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Evidence Project Final Report

- **Note**
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Project identification

1. Defra Project code: SCF0101
2. Project title: Climate Change and Extreme Weather Events, Establishing a Methodology for Estimating Economic Impacts on Agriculture.
3. Contractor organisation(s): ADAS (UK) Ltd
4. Total Defra project costs (agreed fixed price): £ 33,030
5. Project: start date ..... 23 January 2013
   end date ..... 30 July 2013

6. It is Defra's intention to publish this form.

   Please confirm your agreement to do so.....**YES** ☒ **NO** ☐

   (a) When preparing Evidence Project Final Reports contractors should bear in mind that Defra intends that they be made public. They should be written in a clear and concise manner and represent a full account of the research project which someone not closely associated with the project can follow.

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   (b) If you have answered NO, please explain why the Final report should not be released into public domain

Executive Summary

7. The executive summary must not exceed 2 sides in total of A4 and should be understandable to the intelligent non-scientist. It should cover the main objectives, methods and findings of the research, together with any other significant events and options for new work.

Extreme weather events are unusual, severe or unseasonal changes in weather patterns and have the potential to cause significant cost to society. The agricultural sector's exposure to and reliance on the climate makes it particularly vulnerable. It has been well documented that there is an increasing incidence of extreme weather events which can be attributed to anthropogenic climate change. Models to estimate the impact of climate change generally predict only average changes to climate with limited ability to predict extreme weather events. As such defining the economic impacts and responses of agriculture to extreme weather events is difficult.

This project aims to address this limitation by establishing and testing a methodology to estimate the economic impacts of extreme weather events on agriculture in England using scenarios (rather than modelled outputs) of extreme weather events. The context for these scenarios was to explore 'worst case scenarios' for extreme weather, taking account of climate change in 2050.

The overall aim of the research is to develop a methodology to assess costs and impacts of extreme weather events to inform policy. The specific objectives of this study were to answer the following questions:

(a) What extreme events have the potential to incur substantial costs on agriculture?

(b) How do extreme events influence the behaviour of farmers, and the decision criteria (e.g. approach to risk) they use? In particular, are there systematic failures in the perception of risks?

(c) How can the economic cost associated with these events be estimated?

Five sequential but discrete tasks were carried out:

(i) A Rapid Evidence Assessment (REA) of past extreme weather events

(ii) Developing eight extreme weather scenarios for 2050

(iii) Estimating the impact of these scenarios on key agricultural sectors (Arable, Horticulture, Dairying, Sheep, Cattle, Pigs and Poultry)

(iv) Describing a method for using these impacts alongside economic datasets and spatial mapping to estimate economic impacts

(v) Consideration of adaptations.

The REA covers the period from the late nineteenth century to present day and focused on extreme weather events, economic impacts on agriculture and adaptive responses. It identified a number of extreme weather events which were then used to inform the development and characterisation of scenarios.

In developing the extreme weather scenarios for 2050 the insight and expertise of policymakers, climate scientists and industry stakeholders was pooled via a workshop. Using the workshop output alongside Met Office datasets and the REA findings, eight final scenarios were agreed. These scenarios included: mild winters, localised flooding, wet weather, seasonal dislocation and set combinations of extreme events, for example, a mild dry winter followed by severe spring frost. The magnitude of each weather event was defined using existing Met Office datasets and best available knowledge on feasible weather patterns by 2050.

Using the eight defined extreme weather scenarios, ADAS experts in key agricultural sectors (arable, horticulture, dairying, sheep, cattle, pigs and poultry) were tasked with estimating the impacts of extreme weather on their sector. The impact metrics considered fell under four key themes: environment, soil, lands and crops and livestock. Experts were given a common briefing to allow some standardisation and were questioned on sector-specific impacts and adaptations for each extreme weather scenario. Both quantitative and qualitative data was collected for completeness.

From the quantitative data provided by sector experts and using Farm Business Survey data as a baseline of economic performance an Excel-based model was developed. The model translated both direct and indirect effects of weather on agricultural outputs and inputs across nine robust farm types in England on a 'per unit of production' basis (per hectare or per head of livestock). The model also allows for price impacts due to supply changes (both nationally and globally). In order to scale up the impacts for particular weather events, published spatial datasets were used to define the boundaries of likely impact. Datasets included the Defra Census[1], Environment Agency Flood zones and soils data (HOST soil wetness and drought prone soils).

Nine steps are set out in the report to detail how the data can be used to derive aggregate economic impacts. These are:

Step 1: Define the scenario weather event in terms of meteorological parameters, specifying spatial and temporal boundaries.
Step 2: Estimate the change in agricultural production parameters associated with the scenario for key sectors – enterprise yield, product quality, inputs and resources (soil, infrastructure etc) – using expert opinion and/or empirical evidence as available.
Step 3: Calculate the 3-year 'average' economic performance for robust farm types (FBS data) at farm level.
Step 4: Use robust farm type data (from Step 3) in combination with estimates of change in <u>volume</u> due to extreme weather (from Step 2) to estimate the unit <u>value</u> change in output for each crop or livestock type and for each input category.
Step 5: Define the spatial scale for the area affected by the weather event – administrative boundaries (regions, counties) – and overlay with the Defra Census dataset to calculate hectares of crop and head of livestock within that area.
Step 6: Use cropping and stocking data from (Step 5) to scale up the output for each crop or livestock type and for each input category.
Step 7: Adjust for price impacts at UK and global scale.
Step 8: Aggregate the scaled impacts for each enterprise and cost category to calculate total economic impact.
Step 9: Aggregate multiple year impacts

The analysis indicated that from the eight extreme weather scenarios considered, summer flooding and consecutive wet autumn/winters would have the most detrimental impact on economic performance per unit of agricultural land area. The impact of summer flooding (Scenario 1) was estimated to be a net economic loss of £776/ha while consecutive wet autumn/winters (Scenario 2) led to an estimated net economic loss of £537/ha.

When per hectare data was scaled up using Census data and other spatial datasets, the most significant extreme weather event in terms of total economic impact was 'seasonal dislocation' (Scenario 5), a 12-month sequence of unseasonal weather events. The total economic impact of a seasonal dislocation scenario was estimated at a net loss of £1,361 million. This is attributed to it being a nationwide event, whilst flooding events are more localised and demonstrates the impact different extreme events can have

[1] Agricultural Census data is collected annually by survey from a sample of commercial farmers and growers; the data is confidential and is for Defra's internal use only. Aggregated data is published online at https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs/series/structure-of-the-agricultural-industry#publications

over different scales. A number of inter-sector differences were also observed between extreme weather scenarios. Horticulture generally showed some of the biggest potential losses and poultry some of the smallest due to the largely indoor-based production system.

All scenarios were associated with a net economic loss apart from scenarios 3 (Mild Winters) and 7 (Drought with Extreme High Summer Temperatures), where commodity price increases offset volume production losses. The net impact was an estimated economic benefit of £184 million and £23 million for scenarios 3 and 7 respectively. These private benefits are associated with a societal loss as consumers will pay higher prices for food.

Adaptation measures were also considered on a farm scale for each extreme weather scenario for each farm sector. The scope for adaptations to be implemented varied widely depending on the extreme weather scenario and the farm sector. High value horticulture crops already demonstrated a number of adaptations and an ability to take up adaptations as required in the face on extreme weather events. A key issue with adaptation measures is uptake, as most measures incur a cost, while the benefits rely on the incidence of relevant extreme weather events. Whilst suggestions for sector adaptations showed overlap with the Defra list, there were additional ideas for adaptations which merit consideration and follow up work.

The analysis outlined offers a framework for quantifying impacts rather than presenting a definitive analysis of the impact of extreme weather. The eight scenarios outlined are not exhaustive and the model has to capacity to be used to test additional variants including policy changes and incorporate emerging evidence. The methodology has a number of limitations and areas for further work are highlighted.

The most challenging aspect was securing reliable quantitative estimates of impact by sector for the eight scenarios described due to the heterogeneity of farmland, production systems and management, as well as responses and adaptations. More work is necessary in this area and it is suggested that localised case studies would provide a suitable approach. There are also limitations in terms of datasets (detail and availability) and assessing medium-term impacts.

Project Report to Defra

8. As a guide this report should be no longer than 20 sides of A4. This report is to provide Defra with details of the outputs of the research project for internal purposes; to meet the terms of the contract; and to allow Defra to publish details of the outputs to meet Environmental Information Regulation or Freedom of Information obligations. This short report to Defra does not preclude contractors from also seeking to publish a full, formal scientific report/paper in an appropriate scientific or other journal/publication. Indeed, Defra actively encourages such publications as part of the contract terms. The report to Defra should include:
   - the objectives as set out in the contract;
   - the extent to which the objectives set out in the contract have been met;
   - details of methods used and the results obtained, including statistical analysis (if appropriate);
   - a discussion of the results and their reliability;
   - the main implications of the findings;
   - possible future work; and
   - any action resulting from the research (e.g. IP, Knowledge Exchange).

See separately published report.

References to published material

9. This section should be used to record links (hypertext links where possible) or references to other published material generated by, or relating to this project.