9 Appraisal of Flood Risk Management for Agriculture

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OVERVIEW

Flood risk management for farmland is an important element of support to the agricultural sector in Britain. Many floodplain and coastal areas benefit from publicly funded flood defence[1] and land drainage schemes that reduce flood damage and provide opportunities for productive farming (Morris, 1992).

Flood risk management (FRM) for agricultural land can facilitate agricultural production where otherwise it would be impeded – for the whole or for part of the year - by either saturated soils or surface inundation. Agricultural land may be lower than high tide or fluvial flood levels and FRM for agriculture protects these areas from regular flooding, in some cases assisted by pumping schemes. Sea defences can prevent inundation by sea water that can result in complete crop loss and reduced yields in subsequent years. Coastal protection may prevent agricultural land from being lost to the sea.

There is increased use of 'natural processes' and 'non-structural measures' to reduce flood risk in urban areas by retaining water in the general farmed landscape or temporarily storing it in floodplains (Environment Agency, 2018; Morris *et al.*, 2014; SEPA, 2015; cbec, 2017). Simultaneously there has been a drive to integrate FRM in rural areas with other objectives, such as nature conservation, soil protection, water quality improvement and recreation (Yorkshire Dales, 2017), often supported by an 'ecosystems' approach to the management of land and water resources (Posthumus *et al.*, 2010; Rouquette *et al.*, 2011).

The role of appraisal is mainly to determine whether it is worthwhile to provide a given standard of FRM for agriculture (Figure 9.1). This may involve comparing some existing or proposed standard with the 'do nothing' option, recognising that tolerance of flooding and associated damage costs vary considerably amongst land uses (Table 9.1). Appraisal may require a comparison of the financial and economic performance of agricultural land use under a range of different flood risk management regimes, and how these compare with the costs of delivering those options.

Where farming is impossible in the absence of flood defence, the advice is to estimate economic loss (and therefore the benefits of flood defence) in terms of the loss of the 'adjusted' market value of agricultural land.

[1]The terms flood 'defence' and 'protection' are often used in the agricultural case, reflecting the past focus on reducing flooding on agricultural land to enhance its productivity. The term 'flood risk management', however, is now more appropriate for the appraisal of the range of flood management options on farm land, including the intentional use of farmland for the temporary storage of flood waters.

The approaches needed for appraisal are:

- At a broad catchment scale, appraisals will at least require information on categories of land use, and the extent to which these might be affected by a change in flood frequency.
- At a detailed scheme appraisal level, there will be a need to collect primary data and undertake detailed analysis of farming systems, in proportion to the significance of agriculture within the scheme as a whole.
- Such detailed scheme level analysis is usually complex and is not detailed here. The MCM (Penning-Rowsell *et al*., 2013) has the complete coverage of this topic. Recommended methods have changed since the 2005 edition.

Concerns about global food security and the possible impacts of climate change have renewed interest in improving the productivity of British agriculture. Almost 60% of Grade 1 Agricultural Land in England is dependent on flood risk management and land drainage, including coastal defences and pumping infrastructure. However, for major flood events in the UK, agricultural losses tend to be a relatively small proportion of total damage costs. Flooding occurred on between 40,000 ha and 50,000 ha of farmland in different parts of the country in the 2007 summer floods in England and also in the winter 2013/14 floods England and Wales. In both cases 'on-farm' agricultural damage costs only accounted for about 3% of the estimated total economic costs of the event (Chatterton *et al*., 2010; Chatterton *et al.*, 2016). Agricultural flood costs may however be regionally concentrated: agricultural damage costs accounted for about 8% of total estimated economic costs attributed to flooding in Somerset during the long duration winter 2013/14 event.

The assessment of agricultural damage costs here is based on Chapter 9 of the MCM (Penning-Rowsell *et al*., 2013), which draws evidence from the 2007 (Posthumus *et al*., 2009) and 2012 floods (Morris and Brewin, 2013). The estimates here are also consistent with the type and magnitude of costs incurred in the winter 2013/14 floods in England and Wales (Chatterton *et al*., 2016).

For the purpose here, the estimates of damage costs contained in MCM 2013 and MCH 2013 have been updated to 2019 values using Defra Agricultural Price Indices (Defra, 2019) to reflect changes in agricultural output and input prices between 2013 and 2019[2]. For the most part, agricultural commodity prices in the UK are influenced by world market prices, moderated by UK£ exchange rates. During the period 2017-2019 some recovery of global demand and UK£ devaluation associated with EU exit returned UK agricultural output prices to levels that prevailed in the 2011-2013 period.

Adjustment factors applied here to convert UK 2013 prices used in MCM 2013 to 2019 values are 1.00 for all crop outputs and 0.98 for all livestock outputs. UK Agricultural all input prices are adjusted by a factor of 1.00 (consumables 0.98, non consumables – e.g. buildings and machinery 1.07). As a result, estimated agricultural flood damage costs in 2019 values are very similar to those contained in the MCM for 2013.

LESSONS FROM EXPERIENCE

- There is a close connection between the management of flood risk for agriculture and the management of agricultural land drainage as this affects the productivity of farm land. Managing flooding on farm land cannot be seen in isolation of managing waterlogging.

[2] For the purpose here, price adjustments are based on the reported differences in UK agricultural price indices between the three-year periods 2011-2013 and 2017-2019 (2015=100), including projections made in March 2019 for the remaining part of the 2019 year based on Defra (2019) and AHDB (2018) forecasts.

- The main factors affecting the costs of a flood event on agricultural land are the type of land use, and the seasonality and duration of flooding. Flood costs are much higher on arable land than on grassland, especially where high value salad, potatoes and other vegetable crops are damaged. Flooding in summer results in much higher damage than flooding in winter, especially on arable crops and grassland conserved for winter feed. Generally, the longer the period of flooding, the greater is the damage. Most arable crops and grassland can sustain short period winter flooding of less than one week duration, but yields may be affected. Longer floods have much greater impact.
- Over 80% of agricultural damage costs are associated with loss of production or additional production costs incurred. The remainder is associated with damage to property and equipment. Generally, production losses are not insured.
- At the individual farm scale, the bigger the proportion of the total farm area affected by flooding, the bigger is the likely impact on the farm business as a whole and the magnitude of costs incurred.
- Methods to assess the economic impacts of flooding on agricultural land can also be used to help appraise land-based flood risk management options involving ‘natural processes’ such as the retention of flood water in the general landscape, floodplain storage and conveyance, and the creation of wetlands.

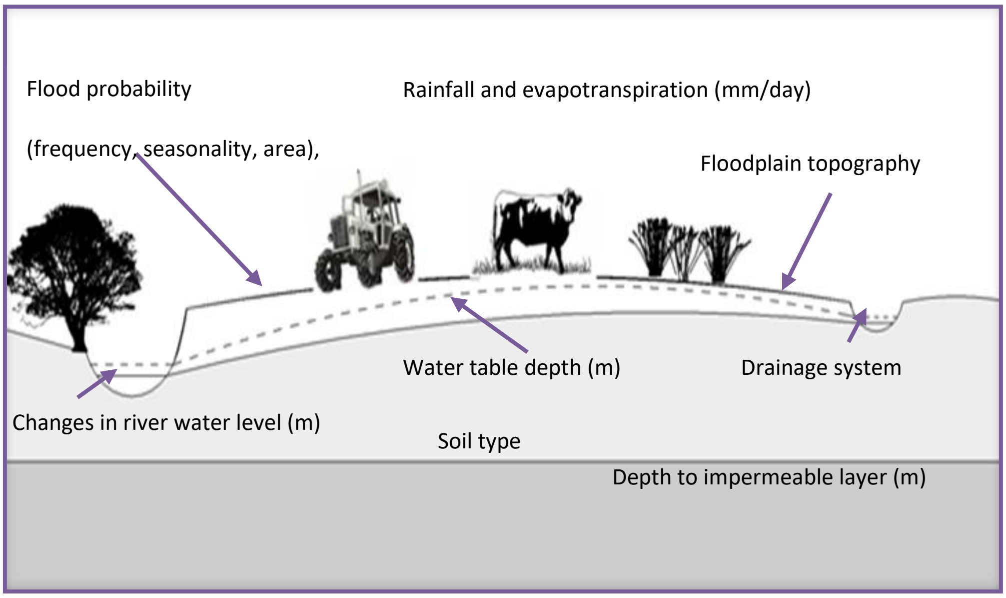

Figure 9.1 Flooding and drainage factors influencing agricultural productivity on floodplain

Table 9.1 Tolerance of flooding according to agricultural land use

Agricultural land use Type	Common minimum acceptable flood frequency: annual probability	
	Whole Year	Summer April-October
Horticulture	5%	1%
Intensive arable including sugar beet and potatoes	10%	4%
Extensive arable: cereals, beans, oil seeds	10%	10%
Intensive grass: improved grass, usually dairying	50%	20%
Extensive grass, usually cattle and sheep	≥100%	33%

METHOD FOR ASSESSING AGRICULTURAL BENEFITS

The principle behind this method is to establish the impact of flooding regimes on agriculture, and then to quantify those impacts as rigorously as possible. Three main steps are required to derive a monetary value of agricultural benefits under different flood risk management conditions. These are listed below.

The greatest detail will be required to assess changes in flood risk management standards for specific schemes on relatively intensively cropped land, including intensive grassland. Less detail is justified for broad scale or 'overview' assessments at the catchment scale.

Step One: Defining agricultural productivity

The first step identifies the total area that is liable to flooding, and hence the 'benefit area' of any flood risk management intervention. The second step determines land use classified into major crop and grassland types (Table 9.1) in order to estimate the likely consequences for the physical and financial performance of arable crops and grassland under different standards of flood risk. The third step assesses the likely soil 'drainage' conditions as determined by field water table levels during critical periods of the farming calendar and the consequences for agricultural productivity (Table 9.2). 'Bad' agricultural drainage, associated with 'sub-surface' flooding and waterlogging of soils, reduces yields and limits land use options. The cost of surface flooding on poorly drained soils is usually less than on well drained soils.

Table 9.2 Drainage conditions for agriculture and water levels in fields and ditches

Agricultural drainage condition	Agricultural productivity class	Depth to water table from surface	Spring time freeboards in water-courses (natural drainage)	Spring time freeboards in water-course (field drains)
Good: 'rarely wet'	Normal, no impediment imposed by drainage	0.5 m or more	1 m sands 1.3 m peats 2.1 m clays	1.2 m clays to 1.6 m sands (0.2 m below pipe outfall)
Bad: 'occasion-ally wet'	Low, reduced yields, reduced field access and grazing season	0.3 m to 0.49 m	0.7 m sands 1 m peats 1.9 m clays	Temporarily submerged pipe outfalls
Very bad: 'commonly or permanently wet'	Very low, severe constraints on land use, much reduced yields, field access and grazing season: mainly wet grassland	Less than 0.3 m	0.4 m sands 0.6 m peats 1 m clays	Permanently submerged pipe outfalls

- For **arable land**, estimates of crop yields can be obtained from farm surveys or from data on regional yields adjusted for local drainage conditions (See Table 9.3: *Common farming performance field drainage conditions (England and Wales)* in Tables and Figures for Chapter 9 on MCM-Online). Farmers are usually able to report the degree to which yields on poorly drained parts of their farm are lower than elsewhere;
- Assessing **grassland** productivity is more complicated, requiring information on type and age or weight of grazing livestock; livestock feeding regime; length of grazing season; liveweight gain or milk yield; and type and tonnage of conserved grass;
- Using data from secondary sources and from farm surveys in the benefit area, it is possible to estimate the productivity of grassland according to the type and number of livestock that can be carried per hectare (ha) under different drainage conditions – see Chapter 9, MCM (Penning-Rowsell *et al*., 2013).

Step Two: Defining the impacts of flooding

These can be distinguished in terms of:

- Frequency of occurrence (including the chance of multiple floods per year);
- Seasonality (especially the distinction between winter and summer floods);
- Duration (from a few days to one or more weeks);
- Depth (as this affects damage to crops and livestock).
- Water quality (including contamination, sedimentation and salinity);
- Soil damage (including compaction and erosion risk, loss of soil biota);
- Carryover effects (chance of crop recovery, impacts on yields in subsequent years).

Flood damage costs comprise damage to arable, grass and other crops, to livestock enterprises and ‘other’ impacts at the farm scale.

Flood costs for arable crops include:

- Loss of the value of output;
- Additional inputs less any savings in uncommitted costs, such as harvesting;
- Remedial work such as 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. This is measured as the energy lost from grass (its calorific value) 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, 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 (see Morris and Brewin, 2013).

The seasonal timing of flooding critically affects flood costs on farm land depending on land use. Summer floods are much more damaging than winter floods (see Table 9.4: *The Impacts of flooding on farm land vary according to type of agricultural land use and the seasonality of the flood event* in Tables and Figures for Chapter 9 on MCM-Online).

In the case of coastal saline flooding, yield losses on most crops are approximately 20% higher than losses due to freshwater flooding, except for potatoes and horticultural crops that would be completely lost. Planting a salt tolerant crop such as barley in the year following flooding may be required, with resultant loss in gross margin compared with normal cropping. Remedial application of gypsum to neutralise saline soils may be required. Coastal flooding tends to result in much higher livestock fatalities than fluvial flooding.

Step Three: Expressing any difference in monetary values

GROSS AND NET MARGINS

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.

The level of detail required depends on the purpose and context of the appraisal. Where the ‘do-nothing’ option involves write-off of agricultural assets, the appraisal can use the estimated reduction in land values as a basis for assessment (as explained below). In many other cases, it will be necessary to estimate the financial (to farmers) and economic (to the national economy) performance of agriculture under different flood management options using the conventions of gross and net margins.

Gross margins per hectare per year of crop or grassland based livestock activity (see Table 9.5 *Indicative Financial and Economic Gross Margins and Net Margins for Selected Crop and Livestock Enterprises and Systems* in Tables and Figures for Chapter 9 on MCM-Online) are used to measure the value of output less variable costs such as seeds, fertiliser and supplementary animal feed if appropriate. Variable costs are directly related to each unit of activity and can be avoided if that activity is not pursued – see Chapter 9, MCM (Penning-Rowsell *et al*., 2013). Gross margins show the monetary gain (or loss) associated with one more (or one less) unit of an activity, assuming other socalled 'fixed' resources available to the business, such as regular labour, machinery, buildings and land (and their associated costs) remain unchanged. Net margins provide an estimate of average annual profit after average fixed costs per ha are subtracted from gross margins.

Defra guidance for appraisal requires two main types of adjustment to financial estimates to derive economic values: namely, the removal of subsidies and allowance for 'displacement' effects. Adjustment to remove direct subsidies from crop and livestock gross margins is no longer required because, with a number of small exceptions, these direct subsidies no longer exist under the current EU Common Agricultural Policy (2013-2020) regime and since the UK exited the EU. Farmers receive income support in the form of annual 'Single Payments' that is not linked directly to (i.e. 'decoupled' from) crops or livestock production. Regarding displacement, Defra advise 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 in FRM standards. This assumption may be moderated where the potential changes are large scale, of strategic importance, or where an area has a special comparative advantage that is not easily transferable.

The estimates in Table 9.5 are given in 2019 values using the adjustments explained earlier. Appraisals of FRM investments should take a long term view, allowing for possible future market and policy conditions. International forecasts (OECD/FAO, 2017) suggest that world agricultural commodity prices are likely to remain flat over the next decade or so in real terms, although there is a 'strong chance of at least one severe price swing in the next 10 years', with added uncertainty due to climate change

There is considerable agricultural policy uncertainty as a result of the UK Government's decision in 2016 to leave the European Community in 2019 (commonly referred to as Brexit), with possible consequences for the economic appraisal of FRM. The EU Common Agricultural Policy is the main mechanism for farm income support and for agri-environmental programmes that include measures supportive of natural FRM. Furthermore, withdrawal from the EU could significantly change patterns of agricultural trade and the prices received by farmers, especially due to competition from imports from outside the EU.

The UK Government has guaranteed that the current regime of agricultural support will remain within this parliament (up to 2024), changes beyond that date and the transition to a new funding framework will commence after this date. While the financial circumstances of farmers may change considerably as a result of changes in income support, the economic assessments made here are for the most part based on international prices of agricultural commodities and these may not change greatly. However, given the high level of uncertainty, it is advisable that appraisals should assess the extent to which FRM projects are likely to be vulnerable to policy changes associated with EU Exit. Estimates of financial and economic performance of farming, as well as incentives for agri-environment options, should be kept under review during the development of a FRM scheme (usefully reviewed in current editions of The John Nix Pocketbook (Redman, 2018).

The estimates contained in Tables 9.5 and 9.7 should be regarded as central estimates. They should be changed by plus and minus 25% to provide a range of low and high estimates respectively for use in sensitivity analysis.

SCENARIOS AND THEIR TREATMENT

Defra (2008) appraisal guidance identifies three scenarios which reflect the nature of changes in flood risk, namely:

- Scenario I: Permanent loss of agricultural land;
- Scenario II: One-off damages arising from infrequent flood events;
- Scenario III: A permanent change in flood risk management standards.

These scenarios justify different approaches and methods for the assessment of flood risk management benefits (see Table 9.6 *Defra advise that different assumptions are made for alternative agricultural flood defence scenarios* in Tables and Figures for Chapter 9 on MCM-Online). Regarding Scenario I, Defra advise that land permanently lost to agriculture should in most cases be valued at its market value (£11,000/ha - £14,000/ha for grazing land and £18,000/ha - £22,000/ha for arable land according to quality and region (Savills, 2018)) less £600/ha to reflect the subsidy effect of farm income support. After a period of firm prices, agricultural land prices are expected to fall slightly over the next 5 years (Savills, 2018).

Regarding Scenario II, estimates of flood costs will reflect the likely impacts on output loss, gross margins and other costs for a given land use. Table 9.7 (in Tables and Figures for Chapter 9 on MCM-Online) contains indicative estimates in 2019 values of the seasonally weighted cost of a single flood occurring in a year by land use and drainage condition.

Regarding Scenario III, the analysis is more complicated because there may be a change in land use and net margins (e.g. from arable cropping to grassland), a change in the costs of a given flood event (e.g. from flooding on arable to flooding on grassland), as well as a change in flood frequency (e.g. from 1 in 10 to 1 in 2 years). More details are given in Chapter 9 of MCM-Online.

Throughout the appraisal process, it is important to identify major sources of risk and uncertainty and the possible effect on benefit and cost estimates. It is advisable to derive a range of low, central and high estimates, with some assessment of relative likelihood, rather than any one single value estimate.

While this guidance generally applies, specific advice should, however, be sought from Defra for:

- High level strategic assessments;
- Large scale schemes of more than 10,000ha; and
- Agriculturally less-favoured areas where there could be significant impacts on vulnerable farming communities and local economies.

DATA NEEDS, SOURCES AND COLLECTION METHODS

It is advisable to start with an exploratory survey of the study area to define the geographical boundary of influence, that is the benefit area, and to determine current flood risk management standards and issues arising.

This ‘overview’ survey will also identify broad categories of land use, dominant farm types and systems, possible flood risk management options, the likely impact of these and the likely attitudes of key stakeholders, especially farmers.

Key informants will include:

- Staff with flood risk management interests in regional offices of the Environment Agency and Defra;
- Local Internal Drainage Boards if relevant;
- Representatives of farmer organisations (such as the National Farmers' Union);
- Local advisors and land agents;
- Environmental and conservation groups such as the local Wildlife Trusts, Farming and Wildlife Advisory Groups (FWAGs), River Trusts and National Parks;
- University Agricultural Economics and Agriculture Departments.

In most cases some form of farm survey will be needed, usually involving a sample of representative farmers that covers the major variations in farm circumstance (e.g. size, tenure, land type, flood risk), farm practices (e.g. enterprise mix, drainage improvements), and farmer characteristics (e.g. age, skills, preferences and motivation).

Those embarking on such a survey should refer to Chapter 9 of the MCM (Penning-Rowsell *et al*., 2013).

For agricultural enhancement schemes, the extent to which flooding and drainage currently constrain farming will be a focus of enquiry, together with the factors that are likely to encourage farmer take-up of potential benefits. Conversely, the scope for, and attitudes towards, reconciling flood storage, wildlife and farming interests will be a focus for wetland and washland development schemes, especially in the context of catchment flood management and shoreline management plans.

REMAINING ISSUES

- Leaving the European Union will impact on UK Agriculture and may affect the economic analysis considered here. However, as of April 2020, the Agriculture Bill is still with Parliament and the detail of the proposed Environmental Land Management Scheme (ELMS) is still being discussed;
- In line with government policy, appraisals in future will seek to integrate flood risk management with other rural land use objectives such as agriculture, nature conservation and other environmental objectives, including adaption to climate change;
- Farm surveys should be carried out by competent and experienced interviewers with knowledge of farm management systems;
- Flooding from estuarine and coastal sources results in greater impact and higher losses than freshwater flooding, and the land is likely to take longer for full production to be restored.

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