Impact of 2014 Winter Floods on Agriculture in England

Prepared for: **Defra**

Prepared by: **ADAS UK Ltd**
Contact:
John.elliott@adas.co.uk

Approved by: Susan Twining

Date: 4 June 2014

0936648

Contents

List of Tables

List of Figures

1. Background

During the period from mid-December through until early February the UK suffered a spell of extreme weather, with a series of very large winter storms battering the country. Much of the UK has suffered from extensive flooding after January 2014; this period saw the highest rainfall on record, with particularly pronounced effects in the Thames Valley and West of England. The resulting flooding was a combination of fluvial, pluvial and groundwater flooding with an element of coastal flooding in some areas[1]. Beyond the problems of land being under water, adjoining areas and areas of poor drainage or high water tables were also subjected to waterlogging of soils, although this study focuses on the impacts of flooding *per se*.

Rainfall in January averaged 150mm across England and Wales, but up to 200mm in Wales and the South West region resulting in flooding in the Somerset levels and Severn Valley.

In February, the average rainfall for the month was 109 mm for England and Wales, but up to 134 mm in the South East region and 142 mm South West region. Most of this rain fell in the first two weeks resulting in continued flooding in Somerset and Severn Valley, and extensive new flooding in the Thames Valley.

Most of the flooding was limited to the low lying areas near water courses, which tend to be grazing land, although some arable and horticulture land was also affected. The severity of flooding varied at a local scale.

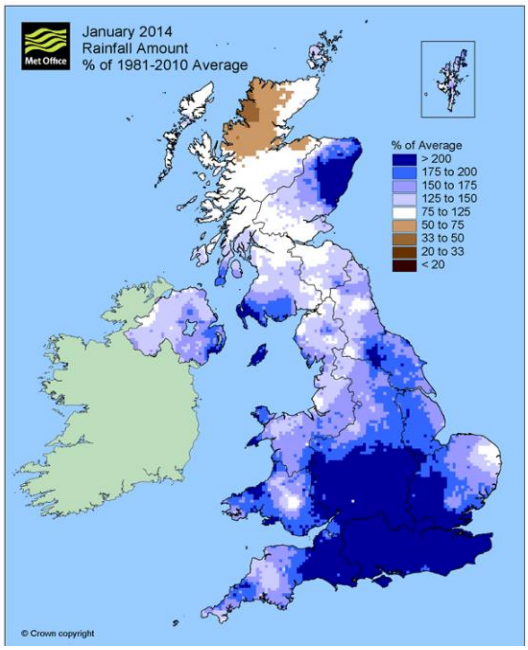


Figure 1: Met Office rainfall anomaly maps for the UK in December 2013 and January 2014, compared to the 1981-2010 average

Away from the main flooded areas, the high rainfall across much of the south of England resulted in saturated soils, ponding in poorly drained areas of fields and some problems with groundwater flooding due to the high water tables. In these areas flooding was caused by a combination of pluvial flooding, where high rainfall on saturated soils generates run-off beyond the drainage capacity and groundwater flooding, where water levels in the ground rise above the surface after prolonged high rainfall.

The floods impacted on the agricultural sector through damage to or loss of established crops (grass and winter-sown arable crops), inability to access land to manage crops or drill new crops, damage to stored crops and forage stocks, costs of movement and/or feeding of livestock, damage to infrastructure and costs associated with the clean-up operation.

[1] http://www.local.gov.uk/flood-and-coastal-erosion-risk-management/-/journal_content/56/10180/3571890/ARTICLE

Research objectives

This research work was commissioned to provide Defra with an early estimate of the economic cost of the floods on different farm sectors and to inform decisions regarding financial compensation measures. This work was undertaken between mid-March and early April 2014 in order to capture an early indication of flood impacts, however this did mean that some impacts were not fully understood as recovery operations were still underway.

The overall aim is to make an economic assessment of the impacts of the winter 2013/14 flooding on agriculture. Specific aims are:

- To assess the extent of the flooding over winter 2013/14 and land affected
- To assess the effects of the flooding on agriculture in the short, medium and long term
- To estimate the economic impacts

Timeframe for analysis

It is important to note that this research was commissioned during the flooding event, after it became evident that there were potentially significant impacts on agriculture but before the waters had subsided. As such, the approach to estimating impacts is necessarily high-level, based on estimates of the land area affected, its agricultural use and limited information on crop damage, associated costs to livestock enterprises or clean-up costs.

For a robust analysis of flood damage costs it would be necessary to undertake an *ex post* study, involving an audit of a reliable sample of affected farms and based on evidence of actual impact. This was evident from analysis of the 2007 summer floods in Britain (Posthumus *et al*, 2009)[2] which found that flood damage costs were skewed, with the majority of the farms facing lower losses than the average and a few farms incurring very high losses.

[2] Posthumus, H., Morris, J., Hess, T.M., Neville, D., Phillips, E. and Baylis, A. (2009) Impacts of the summer 2007 floods on agriculture in England, Journal of Flood Risk Management, pp1-8

2. Methodology

There are two discrete elements of work which need to be undertaken to estimate flood damage costs to agriculture, namely:

i. Scoping the scale and severity of the flooding and mapping the flooded area against land use datasets to estimate which agricultural land use and enterprises have been affected; and

ii. Quantifying and valuing the impacts of the flooding on agricultural sectors in terms of output and inputs and the additional costs incurred due to infrastructure damage, clean-up costs etc.

The methodology used to undertake are considered below in detail.

2.1 Mapping flood events and land use

Scale and severity of flooding

Flood data from the Environment Agency from 7th January to 16th March 2014 indicates that the flooding affected a various parts of the south of England and for the purpose this analysis, a number of discrete flood areas have been identified, as detailed in Figure 2. The mapped flood extents show extensive flooding in many of the southern England river systems with longer term flooding (>30 days) significant in Thames Valley and Somerset Levels.

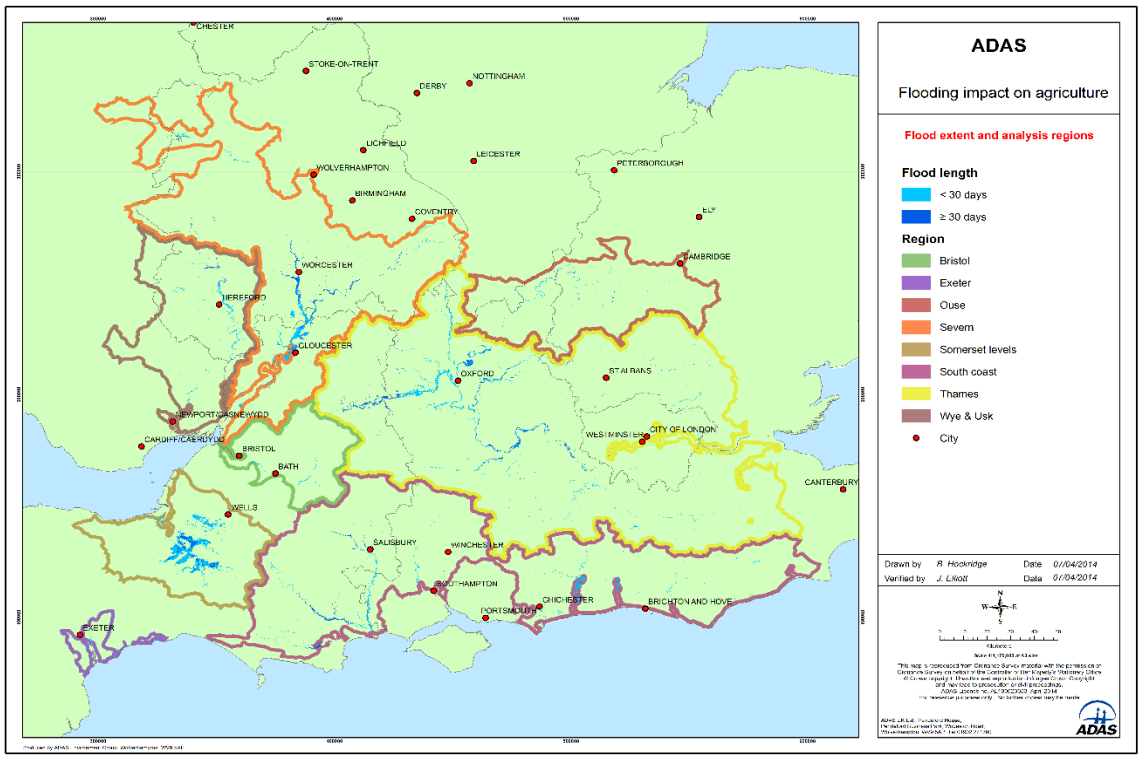


Figure 2: Mapped flood extents for winter 2014 by river system

Flooded areas will be considered in three study regions, as follows:

i. Somerset Levels – as defined by land under water

ii. Thames valley – affected areas along the floodplain

iii. Other areas - including Bristol, Exeter, Ouse, Severn, the South coast and Wye & Usk.

More detailed maps of the Somerset Levels and Thames Valley flood areas are shown at annex 1.

For each study region, the severity of flooding was estimated based on the duration of land under water. While it is recognised that there is not a simple linear relationship between flood duration and severity - short duration flooding on sensitive crops can be severe while longer-term flooding of permanent pasture on floodplains can be tolerated – the analysis of flooding duration across the three regions (see annex 2 and Figure 3 below) indicates relatively constant area under water between 15 and 30 days. Given this and the uncertainties in the accuracy / reliability of the land use data, a simple binary approach was adopted using a single threshold of 15 days for all crops. This threshold 'days under water' was used as a proxy for allocating land area in terms of crop viability i.e. when under water for 15 days or more, crops were assumed be dead or beyond recovery. For winter-sown arable crops and horticultural crops this was estimated at 15 days but established grassland is generally more resilient and might recover after being under water 20-30 days.

Figure 3 below highlights the distribution of land under water over time for the Somerset Levels, indicating an area of around 14,000 hectares which was under water for 3-4 weeks, with the area then falling away over time.

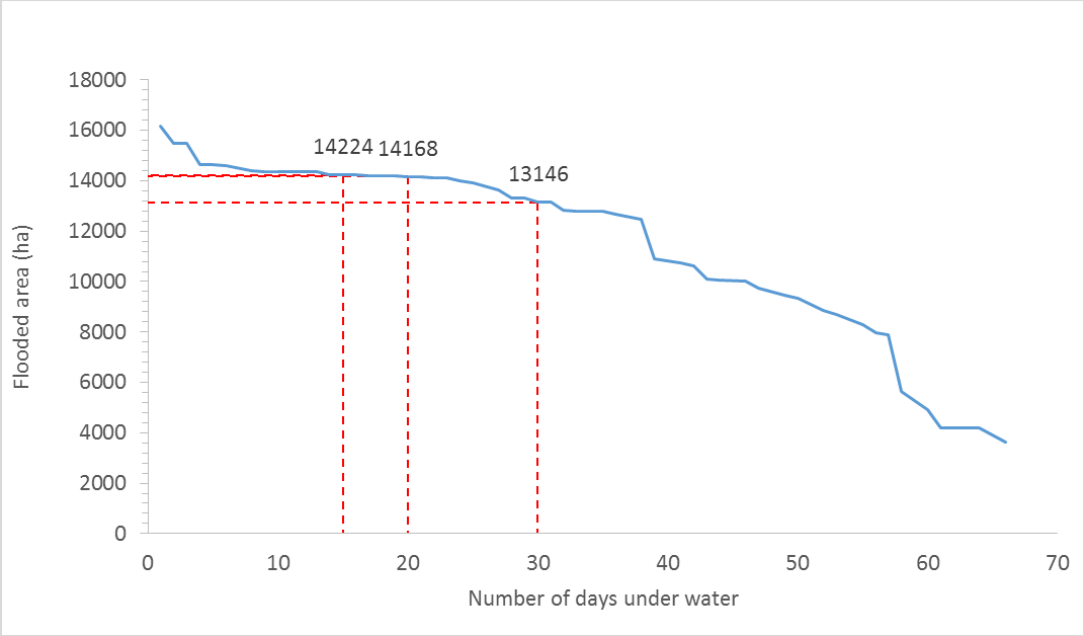


Figure 3: Distribution of land area under water from January 2014 (Somerset Levels)

Land use and associated enterprises

This flooded area was then mapped onto the 1km^2 Land cover and cropping / livestock data (refer annex 3 for detailed methodology), to provide estimates on areas of land use lost to flooding, based on percentage coverage.

The Land cover 1km^2 data was only able to provide limited accuracy when assessing land use coverage, particularly when focusing around linear features such as rivers. The distribution of land use within a given grid square can vary; certain land-use types are more likely to be closer to rivers, while others are more likely to be further away. When analysing the 1km^2 gridded data, an even distribution of land use type for the coverage area was assumed. This could therefore have led to an over or under representation of the coverage of some land use types.

Further data assumptions and limitations include:

- Limited resolution of the satellite data and the accuracy in the classification process.
- Regularity of data availability between areas varied greatly which often led to large data gaps for some areas.
- Analysis carried out on the flood data calculated the maximum time any given area might have been flooded for; large gaps in data may have led to an over-estimation of flood duration.
- There may also have been under-estimation of flood duration where only one period of satellite coverage is provided.
- Information provided by the flood data only describes if the area is flooded or not; it does not provide any further information on the flood depth.

2.2 Estimating damage costs

The analysis of damage costs is required to follow the protocols used by the Environment Agency (EA) for the assessment of flood risk for agriculture, namely the Multi-Coloured Manual (MCM) (Penning-Rowsell *et al*, 2013)[3] and accompanying MCM Handbook. This sets out a preferred approach for the appraisal of flood risk management for agriculture, including the following three steps:

Step One: Defining agricultural productivity

Step Two: Defining the impacts of flooding

Step Three: Expressing any difference in monetary values

The approach used within each of these stages is set out below in turn.

Defining agricultural productivity

The GIS mapping allows for allocating land use into major crop and grassland types but no attempt has been made to map soil class or soil 'drainage' conditions (as determined by field water table levels during critical periods) in order to further qualify the productivity of the land subject to flooding. This reflects the limited timescale for the work, wider uncertainties in the land use data and the fact that the productivity of the land is most often reflected in its land use and stocking rates. Instead a generic approach has been taken, using average economic data for outputs and inputs for the main farm types in England. This limits the robustness of the analysis at a local scale but is proportionate for this high-level analysis.

Defining the impacts of flooding

Flood damage costs are considered using the discrete categories set out on the MCM, as detailed at annex 5. These are - damage to arable, grass and other crops, to livestock enterprises and 'other' impacts at the farm scale.

[3] Penning-Rowsell, E.C., Priest, S., Parker, D., Morris, J., Tunstall, S., Viavattene, C., Chatterton, J. and Owen, D. (2013) Flood and Coastal Erosion Risk Management: A Manual for Economic Appraisal, London and New York, Routledge.

The scope of these costs is broadly defined as follows:

- Flood costs for **arable crops** include loss of the value of output, additional inputs less any savings in uncommitted costs, such as harvesting and remedial work including land restoration and re-sowing crops.
- For **grassland**, the impact of a flood occurring in a given month is assessed in terms of the loss of animal feed, valued at substitute feed prices, less any savings in hay/silage making costs if relevant.
- **Livestock** costs include the cost of relocating and/or housing animals, including additional feed and bedding costs, increased morbidity/mortality and loss of sales.
- '**Other'** costs include damage to field infrastructure (fencing, drains), utilities, machinery, buildings and contents, and the cost of clean-up.

The general formula for estimating the costs of a single flood event is therefore represented as:

$$C_{FARM} = ARABLE + GRASS + LIVESTOCK + OTHER$$

where:

C_{FARM} = cost of flood damage to farming business: agricultural damage (£)
$ARABLE$ = cost of flood damage to arable (or horticultural) crop production (£)
$GRASS$ = cost of flood damage to grass production (£)
$LIVESTOCK$ = cost of flood damage to livestock production (£)
$OTHER$ = miscellaneous costs

The experience from previous flood impact studies, notably the 2007 summer floods, is that it is difficult to anticipate the scale of the economic cost in the immediate aftermath of the flood events. Instead, an *ex post* analysis, involving detailed consultation with a representative sample of affected farms allows a more systematic audit of damage costs and associated indirect costs as used by Posthumus *et al* (2009). In this instance, the requirement is for an outline assessment of costs before the waters have fully receded and a pragmatic approach has been adopted to secure this within the short timescale for the initial phase of this study. It relies on collating the publicly available information and consultation with a group of local stakeholders. Additionally, the ADAS team used its expert knowledge of the agricultural sector and local knowledge of the affected areas to inform the analysis.

The first step was to scope the range of potential impacts by sector based on local knowledge and various publically available reports and news coverage. Key gaps in knowledge were identified and used to develop an outline questionnaire for use in telephone interviews for local stakeholders (see annex 4). The telephone consultation was conducted between 14 March and 31 March 2014 with a range of stakeholders in the Somerset Levels and Thames Valley areas. This was an informal consultation to obtain a range of views on the impacts of the floods to identify the range and some degree of consensus on the scale of these impacts. The range of organisations and individuals were contacted including local authorities, Environment Agency, Natural England, Farming Community Network, veterinary surgeons, agricultural suppliers, auctioneers, local NFU officials, local aid organisations, land agents, farm advisers and some farmers (details in annex 4).

In total, 25 people were consulted in detail, although more were contacted initially with some not having sufficient first-hand knowledge of the flooding and many of their comments were anecdotal. However a number of key people provided

comprehensive detail of the situation on farms, and the challenges that many farmers would be facing in the coming weeks and months. The range of opinions were collated to provide an informed assessment of the short, medium and long term impacts of the flooding in the affected areas (see section 5).

Valuing agricultural damage costs

The monetary value of changes in flood risk management standards can be determined using the accounting conventions of gross margins, fixed costs and net margins, expressed either per hectare (ha) or for a farm as a whole. Indicative data[4] are available from Chapter 9 of MCM-Online (Penning-Rowsell *et al*., 2013) but for this study 3-year average values for output and inputs from the Farm Business Survey (FBS) have been used as detailed at annex 6. For other costs e.g. contractor costs, data has been taken from Nix (2014)[5].

In this case, individual farm data is not available and the analysis relies on a per hectare analysis. However, since agricultural crops can withstand a degree of flooding, particularly where this occurs in the winter period, many annual winter crops will recover to some degree while others may be 'replaced' by spring-sown crops. As such the loss of output and changes to inputs will be incremental rather than absolute in many instances. For this reason, the approach taken here addresses outputs and inputs separately rather than combined as a gross margin.

The economic impacts of flooding are estimated by combining the FBS 'per hectare' data with the percentage change estimates in both outputs and inputs from the stakeholder and expert consultation. This is then scaled up using the mapped land use data to provide an aggregate estimate of economic impact.

While this approach works well for cropping and grassland, it is less helpful for livestock and other costs. These rely more heavily on the stakeholder consultations – both number of farms affected and scale / severity of impact – and expert opinion from ADAS specialists and consultees on the additional costs associated with for example, animal health issues, clean-up costs and time input. The uncertainties associated with the livestock costs are more substantial and are estimated to range by +/-50% around the central estimate, while the arable and grassland impacts are estimated to range by +/-20%. Other costs are also very uncertain and are estimated to range by +/-50% around the central estimate.

Defra guidance for appraisal (2008)[6] requires two main types of adjustment to financial estimates to derive economic values: namely, the removal of subsidies and allowance for 'displacement' effects. Since 2005 farmers have received income support in the form of annual 'Single Payments' that are 'decoupled' from production so this adjustment is not necessary in most cases. In terms of displacement, it is assumed that persistent flooding of high value horticultural crops, field vegetables and potatoes, and commodities subject to quota such as sugar beet and dairy milk, would lead to the relocation of their production elsewhere, displacing wheat as the most common arable crop in the process. For this reason, areas of high value crops and dairying are treated as though they are a wheat crop in the economic analysis of permanent changes. However, for impacts that are likely to be 'one-off', such as loss

[4] Financial and Economic Gross Margins and Net Margins for Selected Crop and Livestock Enterprises and Systems
[5] John Nix Farm Management Pocketbook 44th Edition (2014).
[6] Defra (2008) Flood and Coastal Defence Appraisal Guidance. Economic Appraisal, Supplementary Note to Operating Authorities: Valuation of Agricultural Land and Output for Appraisal Purposes, Department for Environment, Food and Rural Affairs, London

of crop for a single year, displacement (using wheat margins rather than those of high-value crops) is not considered. In practice wheat is perhaps the most 'high-value' crop impacted by the winter flooding in any case.

Most of the costs incurred by farmers are uninsured because they relate to loss of expected income from crops and livestock production rather than damage to property. Damage to the farm household is assumed to be covered by insurance and is excluded from the assessment of agricultural damage costs. A commentary is provided on the extent to which damage costs have been borne by the farmers involved, their insurers or offset through voluntary input and charitable donations.

The overall approach to estimating economic impact is summarised below:

Component	Key assumptions	Data sources
Flood area and duration ↓	Extent of flooding for estimating economic impact is based on the land area under water Jan-Mar 2014	EA satellite mapping
Land use ↓	Flood events based along linear features such as rivers can be approximated using 1km^2 grid data on land use and livestock numbers.	ADAS 1km^2 grid spatial mapping of 2010 June census
Impact threshold ↓	The variable tolerance to flooding (being under water) across crops from <15 days up to 30 days can be approximated using a threshold of 15 days, given the limited change in area over this period (from EA satellite maps)	ADAS mapping of flood areas using EA satellite data.
Crop impacts (arable and grassland) ↓	Winter crops under water <15 days will survive but suffer yield loss; those under water for 15 days or more will not be viable. A proportion of the latter will be re-drilled with spring crops while some will be left fallow. Yields of all spring-sown crops will be impacted as will grass production.	ADAS consultations with local stakeholders and agronomists in Somerset and Thames Valley.
Livestock impacts ↓	Livestock is not impacted but there will be increased feed costs related to the loss of forage and feed stocks, the need to extend housing in spring 2014 and reduced grazing and silage/hay production for winter 2014/15. Bedding costs will also increase as will vet and med costs, due to increased animal health risks.	ADAS consultations with local stakeholders and agronomists in Somerset and Thames Valley.
Other impacts ↓	Damage to infrastructure and clean-up costs will include labour, materials and operational expenses. These are linked to the number of holdings affected but in the absence of this data, are based on per hectare estimates.	ADAS consultations with local stakeholders and agronomists in Somerset and Thames Valley.
Economic costs	Damage cost estimates are based on a bottom-up estimation of scale of impact (outputs and inputs) as reported by stakeholders and using published prices and unit costs (Nix). This is then presented using Farm Business Survey (per hectare) and scaling according to the extent of impact.	Farm Business Survey data (3-year average) and Nix, in combination with the estimated scale of impacts from stakeholder consultation and the flood and land use data.

Figure 4: Diagrammatic flow of method with assumptions and data sources

3. Flood extent and duration and land use

A key measure of the potential impact of flooding is the duration of time for which land is under flood water. Based on the broad literature it is considered that around 15 days is a critical threshold for arable crops in winter, with longer durations for 'improved' grass, and longer still for flood tolerant grass (Morris et al, 2007)[7]. However, given the relatively constant area of land under water in the flooded areas over the period 15-30 days, and uncertainties underlying the robustness of the satellite data (discrete rather than continuous images), this analysis uses a single threshold of 15 days for all crops.

Based on the EA satellite mapping and the 2010 June census 1km^2 data, just over 44,400 hectares of land in total was under water for more than 1 day in the period January to March 2014. Of this 40% (17,800 ha) was flooded for more than 15 days.

Table 1 shows the distribution by land use (winter crops or grassland) across the three flood regions, according to duration under water. An estimated 37% was cropping land (16,600 ha) of which 68% was in winter cropping (11,280 ha). Horticulture represents about 4% of the arable area. Of the winter cropping area affected by flooding, 43% was in Thames Valley, 43% in other areas (mainly Severn) and 14% in Somerset Levels.

Table 1: Summary of flood extents and land use in the flood regions

Crop		% area under water <15 days	% area under water ≥15 days
Winter crops	**All regions**	**60%**	**40%**
	Somerset	57%	43%
	Thames	68%	37%
	Others	54%	46%
Grassland	**All regions**	**60%**	**40%**
	Somerset	57%	43%
	Thames	67%	33%
	Others	59%	41%

Land use varies across the three flood areas (see Table 2). In the Somerset Levels, 80% of the flood area was grassland, 12% winter cropping, 7% destined for spring cropping with less than 1% in horticulture. In the Thames Valley, arable was more important with 37% in winter cropping, 11% destined for spring cropping and less than 1% in horticulture; the remaining 50% was grassland. Across the Other areas 58% of the land flooded was grassland, 26% winter cropping, 12% destined for spring cropping and 3% in horticulture.

A similar analysis of spatially mapped 2010 June census data for livestock is shown in Table 3. This illustrates the concentration of livestock and cattle in particular in the Somerset Levels, with lower numbers of livestock in the Thames Valley (lower area of grassland) but a greater emphasis on sheep in the Thames Valley and Other areas. The distribution of numbers around the 15 day flooding threshold broadly reflects the grassland areas in Table 2Table 1.

[7] Morris, J., Bailey, A.P., Lawson, C.S., Leeds-Harrison, P.B., Alsop, D., and Vivash, R. (2007). The economic dimensions of integrating flood management and agri-environment through washland creation: a case from Somerset, England. Journal of Environmental Management 88: 372-381

Table 2: Land use data of flood extents in Somerset, Thames and Other area* regions

	Somerset cropping (ha)			Thames cropping (ha)			Other cropping (ha)			Total (ha)		
	<15 days	>15 days	Total	<15 days	>15 days	Total	<15 days	>15 days	Total	<15 days	>15 days	Total
Wheat	660	506	1,166	2,085	962	3,047	1,735	1,458	3,192	4,480	2,925	7,406
Winter Barley	75	66	140	272	117	389	180	155	335	527	338	864
Oats	17	13	30	62	60	122	165	126	291	243	199	442
Winter OSR	89	65	154	757	325	1,082	477	409	886	1,323	799	2,122
Field beans (winter)	33	18	51	177	81	258	76	63	139	285	162	447
Mainly winter sown arable	**874**	**667**	**1,541**	**3,353**	**1,544**	**4,897**	**2,632**	**2,210**	**4,843**	**6,859**	**4,422**	**11,281**
Spring Barley	72	55	127	205	93	298	192	149	341	469	298	767
Mixed grain, rye, triticale	11	6	17	14	3	17	44	32	76	69	41	110
Potatoes	28	13	41	12	4	16	96	109	205	136	126	262
Sugar Beet	0	0	0	1	1	2	17	12	29	18	13	32
Stockfeeding	15	9	24	11	4	15	41	31	72	67	44	111
Field beans (spring)	33	18	51	177	81	258	76	63	139	285	162	447
Peas	2	1	3	27	17	43	71	45	116	100	63	162
Maize	288	221	508	138	84	222	489	281	770	914	586	1,500
Spring OSR/linseed	26	13	39	81	47	128	87	78	165	194	138	332
All other crops	16	7	24	39	16	55	43	29	72	98	52	150
Bare fallow	54	38	92	324	93	418	153	108	260	531	239	770
Mainly spring sown arable	**546**	**381**	**927**	**1,029**	**443**	**1,471**	**1,307**	**938**	**2,245**	**2,882**	**1,762**	**4,643**
Field veg	21	11	32	20	8	28	95	208	303	136	227	363
Orchards/grapes	44	27	72	10	2	12	52	77	129	106	106	212
Soft fruit	5	3	8	7	3	10	11	33	44	23	39	62
Other horticulture	3	1	4	7	6	13	11	9	20	21	16	37
Horticulture	**73**	**42**	**116**	**44**	**19**	**63**	**169**	**327**	**496**	**286**	**388**	**674**
Temporary leys	835	554	1,389	710	412	1,123	1,030	767	1,797	2,575	1,733	4,308
Permanent grass	5,227	4,091	9,318	3,736	1,763	5,500	5,142	3,537	8,679	14,105	9,392	23,497
Grassland	**6,061**	**4,645**	**10,707**	**4,446**	**2,176**	**6,622**	**6,172**	**4,304**	**10,476**	**16,680**	**11,125**	**27,805**
Total by region	**7,554**	**5,736**	**13,290**	**8,872**	**4,182**	**13,054**	**10,280**	**7,780**	**18,060**	**26,706**	**17,698**	**44,404**
	57%	43%		68%	32%		57%	43%		60%	40%	

*Other areas comprises Bristol, Exeter, South Coast areas and river catchments of Ouse, Severn and Wye & Usk

Source: EA flood data from satellite maps and ADAS 1km^2 cropping dataset from 2010 June census

Table 3: Livestock data relating to flood extents in Somerset, Thames and Other area* regions

	Somerset livestock			Thames livestock			Other livestock			Total		
	<15 days	=15 days	Total	<15 days	=15 days	Total	<15 days	>=15 days	Total	<15 days	>=15 days	Total
Male cattle < 1 year old	1,339	1,077	2,415	602	337	938	1,033	818	1,851	2,973	2,232	5,205
Female cattle < 1 year old, for Beef	861	650	1,510	423	235	659	683	503	1,186	1,967	1,388	3,355
Female cattle < 1 year old, for Dairy	719	599	1,318	157	90	247	463	346	808	1,339	1,035	2,374
Male cattle 1-2 year old	1,210	934	2,144	538	285	823	1,012	728	1,740	2,760	1,947	4,708
Female cattle 1-2 year old, for Beef	744	565	1,309	431	251	683	683	516	1,199	1,859	1,333	3,192
Female cattle 1-2 year old, for Dairy	694	558	1,253	150	87	236	463	328	791	1,307	973	2,280
Male cattle > 2 year old	658	459	1,117	178	93	271	486	324	810	1,322	876	2,198
Female beef cattle > 2 year old (no offspring)	496	352	847	199	112	311	401	276	677	1,096	739	1,835
Female dairy cattle > 2 year old (no offspring)	634	489	1,124	90	52	142	321	236	556	1,046	777	1,822
Female beef cattle > 2 year old (with offspring)	1,204	892	2,096	705	386	1,091	981	750	1,731	2,890	2,028	4,918
Female dairy cattle > 2 year old (with offspring)	2,517	2,115	4,632	539	352	891	1,699	1,151	2,850	4,755	3,617	8,372
Total cattle	**11,077**	**8,690**	**19,767**	**4,012**	**2,279**	**6,292**	**8,225**	**5,975**	**14,200**	**23,314**	**16,945**	**40,259**
Sows in pig	41	59	99	170	85	255	189	175	364	400	319	718
Total pigs	**1,780**	**1,672**	**3,452**	**3,407**	**1,046**	**4,454**	**2,300**	**1,705**	**4,005**	**7,487**	**4,424**	**11,911**
Breeding Ewes >=1 year for breeding	2,747	1,925	4,672	3,566	1,230	4,796	4,833	4,958	9,791	11,146	8,113	19,259
Lambs < 1 year	3,431	2,363	5,794	4,964	1,767	6,731	6,560	6,842	13,401	14,955	10,972	25,926
Total sheep and lambs	**7,018**	**4,844**	**11,861**	**9,567**	**3,368**	**12,935**	**13,016**	**13,454**	**26,471**	**29,601**	**21,666**	**51,267**
Total poultry	112,683	74,615	187,298	77,560	46,567	124,127	196,353	163,669	360,022	386,596	284,851	671,447
All other livestock (horses, goats etc)	378	228	607	711	296	1,007	1,082	606	1,688	2,172	1,130	3,302

*Other areas comprises Bristol, Exeter, South Coast areas and river catchments of Ouse, Severn and Wye & Usk

Source: EA flood data from satellite maps and ADAS 1km^2 stocking dataset from 2010 June census

4. Research evidence on impacts of flooding

4.1 Arable crops

There has been little recent work on the impacts of waterlogging (flooded/ponded/ saturated soils) on crops in the UK, but research from the 1970s and 1980s identifies the physiological changes and potential yield impacts that can occur. Waterlogged soils can have a number of negative impacts on wheat growth and yield, particularly in relation to soil oxygen deprivation and nutrient uptake. Soils rapidly lose oxygen as a result of water replacing oxygen in the soil pores and if these anaerobic conditions persist, levels of carbon dioxide, methane and volatile fatty acids increase in the soil. The net result is that plants shift their metabolism from aerobic respiration to anaerobic fermentation, which is a much less efficient process and plants need to compensate for the deficit in energy by using up their carbohydrate reserves.

Furthermore, uptake of nutrients such as nitrogen, potassium and phosphorus is often inhibited under waterlogged conditions and the decline in concentrations of these nutrients has been shown in barley to have significantly reduced within just 48 hours. Waterlogging causes the plant's stomata to close and photosynthetic rate has been shown in wheat to decline to values lower than those of well-aerated plants within 72 hours, whilst inadequate nutrient uptake impacts leaf growth and development, potentially causing reductions in leaf area of wheat by 83%.

Research has shown that wheat's ability to survive long periods of waterlogging is dependent on its stage of growth, with impacts greatest in plants that have not started to tiller before waterlogging occurred. Soil may be regarded as waterlogged when the water table of the groundwater is too high, such that roots cannot respire due to excess water in the soil profile. Water does not have to appear on the surface for waterlogging to be a potential problem. Generally, the oxygen level in saturated soil reaches the point that is harmful to plant growth after about 48 to 96 hours.

Impacts may be particularly severe where decomposable organic materials (e.g. organic manures or crop residues) were incorporated and crops established within a few days or weeks of flooding. This is due to the flush of microbial activity associated with decomposing organic matter, which under flooded/anaerobic conditions can give rise to the production of nitrous oxide, hydrogen gas and low molecular weight hydrocarbons such as ethylene, which can have a marked effect on the root development of many crops (e.g. barley, wheat and oilseed rape).

Temperature is also a factor with only small impacts reported by Cannell (1980) on oilseed rape yield when crops were waterlogged for between 10-40 days at 1 to 2 degrees C, but when temperature increased to 6 degrees C, seed yields fell by 14% and oil content by 23%.

Effects of waterlogging on cereal crops include increased nodal root production, chlorosis (yellowing of leaves), premature senescence of leaves and a decrease in tiller numbers. This can be translated into yield reductions of 10-30%. However, the gross effect of a wet winter at a national level is highly dependent on the weather and performance of crops during the summer. For example, favourable conditions during grain filling can offset many of the yield reducing effects (e.g. poor rooting and reduced tillering) of a wet winter.

Nevertheless, long-term surface ponding or flooding can result in complete crop loss in localised areas. This is particularly common in shallow field depressions, particularly where the movement of fine clay and silt particles seals the base of such ponds, thereby reducing infiltration and drainage rates.

For fields flooded for weeks rather than days, we also need to consider impact on soil biology such as earthworms and possible related effects on soil drainage.

Assumptions based on research and expert opinion are shown in Table 4, however it should be noted that there is a high degree of variation depending on growth stage of crop, crop residues and soil and air temperatures.

Table 4: Estimates of yield losses based on research and expert opinion

Crop	Average yield loss <15 days	Yield loss >15 days
Winter wheat	20%	100%
Winter oilseed rape	15%	100%
Winter field beans	No information	100%

4.2 Grassland

Flooding can cause significant damage to grassland. Type of sward, degree of weed infestation, duration of flooding, soil type, amount of silt and debris, and the flow rate of water determine the effects of flooding on pasture damage and the subsequent recovery.

As a rule of thumb, it is thought that after 10 -14 days of submergence under standing water, ryegrass plants will begin to die. However, how individual cultivars respond to anoxic stress varies within and between genotypes.

Flooded soils are not necessarily completely devoid of oxygen. A very small layer near the surface which is in contact with the oxygenated surface water can assist in the translocation of some oxygen into the soil profile. This will depend on the conditions of the flood water. Flowing water tends to contain higher levels of oxygen than standing water, making more oxygen available to the plant.

In contrast, standing water contains less oxygen and, in slow moving or standing water, silt and mud is likely to settle out which can potentially seal the soil surface and have knock-on implications for plant emergence and gas exchange. Flooding also impacts on gas exchange between the roots, soil and atmosphere. Gases and toxins such as methane, ethylene and carbon dioxide can build up in the soils, restricting plant growth further.

The rate of recovery of a soil and pasture after flood waters have receded will depend on a number of factors:

- Soil texture – pasture recovery will be better on light textured soils. Even after the flood waters have receded, heavy soils will retain the water for longer, extending the period of waterlogging.
- Sward height – pastures with lower covers prior to flooding should recover better as they will collect less silt and mud. Longer grass slows water flow which will cause sediment to settle out.
- Silt and mud – sediment deposits of less than 5cm should allow pasture to regenerate relatively quickly. However, deposits of very fine sediment can cause surface sealing reducing water infiltration and aeration creating anaerobic conditions in the soil.

In terms of a grass sward, the weed burden after flooding is likely to be large, as flood waters can introduce new weed species to pastures. In addition, thin, slow recovering pastures and bare soils will allow weed infestation and a reduction in the seed bank of desirable species. Stressed plants may also be more susceptible to disease.

Flood events can also have effects on soil structure, health and fertility. Deposits of sediments on the land can smother grass swards, but can also add nutrients (or contaminants) from upstream. Following prolonged flooding, it is likely that a significant proportion of readily available nutrients such as nitrate and sulphate will have been lost from the soil through gaseous emissions or leaching.

In summary, while there is some research evidence on the type of impacts which can be induced by flooding and waterlogging, these vary to a large degree depending on type of grassland, soil type, duration of flooding and flows and sediment deposits, none of which will be standard. There is however no clear research evidence on the potential losses in grassland due to flooding which can be referenced in this study. Instead a combination of local stakeholder observation and expert knowledge have been used to provide estimates of impact.

5. Consultation evidence on flood impacts

5.1 Somerset Levels

The telephone consultation provided first hand evidence of impacts on individual or groups of farms. In total 15 individuals from a range of organisations or stakeholder groups (details in annex 4) gave informed interviews on the impacts of the flooding in the Somerset Levels. The information from the consultation was used with expert opinion to estimate the level of impacts.

The Somerset Levels had high profile coverage in the press following the unprecedented duration and extent of flooding in winter 2014. Much of the press coverage focused on the worst affected farms where farm buildings were inundated requiring evacuation of livestock. Land use in the area is predominantly grassland, although some crops were affected.

Arable crops

Short term impacts:

Most winter crops that were flooded were unviable due to the duration of the flooding, although some at the periphery of the main flood area have survived largely intact. Unviable winter crops (winter wheat, winter barley and winter oilseed rape) will be re-drilled with spring crops, most likely spring cereals and spring oilseed rape, linseed or maize, although some may be left fallow where soils are compacted or drains damaged, allowing access for remedial work. The earliest access to land for re-drilling was reportedly around 20 March 2014, but other areas will be much later.

Medium and long term impacts:

There may be some impact on cropping plans for 2015 harvest due to rotational considerations but no major change. No long term impacts are expected, although some cropped land that regularly floods may revert to grassland.

Table 5 sets out the cropping data from the flood mapping and applies broad rules on impact based on stakeholder consultation.

Table 5: Summary of crop impacts from consultation with stakeholders in Somerset

Crop	Area (ha)	% area affected	Impact
Winter cereals	1,336 ha	50% unviable	• 500 ha re-drilled with spring cropping • 170 ha fallow
		50% yield impact	• 665 ha affected
Winter oilseed rape	155 ha	50% unviable	• 60 ha re-drilled with spring cropping • 20 ha fallow
		50% yield impact	• 75 ha affected
Winter field beans	50 ha	75% unviable	• 30 ha re-drilled with spring cropping • 8 ha fallow
		25% yield impact	• 12 ha affected
Spring cereals	145 ha	100% delayed drilling plus delay on re-drilled crops	• 545 ha estimated 10% yield impact (HGCA growth guide)

Grassland

Short term impacts:

Grassland in the Somerset Levels has been particularly badly affected with one estimate putting the total area flooded at 17% of the Levels, which is about 3-4 times the normal area flooded. There are varying opinions on the likely recovery of grassland, with some areas expected to recover despite weeks under water

(permanent pasture tending to be more resilient), but other areas will require re-drilling or partial re-drilling. Problems associated with debris and contamination were mentioned by some but this requires further investigation to establish the extent of the problem and impacts.

- 50% of the flooded area not requiring re-drilling but some likely yield losses for grazing and forage stocks – there is no evidence from research but estimated at 25% less production due to poor growth and plant death.
- 25% requiring some re-drilling without full cultivation – costs of re-drilling plus reduced production of 25% and higher growing costs with higher expenditure on herbicides.
- 25% requiring full cultivation and replacement – costs of re-drilling plus reduced production compared to established pasture, although benefits in the following year. Of this, half may be replaced in the spring (depending on weather and soil conditions) and the remainder in the autumn (if outside regular flood zone) or next spring (see below).
- Where grass keep is let out, the expectation is that this will need to be delayed, with reduced income from a shorter grazing season.
- Additional management time to clear up debris.

Medium and long term impacts

Some grassland may not be replaced until the autumn if outside the regular flood zone, or next spring if regularly flooded. This will have further impacts on grazing and forage.

- Estimated 12.5% of flooded area not drilled until spring 2015 so a full year of no economic production, and another year of lower production.
- Some fields may require additional reinstatement costs for repairing blocked drains and soil compaction. This could be up to 10% of the area.

Some land may require additional reinstatement work to repair drains and/or soil compaction as noted in medium term impacts. This may take a number of years depending on the farm financial situation.

Table 6 sets out the grassland area from the flood mapping and applies broad rules on impact based on stakeholder consultation.

Table 6: Summary of grassland impacts from consultation with stakeholders in Somerset

Area (ha)	% area affected	Impact
10,700 ha	25% unviable	• 2,675 ha full cultivation and replacement, half in spring and half in autumn • Benefits in future years from improved sward
	25% some plant death	• 2,675 ha some re-drilling (1,330 ha) • Higher herbicide costs (£15/ha) • Lower production – estimated 25% down so need additional land for forage
	50%	• Lower production – estimated 25% so need additional land for forage
	100%	• Debris clear up

Livestock

Short term impacts:

Individual consultees reported that over 200 farm holdings were affected by the flooding with 16 requiring emergency evacuation of up to 1000 head of stock (mainly beef and some sheep). Some farmers sold stock much earlier than planned. There were a few losses of stock due to injury during handling and transport. There have been additional costs and management required for extra housing and away grazing, with sheep being brought indoors and cattle housed for 1 to 2 months longer than normal while land dries out. The extended housing period will have increased feeding and bedding costs as well as management time. Some farms also lost a proportion of conserved forage and livestock feed, with an estimate of 25 farms badly affected where most forage was lost. This has resulted in additional costs to replace (although some has been provided by Forage Aid). Some vets have reported the effects of stress on livestock, with short term loss in body condition and increased disease due to longer housing and contamination of flood waters.

- Evacuation of 1000 head of stock from 16 locations with associated costs of transport, rent for alternative land and/or housing. Some farmers had to sell their stock with longer term impacts (see below).
- 5-10 stock losses due to transport
- Reduced growth rates due to stress due to transport to alternative premises
- Additional feed for longer housing – forage and concentrate – 2 months additional feeding while soil and grass recovers.
- Additional bedding for longer housing – straw
- Additional management time

There were reports of grain stores and feed stores being inundated with flood water which has caused damage and loss. Some attempts to recover grain have been made, by drying, but there have been concerns over feed safety so affected grain has been condemned. Loss of forage was common with silage bales often stacked outdoors in areas not normally associated with flooding. In some cases only the bottom bales of a stack were affected but in others losses were much greater. Straw for bedding was also affected in outside stacks and in some buildings.

- No clear picture of level but assumed 100 tonnes of grain lost plus associated drying costs
- Value of forage lost based on the costs of replacement
- Value of straw bedding lost based on the costs of replacement

The key assumptions applied to the impact assessment of livestock costs are summarised in Table 7 using stakeholder evidence and expert knowledge of animal husbandry within the research team. These ‘per head’ impacts are subsequently scaled up using the June census data for areas flooded for 15 or more days.

Table 7: Estimated flood impacts for livestock in the Somerset Levels

	Assumptions	Somerset
Cattle		
Forage lost due to flooding	Silage stocks 5t per beast for winter - 50% remaining on farm on 1 Jan 2014	30% of remaining forage lost
Straw lost due to flooding	Straw stocks 0.7t per beast for winter - 50% remaining on 1 Jan 2014.	30% of straw lost
Forage needed for extended housing	2 months for 30% of cattle	1.5t forage per head
Concentrates needed for extended housing		120kg feed per head
Straw needed for extended housing		240kg straw per head
Increased vet costs due to stress and extended housing		£5 per head
Additional concentrates at grass due to reduced pasture / contamination		120kg feed per head
Additional forage required for winter 2014/15	Half of winter requirement	1.25t forage per head
Sheep		
Forage lost due to flooding	Silage stocks 0.3t per ewe for winter - 100% remaining on farm on 1 Jan 2014	30 % of forage lost
Straw lost due to flooding	Straw stocks 0.03t per ewe for winter - 100% remaining on farm on 1 Jan 2014.	30% of straw lost
Forage needed for extended housing	2 months additional housing	240kg forage per ewe
Concentrates needed for extended housing		30kg feed per ewe
Straw needed for extended housing		40kg straw per ewe
Increased vet costs due to stress and extended housing		£1 per ewe
Additional concentrates at grass due to reduced pasture / contamination	Supplement for 2 months at grass	15kg per ewe
Additional forage required for winter 2014/15	Half of winter requirement	150kg per ewe

Medium and long term impacts:

In the livestock sector the impacts of the flooding are likely to last into next season due to the effects on grassland production and conservation of forage. Where significant areas of grassland have been lost or are underperforming, additional land may need to be rented, for grazing or forage, or supplementary feed bought in (some farmers may choose to reduce livestock numbers). Demand for land may result in increased rentals or some land may become less desirable due to increased risk of

flooding. Depending on the location there may be additional travel and transport costs. Additional forage may need to be bought in to feed for next winter.

- Supplementary feeding required for livestock on underperforming grassland.
- Rental costs to replace up to 25% of grazing land that will be re-drilled but not productive.
- Purchase of additional forage (or land rental and transport) for winter 2014/15 (25% of requirement).
- Increase in veterinary and medicine costs due to potential pests and disease (10% increase).
- Assuming sheds are dried out and ready for storage of 2014 crops, there are not expected to be any longer term impacts.

A return to more 'normal' winter rainfall, and improvements in water flow in the rivers through planned dredging, will reduce the potential for longer term impacts. Some land may be abandoned for farming and returned to nature under agreements but this is expected to be nominal.

Other

Short term impacts

It is reported by some respondents that over 250 farms have some level of infrastructure damage including damage to buildings, culverts, farm tracks, fences and hedges. Some farm machinery was also damaged when it could not be moved to safety, including tractors. While some of this will be covered by insurance, other elements will not, including:

- Repairing damage to buildings – mainly covered by insurance
- Machinery damage – mainly covered by insurance
- Repairs to fences, culverts and farm tracks – more information is required on the extent of the damage and likely costs and timescale of repair.
- Expenditure on short term electric fencing
- Medium and long term impacts: The recent flooding may incur higher costs in the future to ensure that buildings and infrastructure are more resilient to flooding.
- Localised flood defence measures around critical buildings
- Larger scale flood defences around farm buildings
- Improved specifications for new buildings and roads to withstand flooding

An estimated 150 farm houses and buildings were flooded with additional expense and management to organise pumping of water, skip hire and other machinery for clean-up measures. Costs are expected to include:

- Pump hire or purchase
- Machinery and skip hire
- Movement and alternative housing of other animals such as horses and pets.
- Security and safety

5.2 Thames Valley

The telephone consultation provided first hand evidence of impacts on individual or groups of farms. In total 10 individuals from a range of organisations or stakeholder groups (detailed in annex 5) gave informed interviews on the impacts of the flooding in the Thames Valley. The information from the consultation was used with expert opinion to estimate the level of impacts.

The Thames Valley was flooded extensively in winter 2014 with more extensive flooding and for a longer duration than previous flooding episodes. Land use in the area is mixed, with about 25% arable cropping in the flood plain, although this varies in different parts of the river system with a higher proportion of arable land in the upper reaches. In contrast to the Somerset Levels the impacts on agriculture in the Thames Valley were in line with a 'normal' flood season despite the high rainfall.

Arable crops

Short term impacts

Most winter crops that were flooded have survived, other than patches in fields and occasional full fields where crops were at more vulnerable stages or flood water was held for longer. Some farmers have taken steps to avoid problems such as moving to spring cropping or changing to grassland under arable reversion schemes in Higher Level Stewardship.

- 10% of flooded winter cropping unviable of which 90% is in relatively small patches within fields and will be left fallow and the remainder to be re-drilled with spring barley, spring field beans, oilseed rape or linseed.
- 90% of flooded winter cropping viable but may have some yield impact of

Table 8 sets out the cropping data from the flood mapping and applies broad rules on impact based on stakeholder consultation.

Table 8: Summary of crop impacts from consultation with stakeholders in Thames Valley

Crop	Area (ha)	% area affected	Impact
Winter cereals	3,560 ha	10% unviable	• 40 ha re-drilled with spring cropping • 320 ha fallow
		90% yield impact	• 3,200 ha affected
Winter oilseed rape	1,080 ha	10% unviable	• 50 ha re-drilled with spring cropping • 50 ha fallow
		90% yield impact	• 970 ha affected
Winter field beans	260 ha	50% unviable	• 100 ha re-drilled with spring cropping • 30 ha fallow
		50% yield impact	• 130 ha affected
Spring cereals	315 ha	100% delayed drilling plus delay on re-drilled crops	• 315 ha estimated 10% yield impact (HGCA growth guide)

Medium and long term impacts

There is no reporting of significant impact on cropping plans for 2015 harvest due, for example, to rotational considerations. There are not expected to be widespread long-term impacts, although some land that regularly floods may revert to grassland, perhaps a nominal 1% of cropping land will change to grassland.

Grassland

Short term impacts:

Grassland in the Thames Valley has largely survived intact although one individual quoted that 80 acres of grass needed to be fully reseeded. Most grassland is permanent pasture which tends to be more resilient to flooding.

- 99% flooded area not requiring re-drilling but some yield losses likely for a small proportion (perhaps 5%) – there is no evidence from research but estimated at 25% less production due to poor growth and plant death.
- 1% requiring full cultivation and replacement – costs of re-drilling plus reduced production compared to established pasture, although benefits in the following year.
- Additional management time to clear up debris.

Medium and long term impacts:

Most grass is expected to recover within the year.

- No major impact.
- Some fields may require additional reinstatement costs for repairing blocked drains and soil compaction. This could be up to 10% of the area.

Some land may require additional reinstatement work to repair drains and/or soil compaction as noted in medium term impacts. This may take a number of years depending on the farm financial situation.

Livestock

Short term impacts:

Some farm buildings were affected by flooding, but most escaped without serious inundation according to local information, and there were no reports of losses of livestock or widespread losses of forage. There may be some impacts from longer housing due to saturated grazing, although few farms only have land on the flood plain so alternative grazing is usually available.

Limited impacts with an estimated 5% of livestock holdings likely to be affected by the need for longer housing and/or loss of forage.

- There are no reports of damage caused to stored produce but there have been reported incidences of grain stores and feed stores being inundated with flood water which has caused damage and loss. Value of forage lost based on the costs of replacement,
- Value of straw bedding lost based on the costs of replacement

Medium and long term impacts:

No medium or long term impacts are expected for livestock. Assuming sheds are dried out and ready for storage of 2014 crops, there are not expected to be any long term impacts.

The key assumptions applied to the impact assessment of livestock costs are summarised in Table 7Table 9 using stakeholder evidence and expert knowledge of animal husbandry within the research team. These ‘per head’ impacts are subsequently scaled up using the June census data for areas flooded for 15 or more days.

Table 9: Estimated flood impacts for livestock in the Thames Valley

	Assumptions	Average Impacts
Cattle		
Forage lost due to flooding	Silage stocks 5t per beast for winter - 50% remaining on farm on 1 Jan 2014	10 % of remaining forage lost
Straw lost due to flooding	Straw stocks 0.7t per beast for winter - 50% remaining on 1 Jan 2014.	10% of straw lost
Forage needed for extended housing	1 month additional housing	750kg forage per head
Concentrates needed for extended housing		60kg feed per head
Straw needed for extended housing		120kg straw per head
Increased vet costs due to stress and extended housing		£5 per head
Additional concentrates at grass due to reduced pasture / contamination		60kg feed per head
Additional forage required for winter 2014/15	Half of winter requirement	1.25t forage per head
Sheep		
Forage lost due to flooding	Silage stocks 0.3t per ewe for winter - 100% remaining on farm on 1 Jan 2014	10 % of forage lost
Straw lost due to flooding	0.03t of straw per ewe for winter. 100% of straw remaining on 1 Jan. Damage by flood waters	10% of straw lost
Forage needed for extended housing	1 month for 10% of ewes	120kg forage per ewe
Concentrates needed for extended housing		15kg feed per ewe
Straw needed for extended housing		20kg straw per ewe
Increased vet costs due to stress and extended housing		£1 per ewe
Additional concentrates at grass due to reduced pasture / contamination	Supplement for 1 month at grass	7.5kg per ewe
Additional forage required for winter 2014/15	Half of winter requirement	75kg per ewe

Other

Short term impacts:

In the Thames Valley there were no reports from stakeholders to suggest significant damage to infrastructure although there was one mention of damage to concrete. There may be some allowance needed for repairing damage to buildings but these are expected to be mainly covered by insurance, namely:

- Machinery damage – mainly covered by insurance
- Repairs to fences, culverts and farm tracks – more information is required on the extent of damage and likely costs and timescale of repair.
- Expenditure on short term electric fencing

Medium and long term impacts:

Farm holdings impacted directly may incur costs beyond the current financial year in terms of clean and remediation costs, for example to drains and fences etc. The 2014 flood event may prompt investment to improve resilience to flooding in future, for example through better defences around farm buildings etc.

5.3 Other areas

In addition to the Somerset Levels and the Thames Valley, Other areas in the South of England were impacted by the winter floods, notably the Bristol, Exeter and South Coast areas and the Ouse, Severn and Wye & Usk river systems. These areas have, in aggregate, been similar in extent of flooding to the Somerset Levels (43% under water for 15 days or more) but in terms of land use are more akin to the Thames Valley (approximately half cropping and half grassland). However, it is anticipated that more of the flooding has been along the established floodplain, impacting on many farm holdings along the river's course rather than affecting large parts of individual farms. In the absence of any local consultation or secondary evidence it has been assumed that the extent of flood impact on land and agriculture is of a similar severity as for Thames Valley.

Estimates of financial impact are based on the aggregate land use data for the Other areas in conjunction with the flood impact assumptions for Thames Valley in terms of viable cropping, yield loss, livestock impacts and other costs.

6. Estimates of economic impact

Using the EA MCM protocols, this section provides estimates of the component costs associated with Arable, Grassland, Livestock and Other impacts in turn. These estimates are based on estimates of the land area impacted from satellite mapping and associated land use based on historic census data. This is summarised across the main affected areas (see annex 1) in Table 10 below. The analysis at 6.1 to 6.4 presents the combined economic impact on the three areas together.

Table 10: Extent of flooding by land use (June Census 2010)

	Somerset levels	Thames Vale	Other areas*	Total
Winter cereals and breaks	1,541	4,897	4,843	**11,281**
Spring combinable crops	927	1,471	2,245	**4,643**
Horticultural crops	116	63	496	**675**
Grass <5 years	1,389	1,123	1,797	**4,309**
Other grassland	9,318	5,500	8,679	**23,497**
Total area	**13,291**	**13,054**	**18,060**	**44,405**

* Bristol, Exeter, South Coast areas, Ouse, Severn and Wye & Usk river systems

Given the timing of the floods, the submergence of planted crops is less critical than (for example) the summer floods of 2007. In the methodology of that incident, a case was made for differentiating between land which was flooded for less than 15 days and that flooded for 15 days or more. This provides two discrete levels of impact which can be combined with the mapped areas for each extent of flooding. In broad terms around two thirds of the mapped flood area was under water for less than 30 days with the remainder under water for 30 days or more (Figure 5).

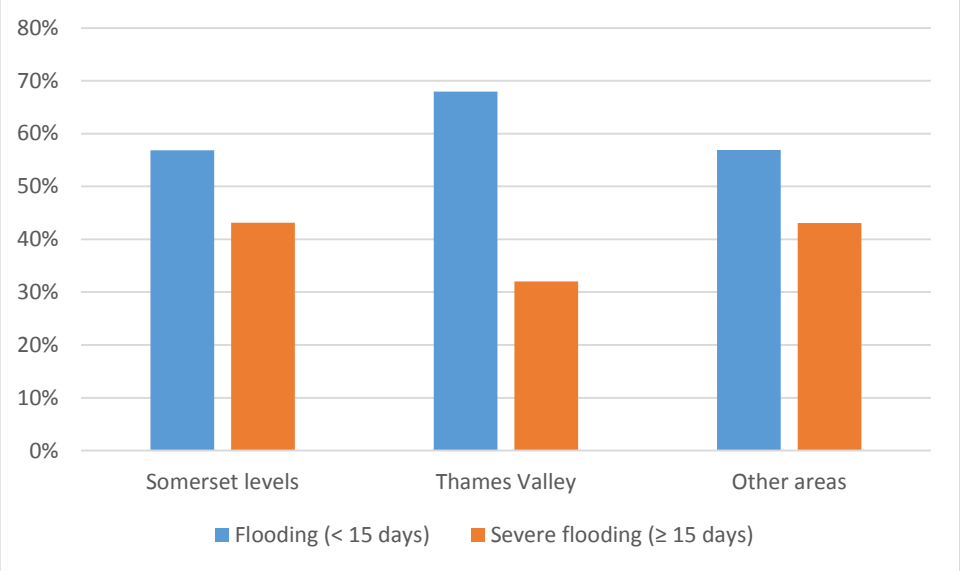


Figure 5: Duration of flooding across the three main flood areas

We have provided estimates of impact for each for these flood extents on arable crop outputs and net cost changes in inputs for both arable crops and grassland. By weighting these impacts by the land use for each for the three areas, an overall estimate of impact has been calculated.

It is apparent that while there is a significant area of arable cropping in the Thames Valley and in Other areas, the Somerset Levels are dominated by grassland (81% land area). This is also evident in the livestock numbers, notably cattle (Table 11) which also highlights the relatively low numbers of pigs, poultry (broilers and layers), and other livestock in the flooded areas. On this basis, the economic analysis is restricted to cattle and sheep.

Table 11: Livestock numbers in flooded area (from 2010 June census)

	Somerset levels	Thames Vale	Other areas*	Total
Total cattle	19,767	6,292	14,200	**40,259**
Total pigs	3,452	4,454	4,005	**11,911**
Total sheep and lambs**	11,861	12,935	26,471	**51,267**
Total laying fowl	766	3,824	14,617	**19,207**
Broilers	102,785	94,766	268,536	**466,087**
Other livestock (goats, horses etc.)	607	1,007	1,688	**3,302**

* Bristol, Exeter, Ouse, Severn, South Coast and Wye & Usk

** Includes lambs from 2010 June census – most not born in 2014 flooding period

While there is no official estimate of the number of individual farm businesses affected, the consultations in the Somerset Levels were informative on this point. It is reported that some 250 holdings were affected and 16 farms evacuated (1000 animals), with 150 houses and farm buildings flooded. Similar testimony was not forthcoming in the Thames Valley consultations and there was no consultation in Other areas.

6.1 Damage costs for arable land

Damage costs for arable land comprise:

- reduced yield in the year of the flood; crop quality impacts are not counted as this applies to only a small proportion of horticultural crops
- additional inputs (fertiliser and sprays) less savings in uncommitted costs
- additional harvesting costs less savings in uncommitted harvest costs
- value of output of replacement crop less costs of crop establishment and production costs (fertiliser, chemicals, labour and machinery) ,where relevant

No allowance has been made for the cost of land reinstatement (restoration cultivation) on the basis that arable land will be cultivated for re-drilling and/or ahead of establishing next year's crop in autumn 2014; some provision is made for these costs in Other damage costs (see section 6.4). Carryover impacts on yield loss and other costs to subsequent year(s) was not relevant for the most part.

Table 12 sets out the estimate of arable damage costs associated with yield as output reductions, based on a combination of impact scale, economic output and area affected. The total estimate is £6.4m.

Table 12: Arable output costs

	Baseline land area (ha)	Area impact from flooding (% change)	Revised land area (ha)	Yield impact from flooding (% change)	Economic output* (£/ha)	Economic impact** (£m)
Winter cereals and breaks	11,281	-39%	6,874	-20%	£1,124	-£6.5
Spring combinable crops	1,968	166%	3,277	-10%	£911	+£0.9
Potatoes and root crops	405	0	405	-10%	£5,135	-£0.2
Horticultural crops	674	0	674	-10%	£8,383	-£0.6
Total						**-£6.4**

* From Farm Business Survey (3-year av.) http://www.farmbusinesssurvey.co.uk/regional/

** Based on baseline area output less revised area output, adjusted for yield loss

Stakeholders in the Somerset Levels reported that half of the winter crops were not viable after flooding and that some 75% of this would be sown to spring crops and the remainder left as bare fallow, however in the Thames Valley area (and other flooded zones), the reported lost area was smaller (ranging from 5-25%), with mainly parts of fields affected where it was unlikely that it would be practical to drill spring crops. The land use figures indicate that over 40% of winter cropping in Somerset and Other areas was under water for more than 15 days, while in the Thames Valley 30% was under water for more than 15 days. A weighted figure of 39% across all regions was used, based on the flood mapping and land use data.

An estimated 30% of the winter cropping land which is unviable is expected to be re-drilled for spring cropping. This will offset the winter cropping losses to some degree but will require additional fieldwork and inputs.

Table 13 sets out impacts relating to change in input costs, including fieldwork associated with establishing spring crops where winter crops have been killed, and allowing for uncommitted costs on fallow land. In addition, spring crops will require lower inputs of fertilisers and sprays and lower costs associated with harvesting and marketing a smaller crop. The total estimate is £0.45 million.

The gross damage cost for arable is the combination of lost output (from Table 12) and additional costs (from Table 13), calculated at £6.9m.

ARABLE = -£6.9m (range +/-20% £5.5 – 8.2m)

Table 13: Arable input costs

	Land area affected (ha)	Weighted impact (% change)	Economic output* (£/ha)	Economic impact (£)
Seed	1,308	100%	-£52	-£67,669
Fertilizers	11,230	10%	-£167	-£187,107
Crop protection	11,230	10%	-£136	-£152,605
Other crop costs	11,230	5%	-£129	-£72,361
Fieldwork (extra spring crops)**	1,308	100%	-£50	-£65,421
Contract (fallow land)***	1,308	100%	£73	£95,279
Total				**-£449,884**

* From Farm Business Survey (3-year av.) http://www.farmbusinesssurvey.co.uk/regional/

** Estimate of additional cost of establishment for spring crops less savings in harvest costs etc. due to lower yields

*** Based on FBS contract costs for Cereals farms

6.2 Damage costs for grassland

For grassland, the main outputs are captured in terms of livestock outputs and margins and are addressed in the next section (6.3). In this section, the effects of flooding are restricted to:

- loss of forage yield (valued at barley feed equivalent)
- additional inputs (fertiliser and sprays) less savings in uncommitted costs
- net savings in forage harvesting costs
- cost of land reinstatement to grassland
- costs of grass reseeding (seeds, fertiliser, labour and machinery)

The loss of forage stock is based on the number of cattle and sheep in the flooded areas and an assessment of the likely forage stock affected. The census data suggests there are approximately 40,000 cattle of all ages and 51,000 ewes and lambs. The average forage stocks are estimated to be 5 tonnes silage per head of cattle – higher for adult cattle and lower for youngstock, and 0.3 tonnes per breeding ewe – giving a total estimated stock of 215,000 tonnes.

Allowing for the fact that prior to flooding around 50% of stock had been used, some 108,000 tonnes of silage remained. Of this an estimated 30% of forage is assumed to have been damaged through flooding in the Somerset Levels, and 10% in the other areas– stakeholder reports varied widely – either through contamination or loss. This represents a loss of some 23,000 tonnes of silage, (assumed to be big bale silage at 40% dry matter and 10MJ/kg DM) equivalent in feed energy to approximately 8,000 tonnes of feed barley. A further 1,000 tonnes of stored grain or animal feed are also estimated to have been lost, taking the grain equivalent to a total of 9,000 tonnes. Valued at £150 per tonne, this represents a net loss of £1.4 million.

The analysis of input costs is detailed in Table 14.

Table 14: Grassland input costs

	Land area affected (ha)	Weighted impact (% change)	Economic output* (£/ha)	Economic impact (£)
Seed (20% grassland <5 yrs.)**	861	100%	-£90	-£77,476
Fertilisers	29,306	10%	-£41	-£120,914
Crop protection	29,306	10%	-£9	-£25,370
Other crop costs	29,306	5%	-£9	-£13,604
Contract work (reseeds)**	861	100%	-£80	-£68,867
Total				**-£306,231**

* From Farm Business Survey (3-year av.) http://www.farmbusinesssurvey.co.uk/regional/

** Estimated costs from Nix

Taking the value of forage stocks damaged and the net additional costs for inputs to grassland, the total grassland costs are estimated at £1.7 million.

GRASSLAND = -£1.7m (range +/-20% £1.4 – 2.0m)

6.3 Damage costs for livestock enterprises

It is reported by stakeholders that any forced sales of store or fat livestock from the Somerset Levels did not adversely affect animal values; indeed a desire to support affected farmers encouraged bidders at market to offer prices at least in line with expected values. As such, the livestock damage costs do not include any provision for reduced value of stock at sale due to flooding. Further, stakeholders reported that very few dairy farmers were affected directly and no account has been taken for impact on milk sales.

In this section, the effects of flooding are restricted to:

- cost of labour and machinery to relocate livestock
- cost of additional labour needed for housing of livestock
- additional costs of conserving feed for housed stock plus costs for purchased feeds over and above estimated forage losses
- additional waste management, water and vet services associated with housed stock
- cost of increased livestock mortalities due to flooding
- net savings in harvesting and storage costs for grass forage

Relocation and associated costs relate to the reported 25 farms which were very badly affected in the Somerset Levels. Over 1000 animals are reported to have been moved and transport costs and housing costs are estimated at around £100,000. Feed costs for animals housed on other units are captured in feed costs.

The additional costs are largely associated with extended housing due to short-term unavailability of grazing land or supplementary feed due to reduced productivity of

that land. Some additional costs relate to animal health impacts. The feed, vet and other livestock costs are detailed in Table 15 based on FBS cost data expressed per Livestock Unit (allows for combining cattle and sheep numbers) and the livestock numbers in the flooded areas, converted to LU.

Additional costs are estimated for:

- extended housing of 2 months for areas flooded ≥15 days and 1 month for areas flooded for <15 days in terms of associated feed (purchased forage and concentrates) and other costs (including bedding)
- additional forage stocks for next winter which will need to be supplemented at varying levels for affected farms; it has been assumed that half of the full winter forage requirement will need to be bought in for all livestock in areas flooded ≥15 days in Somerset next winter and 25% of the full requirement in Thames Valley and Other areas.
- supplementary feed at grazing to compensate for grass quantity and/or quality; this is based on 2 months of supplementary feeding for all livestock in areas flooded ≥15 days in Somerset and 1 month in Thames Valley and Other areas.
- veterinary and medicine costs are estimated to increase by 10-15% on average for all livestock in all areas flooded ≥15 days due to increased treatment for pneumonia, liver fluke etc.
- contract costs will reduce if less silage/hay is made but farms will incur additional costs for waste handling etc. and in the absence of a clear handle on these costs it is assumed that there is no overall change.

Table 15: Livestock input costs

	Animals impacted (Livestock Units)	**Weighted impact** (% change)	**Economic output*** (£/LU)	**Economic impact** (£)
Purchased feed	29,577	75%	-£146	-£3,236,204
Veterinary fees & medicines	29,577	13%	-£26	-£99,951
Other livestock costs	29,577	30%	-£72	-£638,030
Contract costs	29,577	0%	-£49	£0
Transport / housing (1000 head)	n/a	n/a	n.a	-£100,000
Total				**-£4,074,185**

* From Farm Business Survey (3-year av.) http://www.farmbusinesssurvey.co.uk/regional/

** Estimated costs from Nix

The net cost is estimated at £4.1 million including transport costs.

LIVESTOCK = £4.1m (range +/-50% £2.1 – 6.2m)

6.4 Other damage costs

The final category of costs includes the following:

- farm structures and contents
- disruption and replacement of essential farmstead services e.g. power and water
- farm machinery and equipment, including irrigation and drainage equipment
- hedges, fences/gates, land drainage works, tracks
- clean up and debris removal and disposal
- loss of net revenue from services e.g. contracting
- additional borrowing costs
- other farm specific costs

These costs have also been presented on the basis of baseline costs for the farm types involved. There is not an easy alignment of the damage cost categories and the FBS accounts cost centres. Nevertheless, an attempt has been made to provide values based on stakeholder responses.

While the impact of flooding on enterprise outputs and variable costs (inputs) is anticipated to be reasonably consistent across the different flood areas, Other damage costs are expected to be much more significant in the Somerset Levels than in other areas, due to the flooding of farmsteads, the predominance of livestock units and the fact that many holdings had substantial parts of their land under water. Nevertheless, in the absence of individual farm data on this the estimate of Other damage costs in Table 16 is based on the total area flooded across all regions.

Table 16: Other damage costs

	Land area affected (ha)	**Weighted impact** (% change)	**Economic output*** (£/ha)	**Economic impact** (£)
Regular labour*	44,404	50%	-£46	-£1,022,107
Machinery: fuels and oils	44,404	50%	-£45	-£991,558
Machinery: repairs and other	44,404	50%	-£48	-£1,055,237
Bank charges & professional fees	44,404	50%	-£22	-£498,645
Maintenance, repairs and insurance	44,404	500%	-£2	-£549,556
Depreciation of buildings	44,404	100%	-£15	-£678,534
Miscellaneous fixed costs	44,404	50%	-£36	-£790,450
Total				**-£5,586,088**

* From Farm Business Survey (3-year av.) http://www.farmbusinesssurvey.co.uk/regional/

** The Economic Output represents all labour but the impact refers mainly to unpaid family labour.

The net cost is estimated at £5.6 million although this is perhaps the least reliable estimate of damage costs in this exercise, given the scant available data.

OTHER = £5.6m (range +/-50% £2.8 – 8.4m)

6.5 Total economic costs of flooding

Total economic impact

This analysis has focused on the direct and additional costs associated with the 2014 winter floods. These are estimated from the previous sections as follows:

Damage cost	Central estimate (£m)	Range in values (£m)	Key uncertainties which may affect estimate
ARABLE	6.9	5.5 – 8.2 (+/- 20%)	Accuracy of 2010 census mapped data at 1km^2 grid Extent to which FBS data represents productivity in flood areas Proportion on cropped area unviable and share of this re-drilled or left fallow Yield loss on viable cropping and on spring crops (due to delayed establishment / waterlogging effects)
GRASSLAND	1.7	1.4 – 2.0 (+/- 20%)	Forage and feed stocks lost due to flood contamination Grassland input costs, notably seed and cultivation costs for re-drilling swards
LIVESTOCK	4.1	2.1 – 6.2 (+/- 50%)	Accuracy of 2010 census mapped data at 1km^2 grid Extent to which FBS data represents productivity in flood areas Scale of grassland productivity in 2014 and subsequent years and subsequent need to purchase forage and supplementary feed Other livestock input costs, notably vet and med
OTHER	5.6	2.8 – 8.4 (+/- 50%)	Damage to infrastructure on individual holdings across the flood-affected areas (and consequent cost to repair / restore) Extent to which costs have been covered by some combination of insurance, volunteers and charitable donations.
TOTAL	**18.9**		

While there has been limited consultation directly with farmers, it is likely that some farmers are insured for certain aspects of the losses, in particular for damage to buildings and machinery, but not all. The evidence from stakeholder consultations is mixed. For example, it was reported by one consultee that pressure washers, tools, and fertiliser were not covered while hay and grain were. There was also an anxiety about the impact of claims on future insurance costs. Any such future costs are not captured in this analysis.

The role of charitable efforts and volunteers in reducing the actual cost incurred by individual farmers is considerable but is not quantified in this analysis.

Non-financial costs

This analysis takes no account of the non-financial costs to farmers and the environment. This was undoubtedly a highly stressful time for those involved directly in trying to safeguard dwellings, property and livestock and in dealing with the relevant agencies to ensure that protocols were being followed in regard to public health, animal welfare etc. While is not necessarily helpful to try and monetize these effects, it is important to recognise them and the extent to which they may impact on economic performance in future years through increased aversion to risk, adjustment of systems to improve resilience etc.

7. Conclusions

This study of economic costs for the 2014 winter floods has applied the broad methodology set out by Morris (2012) to scope costs, looking separately at arable, grassland, livestock and other components separately and then aggregating these to provide an estimate of net economic cost. This approach is consistent with the Environment Agency protocols for flood risk management as set out in the Multi-Coloured Manual. The distinction between financial and economic costs is observed in part insofar as public subsidies are excluded but no account is taken of displacement (given the timing of the floods and limited areas of high-value crops).

This analysis is constrained by the absence of reliable evidence of actual farm-level economic impact, given that it was undertaken during the course of the flood events. It relies instead on a high-level analysis to assess flood extent, severity and impact, which entails the use of multiple assumptions and proxies and limits the robustness of the economic cost estimate provided. For example, the analysis uses generic datasets, including satellite mapping of flood areas and 1km^2 GIS grid data on land use from the 2010 June census as well as multiple broad assumptions, including using flood duration as a proxy for severity and limited stakeholder consultation to scope farm-level impacts and responses. As such this analysis must be treated with a high degree of caution and the authors have provided some sensitivity analysis.

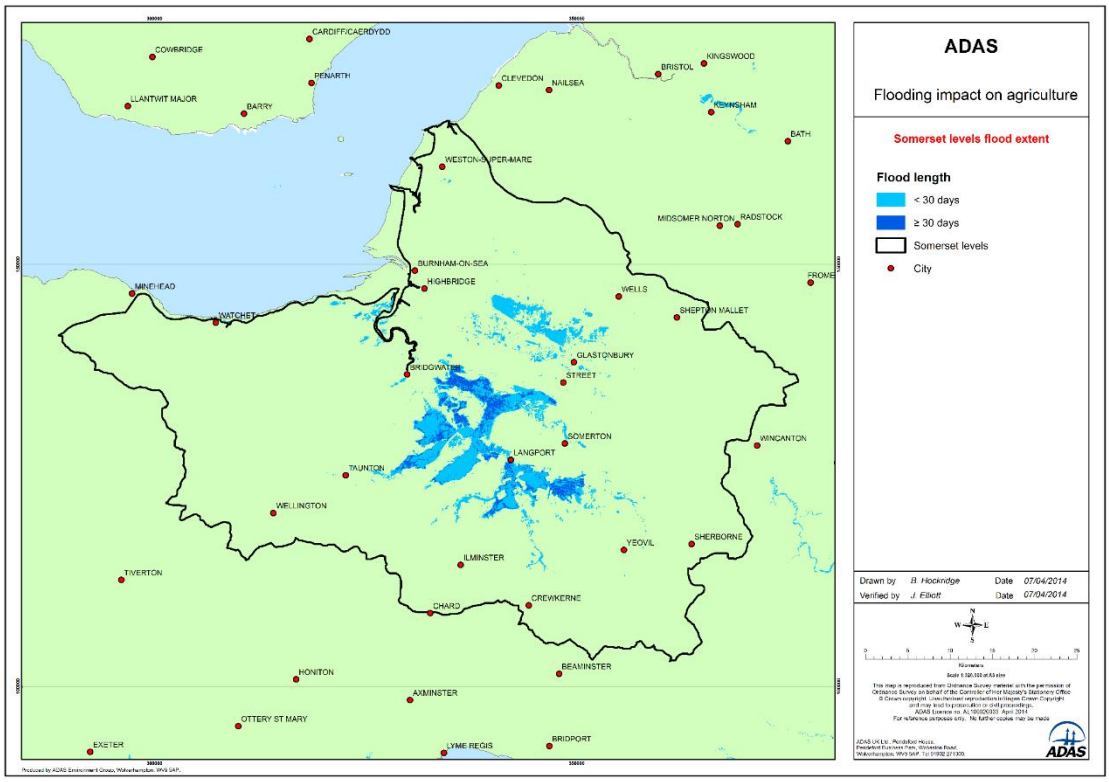
The central estimate of flood damage cost is £18.9 million or £425 per hectare flooded but this is subject to substantial uncertainty and could range from £11.8m using the lower range estimates to £24.9m at the higher range. Even the latter is substantially lower than the estimated cost of the 2007 summer floods (£1207 per hectare), although the latter impacted on ready-to-harvest costs. While the area affected at 44,404 ha was similar to the 2007 floods (estimated at 42,000 ha by ADAS), the average figure was affected by the land use, namely horticulture and arable units. The estimates of damage cost for Cereals and Grazing Livestock farm types was £850/ha and £612/ha respectively. For the 2014 winter floods, two thirds of the land was in grass and much of the arable area affected will be harvested. The estimate of Other costs at over £5m represents 30% of the total damage costs. This is higher than the 20% estimated in previous work and requires further investigation to ensure it has not been overstated. However, it may reflect the fact that these were winter floods with only winter cropping and grassland affected and an opportunity for crops to partially recover and for unviable crops to be re-drilled.

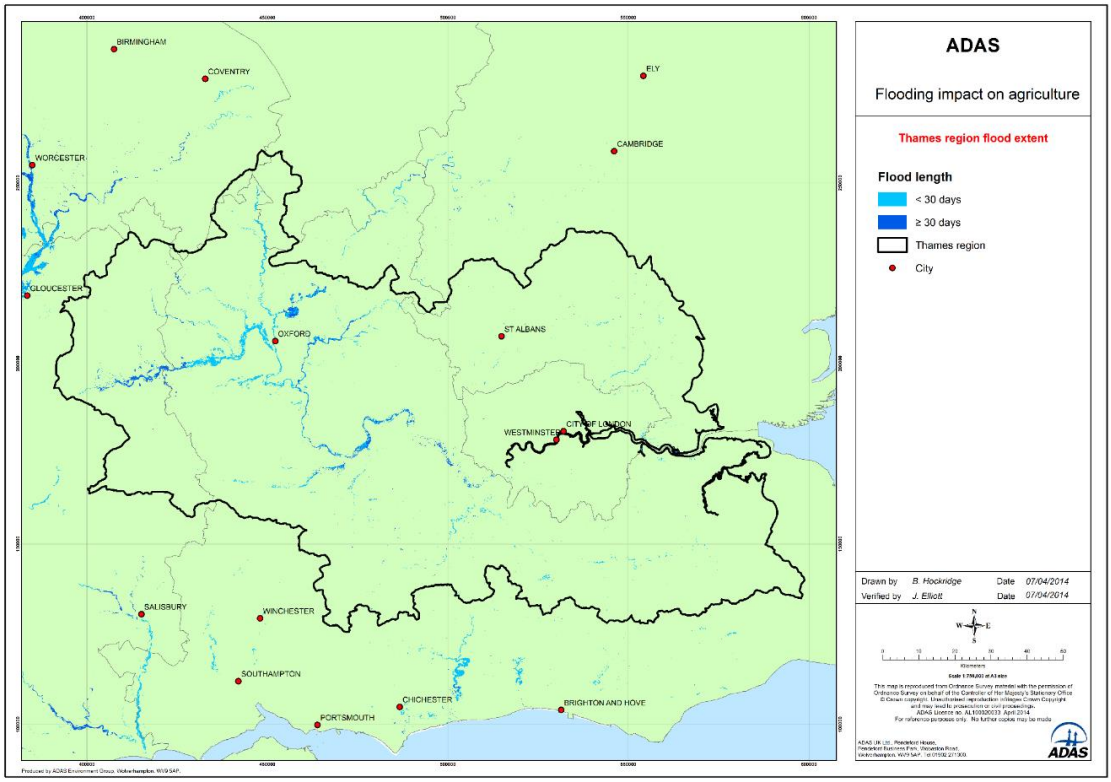
Research undertaken by Posthumous et al (2009) for the 2007 summer floods found that found that flood damage costs were skewed, with the majority of the farms facing lower losses than the average and a few farms incurring very high losses. As such, only a more detailed ex post analysis based on a representative sample of farmers in the affected areas, can provide a robust assessment of actual costs incurred.

It is also important to establish the counterfactual position i.e. the degree of flooding in particular areas which is considered the norm. In principle, extreme flood events should be assessed against this baseline to estimate additional damage costs.

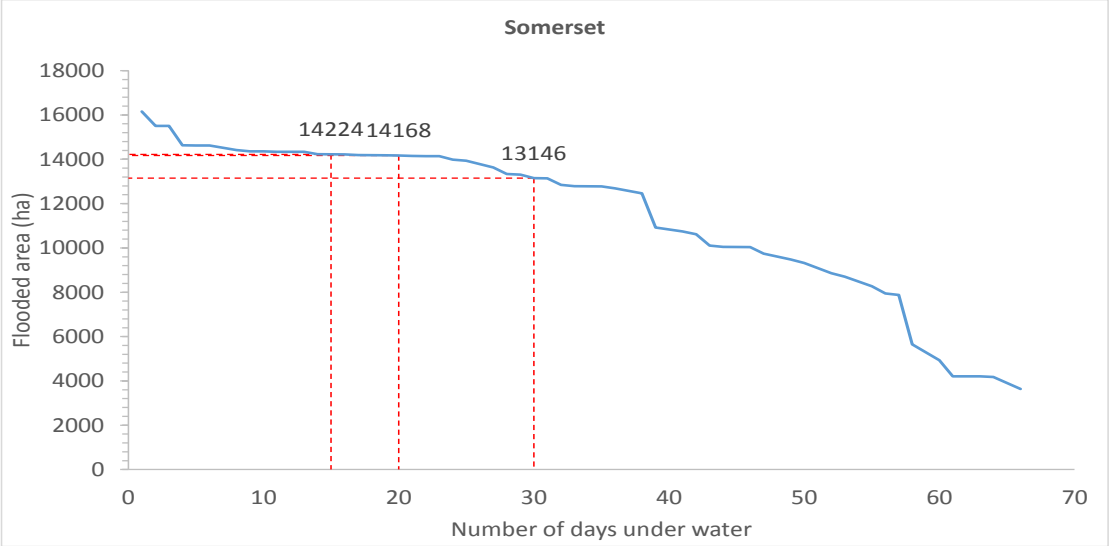
Overall, the cost estimate provides a useful steer on the extent of flood damage to the agricultural sector, not only in relation to short-term public funding for compensating affected farms but also for wider policy. These events are expected to become more common as the impacts of climate change are increasingly felt and it is important that public policy responds to this through strategic adaptation measures such as flood defences but also by incentivising appropriate land use e.g. washlands and other agri-environment options. This will require engagement with the industry at a national and local scale and should be given a high priority.

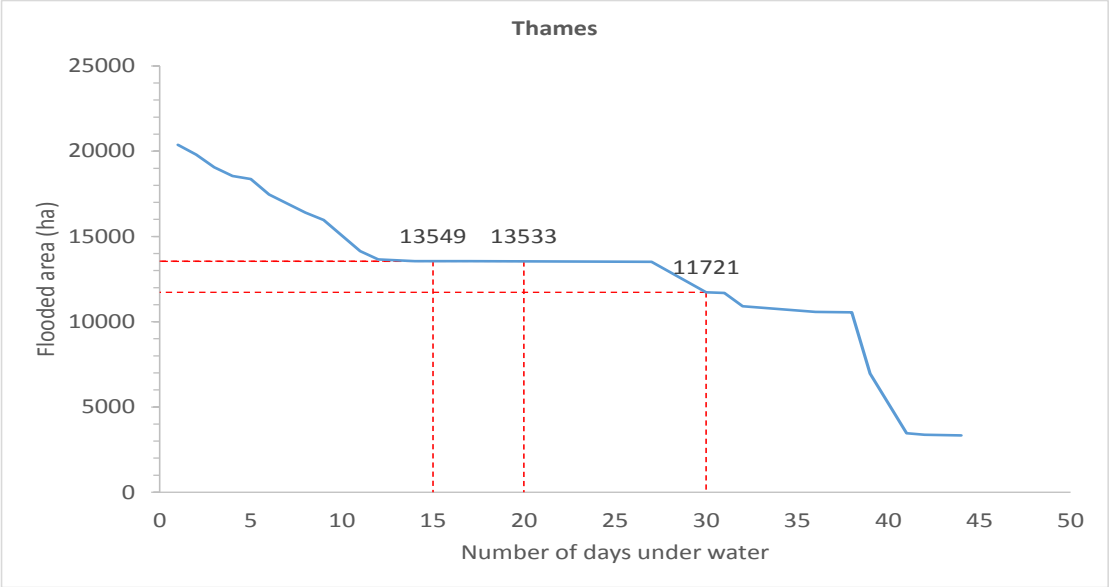
Annex 1: Flood areas in the Somerset Levels and Thames Valley

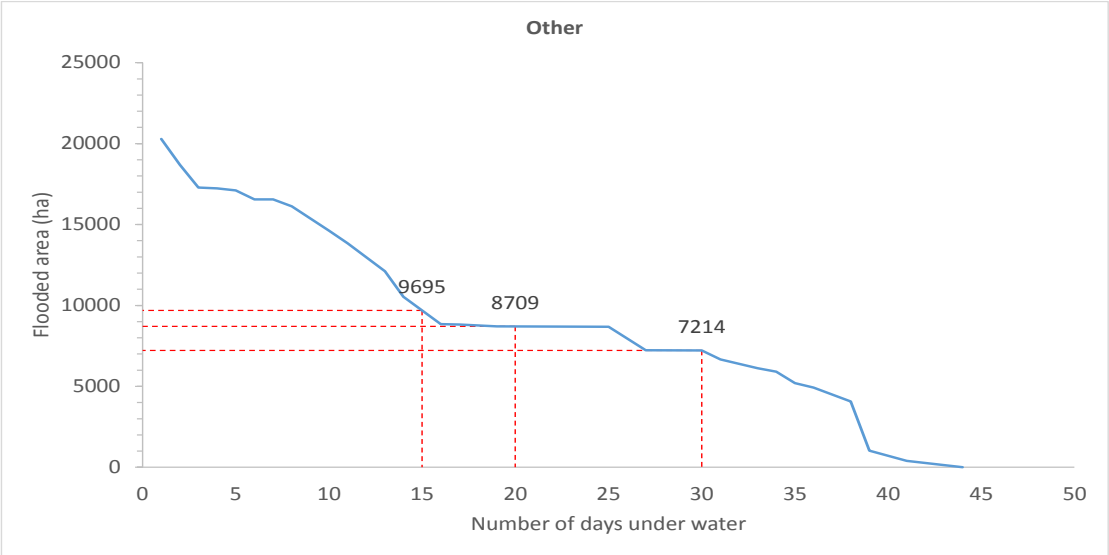




Annex 2: Land area under water over time by flood region







Annex 3: Flood mapping methodology

Land Cover and cropping/livestock 1km^2 data

A 1km^2 dataset of non-agricultural land cover has previously been developed by ADAS by integration of Ordnance Survey data on the location of urban areas, forests and other blocks of non-agricultural land with the CEH Land Cover Map 2000. This methodology resulted in a dataset at 1 km^2 that contained the percentage cover of five broad non-agricultural classes (sea, water, wood, urban, rough grazing), with the remainder being assigned to the class 'agriculture'. The area of agricultural land in this dataset was then divided into arable and grassland in three iterative stages.

The ADAS 1km^2 cropping dataset was derived by multiplying the proportion of each crop for the parish (from June Agricultural census 2010) by the total area of arable land (or grassland) in that cell. Similarly, livestock statistics per 1km cell are derived from parish figures using stocking density estimates on different types of agricultural land. Estimates of the number of livestock per grid cell were obtained by summing the livestock census categories.

Flood Data (©Environment Agency 2014)
Flood outlines were generated from Optical and Synthetic Aperture RADAR (SAR) satellite data during the 2013/2014 winter floods in Southern England. The satellite data was used to show the extent of flooding for catchments in Southern England (including the Tamar, Exe, Parrett, Avon, Severn and Thames river catchments) between 7th January 2014 and 16th March 2014. The satellite data was processed by the Environment Agency to provide a classification for the extent of flooding as either area under water 'Flood' or not 'No Flood' at a given point in time.

The flood data was made up of 43 different images on 23 different days, spanning a period of 69 days. The availability of data was dependent on the orbit cycle of the satellites used, and obtaining cloud-free images. Therefore the time period that the imagery spanned varied by area. Due to the variability in extent and time period, GIS (Geographical Information System) analysis was used to obtain information on the dates of images that covered any given area of land, and the classification status of 'Flood', 'No Flood' or 'No Data' for each date. For each of these land parcels, the maximum length of time that any given area could have been flooded was calculated. For the days between classifications of 'Flood' and 'Flood', or 'No Flood' and 'Flood', or 'Flood' and 'No Flood', the time between these images was assumed to have been flooded. Classifications of 'No Data' were ignored between dates where a classification was known.

If there was only 'No Data' before a known time of 'Flood', the flood period was assumed to have started on the first date of 'Flood'. Likewise, if there was only 'No Data' after a known time of 'Flood', then the flood period was assumed to have stopped on this date. If only a single classification of 'Flood' was available, then the flood length was assumed to be 1 day. Below is a table outlining some example scenarios and how they would be classed.

Table 17: Example of how different flood cover scenarios are interpreted

13/02/2014	16/02/2014	18/02/2014	19/02/2014	22/02/2014	25/02/2014	Max Flood duration
Flood	No Data	No Data	Flood	No Flood	Flood	8 days
No Flood	No Flood	No Data	Flood	No Data	Flood	9 days
No Data	No Data	Flood	No Data	No Data	No Data	1 day
No Data	Flood	No Data	Flood	No Flood	No Flood	6 days

Annex 4: Stakeholder consultation details

Consultees

1. NFU Somerset regional officer
2. Seed and grain merchant
3. RSPB South Somerset
4. Evolution Farm Vets
5. Duchy College, Flag, forage aid & local farmer
6. Somerset Council- Sedgemoor District Council
7. Land agent - Somerset
8. Arable and sheep farmer
9. Somerset County Council- council farms
10. Land agent (Somerset)
11. Sedgemoor market
12. FCN (Farming Community Network)
13. West Berkshire Council
14. Farmer
15. Farmer
16. Farmer
17. Farmer
18. Land agent (Thames)
19. NFU Berks, Bucks and Oxon advisor
20. Vegetable grower
21. Fruit and vegetable grower
22. Agronomist
23. Agronomist
24. Agronomist
25. Agronomist

Telephone interview topic sheet

Respondent name
Organisation
Telephone number
Region
Date of interview
Time of interview
1. Please explain the effects from the 2014 flooding - and where possible the potential costs?
a. Short term (Prompt: submerged land, farms cut off, mortality, damage to farm buildings, feed and bedding lost)
b. Medium term (Prompt: Grazing land effected, clean-up costs, contamination, damage to building and fences)
c. Long term effect (Prompt: change in land use, long term contamination, need to build flood defences)
2. How is the area flooded in 2014 differ to normal- both extent and length of time
a. Extent/area
b. Frequency
c. Length of time
3. How many farm holdings were affected and what type of holdings?
4. What are the main land use impacts from the flooding (Need to drill down to get as much information as possible)e.g.
a. Total crop losses:
i. what crops
ii. area affected
iii. what will be re-drilled in the spring
b. Partial crop losses:
i. what crops
ii. area affected
c. Total grassland losses:
i. Area submerged, grass killed off, re-seeding allowed/possible?
ii. Damage to grassland
e. Land lost to agriculture
f. Other
5. What immediate actions will be required to reinstate the land? What proportion of area does this apply to?
a. Cultivations and re-drilling
b. Cleaning/Removing debris
c. Scarify and drill into existing sward
d. Drainage
e. Other
6. Are there any longer term impacts on land use?
a. Permanent change from cropping to grassland
b. Permanent change to permanent grassland
c. Abandon farming
7. Has any land been contaminated? With what, area affected and impacts?

a. Silt/soil
b. Sewage
c. Debris/ rubbish
d. Other
8. Will the designations of SSSI, CSF etc. affect what you can do to reinstate?
Will grassland simply recover as it floods every year
How long will it take to recover
9. What were the impacts on livestock? (also ask which species)
a. Mortality
b. Moved away – additional rent, cost of transport –
c. Sell stock
d. Reduced milk yields?
e. Poor calving?
f. Health and welfare effect
g. Other
10. What proportion of forage/straw/feed was lost?
11. Did many farmers have to buy feed or collect forage from the forage bank
a. How much and at what cost
12. Are cattle /sheep having to be housed for longer than normal due to flooding?
a. How much longer?
b. Will they be able to go out to their normal pastures in the near future?
c. Is turnout likely to be later than normal?
d. Will farmers have to sell stock as a result pf pasture contamination
13. Are there likely to be any longer term health and welfare issues?
14. What damage was there to infrastructure?
a. Fences
b. Buildings
c. Farm roads and tracks
d. Other
15. What damage was there to machinery
16. Was any likely to be covered by insurance?
17. What were the typical additional management activities, time and costs over and above a normal year (preventing water ingress into building, moving and feeding stock, cleaning up and disposing of debris etc.)?
18. Is there any impact on local rents or land valuations?
19. Were there any local initiatives to support farmers? E.g. Forage aid.
21. When will farmers be back to normal
a. Explore for different farm types and sizes
22. Are there any additional disposal costs?
23. Are there any impacts on the wider supply chain?
a. Milk collections
b. Feed companies
c. Other

Annex 5: Methods for the Estimation of Agricultural Flood Losses

Flood Damage Costs at Farm Level are represented by Morris (2012)[8] as:

C_{FARM} = ARABLE + GRASS + LIVESTOCK + OTHER

where:

C_{FARM} = cost of flood damage to farming business: agricultural damage (£)
ARABLE = cost of flood damage to crop production (£)
GRASS = cost of flood damage to grass production (£)
LIVESTOCK = cost of flood damage to livestock production (£)
OTHER = miscellaneous costs

Estimates of damage costs for ARABLE and GRASS are best estimated per ha flooded and grossed up according to respective areas at the farm scale. LIVESTOCK and OTHER costs are best estimated at the farm scale.

ARABLE flood damage costs:

ARABLE = CROPLOSSARABLE + INPUTSARABLE + HARVESTARABLE+ LANDARABLE – RESEEDARABLE + RESIDUALARABLE

where:

CROPLOSSARABLE= reduced yield (t) and quality at market prices (£) in the year of the flood. (£/ha)
INPUTSARABLE = cost of additional agro-chemicals arable crops less savings in uncommitted costs (£/ha)
HARVESTARABLE = additional harvesting costs less savings in uncommitted harvest costs (£/ha)
LANDARABLE = cost of land reinstatement (restoration cultivation) land (£/ha)
RESEEDARABLE = value of output of replacement crop less costs of crop establishment and production costs (fertiliser, chemicals, labour and machinery), where relevant (£/ha)
RESIDUALARABLE = carryover impacts on yield loss and other costs to subsequent year(s) (£/ha)

GRASS flood damage costs

GRASS = FORAGE + INPUTSGRASS + HARVEST GRASS +LANDGRASS + RESEEDGRASS

where:

FORAGE = loss of energy (based on estimates of forage dry matter (t/ha) and energy value (MJ/t) by grassland type and use, namely hay, silage and grazing– valued at barley feed equivalent (£/ha)
INPUTSGRASS = cost of additional agro-chemicals on grass less savings in uncommitted costs (£/ha)
HARVEST GRASS = net savings in forage harvesting costs (£/ha)
LANDGRASS = cost of land reinstatement grassland (£/ha)
REPLACEMENT = costs of grass reseeding (seeds. fertiliser, labour and machinery) (£/ha)

[8] Morris (2012) Review of factors affecting the damage costs of flooding on agricultural land in support for estimates for the 2012 floods. Report to The Environment Agency, Economics and Social Science (Evidence). December 17th 2012.

LIVESTOCK) flood damage costs

LIVESTOCK = MOVE + HOUSING + FEED + SERVICES + MORTALITY + SALES – HARVESTSAVINGGRASS

where:

MOVE = Cost of labour and machinery to relocate livestock (£)
HOUSING = cost of additional labour needed for housing of livestock (£)
FEED = additional costs of conserving feed for housed stock plus costs for purchased feeds over and above estimated forage losses (£)
SERVICES = additional waste management, water and vet services associated with housed stock (£)
MORTALITY = cost of increased livestock mortalities due to flooding (£)
SALE = loss of value from forced sales (or reduced purchases) of livestock and reduced milk sales due to flooding (£),
HARVESTSAVINGGRASS = net savings in harvesting and storage costs for grass forage (£)

OTHER farm Costs

OTHER = BUILDINGS + UTILITIES + MACHINERY +FIELD INFRASTRUCTURE + DEBRIS + FARM SERVICES +FINANCING + SUNDRY

where:

BUILDINGS = farm structures and contents
UTILITIES = disruption and replacement of essential farmstead services e.g. power and water
MACHINERY = farm machinery and equipment, including irrigation and drainage equipment
FIELD INFRASTRUCTURE = hedges, fences/gates, land drainage works, tracks
DEBRIS = Clean up and debris removal and disposal
SERVICES = loss of net revenue from services, e.g. contracting
FINANCING = additional borrowing costs
SUNDRY = other farm specific costs

Annex 6: Per hectare economic outputs and inputs by farm type (from FBS)

	Cereals	General cropping	Horticulture	Mixed	Dairy	Lowland Grazing Livestock	LFA Grazing Livestock	Pigs	Poultry
Agricultural output per ha									
winter wheat	£1,170	£1,207	£1,391	£1,133	£1,169	£1,207	£3,353	£1,225	£1,195
winter barley	£835	£774	£694	£828	£694	£896	£2,218	£1,148	£1,027
spring barley	£852	£877	£530	£984	£530	£775	£1,823	£1,452	£772
other cereals	£596	£429	£762	£513	£762	£620	£1,302	£392	£604
oilseed rape	£1,174	£1,283	£1,289	£1,186	£1,289	£1,297	£0	£1,288	£1,159
peas and beans	£651	£873	£680	£623	£680	£672	£550	£756	£423
potatoes	£4,072	£5,146	£5,358	£4,956	£5,358	£0	£0	£3,250	£0
sugar beet	£1,945	£1,946	£2,157	£2,043	£2,157	£0	£0	£1,695	£1,529
Other Crops (including horticulture)	£639	£3,025	£15,508	£1,268	£15,508	£2,078	£3,467	£817	£1,016
Agricultural output per head									
milk and milk products	£1,430	£2,556	£0	£2,020	£1,982	£1,195	£1,327	£0	£965
dairy cattle	-£520	-£558	£0	-£188	£0	-£448	-£253	£0	-£133
other cattle	£325	£373	£0	£363	£0	£339	£335	£328	£297
sheep and wool	£103	£109	£0	£106	£0	£104	£73	£102	£88
pigs	£55	£73	£0	£144	£0	£58	£148	£170	£60
eggs	£18	£21	£0	£19	£0	£29	£20	£24	£16
broilers and other poultry	£24	£24	£0	£11	£0	£26	£10	-£11	£10
Agricultural inputs									
Variable costs	**per ha**				**per head**				
seed	£48.91	£118.37	£2,406.09	£39.13	£28.30	£9.73	£5.95	£0.54	£0.02
fertilizers	£149.67	£159.21	£483.18	£102.40	£107.60	£41.26	£44.59	£1.29	£0.03
crop protection	£120.89	£142.63	£354.44	£66.83	£27.75	£8.66	£5.06	£1.32	£0.04
other crop costs	£26.40	£90.17	£2,015.96	£21.85	£18.62	£9.28	£8.67	£0.22	£0.01
Livestock specific costs	**per ha**				**per head**				
purchased feed & fodder	£11.19	£17.43	£20.39	£217.83	£658.96	£117.10	£136.27	£89.71	£6.42
home grown feed & fodder	£4.97	£10.22	£7.80	£71.67	£55.56	£28.78	£16.54	£3.36	£0.02

veterinary fees & medicines	£2.52	£2.77	£5.04	£24.88	£88.34	£25.99	£30.87	£5.02	£0.18
other livestock costs	£8.89	£10.08	£12.99	£78.87	£202.75	£71.91	£70.32	£10.51	£0.59
Contract costs	£72.82	£103.49	£192.12	£77.75	£132.33	£48.94	£37.28	£3.64	£0.16
Casual labour	£10.83	£58.71	£1,343.28	£17.54	£25.51	£9.99	£11.29	£1.07	£0.07
Miscellaneous variable costs (including for work done on other farms)	£4.51	£7.20	£50.35	£2.18	£0.88	£1.34	£1.73	£0.00	£0.00
Fixed costs	**per ha**				**per head**				
Regular labour	£58.95	£145.06	£2,723.18	£99.62	£199.74	£37.58	£30.43	£17.68	£0.93
Machinery: fuels and oils (a)	£51.72	£77.99	£280.02	£58.76	£72.78	£39.01	£40.45	£3.08	£0.11
Machinery: repairs and other (a)	£52.48	£87.36	£345.45	£63.44	£89.82	£42.71	£39.57	£4.30	£0.18
Machinery depreciation	£116.34	£145.73	£458.33	£119.12	£157.40	£82.80	£85.03	£5.73	£0.28
Depreciation of glasshouses & permanent crops	£0.01	-£1.22	£141.23	-£0.13	£0.00	£0.00	£0.00	£0.00	£0.00
General farming costs	**per ha**				**per head**				
Bank charges & professional fees	£25.43	£27.30	£190.27	£23.74	£37.31	£19.89	£18.54	£1.38	£0.12
Water, electricity and other general costs	£59.11	£87.59	£813.04	£75.28	£128.88	£57.94	£53.56	£6.96	£0.70
Share of net interest payments	£19.60	£25.63	£110.95	£22.68	£41.10	£15.08	£14.77	£2.70	£0.13
Write-off of bad debts	£0.07	£0.35	£3.75	£0.00	£0.03	£0.11	£0.05	£0.00	£0.00
Land and property costs	**per ha**				**per head**				
Rent paid	£75.60	£127.02	£424.00			£51.44	£54.38	£7.11	£0.25
Maintenance, repairs and insurance	£3.06	£3.97	£23.54	£2.67	£3.68	£2.07	£2.16	£0.29	£0.02
Depreciation of buildings and works	£16.12	£19.22	£107.71	£27.35	£56.43	£14.08	£13.58	£3.48	£0.43
Miscellaneous fixed costs (including for work done on other farms)	£55.99	£67.66	£79.38	£46.30	£23.03	£24.21	£19.04	£0.44	£0.03