The resilience of potato and horticulture businesses to changes in abstraction licencing

Stakeholder Document

Report for AHDB

TBA00174 – Water Abstraction

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Executive summary

This document provides a briefing for stakeholders in the horticulture and potato industries, using results from a recent AHDB-funded project. The project (AHDB Ref: CP 159) undertook a survey of horticulture and potato growers, to give understanding of current water availability and management for irrigation across Britain. The survey was supported by background research and interviews with industry stakeholders.

This stakeholder document summarises the project results and sets them in the context of the requirements of the current abstraction licencing systems in England and Wales, and Scotland.

Horticulture and potato growers were surveyed in the first six months of 2016. The survey was done using an online questionnaire, supported by an email campaign, telephone calls, and use of paper copies of the questionnaire. There were 688 responses to the survey from growers (excluding duplicates, tests etc.), and 594 provided useful data for subsequent analysis. The responses represented over 64,000 hectares of relevant crops, of which over 40,000 hectares were irrigated. These irrigated crops grown by survey respondents have an output value of £631m, estimated using Defra Farm Business Survey reports and the John Nix Farm Management Pocketbook. Per irrigated hectare, the output value was approximately £15.5k as a mean across all respondents, representing a wide range of £4.4k (for a range of deep-rooted field vegetables) to over £460k (for some high-value glasshouse salad crops).

The need for water varies by sector, in terms of quantity, locations, seasonality, continuity and quality. Where crops are irrigated, generally the use of water is essential for the continuation of the production enterprise, either because the crops cannot be grown without water application, or because the enterprise would fail economically without irrigation.

Survey data are shown for sources of water, storage methods and capacity, application methods, reasons for abstraction restrictions and management technologies. Pointers are given towards other sources of data that support and complement the survey results from this project.

The current water abstraction regulation processes in England and Wales, and in Scotland, are briefly described, followed by information on the proposed reform in England and Wales. The need for reform stems from growing uncertainty in water availability in England and Wales, arising from a growing population (increasing demand) and climate change (affecting availability in unpredictable ways). In light of these pressures, it was felt that a reformed legal framework is necessary to secure water flows in the short-term and facilitate long-term investment in water infrastructures.

It is expected that key features of the reform will aim to:

- Maintain the current threshold for water abstraction licencing (20 m^3/ day)
- Remove the time-limit provision in a licence so that abstraction conditions are based on an assessment of the environmental risk and established in a permit (as well as protecting water resources from over abstraction, removing this provision offers businesses greater flexibility to abstract larger volumes if needed and if the evidence indicates no risk to the environment)
- Incorporate flow based controls for all licence conditions which are evidence based and designed to reflect local conditions
- Establish a system of pre-approved trade among licence holders when water availability is scarce
- Ensure that total permitted abstraction volume in a catchment does not pose a risk to the environment, regardless of whether or not the licence has been fully used or not (i.e. if there is a risk to the environment, avoid having a situation where significant volumes of abstraction remain licenced but not active)
- Extend licencing rules to all forms of irrigation, including trickle irrigation (currently exempt)

The Environment Agency and Natural Resources Wales have the intention of implementing a reformed water abstraction process by the early 2020s.

Growers that abstract water for irrigation should consider how their businesses can better manage water and land so that they are less vulnerable to the risk of limited water availability in the future. Relevant water and land management practices are outlined, with consideration of barriers their adoption.

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1 Introduction to the project

This document provides a briefing for stakeholders in the horticulture and potato industries, using results from a recent AHDB-funded project. The project (AHDB Ref: CP 159) undertook a survey of horticulture and potato growers, to give understanding of water availability and management across Britain. The survey was supported by background research and interviews with industry stakeholders.

This stakeholder document summarises the project results and sets them in the context of the requirements of the current abstraction licencing systems in England and Wales, and Scotland, as background to the proposed legislative changes and its potential implications for the potato and horticulture industries. This document combines available evidence and guidance with additional data gathered through the survey. It also includes recommendations for industry concerning state of the art measures being adapted by businesses to build resilience to water availability challenges, to help them continue in business, improve economic returns and improve their competitive position in international markets. This work takes forward the AHDB Horticulture's "Fit for the future" research strategy and its aim to optimise the management of water use to improve returns and reduce environmental impact, by driving technical innovation in horticulture.

Water is a precious resource that is facing increasingly severe and sometimes conflicting pressures. An increasing population, increasing demand, lifestyle changes and climate change are all contributing to water becoming a progressively more stressed resource. In light of this growing pressure, the UK Committee on Climate Change Adaptation highlights that there is a need for water abstractors to reduce their usage in coming years. Although water abstraction in the UK for agricultural purposes comprises just a small share of total water abstraction, the need to reduce water abstraction extends to all current users.

Against this backdrop, plans to reform the current abstraction licence process in England and Wales are underway and the government has announced its intention to have a new system established in the early 2020s. The current abstraction licence process in England and Wales was set up in the 1960s and is currently regulated by the Water Act, 2003[1]. It is a time-limited, metered licencing system which is managed at catchment level. In principle, any water abstractions over 20 m^3/ day requires a licence.

The Water Act 2003 includes provisions allowing permitting exemptions for water abstraction for land drainage and for water use below 20 m^3/24 hours. It also provides exemptions for certain activities such as abstraction of water for trickle irrigation. Among the expected changes to result from the reform, permits are no longer likely to be time-limited and the exemption allowing water abstraction for trickle irrigation is likely to be removed. Whereas in Scotland, regulation for water abstraction has been updated relatively recently: licences are no longer time-based and there are not exemptions allowing water abstraction for trickle irrigation.

To assess what this all means for horticulture and potato growers businesses in England, Scotland and Wales, it has been necessary to develop a more complete overview of current water abstraction practices by the horticulture and potato sectors. For example, according to the Organization for Economic Cooperation and Development (OECD), there are no reliable estimates for how much water is used for trickle/drip irrigation in the UK as a proportion of total water abstraction (OECD, 2015)[2]. Thus, it has been necessary to build on existing datasets by Defra, Scottish Environment Protection Agency (SEPA) and Eurostat (Statistical Office of the European Communities) by conducting a survey with AHDB levy payers in the potato and horticulture sectors (comprising just over 4,000 levy payers – of which the majority are potato growers). In addition, the survey has enabled the study team to identify knowledge and research gaps which could be addressed under future research and development projects for the benefit of the industry.

[1] Water Act 2003: http://www.legislation.gov.uk/ukpga/2003/37/contents

[2] OECD (2015) Water Resources Allocation: Sharing Risks and Opportunities. Country Profile for the United Kingdom. https://www.oecd.org/unitedkingdom/Water-Resources-Allocation-United-Kingdom.pdf

2 Water abstraction licencing and management reform

2.1 The current abstraction licence process

The current abstraction licence process in England and Wales was set up in the 1960s and is currently regulated by the Water Act, 2003[3]. It is a time-limited, metered licencing system which is managed at catchment level. In principle, any water abstractions over 20 m^3/ day requires a licence. Detailed guidance explaining the current process is available by the Environment Agency (2013)[4].

Generally, licences are granted for either a 12 or 24-year period with a Common End Date which is specific to the catchment area. Note that 12 year licences are more typical, and 24 year licences are generally granted to meet infrastructure needs and require an additional impact assessment to demonstrate that a 24-year licence is necessary and will not have adverse effects on the environment. Each licence includes a set of provisions which take into account water availability in the catchment area, such as location, time of the year, total volume licenced and the source of supply. The licence conditions are intended to mitigate any pressures on water availability.

Licencing exemptions are permitted under the Water Act and, under Section 6, water may be abstracted for agricultural use if the total volume abstracted is less than 20 m^3/24 hours and does not form part of a 'continuous operation, or of a series of operations'. Thus, under this exemption, it is possible for land managers to abstract water for drip irrigation (Picture 1).

Picture 1: The current abstraction licence process provides an exemption allowing water to be abstracted for drip irrigation purposes.

[3] Water Act 2003: http://www.legislation.gov.uk/ukpga/2003/37/contents
[4] Environment Agency (2013) Managing water abstraction. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/297309/LIT_4892_20f775.pdf

Licences incur a one-off registration fee as well as an ongoing subsistence charge. At times, licence holders may also be charged an advertising administration fee to cover the costs of informing inhabitants in their catchment about water abstraction.

Licence holders are required to measure and record the volume of water abstracted and submit annual returns to their local authorities. In addition, site inspections are carried out by the local authorities at catchment level to check compliance with licences. In cases of non-compliance, local authorities have the power to warrant prosecution if the licence holder does not respond earlier warnings, including: an initial site warning, a warning letter, a formal caution or a civil sanction.

In Scotland, water abstraction is regulated under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) (SEPA, 2016)[5]. Unlike England and Wales, the system in place is not time-based. It requires all abstractors to measure the volume of water abstractions and this activity is then regulated according to one of the following three levels of authorisation:

- General Binding Rules (GBR): Low environmental risk activities. If the abstractor complies with these rules, no licence or registration is necessary. Evidence of compliance is necessary, which in the case of water abstraction requires a meter (Picture 2) to measure abstraction. Inland[6] water abstractions below 10 m^3/ day fall under GBR2 and do not require registration or a licence. Examples of such water abstraction is generally understood to be in the case of domestic water use, filling water troughs for livestock, and filling a pesticide sprayer.
- Registration: Small-scale activities which pose a low environmental risk. The need to register where such activities are being conducted and the scale to avoid any cumulative negative effects. In order to register, applicants are required to comply with a number of conditions. The registration process incurs a one-off fee to applicants. Inland water abstractions between 10 and 50 m^3/ day must be registered.
- Complex or simple licence: High environmental risk, requiring site specific conditions to mitigate this risk. All licences incur a one-off application fee, and may also incur an annual charge as well. A licence must be sought for anything over 50 m^3/ day (a simple licence applies for inland abstractions between 50 and 2,000 m^3/ day, and a complex licence applies to any inland abstractions exceeding 2,000 m^3/ day).

[5] SEPA (2016) The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) – A practical guide. http://www.sepa.org.uk/media/34761/car_a_practical_guide.pdf

[6] Surface water (other than transitional water) and groundwater.

Picture 2: Water meters are used to measure abstraction.

All registration and licencing documentation is available via the respective environment agency for the devolved administrations, as follows:

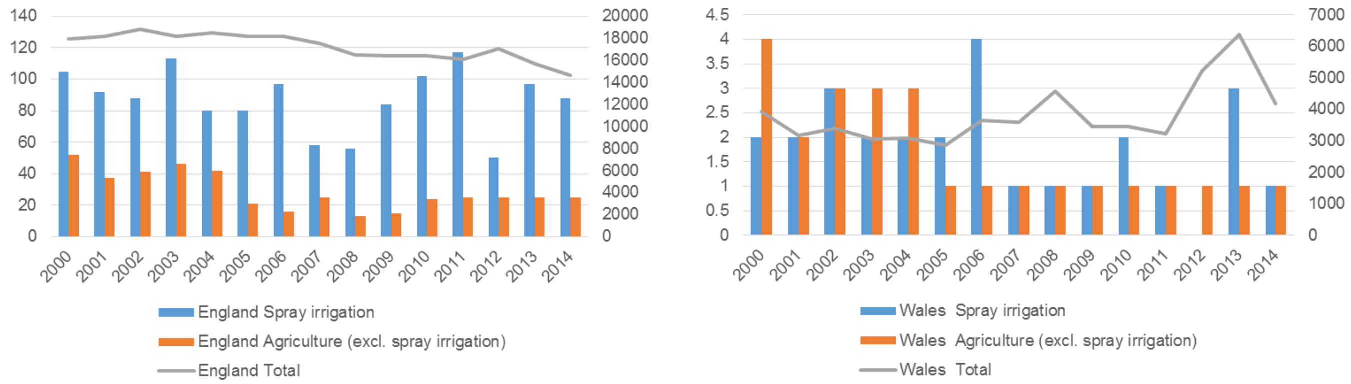
- England: Environment Agency (https://www.gov.uk/guidance/water-management-abstract-or-impound-water)
- Scotland: Scottish Environment Protection Agency (https://www.sepa.org.uk/regulations/water/abstractions/)
- Wales: Natural Resources Wales (https://naturalresources.wales/apply-for-a-permit/water-abstraction-licences-and-impoundment-licences/?lang=en)

2.2 Water abstraction management reform in England and Wales

The commitment to reform the current water abstraction process in England and Wales was announced in 2011 (Defra, 2011)[7].

Currently, water abstraction in England and Wales for agricultural purposes comprises a small fraction of total water abstraction volumes. As illustrated by Figure 1, water abstraction for agriculture accounted for 0.77% and 0.05% of total water abstracted, for England and Wales, respectively (113/14,682 million m^3 in England and 2/4,170 million m^3 in Wales for the year 2014). The volume of water abstracted for irrigation is weather dependent, as greater volumes are required in periods of drought (thus water abstraction data should be considered in a time series, as below), and there are notable differences between regions with the greatest demand typically in the east.

Figure 1: Water abstraction in England and Wales (million m^3). Chart axes on the left hand side denote abstraction volume for agricultural purposes (million m3). Chart axes on the right hand side denote total abstraction volume (million m^3). Source: Consultant's chart derived from data reported by the Environment Agency. [8]



The total number of abstraction licences for agriculture and irrigation in England and Wales was 2,913 in 2014 (of which 94% were in England, comprising 2,745 licences). The greatest proportion of licences were allocated to farms in the South West of England (677), followed by the Anglian region (554 licences). However, in terms of volume abstracted, farms in the South West of England accounted for just 6 million m^3 in 2014 for total agricultural purposes compared to 57 million m^3 in the Anglian region.

In terms of use, in the Anglian region ~93%[9] of abstracted water was used for spray irrigation (averaging 51 million m^3 per annum between 2000 and 2014). In the South West, ~15% of water abstracted between 2000 and 2014 was used for spray irrigation (averaging 1.7 million m^3 per annum; Environment Agency, 2016).[10]

In most cases in England, water use on farms is sourced from the mains water (~2/3 in both 2013/14 and 2014/15). In 2014/15, the greatest share of total water use that was abstracted was reported by livestock grazing farms in less favourable areas (with ~45% abstracted from rivers, streams or springs for immediate use, and ~12% abstracted from bore holes). On horticulture holdings, the share of total water use that was abstracted for immediate use was reported to be ~4% from rivers, streams (Picture 3) or springs, and ~18% from bore holes (Defra and National Statistics, 2016).[11]

[7] Defra (2011) Water for Life. Commitment to reform the water abstraction system made in 2011. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/228861/8230.pdf

[8] https://www.gov.uk/government/statistical-data-sets/env15-water-abstraction-tables

[9] Average of reported and estimated water abstraction data for total agricultural purposes between 2000 and 2014.

[10] https://www.gov.uk/government/statistical-data-sets/env15-water-abstraction-tables

[11] Defra and National Statistics (2016) Water usage on farms: Results from the Farm Business Survey, England 2014/2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/493621/fbs-wateruse-statsnotice-21jan16.pdf

Picture 3: Water meters are used to measure abstraction.

Water used for trickle/ drip irrigation is currently exempt from licensing; according to the OECD, there are no reliable estimates for how much water these systems use as a proportion of total water abstraction (OECD, 2015)[12].

Notwithstanding the comparatively low rates of water abstraction by agriculture in England and Wales, population growth and climate change are expected to result in increased demand for water abstraction by the sector. By 2020, the Environment Agency forecast that agricultural irrigation demands will increase between 15 to 55% across all regions in England and Wales (Frontier Economics and Anglian Water, 2011)[13]. Furthermore, projections by the Committee for Climate Change Adaptation Sub-Committee (CCCA) based on current demand, anticipated global warming and population growth scenarios, indicate that by 2050 there is a high risk of water availability deficits across England and Wales. As such, the CCCA anticipates that the level of water available for water abstraction will be significantly reduced by 2050. Projections set in the medium scenario (assumes a temperature increase of 3.5ºC and a low population growth), indicates that in parts of England and Wales water available for abstraction would be available only for between 5% and 30% of the time (CCCA, 2015)[14]. The CCCA subsequently highlights that there will be a need for current water abstractors to reduce their usage in coming years.

Already, there is evidence of over-abstraction in England and Wales with 6% of recently assessed water bodies failing to meet water availability standards owing to over-abstraction (Defra, 2016)[15].

Following a public consultation which was held in 2013 (Making the Most of Every Drop), Defra and Natural Resources Wales have:

- Published a summary of consultation responses (Defra and Natural Resources Wales, 2014)[16]

[12] OECD (2015) Water Resources Allocation: Sharing Risks and Opportunities. Country Profile for the United Kingdom. https://www.oecd.org/unitedkingdom/Water-Resources-Allocation-United-Kingdom.pdf
[13] Frontier Economics and Anglian Water (2011) A right to water? Meeting the challenge of sustainable water allocation. http://www.anglianwater.co.uk/_assets/media/a-right-to-water-full-report.pdf
[14] Committee on Climate Change Adaptation (CCCA) (2015) UK Climate Change Risk Assessment 2017: Summary of ASC-commissioned research projects https://www.theccc.org.uk/wp-content/uploads/2015/10/2015-11-09-Summary-of-CCRA-research-projects.pdf
[15] Defra (2016) UK Government response to consultation on reforming the Water Abstraction Management System. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/492411/abstraction-reform-govt-response.pdf
[16] Defra and Natural Resources Wales (2014) Making the most of every drop consultation on reforming the water abstraction management system. Summary of consultation responses. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/328442/abstraction-reform-sum-resp.pdf

- Developed policy options to assess the impact of a reform (Defra and Natural Resources Wales, 2015)[17]
- Published a UK Government response to the consultation (Defra, 2016)

The Government's response provides some insight as to current government thinking behind the reform in terms of timeframe, thresholds and implications for existing exemptions. The focus is on achieving smarter regulation whereby administrative costs are minimised and red tape cut. It recognises the need to support businesses with their water needs; however, it equally recognises the need to protect environmental needs and to strike a balance between the two.

As it stands, it is expected that key features of the reform will aim to:

- Maintain the current threshold for water abstraction licencing (i.e. licences are required for water abstraction over 20 m^3/ day)
- Remove the time-limit provision in a licence so that abstraction conditions are based on an assessment of the environmental risk and established in a permit. As well as protecting water resources from over abstraction, removing this provision offers businesses greater flexibility to abstract larger volumes if needed and if the evidence indicates no risk to the environment. Moreover, the proposals define the criteria for determining business needs on an extended time series of 10 years to ensure that fluctuations in weather are fully captured
- Incorporate flow based controls for all licence conditions which are evidence based and designed to reflect local conditions
- Establish a system of pre-approved trade among licence holders when water availability is scarce, which will be designed to ensure a fair market for all abstractors and 'guard against any unintended consequences such as impacts on food security'
- Ensure that total permitted abstraction volume in a catchment does not pose a risk to the environment, regardless of whether or not the licence has been fully used (i.e. if there is a risk to the environment, avoid having a situation where significant volumes of abstraction remain licenced but not active)
- Extend licencing rules to all forms of irrigation, including trickle irrigation (currently exempt) (Picture 4)

Picture 4: The reforms may tighten existing exemptions so that water abstraction for the purposes of trickle irrigation as shown in this apple orchard, are no longer allowed.

[17] Defra and Natural Resources Wales (2015) Future Water Resources Management: Reform of the Water Abstraction Regulation System. Impact Assessment. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/492418/abstraction-reform-ia.pdf

Next steps: Defra and Natural Resources Wales have the intention of implementing a reformed water abstraction process in the early 2020s.

3 Water abstraction and irrigation survey

3.1 Survey details

Horticulture and potato growers were surveyed in the first six months of 2016. The survey was done using an online questionnaire. An email campaign, telephone calls and interviews were conducted to encourage completion of the questionnaire, and paper copies of the questionnaire were sent by post. The subject areas covered by the 23 questions are given in Table 1.

Table 1. Subject areas covered by the 23 questions.

Questions	Subject areas
Q1 to Q3	Contact details and role
Q4 to Q7	Water sources, quantities and crop areas
Q7 to Q11	Volume of water used and information about abstraction licences
Q12 to Q15	Application methods and storage
Q16 to Q19	Management and planning
Q20	Advice Support
Q21	Free text – anything else
Q22 and Q23	BASIS points

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Respondents were categorised by production sector and water resource availability. The sector categories are given in Table 2.

Table 2. Sector categories (HNS = hardy nursery stock).

Main category:	Potatoes	Field Horticulture	Protected Horticulture	Containerised plants grown outdoors
Sub-categories:	Packing	Field vegetables	Protected edibles	Containerised outdoor HNS
	Processing	Bulbs and Outdoor flowers	Mushrooms	Containerised outdoor soft fruit
	Seed	Field Soft fruit	Protected Soft fruit	
		Field HNS	Protected ornamentals	
		Tree fruit		

Water resource availability categories used data on the percentage of time that water is expected to be available in their catchment for consumptive abstraction, as follows:

- less than 30% of the time
- at least 30% of the time
- at least 50% of the time
- at least 70% of the time
- at least 95% of the time

Consumptive use of water is a use that makes water no longer available for other uses, because it has (for example) evaporated, transpired, or been incorporated into crops.

There were 688 responses to the survey from growers (excluding duplicates, tests etc.), and 594 provided useful data for subsequent analysis. The breakdown by main sector is given in Table 3.

Table 3. Responses by main sector.

	Responses	Available contacts	Response (%)
Potatoes	471	2,584	18%
Field Horticulture	429	796	54%
Protected Horticulture	104	402	26%
Outdoor Containerised Plants	48	309	16%

Table 4 shows the production and irrigated areas for each sector, reported by survey respondents, and compared with the UK total areas using data from Eurostat. Data for "all sectors" includes data for crops described as "other" by survey respondents and not allocated to one of the four main sectors. These data show that the survey respondents represented around a quarter of the crop area in horticulture and potatoes, and around 62% of the irrigated area in horticulture and potatoes.

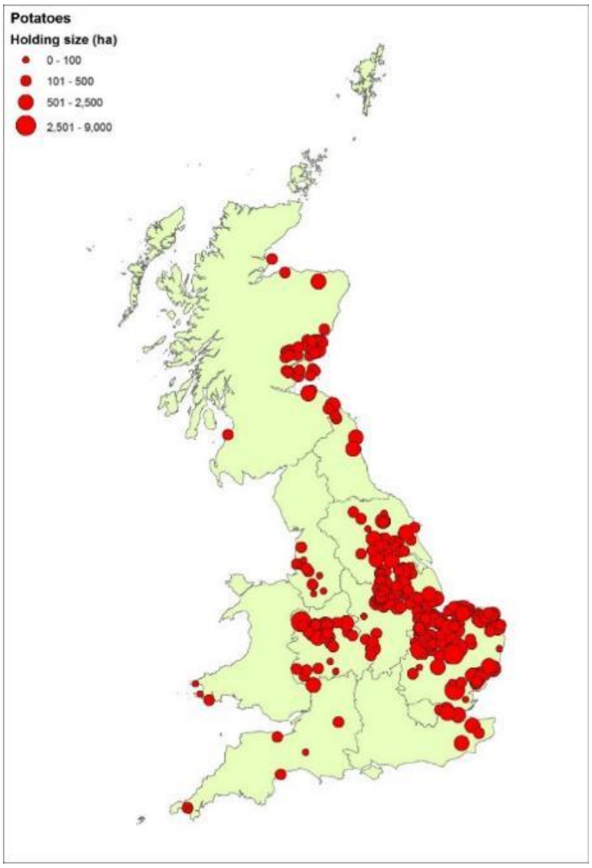
Table 4. Production and irrigated areas for each main sector, as reported by survey respondents, and compared with the UK total areas.

Production sectors	Survey production area (ha)	Survey irrigated area (ha)	UK production area (ha)	UK irrigated area (ha)	Production area covered by the survey (% of UK production area)	Irrigated area covered by the survey (% of UK irrigated area)
Potatoes	30,576	18,027	129,000	39,160	24	46
Field horticulture	24,078	16,655	117,680	23,720	20	70
Protected horticulture	1,280	All	2,420	2,420	53	34
Outdoor containerised plants	258	All	No data	No data	No data	No data
All sectors	64,075	40,786	249,100	65,300	26	62

The geographic distribution of responses (Figure 2) reflected the locations of production sectors and the distribution of irrigation activity.

The maps show a concentration of responses in areas where irrigated crops are most grown (mainly the eastern side Britain, and the West Midlands of England), with a scattering of responses in other areas reflecting the spatial distribution of specialist production sectors (e.g. glasshouse growers in the south of England).

Figure 2. Geographic distribution of survey responses.



The economic output and total gross margin for the areas of crops grown and irrigated by survey respondents is shown in Table 5.[18]

Table 5. Economic output and total gross margin for the areas of crops grown and irrigated by survey respondents.

	Area (ha)	Output (£M)	Gross margin (£M)
Relevant crops grown	64,075	821.1	380.9
Relevant crops irrigated	40,786	630.9	287.3

The output of irrigated crops grown by survey respondents was approximately £15.5k per irrigated hectare as a mean across all respondents, representing a wide range of £4.4k (for a range of deep-rooted field vegetables) to over £460k (for some high-value glasshouse salad crops).

3.2 Survey results

3.2.1 Background from stakeholder interviews: the need for water

The need for water varies by sector, in terms of quantity, locations, seasonality, continuity and quality. Field crops (Picture 5) use more water for irrigation compared with protected and container-grown crops (Picture 6), because the irrigated area for field crops is greater.

[18] These data are estimated using Defra Farm Business Survey reports and the John Nix Farm Management Pocketbook.

Picture 5: Field grown crops use more water for irrigation than protected and container-grown crops.

Picture 6: Protected and container grown crops used less water for irrigation than field grown crops.

Field crops need water for competitive yield and to achieve crop quality requirements. Crops that are irrigated would, in general, be economically unviable without irrigation. For example, potato crops are grown without irrigation on suitable soil types, but the irrigated crops are mainly on soil types where quality cannot be achieved without irrigation. Potato crops are irrigated to control common scab, and to achieve the required size distribution for the market, and to achieve a yield of saleable potatoes that gives an acceptable return to the grower compared with alternative crops.

'Headroom' is a major concern for many growers, and is the difference between typical annual water use and licenced water abstraction volume. Headroom is the extra water that is available to growers in seasons when demand is greatest, and this quantity varies greatly between growers.

Locations where irrigation is required depends on suitability of soil types and topography for the irrigated crops. The seasonality of water requirement for irrigation depends on the crop requirements; field crops generally have demand when soil moisture is limiting (typically April to September); whereas protected and container-grown crops require irrigation throughout the year or production period.

Continuity of supply is essential for protected crops. Half a day without water will be a disaster for a cucumber crop and the grower's business. Storage (Picture 7) is necessary for some businesses to maintain supply continuously, and in some sectors (e.g. leafy salads) major growers already have storage for this reason. For some horticulture crop sectors there are many growers without storage and many growers are unable to install reservoirs because they do not have space, and/or because the cost could not be supported by the business in the face of competition from imports.

Picture 7: Water storage is required by some businesses to main continuity of water supply.

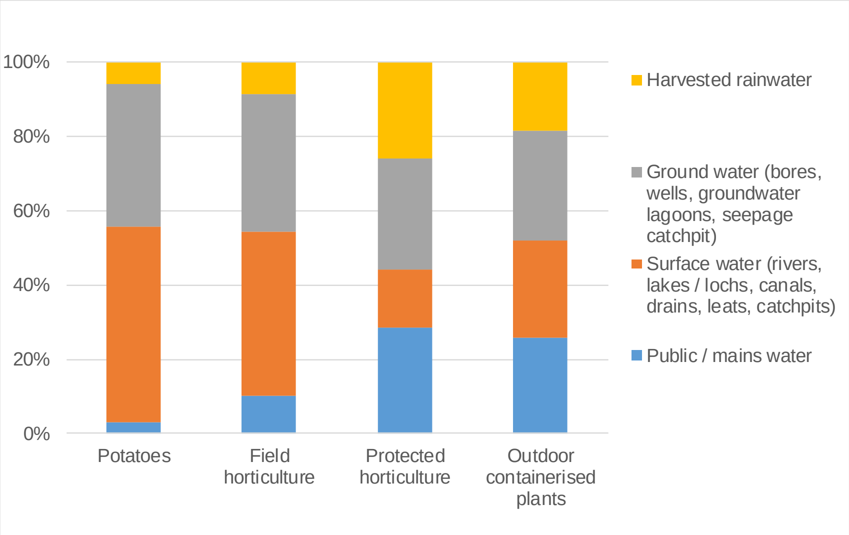
Quality of water is important for most crops, and quality requirements are more important for crops that are eaten uncooked (e.g. leafy salads that are at risk of microbial contamination) and crops that are susceptible to water-borne diseases.

3.2.2 Sources of water and volume used

Surface water was the most used source for potato and field vegetable crops, and least used in protected horticulture. In some sectors of protected horticulture, water quality is highly important and surface water tends to have higher levels of microbial contamination than water from other sources. For protected horticulture and outdoor containerised plants, mains water was more important than for potatoes and field horticulture.

Water sources used for irrigation are shown in Figure 3, as percentages within each main sector of production.

Figure 3. Water sources used for irrigation.



'Headroom' is a major concern for many growers, and is the difference between typical annual water use and licenced water abstraction volume. Headroom is the extra water that is available to growers in seasons when demand is greatest, and this quantity varies greatly between growers.

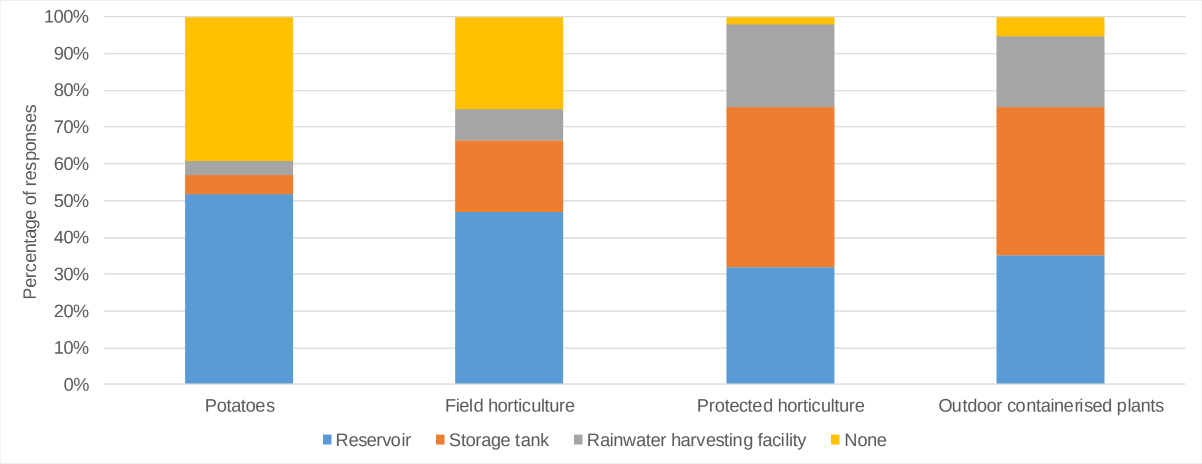
Licenced water abstraction volume total (excluding watercress), from survey responses, was 70.3 million m^3. The highest annual volume of water applied within 2011 to 2015, excluding mains and watercress, also from survey responses, was 51.9 million m^3. This greatest annual usage is 73.9% of the licensed volume, so headroom is 26.1% of licensed volume, to cover a greater need of water than was experienced in the years 2011 to 2015.

3.2.3 Storage

Storage in reservoirs (Picture 8) dominated for potatoes and field horticulture; for protected and containerised production the most common storage facility was a water tank. This is illustrated in Figure 4 as percentages of the number of respondents using alternative storage methods (or no storage).

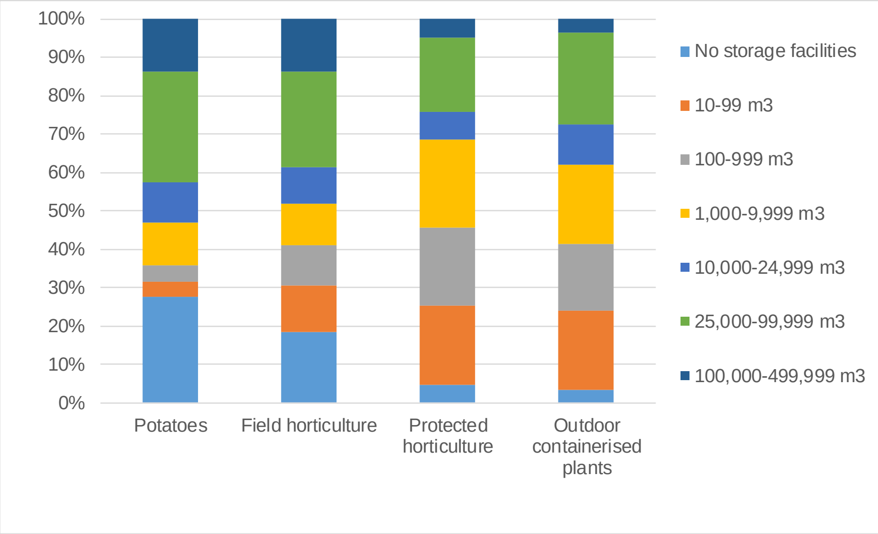
Picture 8: Storage reservoirs are more commonly used for field grown crops such as potatoes, field vegetables and fruit.

Figure 4. Percentages of the number of respondents using alternative storage methods (or no storage).



Storage capacity (Figure 5) was greatest where use of reservoirs was greatest.

Figure 5. Storage capacity (percentage of responses in each main sector).



Key findings include the following.

The need for storage:

- Edible crop producers are concerned about water quality (potential pathogens)
- In protected and containerised production water is required every day
- Storage is necessary for some businesses to maintain supply continuously
- In some sectors (e.g. leafy salads) major growers already have storage

High capital cost:

- Storage carries high capital cost
- Licence durations are short and discourage investment in reservoirs

- In some sectors, installation of storage is not economically viable (e.g. cucumbers)
- A requirement for storage would lead to less UK production and more imports

Barriers to storage

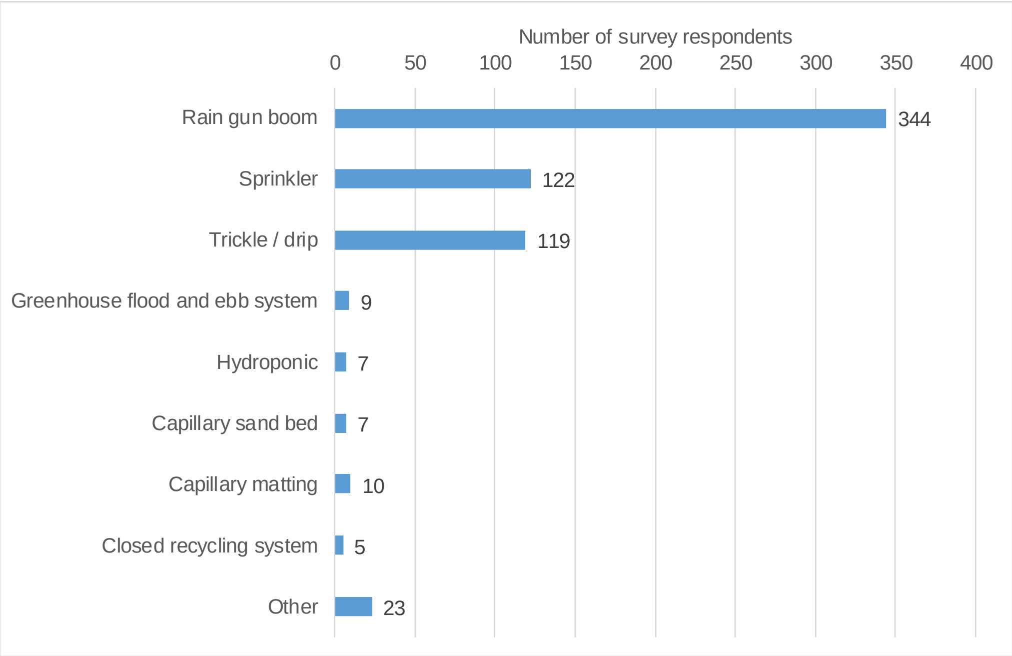
- Planning is perceived to be a major obstacle
- Storage allows the user to change the time of abstraction but does not necessarily decrease water use – perceived problem in applying for grants
- In some sectors (mainly protected horticulture, Picture 9) availability of land is a barrier to storage

Picture 9: Land availability can often be a barrier to storage, particularly in glasshouse crops.

3.2.4 Methods of application

The numbers of survey respondents applying water using alternative methods are shown in Figure 6 (see also Pictures 10 and 11). Rain guns/booms were the dominant application method, especially for potato production and field horticulture. Protected horticulture and outdoor containerised plants use mainly sprinklers and trickle/drip.

Figure 6. Numbers of survey respondents applying water using alternative methods.



Picture 10: Flood and ebb irrigation is used for a wide range of protected products, and flood systems are commonly used for ornamental aquatic plants.

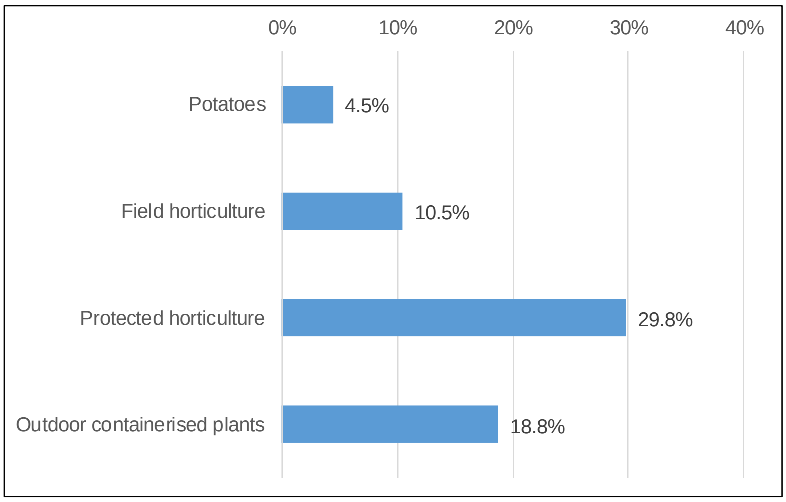
Picture 11: Capillary sand beds are commonly used in the production of container grown hardy ornamental nursery stock plants.

Trickle use is significant (20% of survey respondents), especially for fruit (Picture 12), container growing and protected production. Seventy-six growers indicated that they use more than 20 m^3 per day. Respondents using more than 20 m^3 per day, as percentages of respondents in each production sector, are shown in Figure 7.

The percentage of trickle/drip users is greatest in protected horticulture and least in potato production. The highest percentages are in the fruit industry, including soft fruit (Picture 13) and tree fruit (Picture 14).

Picture 12: Trickle irrigation is significant, particularly in fruit crops like strawberry.

Figure 7. Percentages of respondents in each production sector using more than 20 m^3 of water per day for trickle/drip irrigation.



Picture 13: Drip irrigation is used for all container grown soft fruit crops such as blueberry.

Picture 14: Trickle and drip irrigation is now commonly used for intensively grown pear orchards.

Trickle/drip irrigation is perceived as technically difficult and expensive, especially for potatoes and field horticulture, where the scale of production is greatest and there is least experience of the application technology. For some field crops the crop duration is short, and this is a barrier to adoption of trickle/drip application. There is also a perception that trickle/drip application does not work well on light, sandy soils because lateral movement of water in the soil is less.

There is also concern that widespread adoption of trickle/drip application for field crops could increase water use per ha. This is because there could be a tendency to maintain a lower soil moisture deficit leading to greater water loss when it rains heavily. Furthermore, during the crop growth period, application by trickle/drip is less limited than other application methods by equipment and labour. However, greater water use and more timely application of water can lead to an increase in productivity per ha, which may drive down water use per unit of production.

3.2.5 Restrictions to water abstraction

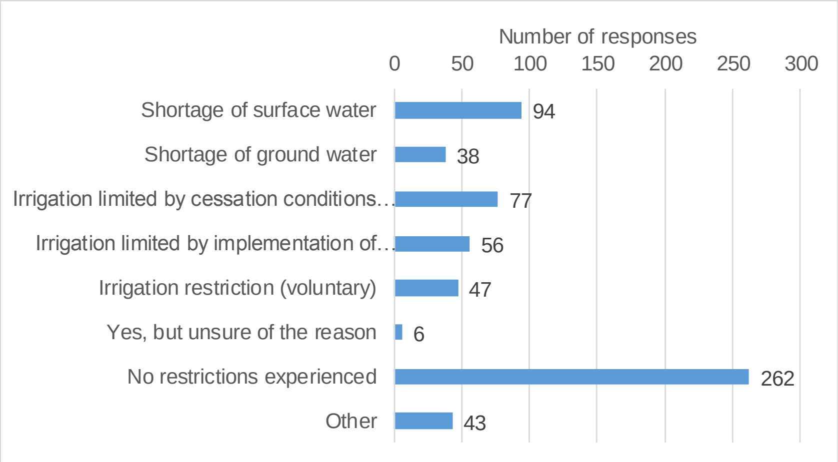
Compared with protected or containerised crop producers, potato and or field horticulture producers:

- Are more likely to experience restrictions
- Have greater use of surface water (especially field horticulture)
- Are more often limited by implementation of drought plans

There are fewer restrictions in catchments with greater water availability. Restrictions are mainly an issues for surface water users, but data indicate some restrictions are also experienced by ground water users. Water storage is perceived to be the main method to avoid restrictions.

The two most common reasons for restrictions were shortage of surface water and cessation conditions on licences (Figure 8). More restrictions were experienced by potato growers and field horticulture businesses, compared with protected horticulture and outdoor containerised plant growers

Figure 8. Reasons for abstraction restrictions.



3.2.6 Management and technologies for irrigation

Many growers use professional irrigation scheduling services or software (65% of survey respondents that answered this question). The percentages of responses within each main production sector, for a range of technologies, is shown in Figure 9, giving an indication of uptake within sectors. The results show that there is the possibility of greater uptake of technologies for improved water management. For example, recirculation of water (Picture 15) in glasshouses has considerable potential for greater uptake, and this could be supported by more technical information through knowledge exchange programmes.

Picture 15: Water is being increasingly collected and recycled in protected crops such as table grown strawberry.

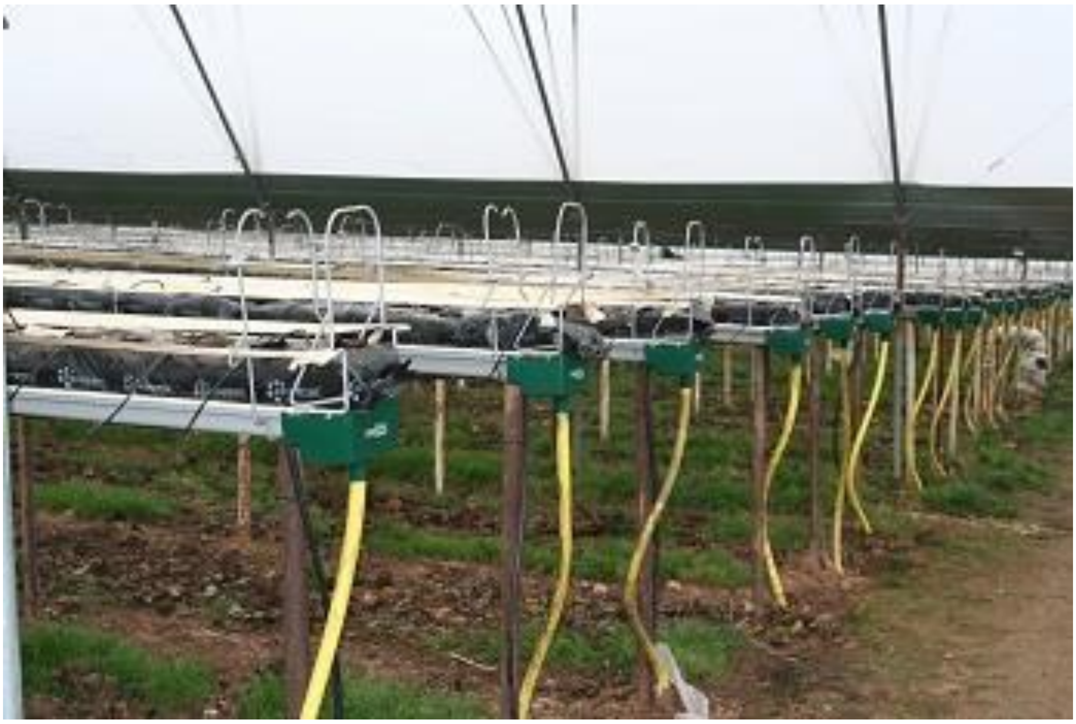
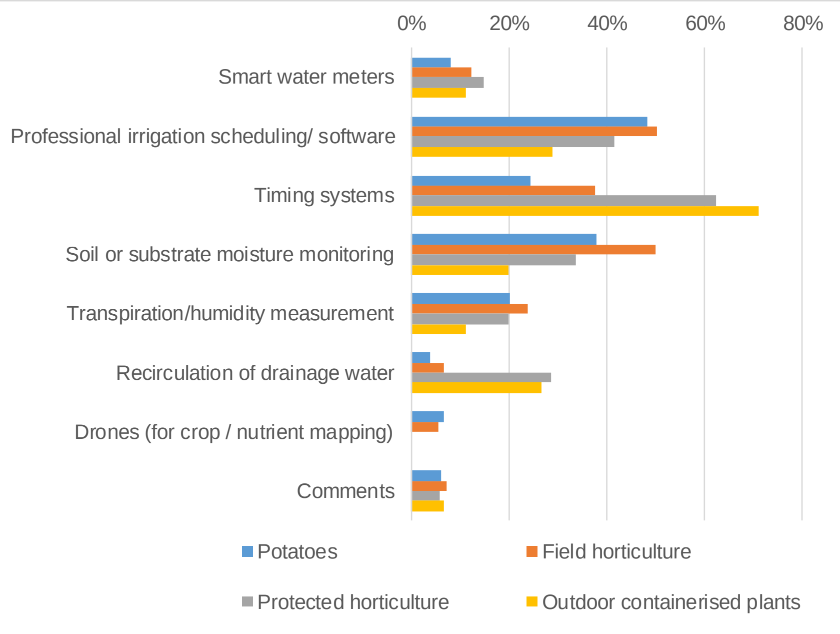


Figure 9. Uptake of technologies: percentages of responses within each main production sector.



Management actions to manage water shortages and/or improve water use efficiency are shown in Figure 10. This shows the percentages of respondents in each main production sector that selected each management option, and it gives an indication of actions within sectors. Care must be taken in the interpretation of these data because there is double counting between sectors where respondents produce in more than one sector.

Management actions with a high level of response included:

- night irrigation,
- improved monitoring and scheduling of crop water use,
- installing new irrigation technologies or systems, and
- prioritising irrigation of different crops.

These management actions have benefits for growers' businesses, through more efficient use of capital equipment, energy water and labour.

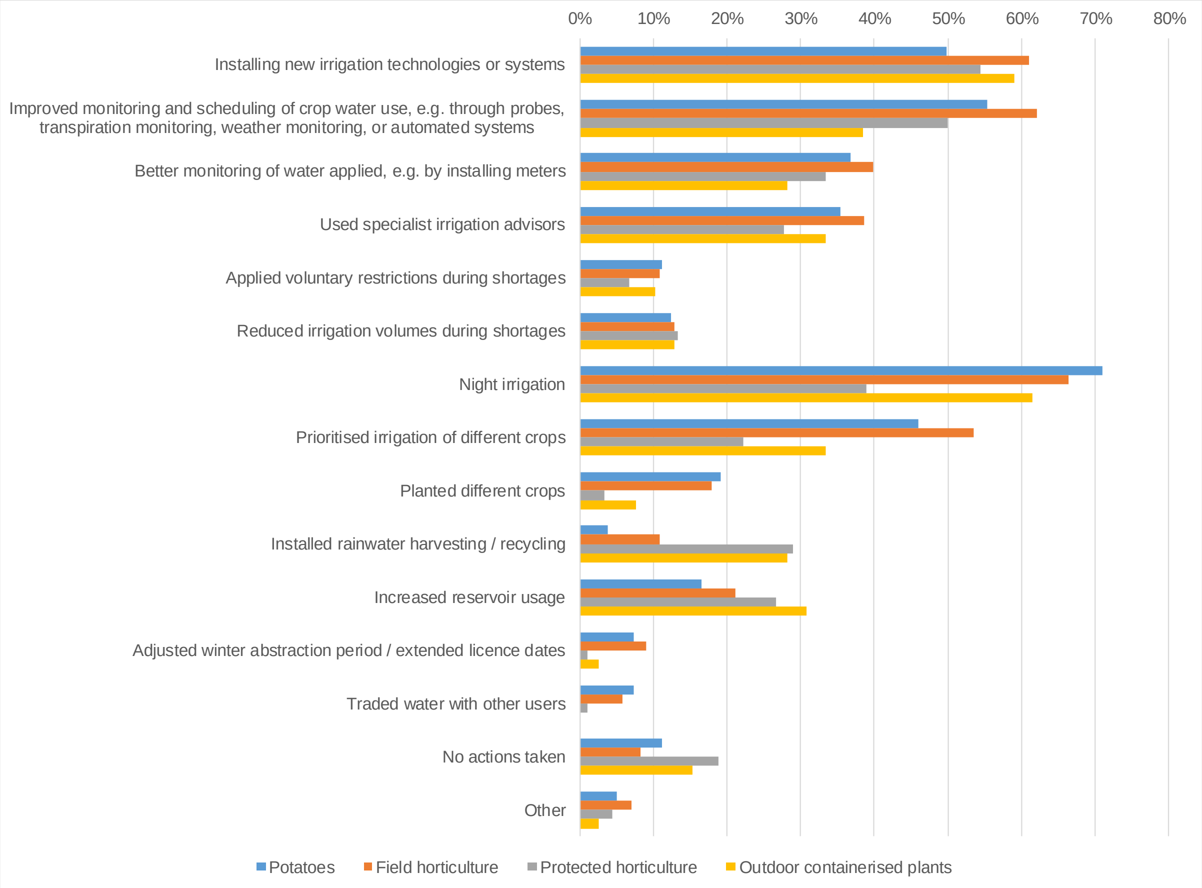
Actions with a low level of response included:

- trading water with other users,
- adjusting winter abstraction period / extending licence dates,
- installing rainwater harvesting (Picture 16) / recycling, and
- applying voluntary restrictions during shortages.

Picture 16: Rainwater harvesting is being adopted by growers producing strawberry crops under protective tunnels.

Some of these actions are suited to a limited number of businesses (e.g. rainwater harvesting), and others are not perceived to have business benefits. There is particular concern about trading of the right to abstract water, with some growers perceiving this as an opportunity for traders to make profits and take money out of the horticulture/potato industries.

Figure 10. Management actions to manage water shortages and/or improve water use efficiency (percentages of respondents in each main production sector that selected each management option).



3.3 Other sources of data

There are several other sources of data on water abstraction for irrigation in Great Britain. The time relevance and the geographic scope both vary, and there is little information available that is recent and at a national scale. Some key reports and sources of data from the last ten years are given below.

3.3.1 Defra and the Environment Agency

The Defra Farm Business Survey and Irrigation Survey[19] provide data for

- Irrigated area by crop (Table 4, p.23)
- Volume of water applied for irrigation by crop (Table 5, p.23)
- Average volume of water applied for irrigation per hectare by crop (Table 6, p.24)
- Crops covered include: early potatoes, main crop potatoes, sugar beet, orchard fruit, small fruit, vegetables…
- Time series: 2001, 2005, 2010

The Environment Agency collect data from water companies, based on returns from license holders; the returns include only a small number of agricultural users. The data are presented in the Defra (2015) Observatory monitoring framework – indicator data sheet.[20] The volume of water abstracted for agricultural use and spray irrigation for England and Wales (2000 to 2013), but there is no distinction by crop. The data sheet provides a comparison of licenced water abstraction to reported water abstraction, and this suggests considerable 'headroom', with around 3.5 times more licenced abstraction than the typical annual reported abstraction.

[19] Defra (2011) Water usage in agriculture and horticulture. Results from the Farm Business Survey 2009/10 and the Irrigation Survey 2010.
[20] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/435394/agindicator-da5-16jun15.pdf

Defra project WT1503 (Evidence on impacts of new authorisations on [water] abstractors[21]) gives an assessment of the number of exempt abstractors, the scale of their abstractions and associated costs and benefits of the abstraction activity. This report provides the area of crops using trickle irrigation in UK in 2010 as weighted average according to broad crop divisions (orchard fruit, soft fruit, glasshouse fruit, field vegetables, protected vegetables, ornamental horticulture, and potatoes). In 2010 most of the area of protected crops and soft fruit was trickle irrigated, together with a large part of ornamental production (46%) and a small part of the field crop area (2% for potatoes and field vegetables). Options for farmers to mitigate the impact of being brought into licencing control are discussed and include on-farm reservoir storage, rainwater harvesting, greywater recycling, efficient recycling, efficient use of water, and use of drought resistant crops.

3.3.2 WATERR – Water Advisory Team for Efficient Resource Recovery[22]

This project supported rural businesses in the South East of England, and a detailed survey was made. However, this project does not provide national data. The work covered water use efficiency and financial returns, best practices, latest developments, and surveyed 110 irrigators across the South East of England, mainly for potato and fruit growers. It was estimated that trickle irrigation accounted for 43% of water abstraction used in irrigation in Kent and South London Area in 2011. Results showed that the best growers were more water efficient, but also used more water per hectare.

3.3.3 WRAP

WRAP (the Waste and Resources Action Programme) have funded a project on freshwater availability and use in the UK.[23] This report provides data on the estimated volume directly abstracted for agricultural purposes in England and Wales. This includes categories for general agriculture, horticulture and nurseries, and orchards according to application (spray direct, spray storage, horticultural/vegetable washing, general use relating to secondary category, large garden watering). Total water consumption is estimated at 93 million m^3 (England and Wales), which compares with 53 million m^3 (GB) reported by respondents to our AHDB survey, as the highest volume of irrigation water applied per annum from 2011 – 2015.

3.3.4 NFU

The NFU has surveyed farmers and growers at five-year intervals and the last available report is from a survey in 2011. The geographic scope is England and Wales. Data are provided on water quantity used and water sources by farm type, water storage, activities that require water including irrigation and investment in water infrastructure.

4 Water use

4.1 Water in agriculture

The overall volume of water used in agriculture averages around 1% of the total water used in the UK. However, the 1% average does not account for the inter-annual and spatial variability which are both dependent on weather. It has been estimated that the total on-farm water use is 300 million m^3 yr^{-1} (Watts et al., 2015). The two main uses in agriculture are drinking water for livestock (41%) and irrigation (38%) (Farm Business Survey (FBS), 2010). Irrigation plays a vital role in agriculture and horticulture production. It provides an element of control that offers greater consistency in both quantity and quality in production. However, there are competing demands for water resources available, particularly in potentially water stressed areas with low rainfall and high population demand.

4.2 Water in irrigation

The UK is generally perceived as a wet country, especially in the west, but irrigation is needed to supplement rainfall, particularly for potatoes, field vegetables (Picture 17) and horticulture crops grown away from the west, or grown under protection. Irrigation is needed to maintain and yields and quality

[21] http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=18618
[22] http://www.emr.ac.uk/projects/waterr-water-advisory-team-efficient-resource-recovery/
[23] http://www.wrap.org.uk/sites/files/wrap/PAD101-201%20-%20Agricultural%20sector%20water%20report%20-%20FINAL%20APPROVED%20for%20publication%20-%2012,03,12_0.pdf

whilst improving reliability in the supply chains (Watts et al., 2015).[24] The levels of irrigation are highest mainly in East Anglia, South East and parts of the East Midlands where the conditions tend to be drier (Watts et al., 2015).

Picture 17: Supplementary irrigation is required for field grown lettuce crops.

Unlike other uses in agriculture, irrigation is considered consumptive and removes water from the water cycle (Watts et al., 2015) by evaporation. Demand from agriculture varies significantly from year to year depending on the rainfall. Total irrigation in England and Wales has varied from a high in 2003 and 2011 of 120 million m^3, to a low in 2012 of 50 million m^3.

The majority of irrigation occurs in the summer months when crop demand is high (FBS, 2010). This is a time when the quantity of water used for other purposes increases which can lead to water scarcity and water shortages (Knox et al., 2010).[25] In 2014 agricultural abstraction in England and Wales was 115 million m^3 with 77% being used in irrigation, (AUK, 2015).[26] The proportion of water used from irrigation has remained roughly the same between 2001 and 2010, with the majority of the water abstracted from surface water (52%, 36Mm^3) and ground water (41%, 29Mm^3) of the total water used for irrigation in 2010 (FBS, 2010).[27] East Anglia and the Midlands account for 75% of reported irrigation abstractions each year (Defra, 2016).[28]

The average volume for irrigation is 843 m^3 per hectare of land in England (FBS, 2010). This average volume of water applied for irrigation per hectare is spatially variable (Table 6). The area of irrigated land in the UK in 2010 was 83,000 hectares with the two largest areas irrigated in 2010 were main crop potatoes (31,800 ha) and vegetables (20,500 ha) (FBS, 2010).

[24] Watts, G., Battarbee, R.W., Bloomfield, J.P., Crossman, J., Daccache, A., Durance, I., Elliott, J.A., Garner, G., Hannaford, J., Hannah, D.M. and Hess, T., 2015. Climate change and water in the UK–past changes and future prospects. Progress in Physical Geography, 39(1), pp.6-28.
[25] http://www.foodsecurity.ac.uk/assets/pdfs/farming-availability-water-report.pdf
[26] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/557993/AUK-2015-05oct16.pdf
[27] Defra (2011) Water usage in agriculture and horticulture. Results from the Farm Business Survey 2009/10 and the Irrigation Survey 2010.
[28] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/435394/agindicator-da5-16jun15.pdf

Table 6. Volume of water used for irrigation in England, by region.

Region	Volume per hectare (m^3/ha)
North East	458
North West & Merseyside	574
Yorkshire & The Humber	803
East Midlands	911
West Midlands	789
Eastern	888
South East (incl. London)	755
South West	562
England	**843**

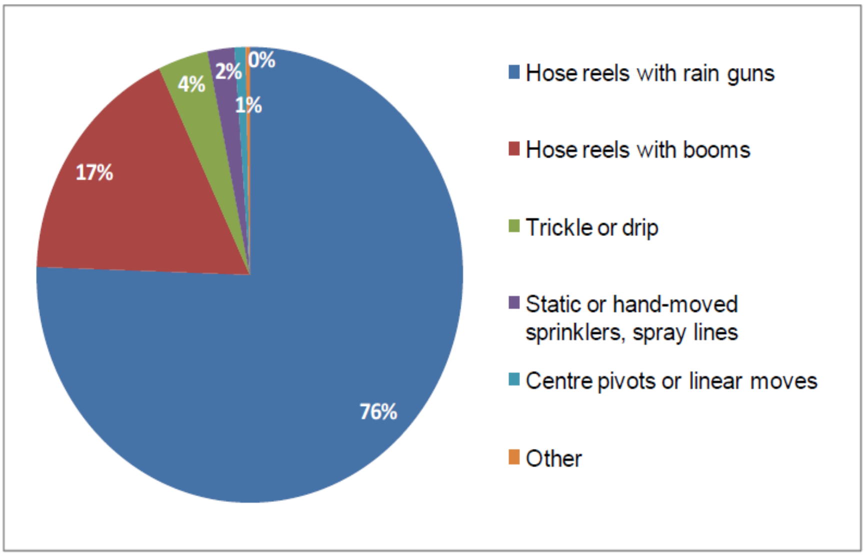
The average surface water consumption in GB for the cultivation of potatoes (Picture 18) is equivalent to 11 m^3/t of potatoes, although this ranges from 19 m^3/t of production in the East of England to 2 m^3/t of production in the North West. There is little variation in the volume of rain water per tonne of production, the quantity of surface water does vary accounting for a quarter to a fifth of water consumption at some sites. Whereas less than 25% of the potato growing area in the South West and North West have any irrigation (Hess et al., 2015).[29]

Picture 18: Significant quantities of irrigation are required for potato production (Photo: Jenny Bashford, AHDB).

[29] Hess, T.M., Lennard, A.T. and Daccache, A., 2015. Comparing local and global water scarcity information in determining the water scarcity footprint of potato cultivation in Great Britain. Journal of Cleaner Production, 87, pp.666-674.

The proportion of irrigation methods by irrigation area are shown in Figure 11 (FBS, 2010). The most popular irrigation methods are hose reels with rain guns (76%) and hose reels with booms (17%), with trickle or drip irrigation accounting for only 4%. Static or hand moved sprinklers (Picture 19) and spray lines account for only 2%.

Figure 11. The proportion of irrigation methods by irrigation area (%).



Picture 19: Static sprinklers are commonly used by hardy ornamental nursery stock growers.

Most irrigation water is abstracted and used immediately without storage (Weatherhead, et al., 2010).[30] 11% of farms have the capacity to store water in tanks, reservoirs, ponds and lakes (FBS, 2010).

4.3 The value of water use for irrigation

The value of water use for irrigation is difficult to estimate because most activities using water for irrigation would cease without available water, and it is not clear what the replacement activity or land use would be. However, it is possible to estimate the output of irrigated crops and their gross margins. We present some estimates in section 3.1 above. In summary, the irrigated crops grown by survey respondents have an output value of £631m, estimated using Defra Farm Business Survey reports and the John Nix Farm Management Pocketbook. Per irrigated hectare, the output value was approximately £15.5k as a mean across all respondents, representing a wide range of £4.4k (for a range of deep-rooted field vegetables) to over £460k (for some high-value glasshouse salad crops).

5 Coping with limited water availability

Limited water availability can lead to crop failure, reduced crop yields and poorer quality crops. Particularly for potatoes, the combined impact of rising temperatures and water scarcity is forecast to reduce potential potato yields by 18-32%, globally between 2040 and 2069 (Obidiegwu et al. 2016)[31]. Water scarcity can also reduce the quality of potato tubers, making the crop more susceptible to diseases such as common scab– see, for example, Knox et al. (2011)[32] for impacts on the UK potato industry and projected water demand. Similarly, water scarcity can affect horticulture crops in terms of continuity of the crop, and volume and quality of yields[33].

The UK government has issued guidance to growers, identifying early actions which can be adopted to reduce the risks associated with water scarcity and to protect their livelihoods (Environment Agency, 2015 – see section 3.2 on 'Agriculture and horticulture')[34]. These actions include:

- Improving irrigation efficiency;
- Extending the period of winter water abstraction (to fill reservoirs at times of high flow);
- Establishing a contingency plan with public water supply bodies; and
- Maintaining a dialogue with local authorities.

There is considerable discussion among researchers concerning irrigation efficiency and its potential to deliver water savings – particularly related to irrigation systems and scheduling. There is also much discussion concerning land management practices with potential to reduce water needs.

5.1 Water efficiencies

Table 7 sets out practical steps which potato and horticulture growers can take to facilitate improved efficiencies in water management.

[30] Weatherhead, K., Kay, M. and Knox, J., 2010. Irrigation water security: promoting on-farm reservoirs in the UK.
[31] Obidiegwu et al. (2016) Coping with drought: stress and adaptive responses to potato and perspectives for improvement. *Frontiers in Plant Science* 6, 542.
[32] Knox et al. (2011) Climate Change Impacts on the UK Potato Industry. Final report prepared for the Potato Council of the AHDB (R404).
[33] Knox et al. (2008) Climate change impacts on water for horticulture.
[34] Environment Agency (2015) Drought response: our framework for England.

Table 7. Practical steps which potato and horticulture growers can take to facilitate improved efficiencies in water management.

Potential techniques to achieve improved water efficiencies	
Drip irrigation systems	Highly uniform application and can help to limit salinity and weeds. This system reduces water use and is suitable for any terrain. Up to 35% water savings can be achieved by replacing high pressure and high flow irrigation systems with low pressure and low flow systems (pers. comm. NIAB CUF[35]). Barriers: Requires maintenance to avoid pipe blockages (particularly in hard water catchments or where the irrigation system is also used to apply fertilisers - fertigation)[36]. Requires energy to deliver low water pressure (although total energy used is less than required to operate sprinklers which typically accounts for ~60% of water application costs; pers. comm. UKIA). Access to adequate power supply can also present a barrier and can increase capital costs where improved pumping equipment is needed. Expensive to purchase and install, and requires training to develop technical skill (see for example the European Innovation Partnership on Agriculture (EIP-AGRI).[37] Reduced water application can reduce crop yield and quality. For potatoes, more water required during scab control periods regardless of the irrigation system (pers. comm. NIAB CUF[38]).
Subsurface irrigation	A variation of drip irrigation which can achieve a highly uniform result – the system is buried below the crop resulting in reduced evaporation and improved distribution efficiency. Barriers: Requires large capital investment to install. Maintenance can be costly as detecting problems is not always evident. Requires training to develop technical skill to operate (see for example EIP-AGRI).[39]
Precision irrigation	Making use of remote sensing technologies to adjust irrigation practices according to spatial variations and avoid overwatering. Barriers: Images can be used to identify crop type and quantify, but not to determine variables in water needs. The use of images is weather dependent (i.e. requires clear skies) and does not provide timely data – i.e. when dry patches are detected it is too late and the damage is done. Thus, the use of images is more effective to pre scan fields to enable any variations in soil or structure to be factor into irrigation (pers. comm. BLSA; Horticultural Trades Association, HTA). Requires Variable Rate Irrigation technologies which are very expensive to design and install. Factoring in spatial variations requires access to soil maps which can be expensive (see for example EIP-AGRI).[40]
Winter storage reservoir	Barriers: The construction of winter storage reservoirs is expensive and there is uncertainty about future water availability for irrigation (Arable Alliance Ltd). Not suitable to all land types, e.g. light land requires reservoir lining which is costly (Dove Associates).
Alternative water sources	Such as rain water harvesting. There are often quality limitations of using borehole water in terms of salinity and pH (Plant Nutrition Consulting).

[35] https://www.2degreesnetwork.com/groups/2degrees-community/resources/pepsi-co-uks-i-crop-allows-growers-produce-5-higher-yields-with-49-less-water/

[36] For information on fertigation see for example: Defra HortLink HL0165LFV 2003-2007. Sustainable improvement of vegetable quality, water and nutrient use efficiency using dynamic fertigation; J.M. Monaghan Rahn, CR and Hilton, H. W. Wood, M. 2010 Improved efficiency of nutrient and water use for high quality field vegetable production using fertigation. Acta Horticulturae 852 145-152

[37] EIP-AGRI Focus Group (2016) Water and agriculture: Adaptive strategies at farm level. Final Report. https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_fg_water_and_agriculture_final-report_en.pdf

[38] https://www.2degreesnetwork.com/groups/2degrees-community/resources/pepsi-co-uks-i-crop-allows-growers-produce-5-higher-yields-with-49-less-water/

[39] EIP-AGRI Focus Group (2016) Water and agriculture: Adaptive strategies at farm level. Final Report. https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_fg_water_and_agriculture_final-report_en.pdf

[40] EIP-AGRI Focus Group (2016) Water and agriculture: Adaptive strategies at farm level. Final Report. https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_fg_water_and_agriculture_final-report_en.pdf

Potential techniques to achieve improved water efficiencies	
Water reuse	There is considerable attention at an EU level to increase the volume of water reuse in agriculture[41]. Currently water reuse represents just 0.6% of total global water use (of which 32% is used for agricultural purposes) (Amec Foster Wheeler, 2016)[42]. Techniques to recycle nutrients and water post plant treatment with techniques for disinfecting have been developed e.g. UV and slow sand filtration (WIRE, Water and irrigated resilient Europe – Project and Demo Sites)[43].
Irrigation scheduling	Existing techniques to improve irrigation scheduling include: water balance calculations, soil sensors, and models. Sensors used include humidity sensors, soil water sensors, turgor pressure sensors, multi sensors (e.g. humidity, light, soil water); sensors are used with software for glasshouse control or irrigation scheduling (pers. comm. HTA). Emerging sensor technologies include: nano-sensors, sap-flow, dendrometers (EIP-AGRI)[44]. Barriers: Knowledge needed to decide on triggers and irrigation needs. Lack of reliable information to inform growers about which technologies are best suited to their needs – and how to interpret the data gathered (e.g. in terms of monitoring assessing soil water deficit, deciding on deficit thresholds, recommending irrigation amounts; pers. comm. Plant Nutrition Consulting).

5.2 Land management

In addition to improvements to efficiency, certain land management practices can help to improve soil water availability and retention. See, for example, AHDB's technical notes to better understand irrigation needs:

- Irrigation and water use[45] (Best practice guide for potatoes)
- Seasonal water management for potatoes[46]
- Over-watering potatoes and the risk of growth cracks[47]
- Late-season management of irrigation to avoid bruising and manage skin set[48]

EIP-AGRI[49]: the European Innovation Partnership on Agriculture (EIP-AGRI) is a platform intended to facilitate the development of innovation in the field of agriculture 'to foster competitive and sustainable farming and forestry'. The platform serves to improve collaboration between relevant stakeholders, in particular improving networks between the demand and supply sides, to contribute to the provision of a secure and stable supply of food, feed and biomaterials. The following points are from the "EIP-AGRI Focus Group (2016) Water and agriculture: Adaptive strategies at farm level".

- Soil management for improved water availability – low soil disturbance to reduce runoff and evaporation
- Crop diversification
- Establishing natural water retention measures such as buffer strips, grassland, terracing, ponds, etc.
- Options to develop more resilient crop species [and varieties] to water scarcity are currently being explored and may be an alternative to help potato and horticulture growers cope with limited water availability in the future.

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[41] http://ec.europa.eu/environment/water/reuse.htm
[42] Amec Foster Wheeler (2016) EU-level instruments of water reuse. http://ec.europa.eu/environment/water/blueprint/pdf/EU_level_instruments_on_water-2nd-IA_support-study_AMEC.pdf
[43] http://www.eip-water.eu/sites/default/files/WIRE_demo%20sites.pdf#overlay-context=WIRE
[44] EIP-AGRI Focus Group (2016) Water and agriculture: Adaptive strategies at farm level. Final Report. https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_fg_water_and_agriculture_final-report_en.pdf
[45] http://potatoes.ahdb.org.uk/sites/default/files/publication_upload/Irrigation%20for%20potatoes_0.pdf
[46] http://potatoes.ahdb.org.uk/sites/default/files/Seasonal%20Water%20Management%20for%20Potatoes.pdf
[47] ttp://potatoes.ahdb.org.uk/sites/default/files/AHDB%20Potatoes_Over-watering%20Technical%20Note_FINAL_31Jul15_4.pdf
[48] http://potatoes.ahdb.org.uk/sites/default/files/publication_upload/20%2008%202015%203%20Late-season%20water%20management.pdf
[49] EIP-AGRI Focus Group (2016) Water and agriculture: Adaptive strategies at farm level. Final Report. https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_fg_water_and_agriculture_final-report_en.pdf

- The use of water retaining products in soils: The use of certain products, such as biochar or zeolite, can marginally increase the water holding capacity of soils.

5.3 Barriers to water management improvement

In the context of potato and horticulture growers, survey respondents have indicated a low uptake of the less intensive irrigation systems. This is also evident in country wide statistics which indicate that in 2010 irrigation in the UK was predominantly applied with rain guns (76%) and booms (17%, Picture 20). While sales figures for 2016 indicate that there has been an increase in boom irrigation systems, the number of sales for drip irrigation systems remains constant and comparatively low[50]. Survey respondents also indicated a low uptake of technologies to support water management (such as smart water metres, professional irrigation scheduling services / computer programme, timing systems, soil or substrate moisture monitoring, transpiration/humidity measurement, collection of drainage water for recirculation, and drones for crop / nutrient mapping).

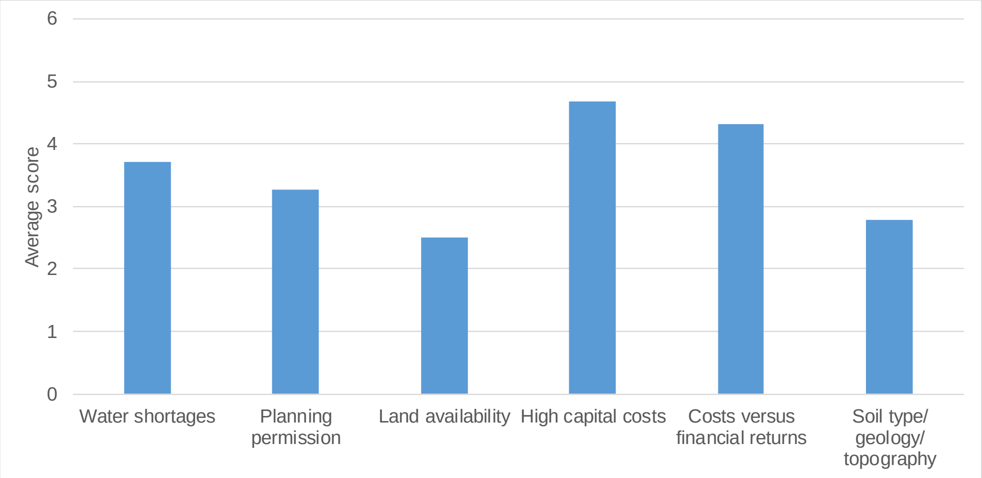
Picture 20: Boom irrigation and rain guns are the most commonly used forms of irrigation in field grown crops (Photo: Jenny Bashford, AHDB).

Specifically, the survey asked respondents to identify what actions they have taken in the past five years to manage water shortages and/ or improve water use efficiency. Respondents most commonly reported that they had taken the following actions: night irrigation, improved monitoring and scheduling of crop water use, installing new irrigation technologies or systems, and prioritising irrigation of different crops. Few respondents reported making use of the following actions: trading water with other users, adjusting winter abstraction period / extending licence dates, installing rainwater harvesting / recycling, and applying voluntary restrictions during shortages.

According to survey respondents, the most important barrier for low uptake of the less intensive irrigation systems is the high capital costs required to purchase the equipment and install it. Figure 12 shows barriers to water storage: average importance ranking on a scale of 1 (least important) to 6 (most important).

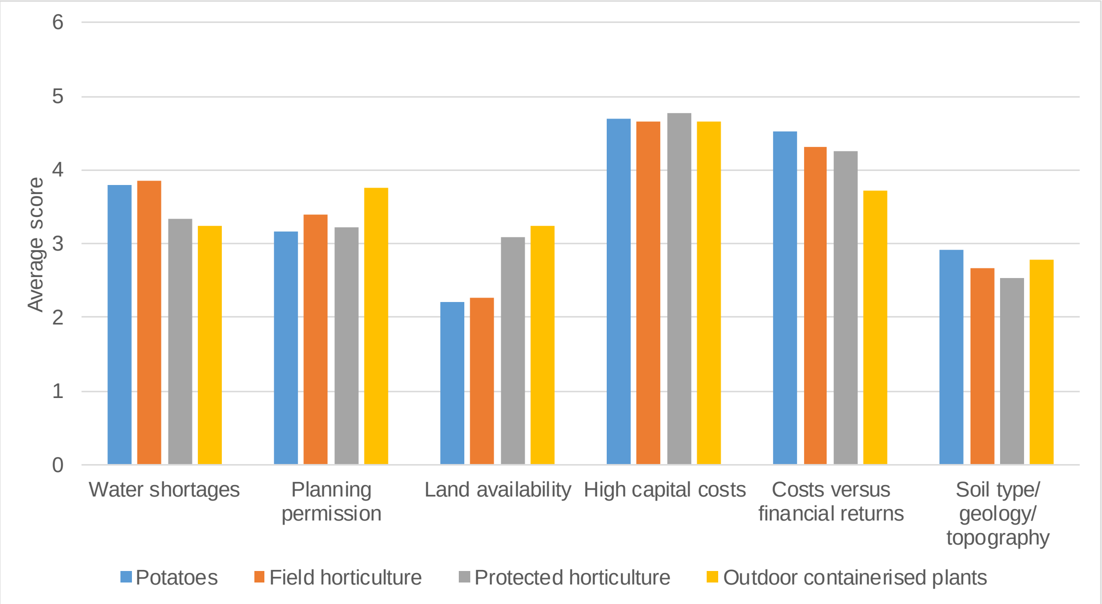
[50] https://www.2degreesnetwork.com/groups/2degrees-community/resources/pepsi-co-uks-i-crop-allows-growers-produce-5-higher-yields-with-49-less-water/

Figure 12. Barriers to water storage: average importance ranking on a scale of 1 (least important) to 6 (most important).



Water shortages had greater importance for potato growers and field horticulture, compared with protected horticulture and outdoor containerised plants, reflecting the greater quantities of water used by potato growers and field horticulture. Figure 13 shows barriers to water storage for each main production sector: average importance ranking on a scale of 1 (least important) to 6 (most important).

Figure 13. Barriers to water storage for each main production sector: average importance ranking on a scale of 1 (least important) to 6 (most important).



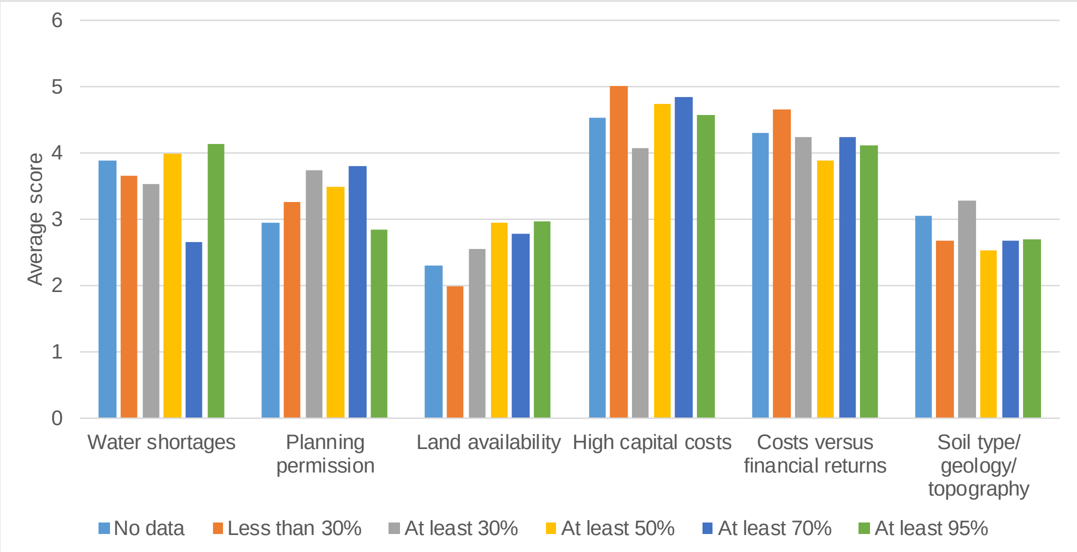
Land availability had greater importance for protected horticulture and outdoor containerised plants compared with potato growers and field horticulture, reflecting the smaller land areas typically available to businesses in protected horticulture and outdoor containerised plants. This point was again raised in the follow up interviews by a representative for the Cucumber Growers Association and by experts on the technical panel.

Costs *vs* financial returns had greater importance for potato growers and field horticulture, compared with protected horticulture and outdoor containerised plants; for the latter two main sectors, irrigation is essential to business continuity, rather than a choice.

There were no strong patterns in the data for water availability categories (Figure 14).

Lack of information also appears to be a barrier to uptake for many survey respondents with several information gaps identified in relation to: water abstraction and what is currently permitted as well as what is being discussed in relation to the reform; collaboration between water users in a catchment area; installation of water storage facilities; reusing water (including the installation of rainwater harvesting systems and water quality in terms of removal of plant pathogens and acceptable salinity levels, etc.).

Figure 14. Barriers to water storage for each water availability category: average importance ranking on a scale of 1, least important, to 6, most important.



5.4 Solutions

Water scarcity is a global concern and as such solutions are being discussed in multiple fora. At an EU level, a focus group on water and agriculture has been established as part of the European Innovation Partnerships initiative[51]. Over the course of the past year experts from across the EU have joined forces to identify what farmers are currently doing in response to water scarcity, assess success and fail factors, identify needs for the farming sector and propose actions "to stimulate the knowledge and use of adaptation measures/strategies to water scarcity and to multiply positive effects within the agricultural sector."

The Focus Group identified the following needs to support farmers in overcoming barriers to adopting actions that can help alleviate some of the pressures caused by water scarcity:

- Cost-benefit assessments at farm level to show clear economic returns. Moreover, this study has found that there is a common scepticism among growers that efficiency will only achieve minor improvements (pers. comm. British Leafy Salads Association, BLSA)
- Benchmarking and targets for water productivity under good agronomic management to set targets for water use to help farmers identify where water management could be improved.
- Knowledge sharing and awareness raising
- Lack of training – especially for interpretation of data to inform optimal irrigation and best practices for irrigation system maintenance
- Develop drought resilient crops and technologies to reuse water to protect against human pathogens
- Improve institutional support

[51] https://ec.europa.eu/eip/agriculture/en/content/water-agriculture-adaptive-strategies-farm-level

6 Recommendations for the industry

6.1 Knowledge exchange

- Provide regular updates on the planned changes to abstraction licencing.
- Support growers to increase recirculation of water in protected and container production.
- Growers need improved knowledge of new technologies and systems for water application.
- Training programmes are needed for irrigation system maintenance.
- Provide guidance and training to growers and their advisors for interpretation of data from new technologies.
- Share knowledge of water management best practices.

6.2 Actions for growers and their advisors

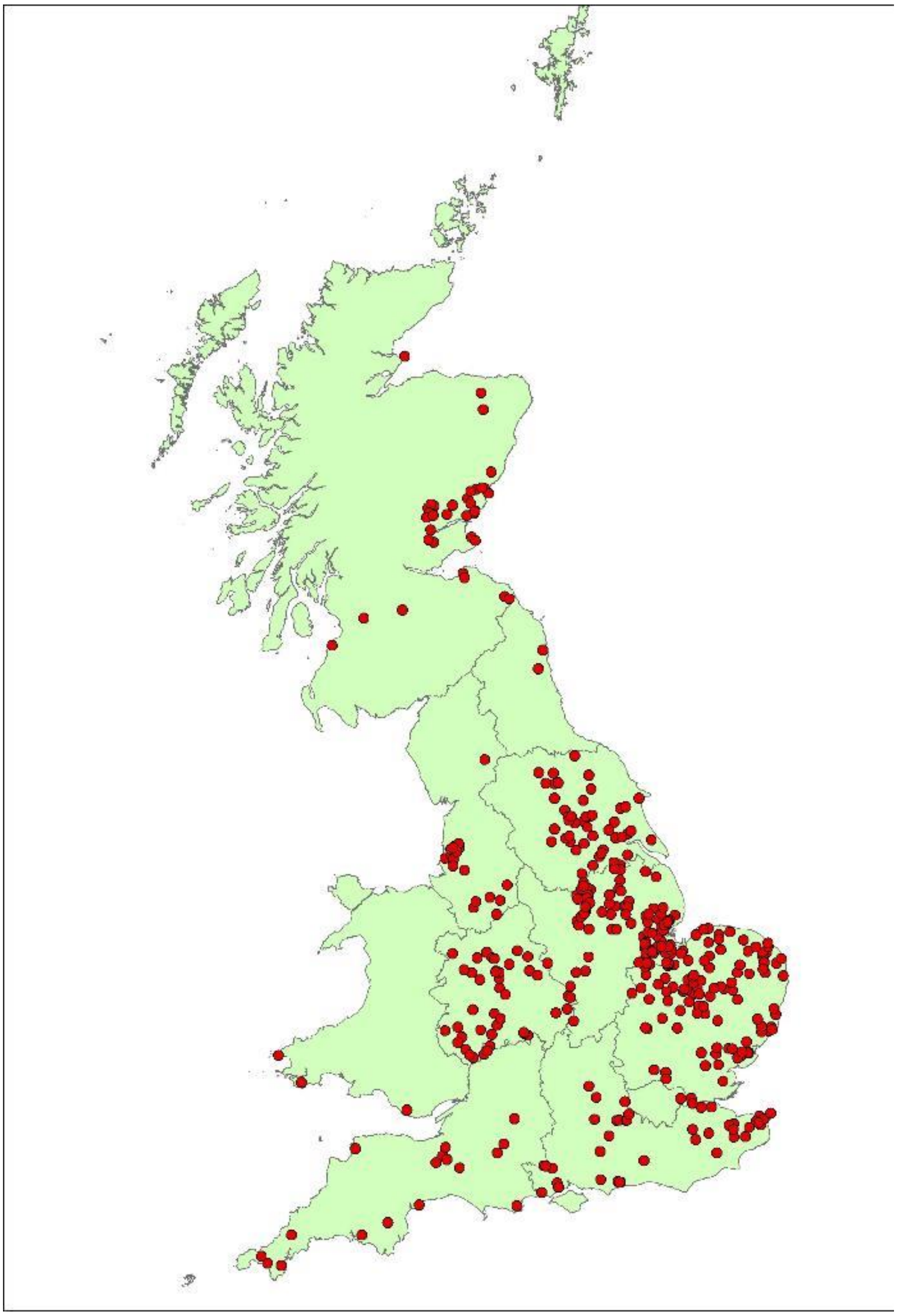
- Growers should quantify their 'headroom' and take account of this in business planning.
- Cost-benefit assessments at farm level are needed to economic returns from improved water management.
- Land management improvements are needed to improve soil water storage and retention.
- Consider feasibility of investing in water storage on holdings, e.g. reservoirs.
- Maximise rain water harvesting and grey water recycling where this has business benefits.
- Identify how water management at a holding level could be improved.
- Make cost-benefit assessments a holding level to show clear economic return.

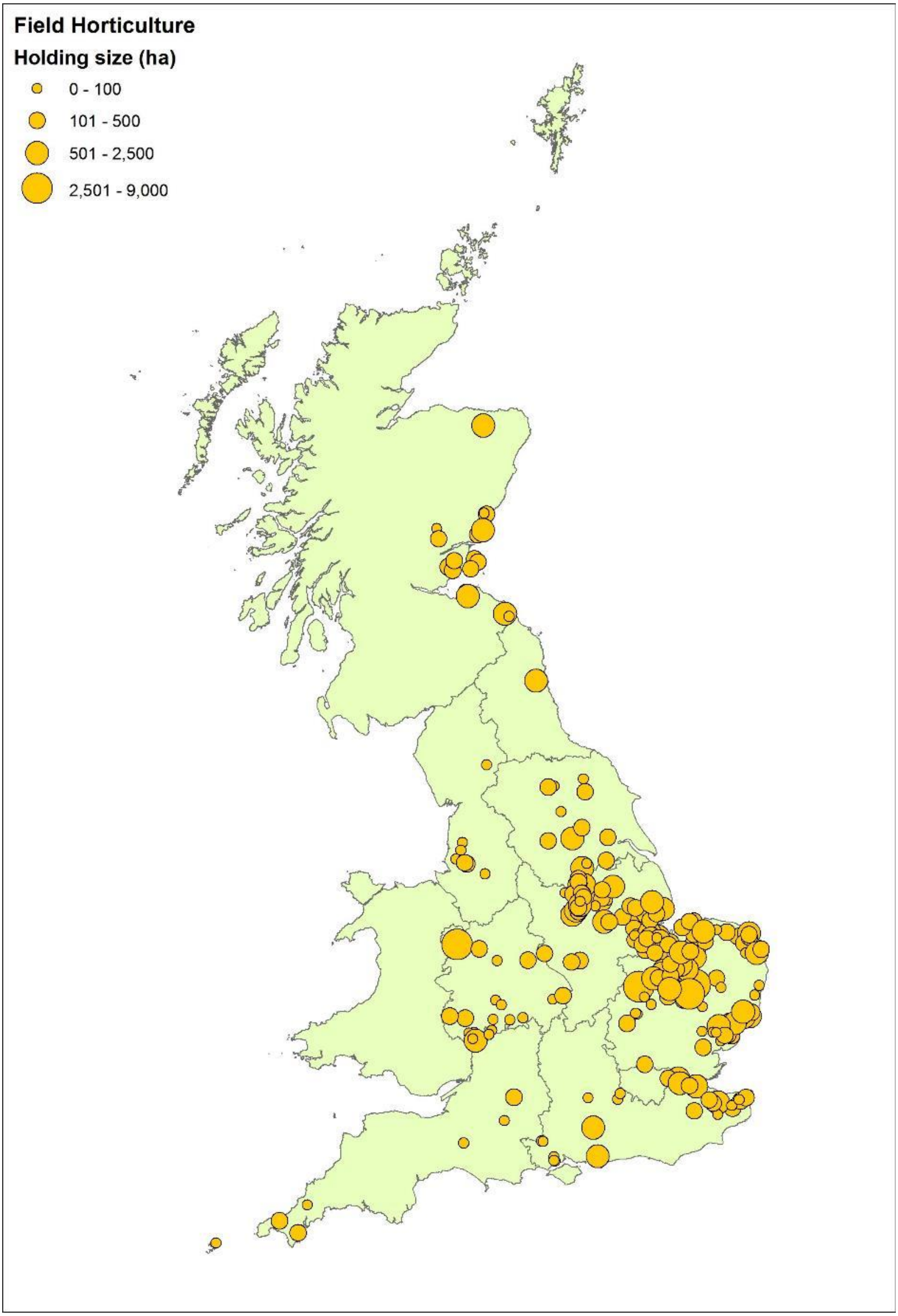
6.3 Research needs

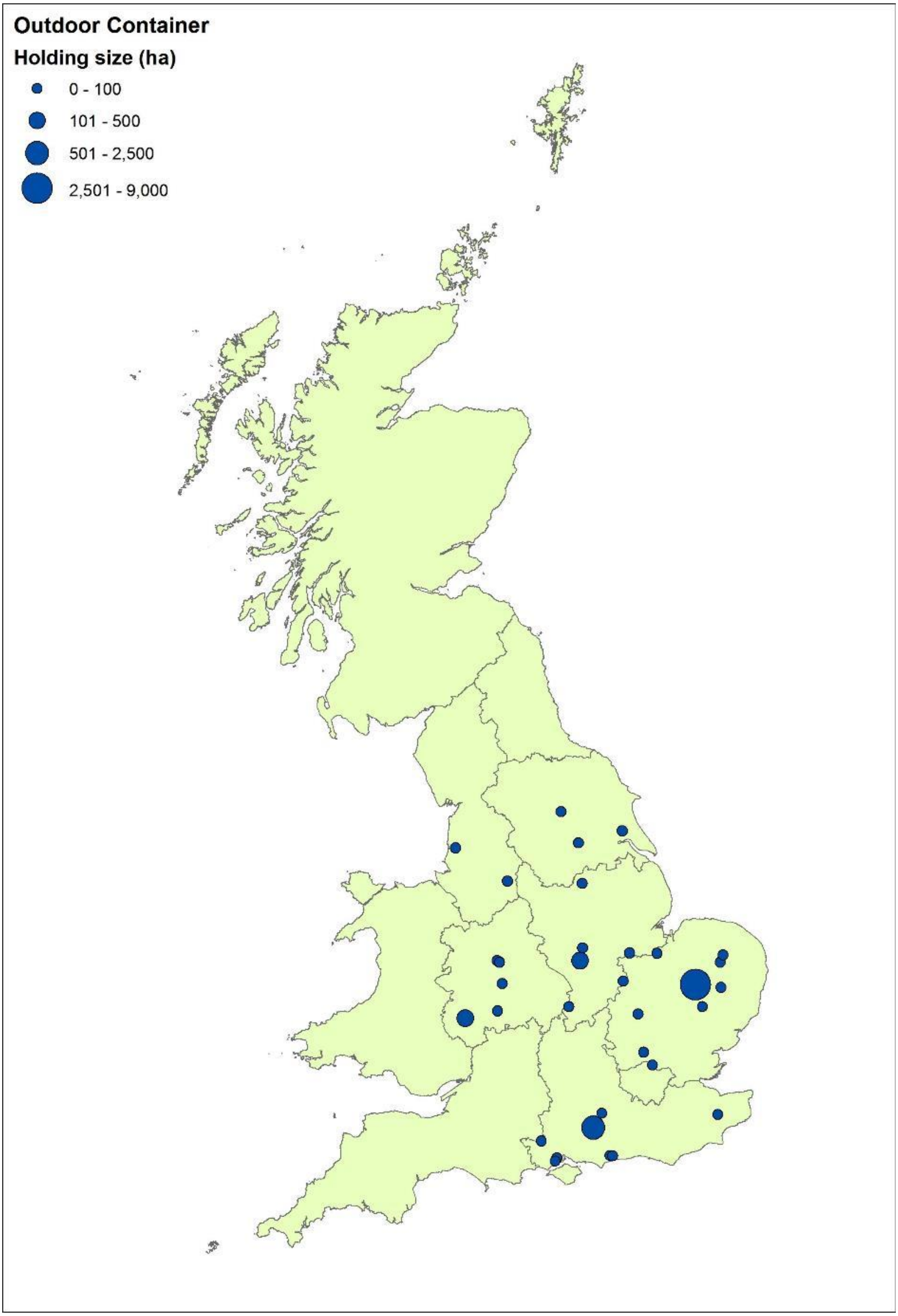
- There is a need to more benchmarking of water use for a range of crops to help growers identify improvements.
- Development of drought resilient crops and technologies should be accelerated.
- Improve the understanding of water use efficiency by crops (related to crop uptake).
- Knowledge for understanding data from new technologies needs to be better organised to facilitate knowledge exchange.

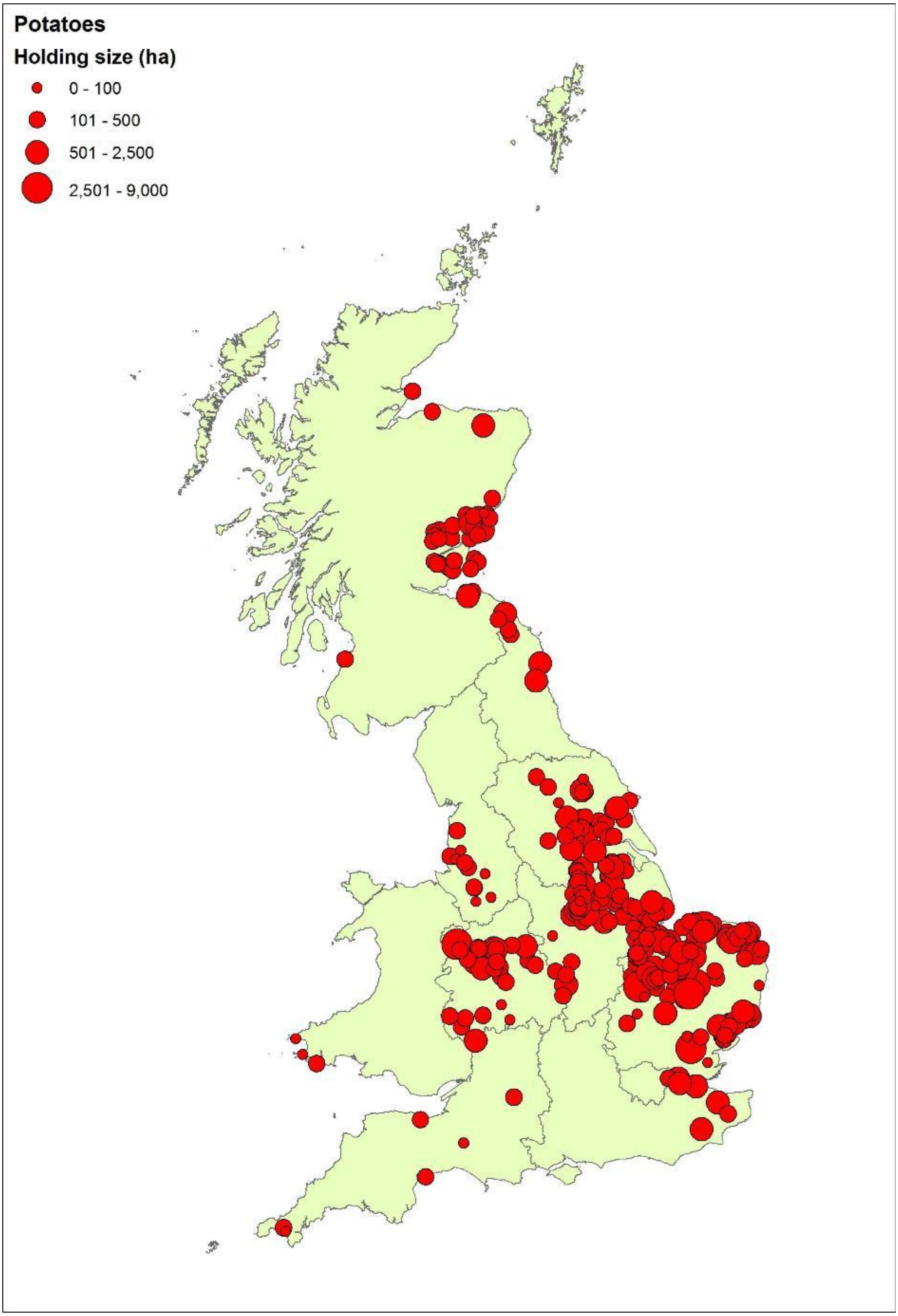
Appendix 1: supplementary images

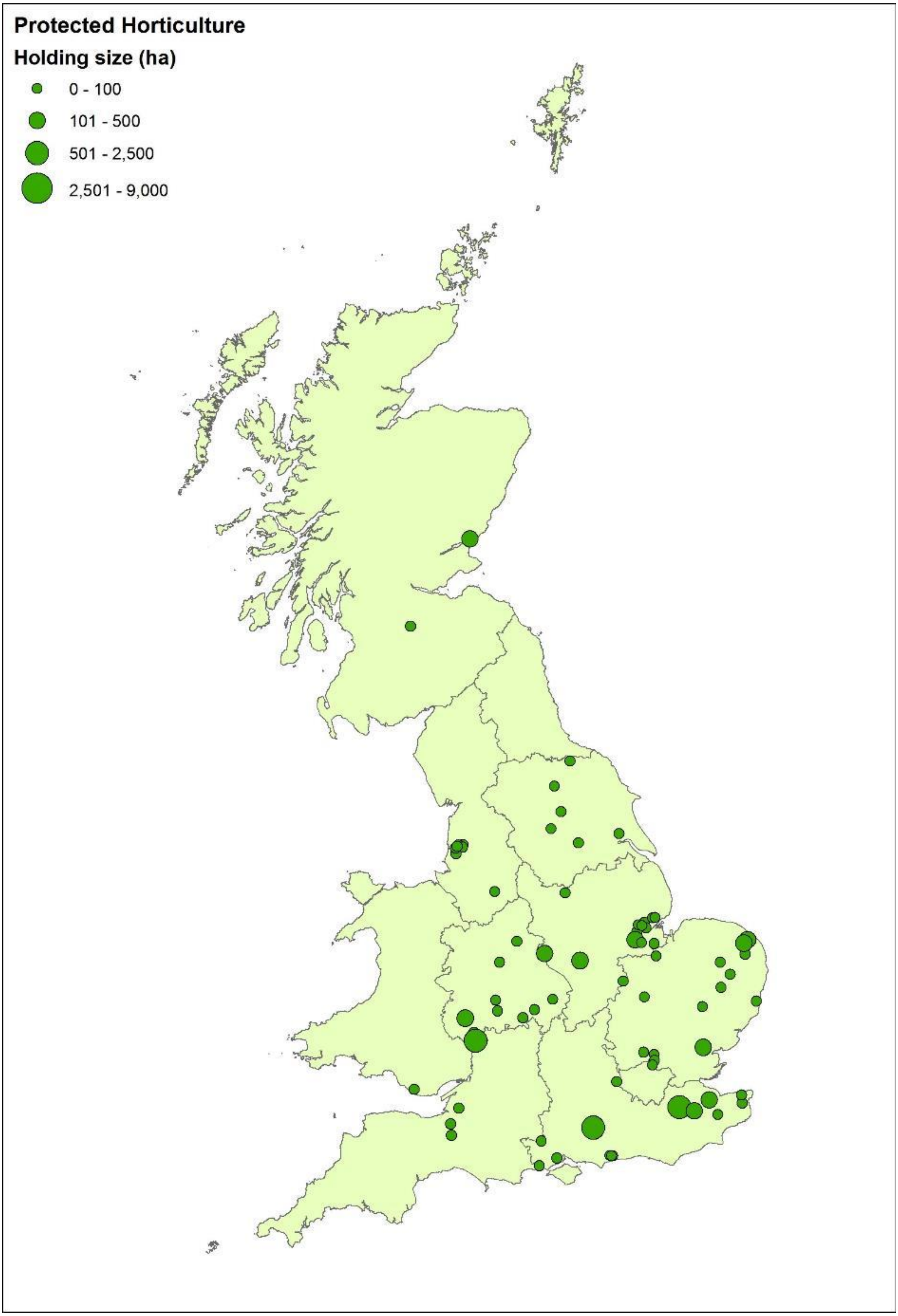
The maps that follow show survey response locations (first map), then subsequent maps show survey response locations by holding size, storage capacity, water availability category, and area of irrigable land. These can be provided as separate files on request.

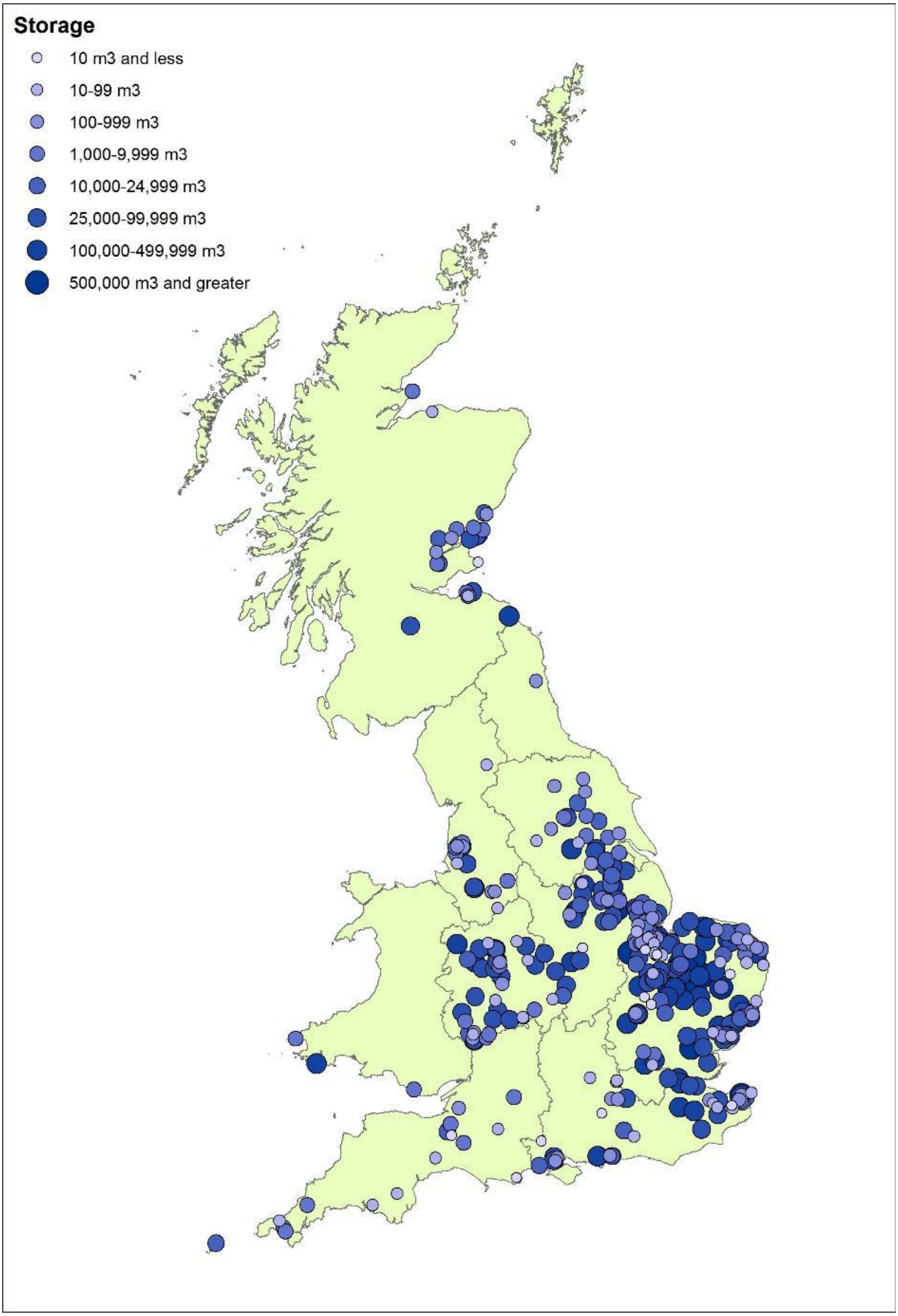


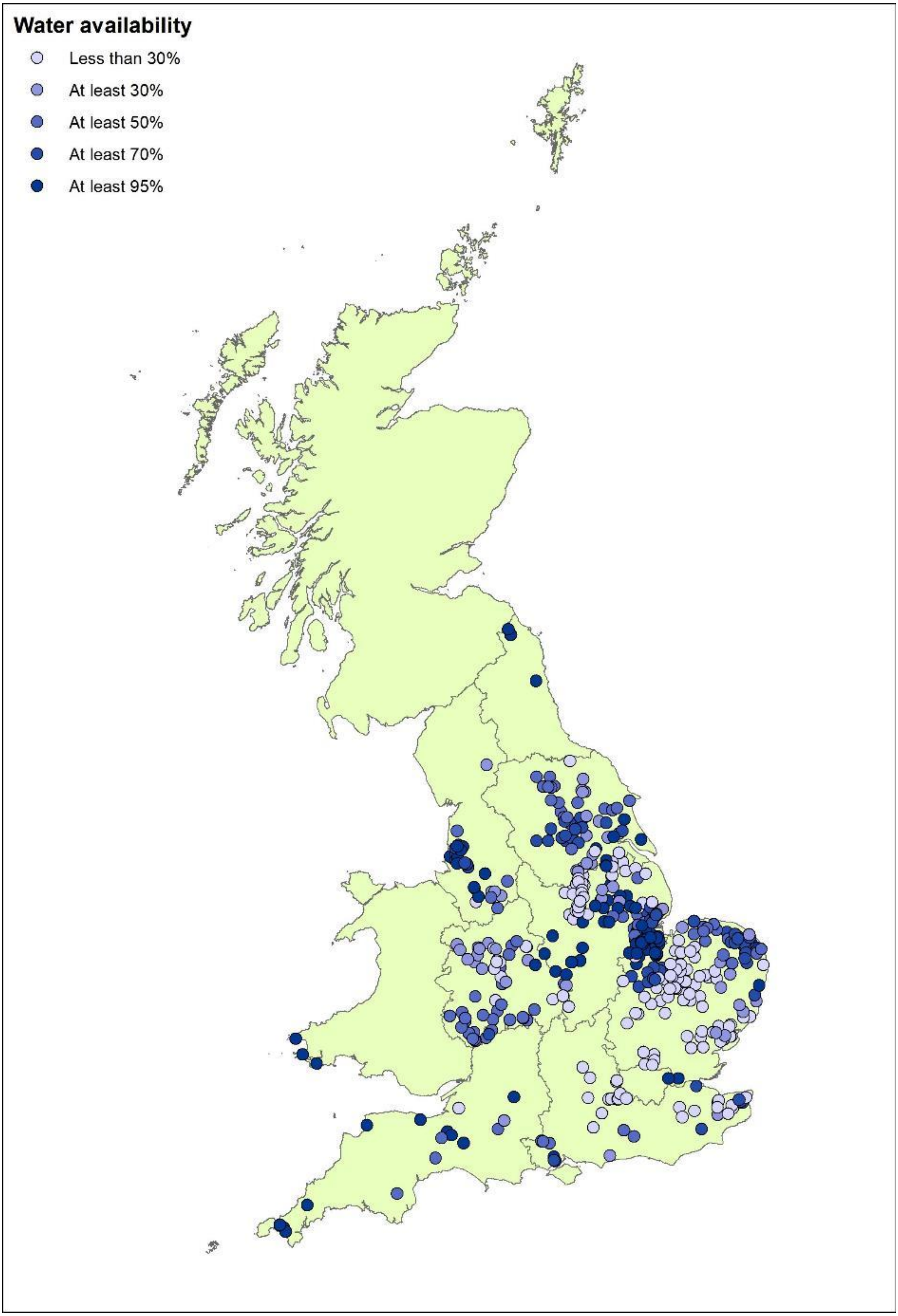

Field Horticulture
Holding size (ha)
0 - 100
101 - 500
501 - 2,500
2,501 - 9,000

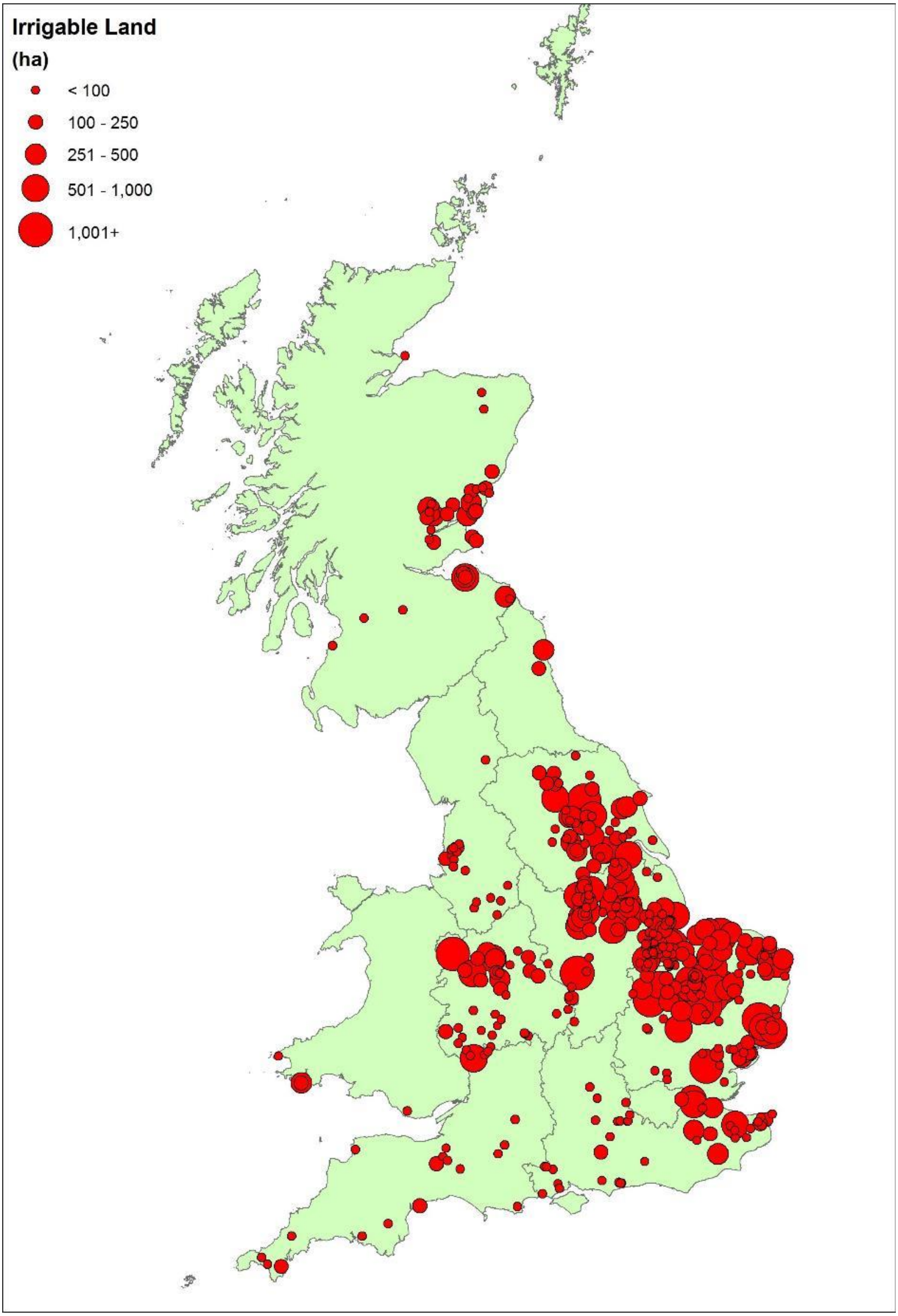

Outdoor Container
Holding size (ha)
0 - 100
101 - 500
501 - 2,500
2,501 - 9,000


Potatoes
Holding size (ha)
0 - 100
101 - 500
501 - 2,500
2,501 - 9,000

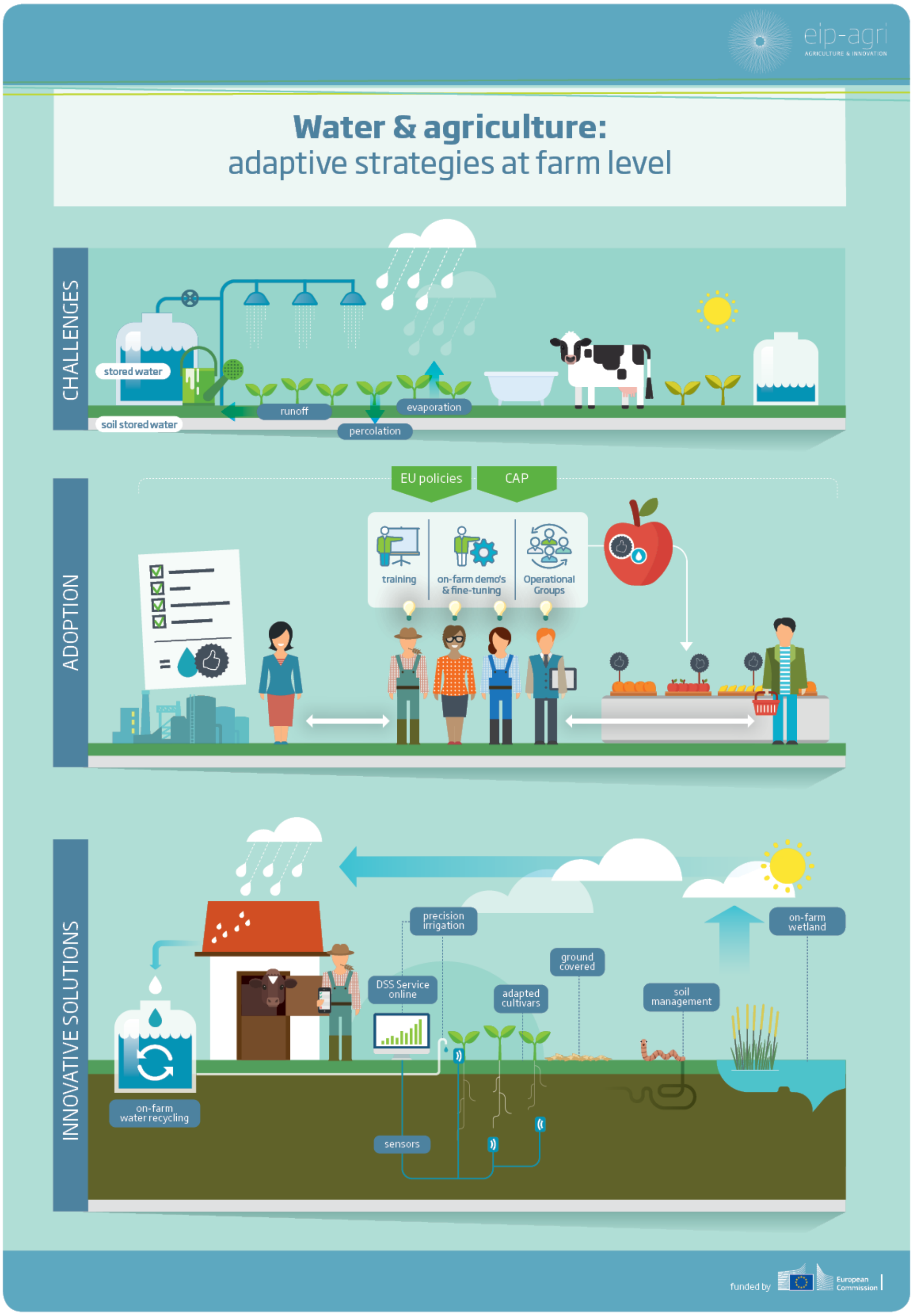

Protected Horticulture
Holding size (ha)
0 - 100
101 - 500
501 - 2,500
2,501 - 9,000


Storage
10 m3 and less
10-99 m3
100-999 m3
1,000-9,999 m3
10,000-24,999 m3
25,000-99,999 m3
100,000-499,999 m3
500,000 m3 and greater


Water availability
Less than 30%
At least 30%
At least 50%
At least 70%
At least 95%


Irrigable Land
(ha)
< 100
100 - 250
251 - 500
501 - 1,000
1,001+

EIP-AGRI Infographic Water & agriculture[52]



[52] https://ec.europa.eu/eip/agriculture/en/content/water-agriculture-adaptive-strategies-farm-level

The following two images were provided by Jenny Bashford of AHDB (in addition to Pictures 18 and 20) and should be acknowledged if used in the Stakeholder Document. These can be provided as separate files on request.

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