (EC)	Horizon 2020	2014 to 2020
Brief description of scheme The latest EU Research and Innovation programme spans a number of sectors of relevance to HDC including (i) food security, sustainable agriculture and forestry, marine, maritime and inland water research and the bioeconomy, and (ii) climate action, environment, resource efficiency and raw materials to achieve a resource and water efficient and climate change resilient economy and society, the protection and sustainable management of natural resources and ecosystems, and a sustainable supply and use of raw materials, in order to meet the needs of a growing global population within the sustainable limits of the planet's natural resources and eco-systems. **Direct or collaborative funding support for HDC** A number of EU H2020 Calls are currently open (e.g. improved nutrient and resource efficiency) in which proactive HDC participation could be envisaged. The HDC could either provide industry –in-kind support to research collaborations including a UK partner, where HDC levy grower sites could be used as case studies for experimental work, or engaged in the project as key experts. Tapping into H2020 R&D funding seems an important opportunity for HDC; other similar organisations are known to be operating in the EU actively participate in such R&D projects. The HDC could also provide support funding for UK based research organisations/universities involved in such projects; this strengthens proposals significantly and would expose the HDC to EU research.		
Funding available SFS €100 million	**Website** http://ec.europa.eu/programmes/horizon2020/en/what-horizon-2020	

Funding organization	**Funding scheme**	**Funding period**
UK Research Council (UKRC)	BBSRC Horticulture and potatoes initiative (HAPI)	2013 - 2018
Brief description of scheme As part of its portfolio of activities related to food security, the BBSRC launched a new collaborative funding activity to support high quality, industrially relevant research on potato and edible horticulture crops. The Scottish Government and NERC are also involved. Six key research areas to improve food security have been identified, including (i) changing seasons, (ii) crop maturity and spoilage, (iii) soil, (iv) pests and pathogens, (v) seed quality and vigour, and (vi) resource use efficiency. The first round of funding has been completed and 4 projects are underway (total value £3M) focusing on potatoes and onions. A second call for proposals has recently closed, with an indicative budget of £4M. **Direct or collaborative funding support for HDC** Whilst all the key research areas defined in the BBSRC HAPI initiative are of relevance to		

the HDC, and efforts should be made to support projects that align with the their research strategy, two specific themes (changing seasons and resource use efficiency) have direct relevance to the HDC Water Strategy. Recognising that the BBSRC HAPI require a very strong plant science component, the HDC should proactively engage with proposals that offer scope to address any of the water priorities identified in Section 2.2 (prioritisation of water R&D). HDC involvement could be via either funded or in-kind support for knowledge transfer and dissemination, and providing input from grower panels.

Funding available:	**Website**
Up to £7M through two calls	http://www.bbsrc.ac.uk/hapi

Funding organization	**Funding scheme**	**Funding period**
UK Research Council (UKRC)	Technology Strategy Board (TSB)	2009 to 2015

Brief description of scheme The aim is to accelerate economic growth by stimulating and supporting business-led innovation. Food is one of 13 priority areas, with research required to identify ways to increase productivity of crops and animals and decrease the environmental impact of the industry. The TSB programme includes a number of schemes of direct relevance to addressing water related (and other) strategic R&D priorities for the HDC. These include (i) Catalyst, to accelerate early-stage ideas towards commercialisation, (ii) Catapults, a new network of centres designed to advance innovation in specific fields focusing on technology application, (iii) Collaborative R&D, to help companies tackle specific technical or societal challenges to create new products, processes and services, and (vi) Demonstrators, to accelerate introduction of new products, systems and services through demonstration, testing and validation in the real world at large scale.

Studies can focus on *plant breeding (e*xploitation of modern breeding techniques and genomics technologies to deliver faster rates of productivity growth and improved crop resilience to biotic and abiotic stress factors; *crop protection (s*olutions to threats posed to UK arable and horticulture output by withdrawal of plant protection products under EU legislation and by climate change including water stresses; or *crop nutrition and management (*mechanisms and technologies for efficient establishment, provision of crops with nutrients without current levels of loss to the atmosphere and water and harvesting). For example, the Agri-Tech Catalyst supports innovative ideas from any sector, including horticulture, which can help make the UK a world leader in agricultural technology, innovation and sustainability. Three categories of grant are available, (i) early-stage awards, (ii) industrial research awards and (iii) late stage awards.

The TSB also administer SAF-IP (Sustainable Agriculture and Food Innovation Platform) which is investing £75m in 4 key areas: crop productivity, sustainable livestock production, waste reduction and management, and greenhouse gas reduction. No current calls open, but details provided on TSB website https://connect.innovateuk.org/web/sustainable-agriculture-and-food-innovation-platform

Direct or collaborative funding support for HDC

The TSB provides a rare and excellent opportunity to help the HDC and its growers gain new knowledge on water-related challenges and/or develop new approaches or

technologies to address selected R&D priorities. As with the BBSRC HAPI initiative, the HDC should proactively engage with proposals that offer scope to address any of the water priorities (Section 2.2) with involvement via either funded or in-kind support for knowledge transfer and dissemination, and/or providing input from individual growers for field testing or expert opinion via grower panels.	
Funding available In partnership with Defra and the BBSRC, the scheme will invest up to £90m	**Website** https://www.innovateuk.org/food

Funding organization	**Funding scheme**	**Funding period**
UK Research Council (UKRC) BBSRC	AgriFood Advanced Training Partnership (ATP)	2013-2017

Brief description of scheme The AgriFood Advanced Training Partnership (ATP) is one of four higher level training partnerships funded by the BBSRC to deliver skills and training to businesses in the agrifood sector. Training is delivered by four university and research institute partners (University of Nottingham, Harper Adams University, Cranfield University and Rothamsted Research) as well as industry partners (Campden BRI and Cambridge University Farm). The programme offers a range of flexible training options enabling agriculture related employees to participate in one day workshops, field days, short courses and accredited postgraduate programmes. The AgriFood ATP offers specialist courses in soil and water management, crop protection and crop production, and has delivered modular short courses for growers, agronomists, and staff in the agrifood sector.

Direct or collaborative funding support for HDC

This programme provides a valuable funding opportunity to help HDC deliver advanced training in soil and water management (and other subject areas) to its core levy payers and staff. For example, a very well subscribed course entitled “Advanced Practitioner in Potato Production and Management is now in its second year, and provides participants with postgraduate level training in subjects covering soil and water management, equipment technology choice, water resources, water regulation and climate impacts and risks. Currently developed and targeted to the potato industry sector, these modules could readily be updated and made relevant to field vegetable and other HDC crop panels. The AATP training also provides an excellent opportunity for sharing best practices and disseminating new research knowledge; it could be used to support HDC KT initiatives and provides full bursaries for participants. HDC should consider how such funding could be used for its grower base, whilst full funding bursaries remain available (see below).

Funding available *100% bursaries* currently available until end 2014 (subject to funding availability). Subsidy rate will then fall to 50% until end 2015.	**Website** http://www.agrifoodatp.ac.uk/aatp/index.aspx

In addition to these main sources of funding, other initiatives also exist which provide good opportunities for the HDC to extend their reach into water research. The HDC water strategy should also be aware of the following:

- **Water Security Knowledge Exchange Programme** (WSKEP): A long-term initiative funded by the Natural Environment Research Council (NERC) which aims to accelerate uptake of research and help inform the direction of future science to ensure sustainable use of water in the future (http://www.wskep.net/). The WSKEP has 9 main themes, three of which are of relevance to the HDC, including drought, flooding and food. Events and technical meetings are held on these topics to highlight the latest research.
- **Horticultural Innovation Platform (HIP)** Provides a 'think tank' to scope strategies to meet the technical requirements for the UK horticultural industry. It supports development and exploitation of scientific opportunities via three work streams: (i) 'Funding Innovation' to navigate the funding landscape to increase innovative research and development, (ii) 'Growing Science' to provide 'a gateway to global science', and (iii) 'Improving Business' for 'Identifying opportunities to grow UK horticulture' (http://www.hip.org.uk/. These work streams should of course provide HDC with awareness of and direct access to funding opportunities to apply for funding to support projects that will address some of the water R&D priorities listed in Section 2.2.

4.4 Alternative options for R&D delivery

In addition to identifying alternative sources for funding, it is important the HDC are also aware of alternative options for supporting delivery of water (and other crop production) research. The conventional approach relying on contract research is expensive, but necessary where specific experimental crop trials and/or laboratory testing is needed. However, not all research needs expense facilities and innovative approaches could maximize levy payer funds even further. The HDC already support 3 year PhD scholarships and the undergraduate Final Year Bursary Scheme. The studentships are highly competitive given the limited number available. But not all research needs PhD level investigation; the HDC should consider more flexible approaches, including:

- Offering funding for 1 year MSc by Research projects;
- Offering funding for 3 month MSc thesis projects to tackle discrete pieces of work;
- Engaging with universities (e.g. Lancaster, Harper Adams, Nottingham, Reading, Cranfield, Warwick etc) to use undergraduate or post graduate (MSc) theses, and 'group projects' to tackle R&D needs. These are particularly suited to shorter focussed studies, literature or data syntheses, or exploratory modelling or simulation studies, and;
- Investigating opportunities for co-funding with agri-food charities.

4.5 Matching funding opportunities to HDC water priorities

By combining the ranked R&D priorities identified by HDC growers with information on alternative funding sources, Table 6 provides a matrix funding summary to inform HDC water R&D investment planning. Of course, other funding options will emerge over time and R&D priorities will also change, but it is useful to identify how best the existing sources of funding could help finance the current water related R&D priorities.

Table 6 Matching funding opportunities to HDC water priorities.

Issue	Funding source				
	EC H2020	BBSRC HAPI	TSB	BBSRC AATP	Other (AHDB)
1. Improve grower awareness of potential impacts of new water regulation on business	✗	✗	✗	✓	✗
2. Update guidance on irrigation scheduling technologies to maximize yield and quality	✓	✓	✓	✓	✗
3. Quantify links between poor irrigation performance, crop production and profitability	✓	✓	✓	✗	✓
4. Position statement on importance of water and contribution it makes to horticulture	✗	✗	✗	✗	✓
5. Improve knowledge of alternative water sources and impacts of water quality on production	✗	✗	✗	✓	✓
6. Improve knowledge of risks associated with low quality irrigation and options minimize risk	✗	✗	✓	✓	✓
7. Improve grower understanding of water harvesting/reuse options for horticultural irrigation	✗	✗	✗	✓	✓
8. Improve knowledge of impacts of irrigation on diffuse pollution (nitrate leaching, phosphate, etc.)	✓	✗	✗	✗	✓
9. Understand how soil management and mulches can make more effective use of rainfall	✗	✗	✗	✗	✓

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7 Appendix: Issues identified at water workshops

These are the issues raised at the workshop, collated according to themes. Those in *italics* were identified by respondents to the survey.

6.1 Water resource/regulation issues

1. Water availability will be a big strategic issue with increasing land rental and need to secure land with reliable water for FV
2. We're focussed too much on 'how you use it' rather than 'where you get it from'. Where does water fit into modern production?
3. Reservoirs
    - Planning and storage reservoirs. The planning system is a major disincentive to on-farm storage. What are the incentives for winter storage?
    - HNS farm units do not have much land, constrained by space for storage; keen to have ERDP grants but no land to actually put reservoirs on.
4. Microbial water quality. Risk is high. Increased emphasis on "due diligence" and traceability from retailers following the horsemeat scandal.
    - What are the "correct" levels to treat to? [1] Retailers and food processors / manufacturers tend to have their own standards and criteria.
    - What are low-cost water treatment options?
    - In-situ treatment of reservoir water (e.g. aeration).
    - Water sampling guidance for faecal coliforms is still a big issue
5. Chemical water quality.
    - Treatment of recycled water in glasshouses.
    - Use of biological treatment systems for ornamentals (not for edibles)
    - Need to know more about saline/brackish water use in FV, what are the acceptable limits for irrigation use on pots, celeriac, and celery? Also how should we be scheduling these crops to maximise quality? Also role of biochar in reducing/buffering salinity. With increased aridity, salinity will become a more important issue.
    - There will be a shift away from unreliable good quality water, to more variable quality water and how do we deal with that? It may be more reliable but quality more variable and probably lower. There could also be long term impacts of lower quality water use on soil.
6. Regulation.
    - Temporary water use bans a disaster for horticultural production. £800m farm gate value in HNS.
7. Water harvesting / recycling/re-circulation.

[1] HDC have fact-sheet on Water Quality with guidance for growers and an online tool.

- 30% applied runs off – need better/new recirculation installed on older production systems; at best only 50% of the industry recirculate.
- Effective use of rainfall. What are the impacts of rainfall on quality? How to make best use of rainfall to reduce irrigation.
- In PC, need to promote better water capture, reuse and recycling.
- For PC, major challenge is in recirculating – growers that aren't recirculating have the greatest potential for uptake of new technologies and water saving.
- *Define treatment requirements for re-circulated water. - Relate water savings/recirculation to costs.*
- *Biological filtration*.

6.2 Irrigation technology and management issues

1. Technology choices.
    - Financial appraisal on "improved" irrigation systems. What is the return on investment, particularly when considering replacement of existing systems? What are the incentives to get growers to use water more efficiently?
    - Water in the UK is still relatively cheap compared to other counties, for example Spain, where it is very carefully managed.
    - What are the barriers to uptake? E.g. fitting "improved" irrigation into existing production technology.
    - Promoting confidence in change, e.g. through relevant case-studies. Dissemination of international best-practice.
2. Plant responses to water stress.
    - How stressed can the plant get before quality or yield suffers (related to growth stage, weather, etc.)?
    - Plant sensitivity (quality) to waterlogging.
    - *Effects of water (lack of/too much/irrigation) in relation to canker*
3. Scheduling
    - Cost-effective scheduling. Evaluation of sensor technologies. Systems that are not over complicated. What is the right sensor? How many do you need depending on soil variability, etc.
    - Clear guidelines for scheduling for quality on many FV not available, but whether growers would adopt them is questionable.
    - Pushing on/holding back schedules
    - Workshops on scheduling might help growers understand benefits – Maybe ATP can help support KT/training on water management in soft fruit
    - Remote sensing of canopy development and new technologies coming on stream – need confidence on how good they are and how they can inform management practices
    - Plant-based irrigation scheduling. Applying water in response to plant need and timing in relation to harvest (quality impacts on soft fruit).
    - Irrigating early crops under plastic is a challenge

- Nurseries typically grow >1000 different types of plants, some fast/slow growing, different water requirements etc, managing that diversity is a challenge under current irrigation application systems.
- *Awareness/research on impact of chronic over irrigation*

4. Soil management
    - Better management of soil needs to be combined with water management. Harvest is happening for longer and later when the weather is getting worse creating soil/water problems
    - TF wet autumn caused compaction in alleyways, reduced infiltration and created problems for surface water management in narrow rows as planting density is high.
    - Soil management for water conservation. Integrating water conservation with other practices (e.g. mulching).
    - Coping with a changing climate also a challenge – linking better water management with soil management key – reduce runoff and ponding. Current management practices do not maximise soil conditions for make most effective use of rainfall.
    - Soil management (capping).
    - Erosion management (affects single farm payments).
    - Controlled wheelings cause a problem for compaction and runoff
    - Biological improvement of soil structure (e.g. earthworms)
    - *Increasing field capacity (for short term storage) must have a high government priority and reducing surface ponding would be a grower priority*
5. Benchmarking
    - Benchmarking tends to be within Producer Organisations. Sector benchmarking may be appropriate in field veg and salad sector.
    - Water is still too cheap; benchmarking water use in tomatoes would help highlight costs
6. Precision irrigation
    - There is a need to rejuvenate the gantry systems and combine them with thermal imaging (Bill Davies early Hortlink work that stalled) now that technologies and costs are better and cheaper. Precision irrigation for NHS.
7. Protected cropping
    - Current thinking in HNS irrigation for containers and PC is 2D - no rainfall; need to over irrigate deliberately to get water in the pot.
    - Guidance needed on best practice in managing runoff from strawberry beds – a lot of silt getting into rivers through poor water management

6.3 Excess water

1. Managing tunnels
    - Managing runoff water from tunnels. Ingress of water from inter-tunnel lanes.
    - Plastic polytunnels have aggravated localised ponding/flooding problems around strawberry production units.
2. Waterlogging

- Problems with *Phytophthora* diseases - shifted from being a winter problem to an annual /summer problem in HNS.
- Wet conditions have created new plant stressed conditions – can't spray a stressed plant. Increased blight incidence a problem

3. Managing runoff on very flat land.
4. Saline inundation & land recovery.
5. Flailing hedges has blocked ditches and created problems for dealing with excess water/drainage – need to bring field drains and ditches back into operation.

6.4 Wider industry issues

1. Big challenge is in increasing grower uptake of research, not necessarily more R&D
2. Need for factual evidence.
    a. Need to promote the "value" of water used in horticulture to the public (including policy makers). Generally the public has a poor perception of water used. Reliable information on footprints (in relation to value of outputs).
    b. Response to abstraction regulation reform is a sector priority. Who is representing growers' interests?
3. Working together
    a. Growers tend to work on their own. No culture of working together. Little interest in WAGs. Relevant growers tend to talk informally.
    b. HNS needs to be much better connected to the process/debate on water for agric/hort; it is currently dominated by FV and pots, but needs to embrace PC much better
    c. Horticulture has many very specific production issues, but still needs a stronger more collective voice on water issues
4. Precision agric with min till creating problems for following crops including FV
5. Catalyst for change – need to engage better with others who are lobbying
6. HDC
    a. HDC should have a much stronger international stance – including involvement in EU projects, the CLOSE and LEONARDO initiatives?
    b. HDC should be more active in dealing with current abstraction reform issues – what is going to happen to trickle irrigators?
    c. HDC should be more actively supporting NFU lobbying govt on abstraction reform. HDC Board attitude is that HDC should be providing the facts and guidance to help develop best practice. More of a lobbying voice should come through AHDB supporting NFU, not direct from HDC
    d. HIP – not clear how HIP will link with HDC initiatives