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RELU Integrated Floodplain Management

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Integrated Management of Floodplains	
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Contents

1 Background

The last 25 years have witnessed a change in the priorities for the use of rural land in the United Kingdom. Whereas previously the focus was predominantly on agricultural production to achieve national self sufficiency, since the 1980s environmental objectives, such as the protection of wildlife habitats and countryside recreation, have exerted greater influence over the way land is managed. More recently, greater attention has been given to the conservation of natural resources, such as soil and water, because some types of agricultural land use can exacerbate soil erosion, water pollution and flooding. Thus, the management of land is now expected to deliver a range of objectives such as farming, nature conservation and water-resource management, often simultaneously. A further complication is that these different objectives are typically the concern of different 'stakeholders' who are interested in particular benefits provided by land, such as farmers, conservationists or flood-risk managers. The multiplicity of objectives presents a major challenge for policy and practice – how can land be managed to meet diverse and competing demands? Finding an answer is further complicated by the prospect of climate change.

Many of the challenges facing rural land management are being played out in England's floodplains, where opportunities for land use are determined by the management of the soil water regime (i.e. field water-table depths and duration of surface water). These areas contain more than half of England's Grade I agricultural land. Many were 'reclaimed' by means of publicly funded agricultural flood defence and land drainage schemes; all part of wider programmes of support to farming to enhance food security (and support the rural economy) in the public interest during the period from the 1930s through to the early 1980s. Since then, no new flood defence schemes have been implemented solely for the purpose of agricultural enhancement, although many are maintained and operated to provide continued benefit for farming.

Changing policy priorities have encouraged a re-appraisal of land management options for lowland floodplains. This is evident in policies associated with the Reform of the Common Agricultural Policy and those concerned with European environmental regulation such as the Water Framework Directive, the Habitats Directive and the Floods Directive. Particular concerns with flooding, following a succession of major flood events (in 1998, 2000 and 2007) have called for a 'joined up' approach which includes using agricultural land to contribute the management of flood risk alongside other purposes, whether farming or biodiversity. This is evident in Government Strategies in England and Wales such as Making Space for Water and the new Flood and Water Bill (Defra, 2009).

These contemporary issues confirm the challenges facing land managers and policy makers as they seek to balance the diverse and often competing demands for the services provided by floodplain land. Just when farming seemed to be less important, global food shortages in 2007/8 revealed the strategic importance of food security and an energy crisis (which called for bio-fuels to replace fossil fuels) put agricultural production firmly back on the political agenda. Meanwhile, the catastrophic floods of summer 2007 provided an example of the extreme events that might become more common with climate change, showing how agricultural land can provide storage of flood waters to reduce damage in urban areas. Given these real challenges, the working hypothesis driving this research is that a historical review of the way floodplains have been managed for different purposes over time, combined with evidence of the relationships between the water management, land use and

benefits to people, can help to inform future decisions in ways that will appeal to key stakeholders, including those government agencies that represent the public interest.

2 Objectives

This research project set out to understand (i) the factors influencing changes in land use and farming practices on floodplains that were previously engineered to provide flood defence and improved land drainage for agriculture, and (ii) the way that the land and water resources can be managed to achieve a range of desirable outcomes (such as food production, nature conservation and flood risk management) either separately or concurrently. It particularly aimed to assemble data and develop methods that could help inform decisions by organisations with responsibility for the management of floodplains, such as government agencies, regional drainage organisations, farmers and their associations, conservation bodies and other organisations, including those providing advice and technical assistance.

The specific objectives (as specified in the research brief), and an indication of how they were addressed, are as follows:

1. *Explain the influence of factors affecting the adoption of land and water management practices in floodplain areas.* This has been successfully addressed by (i) an historical review of the market, policy and other drivers affecting land use and related investments in agricultural land drainage (ii) a personal survey of 67 farmers covering 8 agricultural land drainage and flood defence schemes in England that were previously reviewed for the purpose of agricultural benefit assessment by the research team in the early 1980s, (iii) an analysis of changes in land and water management in these schemes since their inception, drawing on current and historical data. At the time of writing analysis of these historical data is not complete.
2. *Determine the outcomes of land and water management in terms of farming, nature conservation, amenity, biodiversity, landscapes and flood risk management* This was successfully addressed by analysis of data collected from (i) personal farmer surveys (ii) regional farm business statistics (iii) field scale hydrological monitoring (iv) field and landscape scale ecological and environmental assessments and (v) historical hydrological data and catchment management plans.
3. *Develop an analytical framework to assess and classify the main functions, uses and values of managed floodplain areas, identifying potential synergy and conflict amongst major stakeholder interests.* This was successfully addressed (i) by the development of an 'ecosystems framework' (as explained below) to evaluate the range of benefits provided by floodplains under different management regimes and the relationships between them and (ii) by stakeholder analysis that links interests with main types of ecosystem benefits
4. *Develop databases and methods to support the design and appraisal of integrated rural floodplain management regimes and related policy interventions*. This was successfully addressed by development of databases and methods to support (i) the definition of land use scenarios and related ecosystem benefits (ii) economic appraisal of agricultural systems, (iii) the design of water regime (flooding and soil wetness) suitable for different land uses (including wildlife habitats) (iv) ecological assessment (including appraisal of different techniques).
5. *Provide guidance on the promotion of sustainable solutions amongst the main end-user constituencies*. This objective has been successfully addressed through the delivery of specific outputs relating flood impact assessment, the appraisal of land management options and policy choice to international, national

and regional organisations, in accordance with our communication strategy, as explained below.

6. *Identify major areas of uncertainty and risk which warrant further research.* The reliability and robustness of evidence about socio-economic, hydrological and ecological factors and interrelationships were assessed and reported during the ecosystems and scenario analyses. Implications for research have been identified as explained below.

3 Methods

Figure 1 shows the conceptual framework that guided the study methods. The concept of ecosystems was used throughout the work, linked to stakeholder interests and values. Three main disciplinary perspectives of social, ecological and engineering sciences were brought together to determine how water regimes in floodplains have been, and can be, managed to achieve a range of intended outcomes.

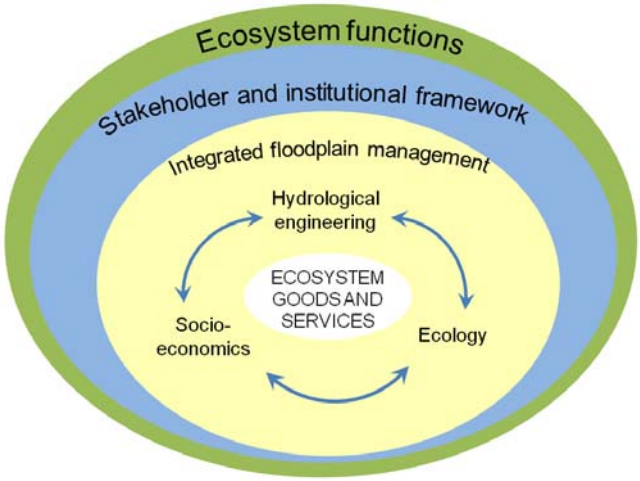


Figure 1 The conceptual framework for the integrated floodplain project.

Research methods involved a number of highly integrated components, each informing the other. It is noted that a key research purpose is the development of data and methods to support decision-making for floodplain land and water management.

Eight agricultural land drainage and flood defence schemes, out of 22 schemes previously studied to assess agricultural benefits by some of the research team in the 1980s, were selected for detailed study. The 8 sites were selected, to cover a range of land uses, farming systems, soil types, hydrological and engineering features, and geographical locations (Table 1).

Table 1 Agricultural Land drainage and flood defence schemes selected for study.

Location	Scheme / Water course	Total benefit area (ha)	Reach	Length (km)	Date of scheme	Nature of major works	Land use before	Land use after
Notts	*Beckingham*, R. Trent	900	Beckingham Marsh	*6.7*	*1960*	Floodbank improvement & arterial works. Pumping	Permanent grassland, marsh, little arable	Cereals, improved grassland
Worcs	*Bushley*, R. Severn	146	Bushley to Upper Lode	4.9	1972	Floodbank improvement	Permanent grassland	Cereals, improved grassland
Cumbria	*Cuddyarch* Sough, R. Wampool	283	Full length	2.5	1974	Channel works	Permanent grassland, rough grazing	Improved grassland
Notts	R. *Idle*	321	Mattersey to Bawtry	8.0	1981	Channel works & embankments	Permanent grassland, arable	Cereals, root crops, improved grassland
Salop	R. *Morda*	540	Morton Br. to Vyrnwy confluence	9.8	1971	Channel works & embankments	Permanent grassland, bogs	Cereals, improved grassland
E. Sussex	R. *Rother*	4700	Scots Float Sluice to Bodiam		1968	Floodbank improvement, pumping & arterial works	Permanent grassland, rough grazing, some arable	Cereals, root crops, improved grassland
Lincs	*Sempringham* , 40 foot Drain	825	Sempringham Fen		1966	Pumping & arterial works	Permanent grassland, some arable	Cereals, some permanent grassland
Somerset	R. *Yeo*, (and Kingsmoore Drain)	1500	Ilchester to Long Load Bridge	4.8	1971	Pumping & arterial works	Permanent grassland	Improved grassland

Name in *italics* is the reference used throughout this report.

Personal farm interviews were carried out with farmers (67 in total) on each study site, some of whom had been interviewed in the 1980s, to record current circumstances and farming practices, as well as detailed information on land use and drainage conditions. Drawing on previously recorded information, supplemented by other sources, this enabled an analysis of changes over time, in some cases over 40 years – from the early 1960s when schemes were first implemented to the present. During site surveys, insights into historical and current issues affecting land and water management were obtained.

Agricultural and related environmental policies were reviewed to explain the factors influencing land use and farming practices, especially regarding incentives for land drainage for agriculture on the one hand, and more recently incentives for nature conservation in farmed areas (Morris et al., 2009).

Hydrological monitoring. On each scheme, "dipwells" were installed in one representative field and electronic gauges were used to monitor water-table fluctuations over time. A further gauge was installed in the adjacent watercourse. These field water-table records at a temporal resolution of 1 hour over ≈2 years, were used to calibrate and validate a model to simulate field water-table depth from weather, soils and water course levels. This allowed field water-table depths to be extrapolated for a longer time period than the period of measurement.

Flood frequency estimation. Local peak river flow data were used to estimate the probability of high flows at each scheme which could be related to the risk of flooding and the discharge of peak flows.

Ecological assessments were carried out using a habitat classification system (JNCC Phase 1 and 2) to show the relationship between water regimes (surface flooding and soil-water-table depth) and habitat potential, with particular reference to vegetation. The links between vegetation and the diversity of fauna were made at the landscape scale, allowing for the size, connectivity and degree of disturbance of the site. Existing wildlife habitats and species occurrence were recorded for each site, as well as their potential for enhancement. In this process, 7 alternative techniques for ecological assessment were tested and recommendations made accordingly (Rouquette et al, 2009); and two methods of assessing the impact on species were developed. The relationship between river restoration and floodplain restoration was also assessed using a subset of sites, including for example the scope for ecological restoration of rivers that serve predominantly farmed areas.

Water regime requirements for different land uses, including farming and nature conservation, were defined drawing on research literature, expert judgement, and observations from farm surveys. This work defined the tolerance of different types of agricultural land use as well as different 'natural' habitats to the frequency, seasonality, and duration of surface flooding and soil water-table depth.

Agricultural benefit assessment involved the development of data and estimation methods to show the impact of changes in flooding and waterlogging on crop and livestock production and financial and economic performance of agricultural enterprises. This method was used in scenario analysis. It was used, and further developed in the assessment of the agricultural damages due to the summer 2007 floods (Posthumus et al., 2008) (see below)

An ecosystems framework was developed to represent and value the diversity of benefits that floodplains provide. Many of these, such as the regulation of flooding and the provision of habitats and landscape, are non-market public goods, which are harder to value than the traded products of agriculture. A stakeholder workshop, supported by evidence from this project and other research sources, helped to identify and rank 14 key indicators to represent the potential flow of services from

floodplains. These indicators were used to analyse the relative 'ecosystem performance' of land-use options on the 8 sites using spreadsheet based data and estimation routines.

Scenario analysis was used to model alternative uses of floodplain land designed to serve particular objectives and dominant stakeholder interests. Six scenarios were considered, namely (i) the current 2006 land use,: and five others which aimed to maximise the achievement of particular outcomes, namely (ii) maximum agricultural production, (iii) maximum biodiversity within an agriculturally managed landscape, (iii) maximum biodiversity not tied to agriculture, (v) maximum flood-risk management (flood storage) and (vi) maximum farm incomes (Posthumus et al., under review). The type and land use and, critically, the type of water-regime management required to deliver these alternative outcomes were determined for each of the 8 study sites, using the ecosystem indicators previously referred to.

Stakeholder analysis involved the development of a novel computer based tool (in collaboration with the RELU farming and Biodiversity project) to map the relative interest and influence of key stakeholders in water regime management in floodplains, showing how these are closely attuned to particular types of ecosystem services, such as farming, nature conservation, or flood control.

The summer floods of 2007 occurred during the research period, seriously affecting some of our study sites and farmers. With additional funding from RELU and the Environment Agency, the methods devised here were used to assess in detail the impacts of flooding on agriculture. This involved personal surveys of an additional 78 farmers in three regions of England affected by flooding. Concurrently, and as part of this research, additional funding from the Commission for Rural Communities enabled an assessment of the impact of the floods on rural households, non-farm businesses and communities and funding from NERC allowed the team to assess flood impacts on wildlife habitats. The research team also gave evidence to the Pitt Review on Lessons from the 2007 Floods.

Data and methods developed in the course of the study have considerable potential to inform major policy areas associated with flood-risk management, food security, the protection and enhancement of biodiversity, and support to the rural economy, as further demonstrated below.

Ethical standards and confidentiality were maintained in the course of data collection and analysis. Some farmers found the recall of the flood events of 2007 particularly distressing. This required sensitivity in the way information was obtained and used. The wishes of those few who preferred not take part in the surveys was respected. Confidentiality has been maintained in stored data sets, such that sources of potentially sensitive information are not attributable to individuals.

4 Interdisciplinarity

Integration has been a key characteristic of the research methods, combining social, economic, ecological and engineering perspectives (as explained below), with hydrology as the central pivot. It is the management of water regimes (flooding and soil water-table depths) that determines the potential for different land uses in floodplain areas and the resultant type and distribution of benefits to people and communities. Hydrology has been the 'glue' that has effectively joined up the various components of this research. Integration has been achieved by close and shared working by the research team. For example, research specialists have swopped roles during data collection and analysis, team field visits have been made and presentations and published outputs have been jointly prepared, co-authored and/or delivered by our multidisciplinary team working together.

5 Results

Figure 2 Images of our floodplain study sites

This section reviews a selection of results achieved to date. Analysis of data is ongoing such that further results will become available. Publications and other outputs to date are listed in Appendix 1.

5.1 Policy review

An historical review of agricultural policy in England showed that the incentives given to agricultural production and the supporting role of flood defence and land drainage have varied over the last 70 years or so. This review (contained in Morris et al, 2008; Morris et al 2009) helps to explain the changes in land use and management observed on our 8 case study sites.

The 1930s were characterised by a period of ***recovery*** from depression. 1930 the Land Drainage Act, supported by grant aid, facilitated large scale public works to improve agricultural productivity by alleviating flooding and establishing arterial drainage networks to evacuate excess water and control field water levels. The ***War years*** (1939-45) witnessed further public support for improved drainage, with large areas converted from pasture to arable land as part of a programme of 'digging for

victory'. In the post war period, agricultural **enhancement** gathered pace through to the late 1970s (and beyond accession to the European Union), emphasising "Food from Our Own Resources". Major public investments were made in flood defence and land drainage for agriculture. Field drainage by farmers was typically eligible for 60% grant aid, involving over 100,000 hectares in 1972 for example. Throughout this period drainage for agriculture was regarded as a 'public good', worthy of public funding, delivering benefits beyond those enjoyed by farmers themselves. Seven of the eight schemes reviewed here were implemented during this period of agricultural enhancement.

The 1980s and 1990s were characterised by **structural adjustment** in agriculture in the face of concerns about environmental damage, over production and excessive costs of agricultural subsidies. A combination of production quotas, environmental legislation, reduction in grant aid, and new environmental 'management agreements', very quickly removed the justification for further agricultural flood defence and drainage improvements, especially those funded by the tax payer. Grant aid for field drainage was discontinued and, for the most part, flood defence for agriculture alone did not meet the cost benefit criterion for public funding.

The current post-2000 agricultural **reform** period witnessed major changes in farm income support, and a plethora of measures to enhance environmental stewardship, including restoration of floodplain habitats, the protection of soils and improvement of water quality. The extreme floods of 2000 and 2007 further promoted a new approach to land and water management at the catchment scale. Here agriculture is perceived not only as part of the problem (e.g. as a source of run off) but also as part of the solution (e.g. providing floodplain storage). Flood risk management for agriculture, linked to initiatives such as Making Space for Water, Catchment Sensitive Farming, and the new Flood and Water Management Bill (2009) are examples of this new approach.

Thus the rationale for land drainage for agriculture, set in the context of broad policy drivers, has changed over time, and with it the incentives to farmers. This is clearly evident in our review of changes in land use and management for land drainage schemes enacted during the agricultural enhancement period, as explained below.

5.2 Evidence of land use change in floodplains

The comparison of the results of the farm survey carried out in this project and those carried out in the 1980s showed that although the land use changed significantly following the land drainage improvement schemes, since the 1980s there has been little change in land use (Figure 3). However, there has been a tendency towards less intensive use of land, for example a shift from dairy to beef (reflecting a national trend) or from root crops to cereals.

Farmers reported that the wetness of fields associated with water tables had changed with consequences for yields. On roughly 20% of the land area, farmers reported that the water table had fallen since the 1980s and in some cases yields had increased as a result. On a similar proportion of the area, however, water tables were reported to have risen and yields or grazing seasons have been reduced and farm operations constrained. More detailed analysis of results will be carried out to explain this observed variation.

The characteristics of the farming community in the study areas had also changed with more farmers with formal agricultural qualifications; fewer young farmers (<35 years); and fewer who expect sons / daughters to follow-on in the family business. Although there has been a large take-up of Entry Level Stewardship schemes, there has been little interest in the Higher Level scheme.

Thus, it is clear in the 1960s and 1970s farmers responded to incentives and assistance to take up potential agricultural benefits, involving land use change and intensification. Since the 1980s, however, there has been little extra take-up and, if anything, a tendency towards less intensive farming in response to changing policies and market conditions.

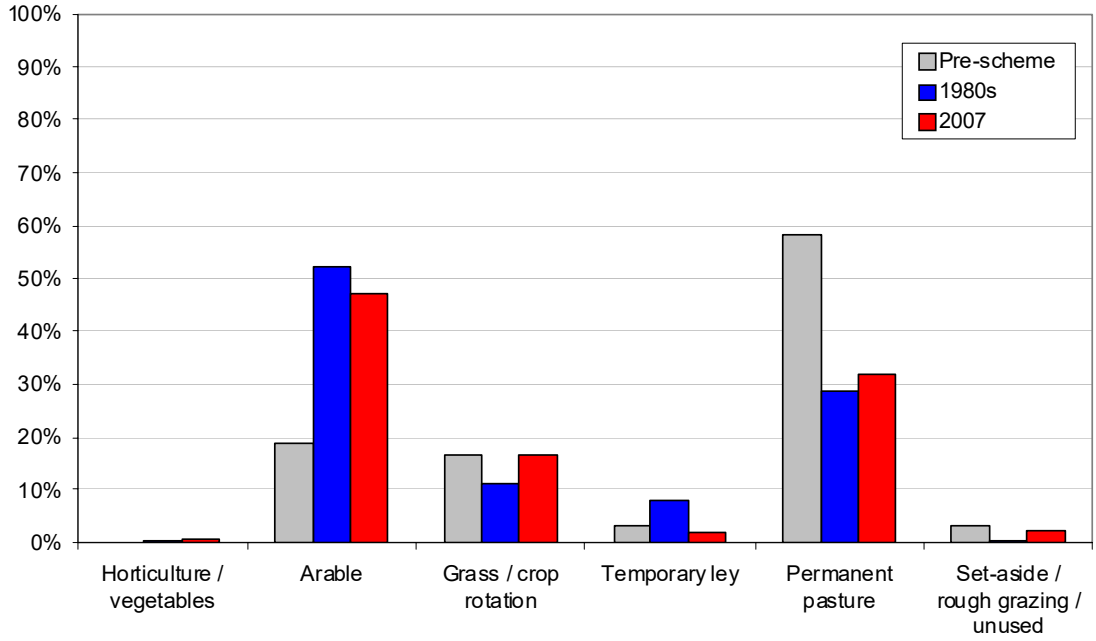


Figure 3 Observed changes in floodplain land use over the 8 schemes.

5.3 Ecological assessment

Ecological surveys revealed the current habitat and biodiversity features of each site (Table 2). Two scenarios in particular examined in detail how habitats would occur if the sites were managed to maximise biodiversity with no constraints (*Biodiversity scenario*) or to maximize biodiversity within an agricultural context (*Agri-environment scenario*).

The *Biodiversity scenario* typically favours “wet” habitats such as reedbed, fen and wet woodland and the hydrological regime is characterised by frequent flooding and slow natural drainage (Table 2). In contrast, under the *Agri-environment scenario* the most appropriate land use is generally a combination of wet grassland for breeding waders and species-rich hay meadow (Figure 4). These habitats can tolerate medium-duration flooding and moderate drainage.

a) b)

Figure 4 Some typical floodplain-meadow plant species: a) meadowsweet (*Filipendula ulmaria*) is found in moist hollows on the floodplain whilst b) common knapweed (*Centaurea nigra*) is indicative of better drainage.

Table 2 Notable biodiversity features recorded during site surveys (current situation) and projected to occur following adoption of the biodiversity scenario.

Site	Current situation	Biodiversity scenario
Beckingham	Part of site owned by RSPB has undergone arable reversion to grassland. Veteran willow trees, water voles, lapwing and curlew.	Large reedbed creating potential bittern habitat, and wet woodland supporting a wide range of flora and fauna.
Bushley	Ancient species-rich hedgerow, rich assemblage of damselflies and dragonflies, Cetti's warbler, skylark, yellowhammer.	Flower-rich traditional floodplain hay meadow. Reedbed and wet woodland.
Cuddyarch	Includes Broad Dales SSSI, an important unimproved floodplain meadow.	Variety of habitats including wet woodland, rush pasture, fen, reedbed and hay meadow supporting a wide range of biodiversity.
Idle	Veteran trees, water vole, lapwing, oystercatcher, skylark, reed bunting and yellowhammer.	Large area of species-rich lowland fen and reedbed, supporting native flora, insects and birds.
Morda	Numerous ancient species-rich hedgerows and associated veteran trees.	Variety of habitats including floodplain grazing marsh, rough pasture and wet woodland supporting a wide range of biodiversity.
Rother	Species-rich ditches, water voles, dragonflies and damselflies, marsh mallow moth, lapwing, snipe and golden plover.	Large reedbed and fen creating potential bittern habitat, and wet woodland supporting a wide range of flora and fauna
Sempringham	Lapwing, skylark and yellowhammer.	Large reedbed creating potential bittern habitat, and species-rich lowland fen.
Yeo	Veteran trees and hedges, otter, water vole, lapwing, snipe,	Large reedbed creating potential bittern habitat, and wet

	skylark, yellowhammer.	woodland supporting a wide range of flora and fauna.

Detailed ecological data from 8 sites, allowed a comparison of the use of seven alternative approaches to assessing the value of nature-conservation interest (see Rouquette *et al*., 2009 for further details). Some of these methods use predefined targets for biodiversity, some use preferences expressed by stakeholders, and others use monetary values. It was shown that the methods gave broadly similar results and were highly correlated, but each method emphasised a different aspect of conservation value, leading to different rankings of the scenarios tested for each site. The advantages and disadvantages of each method were evaluated and are summarised in Table 3.

Table 3 Key advantages and disadvantages of different habitat valuation methods tested on 8 case study sites (from Rouquette *et al*., 2009).

Method	Advantages	Disadvantages
1. Ecological Impact Assessment method	Principles well understood, differentiates well between scenarios.	Too many categories, so can be confusing. Some subjectivity.
2. Reserve-selection criteria	Objective, repeatable, well established criteria.	Time-consuming to develop
3. Reserve-selection criteria guided by stakeholders	Links objective criteria with stakeholder values.	Some additional criteria hard to evaluate.
4. Simple stakeholder choice	Involves stakeholders, straightforward.	Did not score agricultural habitats. Context important.
5. Target based criteria:		
a) Net area of BAP habitat created	Quick and easy.	Insensitive as scenarios all score either zero or maximum. Favours large sites.
b) % of national targets	Quick and easy	Assumes all targets are equal. Habitats have been treated inconsistently by national target setters.
c) % of regional targets	Quick and easy	As above, plus highly variable across regions.
6. Agri-environment scheme payments	Good indicator of likely farmer uptake. Easy, transparent, repeatable. Expresses results in monetary terms.	No clear link between agri-environment payments and the value of ecological outcomes (measures income forgone rather than ecological value).
7. Contingent valuation	Indicates the value that society places on habitats. Expresses results in monetary terms.	Based on whole series of assumptions embedded within the original model. Habitats in the ELF model are broader than those being used in our study.

Each method appeared to have its strengths; monetary valuations are appropriate in some contexts, stakeholder preferences are paramount in others, but where objectivity is key, assessment against independently defined criteria or targets would be the preferred method. We therefore chose to use the Ecological Impact Assessment method in our ecosystems framework to provide a habitat value and used a general species model involving all UK BAP vertebrates and plants to assess species value.

5.4 Summer 2007 floods

Estimates were derived of the costs imposed on agriculture by the severe summer 2007 floods which occurred in the West Midlands, Oxfordshire and Yorkshire &

Humberside (Figure 4). These are reported in detail in Posthumus *et al*, (2008, 2009).

Analysis of information derived from personal interviews of a sample of 78 farmers affected by flooding showed that:

- Flood damage costs for arable production mainly consisted of lost yields and crop damage.
- Flood damage costs for livestock production mainly consisted of loss of grass for animal feed (grazed or conserved).
- Farms suffered damage to farm buildings, farm machinery and other assets
- Damage costs varied considerably amongst farms according to type of farm and area affected. The average cost was £90,000 per farm, and the median (50% of the sample) was £42,000.
- Most agricultural losses were not insured. Some farmers were insured against flood damage to farm assets, in particular farm buildings and machinery, and some livestock farmers received charitable gifts for the immediate purchase of animal feed. However, on average these compensation payments covered only 5% of the total damage costs incurred, and many farmers received nothing.

Applying the derived estimates of average flood damage cost of £1,153 per flooded hectare to the estimated 42,000 hectares of agricultural land flooded in England, the total agricultural damage costs amounted to £50 million (Table 4). These costs constitute about 1% of the Gross Value Added of the agricultural industry in England in 2007.

a) b)

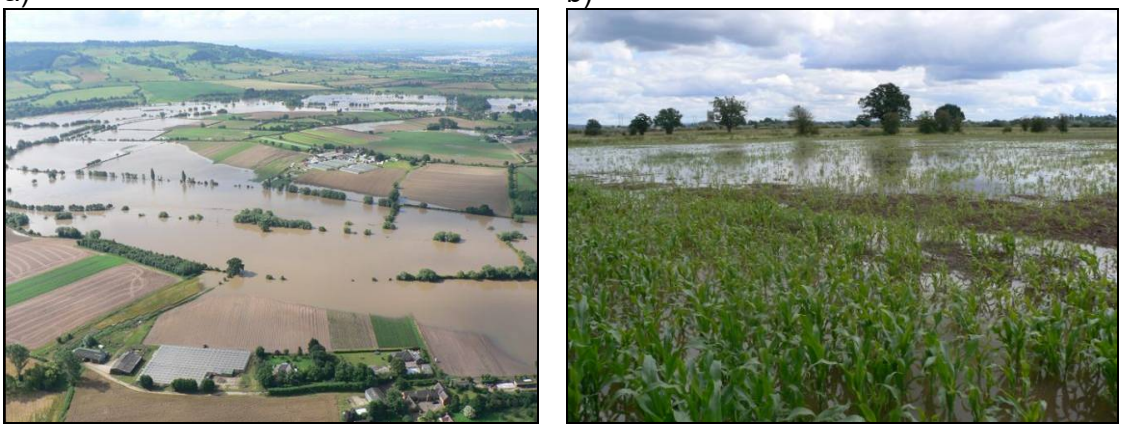


Figure 5 Flooding of agricultural land in summer 2007. a) River Avon (Gloucs) b) maize field on the River Severn (Worcs) after the flood.

The study made recommendations concerning data and methods for the estimation of agricultural flood damage costs that can be used in the cost benefit analysis of flood risk management options. It also strongly recommended a review of actions that can be taken to help farmers to adapt to a possible increase in flood frequency associated with climate change by increasing resilience. In particular, it is recommended that more attention is given to land drainage in farmed areas as a means of evacuating flood water and controlling ground water levels after flooding.

Table 4 Estimated damage costs to agriculture of the Summer 2007 flood events.

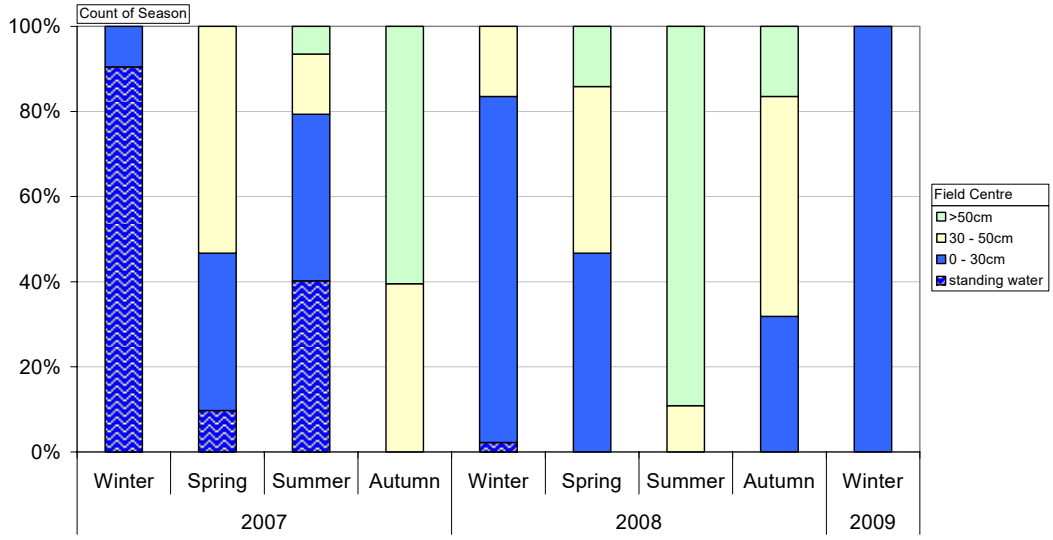
Region	Yorks & Humbs. £ mil	W Mids £ mil	Oxon £ mil	Total £ mil	Total £/ha*	% of Total
Loss of arable production	19.4	8.6	6.1	34.1	812	70
Loss of grassland & livestock production	2.7	3.7	3.8	10.1	240	21
Non-production costs	1.5	0.9	0.9	3.3	79	7
Non-farm income lost	0.4	0.2	0.3	0.9	22	2
Total	**23.9**	**13.4**	**11.0**	**48.4**	**1,153**	**100**

* per hectare flooded.

5.5 Hydrological monitoring and modelling

An example of results from field water-table monitoring is shown in one field in Beckingham Marsh. Figure 6 shows the proportion of time that the field centre had standing water or a water table was high (0 – 30cm from the surface), medium (30 – 50cm) or low (>50cm) by season for Beckingham Marsh over the study period. The water table was within 30cm of the soil surface most of the time in winter and for half of the spring. This limits land use options as the soil cannot support livestock or traffic when wet.

Both 2007 and 2008 were wetter than average years across England as a whole, with particularly wet summers (77% and 46% wetter than average respectively). For example, in 2007 there were 65 days with standing water including 30 days in the summer. As such, the field monitoring data did not show the seasonal variations in field water-table position that might have been expected in a drier year.



Notes: Winter: Dec – Feb. Spring: Mar – May. Summer: Jun – Aug. Autumn: Sep – Nov. Winters 2007 and 2009 were incomplete.

Figure 6 Proportion of time with standing water or field water table is high (0 – 30cm), medium (30 – 50cm) or low (>50cm) by season for Beckingham Marsh.

The tolerances of different types of agricultural crops and 'natural' vegetation species to seasonal flooding and water table height were derived, based on site observations, research literature and the expert judgement of the team. This was an important output of the research, informing the relationship between water regime and land suitability for different purposes, and the subsequent analysis of land use scenarios.

5.6 Ecosystems and scenario analyses

The development of a quantitative ecosystems framework to assess the relative performance of alternative land use scenarios was in itself an important and intended output of the research.

By way of example, Figure 7 shows the results derived from scenario analysis for the Beckingham Marshes case. Here the ecosystem indicators are normalised across all scenarios so that all indicators scored between 0 (worst performance) and 1 (best performance). The agri-environment and maximum income (assuming environmental payments) scenarios deliver most ecosystem goods and services. These two scenarios are very similar in terms of land use and farming system. The scores shown are un-weighted and thus all the ecosystem services are considered of equal importance.

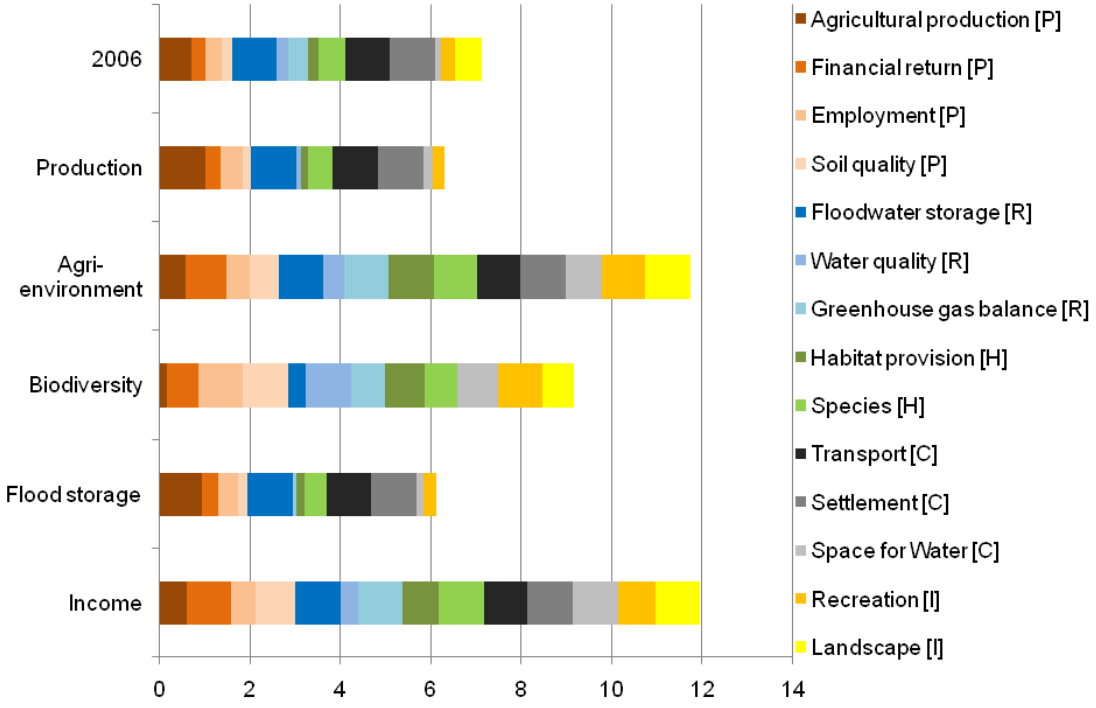


Figure 7 Example of the relative ecosystem performance of alternative land use scenarios on the Beckingham Marshes, Nottinghamshire.

Figure 8 illustrates the potential synergies and conflicts in ecosystem services under the different scenarios in one of the case study sites. The flood storage and production scenarios are very similar in terms of hydrological regime, land use, and thus indicator values. Both scenarios score highly on production, flood water storage and reduced flood risk for settlement and transport, but they score low on environmental enhancement (e.g. water quality, greenhouse gas balance, habitat and species). The scores for recreation, landscape and space for water are also low. In contrast, the agri-environment, income and biodiversity scenarios have generally a positive environmental impact. However, the biodiversity scenario results in an increased flood risk for settlement and transport and reduced flood water storage as the flood banks are breached and flooding is uncontrolled.

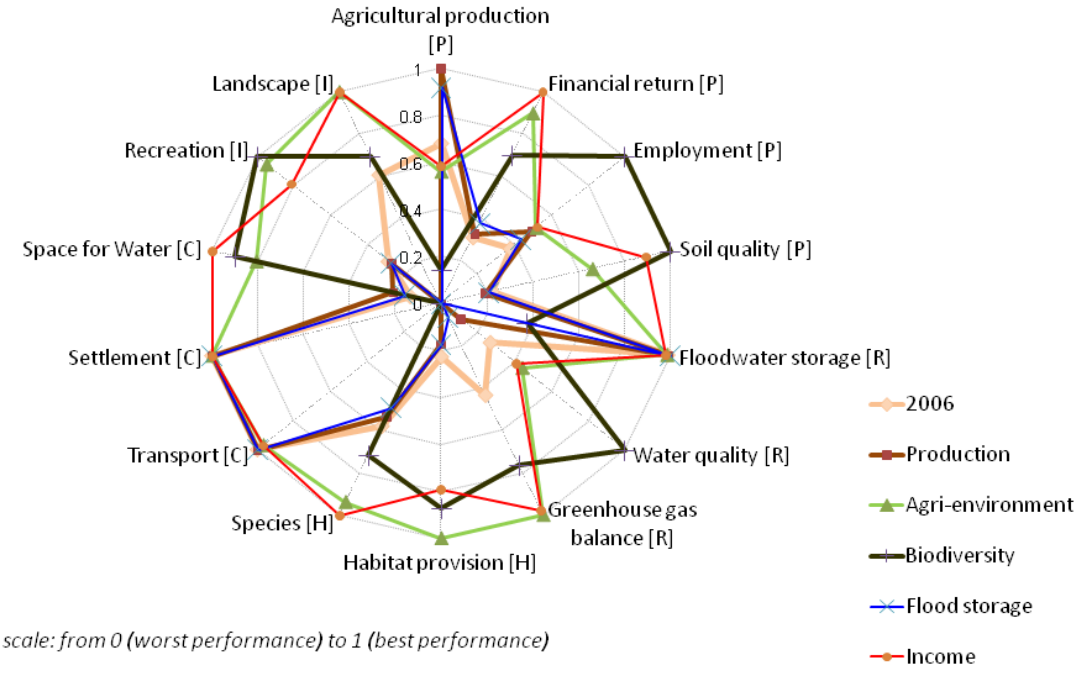


Figure 8 Synergy and conflict amongst land use scenarios for the Beckingham Marshes, Nottinghamshire.

Similar results have been obtained for the other study sites. There are both synergies and conflicts between ecosystem services delivered by lowland floodplains. As expected, there is typically conflict between agricultural production and environmental outcomes such as water quality, greenhouse gas balance, habitat and species. Other relationships, however, are less obvious and may challenge commonly held beliefs. There is for example, potential synergy between short duration flood storage (to deliver benefits to urban areas downstream) and agricultural production. Contrary to popular belief, there is potential conflict between flood storage and biodiversity. The latter can be extremely sensitive to flooding and yet requires high ditch and water-table levels that use up potential flood storage capacity. 'Making space for water' by reconnecting rivers with floodplains may not in some circumstances provide the degree of control required by flood managers. These results can provide a basis for quantifying these relationships, recognising the importance of local conditions (Posthumus et al, 2009).

5.7 Stakeholder analysis

The study showed that floodplains provide a wide range of actual or potential benefits to people as individuals, and as members of organisations and communities. In this respect, a wide range of 'stakeholders,' are interested in, and exert influence over, the management of land use and water regimes in floodplains.

Figure 9 shows the results of mapping stakeholder interests/influences obtained in a workshop with representatives from a range of interest groups. Stakeholder interests were also classified according to the main type of ecosystem service and related indicators. These results were consistent with those obtained from individual site observations. As shown in Figure 9, stakeholders with high interest and high influence typically hold formal land ownership or occupancy rights, such as farmer producers, or statutory powers associated with the regulation of water such as Internal Drainage Boards and the Environment Agency. Organisations such as Local Government and the Association of British Insurers (ABI) are interested in the carrier function as this relates to human settlements exposed to flood risk. Stakeholders

with an interest in habitat and information functions have tended to have relatively limited influence, although, as observed in practice, conservation organisations have acquired land in order to convert it to wildlife habitats. Alternatively, they might push for publicly funded programmes to enhance biodiversity on farmland. The results of the stakeholder analysis provide an understanding of current spheres of interest and influence. Linked to scenario analysis, it can help inform dialogue amongst different groups.

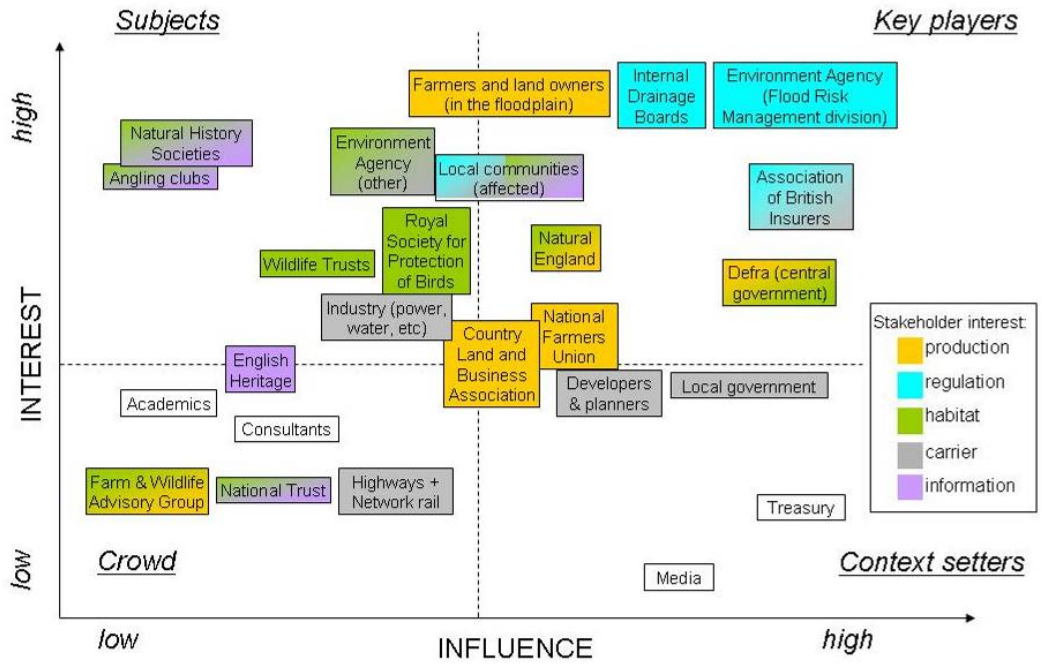


Figure 9 Interest and influence of stakeholders regarding types of ecosystem services of lowland floodplains derived from a participatory workshop.

5.8 Implications for policy and practice

It is clear from our historical review that the management of lowland floodplains is a product of policy interventions that have promoted particular objectives at different times. 'Reclamation and improvement' for agriculture, supported by public funding, were the dominant purposes for over 50 years until the 1990s. In the last decade in particular, however, greater recognition has been given to the range of ecosystem services provided by lowland floodplains, including water regulation, carbon sequestration, landscapes and wildlife, and recreation and amenity.

The analysis here helps to identify and place values on these diverse floodplain benefits, many of which take the form of non-market public goods. It also shows that some of these benefits, and the stakeholder interests that they serve, are complementary and some are in conflict.

An ecosystems framework of the type developed here can help to achieve the integrated, joined-up approach to the management of floodplain land (and natural resource management in general) which is currently a recurring policy theme, as explained in the introduction to this report. In particular it can inform discourse amongst interested parties about what can and cannot be achieved. It can also help design, promote, fund and reward new forms of land and management that deliver intended outcomes in the most cost effective and socially acceptable ways. The outputs of this research can therefore help make the link between the valuation of land and water services in floodplains and their governance, thereby addressing at least part of the question – what is floodplain land for, who should decide and how?

The follow up work to this project aims to do this through its dissemination and communication programme, emphasising knowledge transfer and capacity building amongst the potential user community.

6 Capacity-building and training

The project benefited from an excellent team of young researchers with specialisations in engineering, social sciences and ecology who achieved a high level of cooperation and joint working during data collection and analysis stages. This was facilitated by the geographical proximity (10 miles) of the research organisations.

The PDRAs attended a series of specialist and general research training programmes offered by the RELU programme and research Councils (listed in Appendix 1), including those on interdisciplinary working.

The research team contributed to many policy and practitioner conferences, including the major annual conferences of potential end users communities, such as the Defra Flood and Coastal Management Annual Conference, the Chartered Institute of Environmental Management (CIWEM) and the River Restoration Annual Conference. It made two contributions to the European FloodRisk2008 Conference, as well as presentations to European symposia.

The project linked with the EPSRC Flood Risk Management research Consortium, making project based contributions at conferences and work shops.

All our PDRAs have taken up career research / consultancy positions which build on the experience developed in the project.

7 Outputs and data

Data sets have been lodged with the data management service on (i) field hydrological records (ii) ecological inventories (iii) farm surveys (site surveys and summer flood studies) and (iv) farm surveys and reports of the previous studies carried out in the 1980s by team members.

The project has to date produced 4 journal papers,1 book chapter, 4 conference papers fully published in proceedings and 3 peer reviewed technical reports to external agencies presentations. 16 presentations have been made to other conferences involving published abstracts as well as over 20 other external presentations, many to potential end user communities. 3 BBC4 radio interviews were given concerned with floodplain and flood management.

Data and methods relating to agricultural benefit assessment of flood defence and drainage have been compiled. These are being used to support Defra/EA in guidance for flood risk benefit assessment. The results of the summer flood studies were used to inform EA flood risk management strategy, the Pitt Review of the Summer Floods 2007, and the Updated (2008) Foresight Flood Defence Project.

The compilation of data and methods to support an ecosystems assessment of floodplain land use options is an important output

8 Knowledge transfer, user engagement and impacts

The main focus to date has been on working with individuals and organisations involved in floodplain management to develop data and methods to support decision making. Outputs (and impacts) so far have mainly targeted high level policy users and the research community. Now that methods to support decision making are available, it is timely to focus on knowledge transfer and capacity building amongst the end user communities, notably Defra and the Environment Agency, drainage

organisations, Local Government, and farmer and wildlife groups with whom we have ongoing relations.

Example of user engagement and impacts are as follows.

- The project engaged with over 140 farmers, and the staff of Environment Agency, and farming and conservation organisations in 7 EA administrative areas. Throughout, care was taken to communicate research purpose and approach.
- A national stakeholder workshop engaged key informants to prioritise benefits from floodplains. This informed the approach to the assessment of ecosystems services.

Specific outputs were delivered to policy fora. The estimates of agricultural flood damage costs during the summer 2007 floods have been used by the Environment Agency to inform its revised Flood Risk management Strategy (2009). The research contributed to the Flood Foresight Updating Project (2008) which informed the Pitt Review (Learning Lessons from the 2007 Floods).

The development of benefit cost methods for agriculture and the estimates of summer 2007 damage costs will be used to update the agricultural component of 'The Benefits of Flood and Coastal Risk Management: a Manual of Assessment Techniques' (Penning-Rowsell et al. 2005).

Members of the research team joined the Environment Agency's Quality Review Panel to review the draft Catchment Flood Management Plans produced by the EA regions.

Drawing on the RELU work, a technical paper was produced for OECD on the role of agriculture in the mitigation of and adaptation to flooding in the context of climate change (to be published in 2009).

Contributions to BBC Radio 4 Farming Today programme in its reporting on the aftermath of the 2007 floods, highlighting the role of rural land for the temporary storage of floodwaters as part of catchment scale flood risk management. 2 other contributions to BBC Radio 4's 'Costing the Earth' also drew on the RELU floodplain work.

Material was prepared for a 'topic day' for the Great Land Use debate on 'Is rural land management the problem or the solution to flooding in our towns and cities?'

The project team have participated in a range of stakeholder and public engagements and workshops, as referred to above.

The PI joined the Lead Expert Group for the DIUS Foresight Land Project which is exploring long term futures for land use in England, providing a link to the RELU Research Programme

The relevance of the project to policy and practitioners is evident in the award of additional funding for rural flood impact studies. This included joint funding from ESRC /RELU, Environment Agency and Commission for Rural Communities. A parallel project was funded under the NERC Urgency programme to assess impacts on floodplain conservation sites.

The RELU project continued to interface with the EPSRC Flood Risk Management Risk Consortium (FRMRC) programme for example on Policy and Stakeholder Analysis (Edinburgh, June 2008) and on sustainable floodplains with the OnTrent Initiative (www.ontrent.org.uk) in which our Trent Beckingham Marshes case study site was used to explore research methodology, preliminary findings, and the management of integrated floodplains.

The research team is currently using the project results to prepare a response to the Floods and Water management Bill (2009)

9 Future research priorities

There is need to improve our understanding of ecological and hydrological aspects of floodplains, as well as the relationship between valuation of floodplain ecosystem services and governance.

9.1 Ecological aspects :

i. Monitoring the vegetation response to major flood events to ascertain whether exceptional flood events (e.g. with return periods longer than 100 years) have positive or negative implications for floodplain biodiversity;

ii. Research to determine the suitable management of floodplain natures reserves in the context of a fragmented landscape.

9.2 Hydrological aspects

i. Modelling to determine how the flood attenuation effect of floodplain land changes the design standard of the floodbanks and hydrological setting. Will reconnecting rivers with their floodplains always provide benefits in terms of flood alleviation?

9.3 Social and economic aspects

i. Development of methods to join the ecosystems services approach, including valuation of benefits, with decision making and governance, using the methods developed here as part of deliberative approaches which engage stakeholders;

ii. Economic valuation of landscape and biodiversity benefits for alternative floodplain management scenarios;

iii. Assessment of cost effective measures for floodplain management that are acceptable to key stakeholders and capable of achieving intended outcomes in practice, set firmly in the context of policy frameworks such as making Space for Water, Catchment Flood Management Plans, and the Food and Water Management Bill;

iv. Appraisal of institutional arrangements, including entitlement and reward systems, appropriate to apply the ecosystems framework as a basis for decision making and governance;

There is clearly a need to link principles, policy and practice by implementing a number of large scale experiments which demonstrate how floodplains can actually be managed to achieve multiple benefits in ways that appeal to a range of stakeholders.

Acknowledgement :

The research team thank the UK Research Councils, the RELU Programme Directorate, staff of the Environment Agency, Internal Drainage Boards, Farmer Associations and Conservation Organisations, the many farmers who freely gave of their time, as well as many others who helped us in this research.

Appendix 1 Outputs and activities from Integrated Floodplain Management Project

Journal papers

published (June 2009)

Posthumus, H., J. Morris, T. Hess, D. Neville, E., Phillips, A. Baylis (2009in press) Agricultural damage caused by the summer 2007 floods in England. *Journal of Flood Risk Management* , 2009, 1-8, doi: 10.1111/j.1753-318X.2009.01031.x

Reed, M., A. Graves, D. Norman, H. Posthumus, K. Hubacek, J. Maule, J. Morris, C. Prell, C.H. Quinn, S.T. Stagl, L.C. Stringer (2009) Stakeholder analysis for natural resource management. *Journal of Environmental Management* 90: 1933-1947. doi:10.1016/j.jenvman.2009.01.001

Rouquette, J.R., H. Posthumus, D.J.G. Gowing, G. Tucker, Q.L. Dawson, T.M. Hess, J. Morris (2009) Valuing nature-conservation interests on agricultural floodplains. *Journal of Applied Ecology* 46(2): 289-296. doi:10.1111/j.1365-2664.2009.01627

under review (June 2009)

Posthumus, H., J.R. Rouquette, J. Morris, D.J.G. Gowing, T.M. Hess (under review) A framework for the assessment of ecosystem goods and services; a case study on lowland floodplains in England. *Agricultural Systems*

in preparation

Morris, J., T.M. Hess, H. Posthumus, J.R. Rouquette, D.J.G. Gowing (*in preparation*) The history of floodplain management in England.

Morris, J., H. Posthumus, T.M. Hess, J.R. Rouquette, D.J.G. Gowing (*in preparation*) Cost-benefit analysis of integrated floodplain management.

Posthumus, H., J. Morris, P. Trawick (*in preparation*) The impacts of the summer 2007 floods on rural communities.

Rouquette, J.R., D.J.G. Gowing, G. Tucker (*in preparation*) Valuing nature in floodplains: the assessment of species.

Rouquette, J.R., H. Posthumus, D.J.G. Gowing, T.M. Hess, J. Morris (*in preparation*) Flood water storage and nature conservation: conflict or synergy?

Rouquette, J.R., H. Posthumus, J. Morris, D.J.G. Gowing, and T.M. Hess (*in preparation*) Assessing ecosystem goods and services under changing land and water management. *Agriculture, Ecosystems and Environment*

Book Chapter

Morris, J., H. Posthumus, T.M. Hess, D.J.G. Gowing, J.R. Rouquette (2009) Watery land: the management of lowland floodplains in England. In: M. Winter and M. Lobley (Eds.) *What is land for? The food, fuel and climate change debate.* Earthscan *pp.320. ISBN 9781844077205.*

Published Technical Reports/Science Papers and Other publications

Morris, J., T.M. Hess, H. Posthumus. (2008) *Agriculture's role in flood adaptation and mitigation – policy issues and approaches*. Technical paper COM/TAD/CA/ENV/EPOC/RD(2008)54. OECD. (*in press*)

Morris, J., H. Posthumus, P. Trawick, T.M. Hess, D. Neville, E. Phillips, M. Wysoky (2009) *Impacts of summer 2007 floods on rural communities in England.* Cranfield University. Report to the Commission for Rural Communities, Cheltenham,

Posthumus, H., J. Morris, T. Hess, D. Neville, E. Philips, M. Wysoki (2009) *Agricultural damage caused by the summer 2007 floods in England*. Environment Agency Science Report. Environment Agency, Bristol. (*in press*)

Posthumus, H., J.R. Rouquette, D.J.G. Gowing, T.M. Hess, J. Morris, P. Trawick. 2008. *Stakeholder workshop report: Integrated floodplain management.* (available *online on RELU website*)

Conference papers –

papers published in proceedings

Morris, J., T. Hess, H. Posthumus, P. Trawick, D. Neville, E. Phillips and M. Wysoki (2008) Impacts of the summer 2007 floods in rural England: rural flood proofing – Cinderella or suitable case for treatment? *Defra Flood and Coastal Management Conference*. Manchester, 1-3 July 2008

Morris, J. and H. Posthumus (2007) Multi-functional agriculture in UK floodplains: opportunities for agriculture to deliver ecosystem services. *XXII Congress of the European Society for Rural Sociology.* Wageningen, 20-23 August 2007

Posthumus, H., Morris, J., Hess, T.M., Trawick, P., Neville, D., Phillips, E. and Wysoki, M. (2008) Impacts of the summer 2007 floods on agriculture in England. In Samuels, P., Huntingdon, S., Allsop, W. and Harrop, J. Flood Risk Management: Research and Practice. CRC Press / Balkema, ISBN 978-0-415-48507-4.

Posthumus, H., J.R. Rouqette, J. Morris, T.M. Hess, D.J.G. Gowing, Q.L. Dawson (2008) Integrated land and water management in floodplains in England. *FLOODrisk 2008 Conference*. Oxford, 30 September – 2 October 2008. In: Samuels, P., Huntingdon, S., Allsop, W. and Harrop, J. Flood Risk Management: Research and Practice. CRC Press / Balkema, ISBN 978-0-415-48507-4.

conference presentations and published abstracts

Hess, T.M. (2008) *Joining things up in floodplains*. River Restoration Centre Annual Conference, 16 April 2008

Hess, TM (2009) *Changing land use and hydrological status of some lowland floodplains in England*. River Restoration Centre, Conference, 2 April 2009.

Morris, J. (2006) *Ecosystems Functions and Regulation (including flood management).* Annual Conference of the Institute of Agricultural Engineers, Silsoe, Bedford, 15th March 2006

Morris, J. (2006) *Integrated Floodplain Management*. River Restoration Centre, 7th Annual Conference, Edinburgh, May 2006

Morris J (2007) *Economics of Land Use and Ecosystems*. River Basin District Planning and Land Use, Planning the Lessons into Practice, November 6th 2007, London, A CIWEM – CMS Conference

Morris, J. (2007) *Better floodplain management.* Research on rural resource management and the rural economy: addressing the local and regional dimension, RELU Conference, Edinburgh, 16 May 2007

Morris, J. (2007) *Flood Risk Management Policy Issues*: Rural. FRMRC Annual Assembly, Edinburgh, 11 July 2007

Morris, J. (2007) *Valuing Ecosystem Services for Floodplain Management*, River Restoration Conference, Edinburgh, April 2007

Morris, J (2009) *Ecosystems services – the case of rural floodplains*. RELU Annual Conference, 4th June, Congress House, London

Morris, J (2009) *Joining things up in Floodplains*, CIWEM Annual Conference, Olympia, London.

Morris, J (2009).*The Case of Rural Floodplains*. Rural Land Use in the North of England : Future Challenges. *2009 Festival of Social Science/National Science and Engineering Week.* York, March 12th 2009

Posthumus, H. and J. Morris (2006) CAP-reform and controlling water runoff from farmland in England and Wales. COST 634 conference: *Farm level adoption of soil and water conservation measures and policy implications in Europe.* Wageningen, 1-3 October 2006

Posthumus, H., and J. Morris (2007) Engaging stakeholders in transdisciplinary research on agriculture and flood risk management. *XXII Congress of the European Society for Rural Sociology.* Wageningen, 20-23 August 2007

Rouquette, J.R., Gowing, D.J., Tucker, G., Posthumus, H., Dawson, Q.L., Hess, T.M., and Morris, J. (2008) Evaluating Alternative Land Use Options in Rural Floodplains. *The British Ecological Society Annual Meeting*, Imperial College, London, 3-5 September 2008.

Rouquette, J.R., Gowing, D.J., Tucker, G., Posthumus, H., Dawson, Q.L., Hess, T.M., and Morris, J. (2008) Evaluating Alternative Land Use Options in Rural Floodplains. *European Ecological Congress*, Leipzig, Germany, 15-19 September 2008.

Rouquette, J.R., Gowing, D.J., Tucker, G., Posthumus, H., Dawson, Q.L., Hess, T.M. & Morris, J. (2008) Assessing Alternative Land Use Options in Rural Floodplains: An Ecosystem Services Approach. *Symposium on "Biodiversity of Surface Waters, Floodplains and Groundwater*", Bonn, Germany, 29-30 October 2008 (invited speaker).

MSc theses

Braendle, J. (2007) A linear programming framework for integrated floodplain management. MSc thesis. Cranfield University

Morgan, M. (2006) A social and economic analysis of the Beckingham Marshes using ecosystem services. MSc thesis. Cranfield University

Páll, Z. (2008) Linear programming model for integrated floodplain management. MSc thesis. Cranfield University

Siwek, A. (2007) The ecological value of floodplains: implications for washland creation on rural floodplains along the river Trent. MSc thesis. Cranfield University

Workshops

Stakeholder Workshop Integrated Floodplain Management, April 28th 2008, London.

RELU workshop on Stakeholder Analysis. Leeds University, May 30th 2007

Other Presentations

Gowing D.J.G. (2009). Water management for floodplain meadows. Wildlife Trusts workshop, Preston Montford Field Centre, 18th May 2009.

Gowing, D.J.G. (2009) Hydrological management for conservation. At Field Studies Council Shrewsbury. 2nd April 2009.

Gowing, D.J.G. (2009) *Water management for nature conservation: conflicts and synergies.* Public Lecture at Birkbeck College organised by the Ecology and Conservation Studies Society. 20th February 2009.

Gowing, D.J.G. (2008) Presentation to Cambridge Conservation Forum. Girton College, Cambridge University. 11th January 2008

Gowing, D.J.G. (2008) Presentation to Flitwick Moor SSSI Stakeholders on floodplain management. At Bedford Group of internal Drainage Boards, 6th November 2008

Gowing, D.J.G. (2008) Presentation to Pell Frischmann consulting engineers on Biodiversity considerations with respect to Urban development in the floodplain of Shenley Brook, Milton Keynes. Pell Frischman Offices, Milton Keynes, 8th October 2008

Gowing, D.J.G. (2008) Presentation to the Institute of Professional Soil Scientists on floodplain grassland management for conservation. ICS, London, 21st October 2008.

Hess, T.M. (2008) *Valuing ecosystem services in lowland floodplains in England*. "Wetlands and Aquatic Ecosystems: Their Functions and Values". A knowledge exchange workshop for research scientists and practitioners from Europe and Southern Africa, Worcester college, Oxford, 24th - 25th November 2008.

Morris J (2007), *Futures for Land and Water Management*. FCO Conference, Instituto Technico Superior, Lisbon, Nov 28th 2007

Morris, J. (2007) *Better floodplain management*. Farm systems modelling workshop, Sheffield, 1 October 2007

Morris, J. (2008) *Water and ecosystems: joining things up.* KCL/SOAS London Water Group, London, 28 January 2008

Morris, J. (2006) *Ecosystems Functions and Regulation (including flood management).* Annual Conference of the Institute of Agricultural Engineers, Silsoe, Bedford, 15th March 2006

Morris, J. (2006) *Overview of RELU Integrated Floodplain Management Project*. RELU Stakeholder Forum, London, May 2006

Posthumus, H. (2007) *Exploring the potential for integrated floodplain management in the Beckingham Marshes.* FRMRC RPA 8 meeting: Sustainable development of floodplains and wetlands, Nottingham, 26 January 2007

Posthumus, H. (2007) *Integrated floodplain management in the Beckingham Marshes.* FRMRC RPA 8 meeting: Sustainable development of floodplains and wetlands, Nottingham, 19 March 2007

Posthumus, H. (2007) *Integrated floodplain management in the UK: stakeholder interests.* Survey of existing bargaining between stakeholders and farmers, FHRC Middlesex University, 29 November 2007

Posthumus, H. (2007) *Summer flood events: rural space*. Water, Environment and Society seminar series: the summer 2007 flood events. ESRC Seminar Series: Lancaster, 14 December 2007

Posthumus, H. (2007) *The impact of agricultural policy on land and water management in the UK.* Countryside and Community Research seminar series, Cheltenham, 15 March 2007

Posthumus, H. (2006) *CAP-reform, land management and flood risk.* BHS annual meeting, Silsoe, Bedford, 22 March 2006

Posthumus, H. (2006) *Rural land use and flood risk management: socio-economic and policy aspects.* Third annual assembly FRMRC, Sheffield, 10-12 July 2006

Rouquette, J.R. (2008) Integrated Floodplain Management: An Ecosystem Services Approach. Invited seminar presented to the Catchment Science Centre and Department of Animal and Plant Sciences, University of Sheffield, 12 November 2008.

Training

PDRA	Training
Q.L Dawson	2-day training course on 'ACCESS', Cranfield University, November 2006
H. Posthumus	2-day training course on 'ACCESS', Cranfield University, November 2006
H. Posthumus	3-day training course on 'Stakeholder Engagement', Dialogue Matters, February 2007
H. Posthumus	2-day training course on 'Getting Research into Practice', ESRC, November 2007
H. Posthumus	1-day training course on 'Data Management', RELU, June 2008
H. Posthumus	2-day master class on 'Interdisciplinarity', ISSTI, June 2008
J.R. Rouquette	Course on 'Economics of Environment and Resource Management', Cranfield University, 2007
J.R. Rouquette	Course on 'Grass Identification in Spring', Professional Development Course run by the Field Studies Council, 2007
J.R. Rouquette	2-day master class on 'Interdisciplinarity', ISSTI, June 2008
J.R. Rouquette	Training course on 'Plant Identification for Surveying, Evaluating and Monitoring Conservation Sites', July 2008

RELU integrated floodplain management

Morris, Joe

2009-06