Natural Infrastructure Schemes in practice

How to create new markets for ecosystem services from land

green alliance...

National Trust

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How to create new markets for ecosystem services from land

By William Andrews Tipper and Angela Francis

Green Alliance
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Contents

Executive summary

Leaving the EU will significantly disrupt UK agriculture. Likely consequences include: changes to the availability and cost of labour; the size and terms of subsidy payments; the potential imposition of new import and export tariffs; and, should certain trade deals be struck, increased competition from low cost food imports. For many farmers, and some entire farming sectors, this is an existential threat.

To help manage some of the pressures being felt by farmers, the government has committed to keeping agricultural support payments at their current level (around £3 billion per year) until 2022. While it is not currently known what will happen after this point, the total amount of money paid to farmers seems highly likely to fall.

Payments for ecosystem services (PES) has emerged as a powerful idea that could help farmers offset reductions to basic subsidy payments. While much of the debate has focused on funding PES schemes with public money we recently proposed a new model of Natural Infrastructure Schemes (NIS), a market-mechanism based on private contracts for farmers, to improve the ecosystem services generated by their farmland.[1]

This report explores the route to commercialising the NIS model. We have identified three conditions that must be met for NIS transactions to be possible; these are technically viable water attenuation projects; provable cost savings for private organisations that would otherwise be exposed to high costs from flooding; and the development of a robust commercial framework including contract and payment terms.

We also explore the economic viability of NIS transactions, based on a thought experiment for a flood risk management scheme in north west England. This region will be hit particularly hard by post-Brexit policy changes; over a third of all farms, around 1,800, in Cumbria and Lancashire are upland livestock grazing farms. On average, upland farmers are losing £10,800 a year on their farming business, and rely on farming subsidy payments to stay afloat. It is also a region that is vulnerable to extreme flooding.

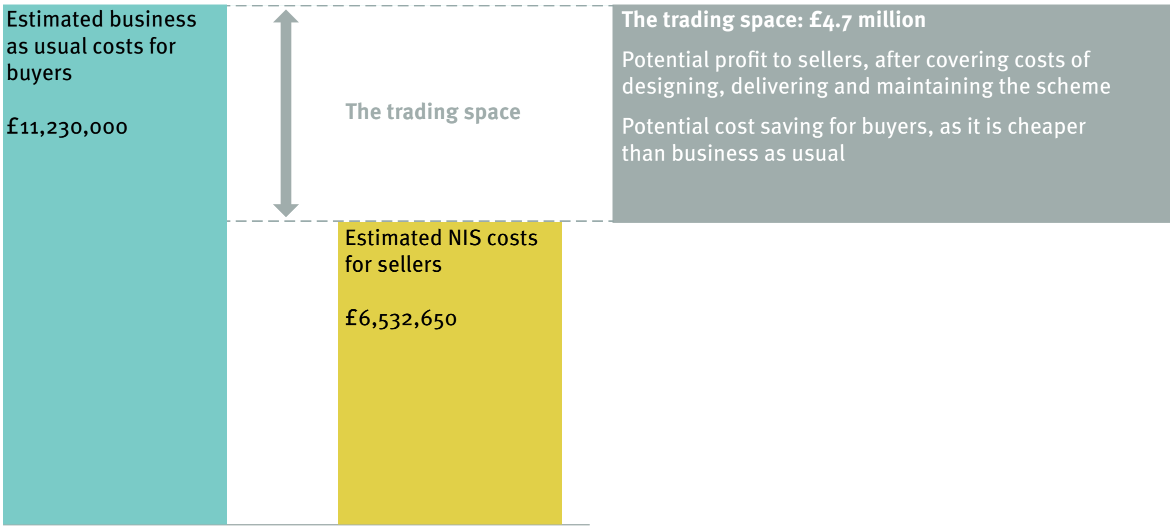
Natural Infrastructure Schemes

This concept is a market in avoided costs, which we have applied, as an example, to flood and water contamination. Water companies, infrastructure operators and public agencies would enter into contracts with upstream farmers to engineer their land to deliver 'slow, clean water'. This would involve contracting to carry out environmental infrastructure developments like soil aeration, tree planting or creating attenuation ponds to reduce flood risk or water quality problems, as an alternative to building hard infrastructure.

Funding for the schemes would come from money that buyers would otherwise spend on traditional solutions, for example water treatment facilities or flood defence measures. This market would be viable in locations where upstream land management would be cheaper than hard infrastructure, viewed over a ten to 20 year time horizon.

Based on the latest available data, the downstream costs of river flooding and water contamination are in excess of £2.4 billion per year. This includes spending by water companies, electricity network companies, transport authorities and the Environment Agency, and insurance pay outs.

A new market is possible as Natural Infrastructure Scheme costs are lower



Drawing on the latest modelling and data, our NIS thought experiment reveals that:

- A group of ten upland farmers could offer a Natural Infrastructure Scheme, using only ten per cent of their land, that would protect a downstream town against a severe one in 75 year flood event.
- Downstream organisations would currently pay £11.2 million to deliver this level of protection. These 'buyers' would include Network Rail, the local electricity supplier, the local water and sewerage company, the local authority responsible for maintaining roads, the insurance sector and local businesses.
- The scheme would jointly cost the ten farmers around £6.53 million over 15 years to create and maintain it. This includes the lost income from taking land out of agricultural use.
- Based on these estimates, the NIS would save £4.7 million compared to business as usual options. Splitting this saving equally would give the group of buyers a cost saving of £2.35 million over 15 years, and the farmers would earn £15,658 each in profit per year for 15 years.

The NIS offers a triple win:

1 A new, commercial revenue stream for upland farmers who might otherwise struggle to stay in business.

2 Improvements in the flood protection of vital infrastructure, at lower cost than current business as usual approaches.

3 Improvements to the natural environment through the creation of new natural infrastructure on farmland.

There are four ways the government could support the emergence of this market:

- **Use smart regulation** to remove barriers and encourage behaviour change.
- **Improve local planning and procurement** of flood risk mitigation.
- **Provide research funding** to increase knowledge about, and reduce costs of, natural flood management.
- **Introduce quantifiable objectives** for environmental restoration in the forthcoming 25 year plan for the environment.

An economic opportunity at a time of change

UK farming is under severe financial stress. Over 40 per cent of farms are operating at a loss.[1] Levels of farm borrowing have almost doubled over the past ten years, with nearly a fifth unable to service short term debts.[2] This has exacerbated underlying long term declines in the health of the natural environment, leaving some farmers stuck in a cycle of working the land ever harder just to break even.

Further diversifying farm incomes will be essential to help manage the pressures faced by the sector. One vital but under explored option is for farmers to sell the environmental services derived from their land.

Our analysis is that there is considerable potential for private markets to support maintenance of some ecosystem services. The strongest case can be made in relation to water. Our publication *New markets for land and nature: how Natural Infrastructure Schemes could pay for a better environment* identified how £2.4 billion is being spent every year by utilities, local authorities, insurance companies, public agencies and others to manage the problems arising from water contamination and flood risk.[3] In many instances, changing how land is managed could reduce the scale of these problems, or eliminate them altogether, at equal or lower cost.

There are already examples of farmers being paid to manage their land to support improvements to water quality and flood risk. We explore these in more detail on page 13.

However, the fact that money is changing hands does not mean that a market exists. Payments to farmers are generally for managing land in a particular way, making it difficult to judge the value of what is being delivered, while poor or non-existent enforcement means that it is not always possible to know whether schemes have even been delivered.

Three factors will stimulate development of the market for Natural Infrastructure Schemes (NIS):

1. Brexit

The UK's departure from the EU will disrupt farming in many ways: these include changes to the availability and cost of labour; the size and terms of subsidy payments; the potential imposition of new import and export tariffs; and, should certain trade deals be struck, increased competition from low cost food imports.[4]

2. Public finances

Reducing public debt remains a political priority and a major challenge. Reductions in public spending will be inevitable and any continuing public payments to farmers are likely to have to meet stringent value for money tests.

3. Climate change

The severity of flood risks and water stress is projected to increase in many parts of the country. Increasingly, local conditions are limiting the effectiveness of hard engineered solutions to these problems. Additional hard flood defences to protect vulnerable communities and infrastructure are, in many instances, too expensive, given the relatively modest assets they protect. Similarly, additional water treatment plants to meet regulatory water standards, caused by factors such as pesticide run-off from farmland, may be too expensive or not sufficiently effective to justify.

In this report we explore the route to commercialising ecosystem service provision. It is structured in three parts. First, we set out the conditions required to underpin viable transactions and a successful market; second, with a thought experiment, we demonstrate the profitability of this model in an upland setting; and, third, we provide an overview of the barriers to market development and recommendations for how to overcome them.

Understanding the route to market

Three conditions for success

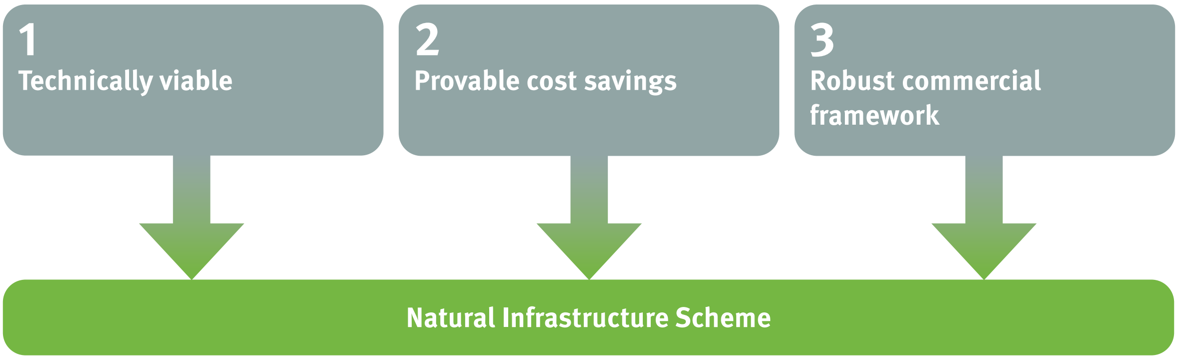
The current regime of agricultural subsidies has been guaranteed up until 2022, which provides a cushion to support development of new markets for ecosystem services from farmland. Our assessment is that these markets could be widespread provided the following three conditions for success are met, which we explore in more detail in the following three chapters.

Technically viable
Viable projects will require a location where land management could increase water holding capacity and reduce the passage of pollutants into water bodies, so as to deliver quantifiable improvements to downstream flood risk or water quality.

Provable cost savings
It will be necessary to demonstrate cost reductions for organisations located downstream from the scheme, to persuade them to fund the NIS in anticipation of future savings.

Robust commercial framework
A new type of contract will be needed that is fair, legally robust and enforceable. The price agreed should deliver a return to all parties, and payment terms should reflect the need for ongoing monitoring and maintenance of the scheme.

Three conditions needed for a successful Natural Infrastructure Scheme



Costs incurred by sellers

One-off cost of designing and delivering the scheme

Interest or other financing costs

Ongoing scheme maintenance costs including monitoring, evaluation and compliance

Agricultural or other income foregone

Costs avoided by buyers

Spending avoided or deferred as a result of the scheme, eg infrastructure upgrades, creation of new infrastructure, other spending to avoid disruption to business critical services

Spending on restoring infrastructure or services after major events such as flooding

Once the three conditions have been met, the viability of an individual transaction will be determined by the relative weighting of costs to the buyers and sellers. The transaction is viable where the buyers (water companies or other agencies) pay less to implement the measures under the scheme than they would for other solutions; and where the return to the seller (ie a farmer) is greater than they would earn from farming the land.

Assessing if a scheme is viable

Define customer needs

Water company
Has to meet regulatory thresholds for nitrate levels in rivers

Electricity Distribution Network Operator
Has to ensure electricity substations are resilient to 1:1,000 year flood

Network rail
Has to ensure resilience of rail network

Determine how needs could be met by natural engineering

For example, reduce surface run-off of fertilisers to reduce river nitrate levels to Xppm

For example, increase water holding capacity in the upper catchment by X cubic metres to reduce flood peaks up to a 1:X level event

Conduct technical and economic assessment

Potential actions	Risks and implications
Changes to agricultural practices	**Farmer** Revenue foregone; capital cost of earthworks; cost of borrowing
Changes to land use (riparian and in field)	
Land drainage modifications	**Customers** Cost effectiveness vs other options
Alterations to the course of a river	
Creation of new structures in rivers	

Decision

Is the NIS transaction viable?

Is it technically viable?

For a scheme to be technically viable, it must be possible for changes in land management to attenuate sufficient volumes of water and quantities of pollutants in the upper catchment. This will depend upon a number of factors:

<table>
<tr><th>Factors</th><th>Influence on flood risk and water quality</th><th>Current status and trends</th></tr>
<tr><td>Land use
The mix of agriculture, housing, recreation etc</td><td>Grazing land may be more likely to contribute to flood events (eg through soil compaction) while arable land may be more likely to contribute to water quality problems (due to soil loss or effluent run-off).</td><td rowspan="5">• Over 70 per cent of UK land is managed for agriculture. Approximately 6.4 million hectares in England and Wales has been drained for agriculture using piped systems.[5]
• Development of land in floodplains, whether for agriculture, housing or infrastructure, typically involves a range of changes to natural features. Ninety per cent of floodplains are no longer fit for purpose, according to recent research.[6]
• Over half of English farms have problems with soil compaction, which reduces water infiltration and increases rates and volumes of run-off. This increases downstream flood risk and increases pollution and sedimentation in waterways.[7]
• Over 140 groundwater sources were closed from 1975-2009 due to quality problems, removing over 400 megalitres from the public water supply.[8] Across the south east, it has been projected this will lead to 200 megalitres per day becoming unavailable in the next few years.[9]</td></tr>
<tr><td>Topography
Arrangement of natural and manmade surface features</td><td>Sloping fields that run down towards rivers have higher levels of run-off, which can cause both flood and water quality problems.</td></tr>
<tr><td>Geology
The permeability of different types of soil and bedrock</td><td>Permeable rocks, like chalk, allow water infiltration. This can increase water quality challenges by allowing transmission of pollutants from land into underground aquifers.</td></tr>
<tr><td>Hydrology
How water moves through the catchment, including artificial drainage</td><td>Canalisation of rivers (straightening and dredging) is widespread. This speeds up the flow of water through a catchment, potentially increasing flood risk and severity at points along the river course.</td></tr>
<tr><td>Weather
Rainfall levels and patterns, and whether they lead to drought or flood</td><td>Average rainfall is less important than when and how rain falls. Prolonged periods of rainfall will raise the water table and saturate the land, reducing its absorptive capacity. Prolonged dry periods can also reduce absorptive capacity, as well as increase the concentration of pollutants in surface and subsoil water bodies.</td></tr>
</table>

The land management plan for any given site would need to consider these factors in the local context. The plan would include some or all of the following measures:

- Changes to agricultural practices to improve soil, eg minimum tillage farming.
- Changes to land use not adjacent to rivers, eg bunds and tree planting.
- Changes to land adjacent to rivers, eg riparian strips, attenuation ponds and treatment wetlands.
- Modifications to drainage infrastructure to increase soil moisture levels, eg blocking subsoil pipes or grips (surface channels).
- Alterations to river courses, eg remeandering, measures to reconnect rivers with their floodplains.
- Creation of new structures in rivers, eg woody debris and log jams.

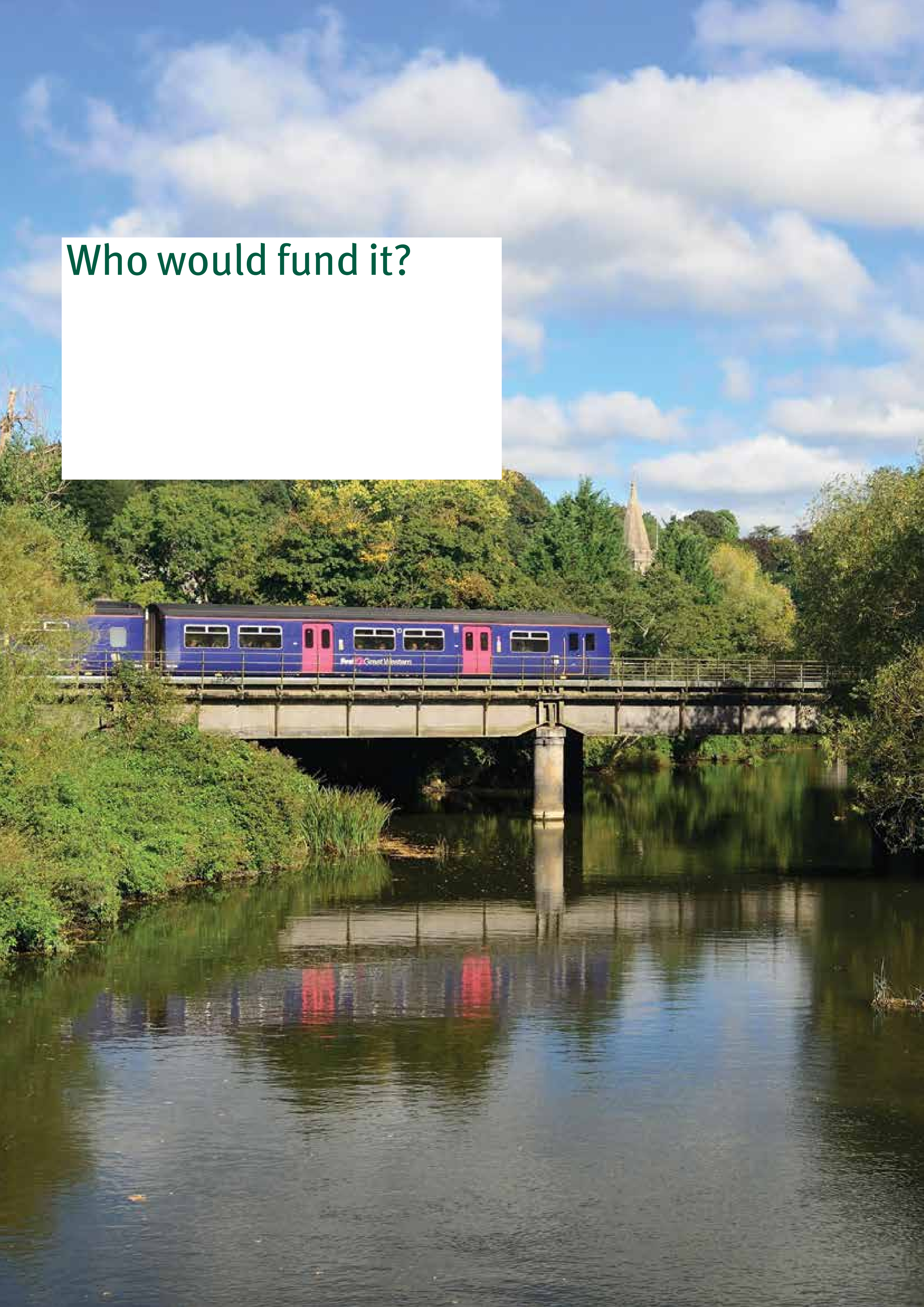
These types of approaches have been trialled widely. While existing projects have been mostly small scale, a number have provided compelling evidence of their effectiveness (see below). Significant additional resources are being invested in gathering more evidence, including at a larger scale, by government, research institutions and water companies.[10]

Furthermore, publicly funded agri-environment schemes are helping to deliver insights that will be relevant to design of this market, such as the impact of payment for results schemes, and factors that influence farmer collaboration.

Natural engineering in action[11]

Project	Benefits
Exmoor Mires Peat regeneration, moorland grip-blocking, ditch blocking.	Thirty two per cent reduction in storm flows, improved water quality, increased carbon storage, and increased wildlife on the moors.
Holnicote Moorland grip-blocking, use of woody debris in rivers, vegetation planting, creation of earth bunds and leaky sluices.	Ten per cent reduction in flood peak during actual event with an estimated 75 year return period.
Banbury Creation of earth bunds and flood storage areas.	Flood risk reduced from one in five years to one in 200 years for residents of Banbury, protecting 400 homes and 73 businesses.
Lustrum Vegetation planting, pond creation, engineered debris dams.	Reduced flood risk by 11.5 per cent, protecting 150 properties.
Thacka Beck Pond creation, reconnecting rivers to floodplain using earth banks.	Reduced the risk of flooding in any given year from 20 per cent to one per cent.
Netherton Burn Creation of earth bunds, offline ponds, deepening existing ponds and ditch blocking.	Fifty seven per cent reduction per year in pond sedimentation, preventing 22 tonnes of sediment and nutrients entering the ponds.
Crake Trees Manor Wetland creation and restoration, creation of sediment traps and vegetation planting.	Traps up to 18 tonnes of sediment per year that would otherwise enter the water course.

Who would fund it?



The amount of private money already being spent on managing flood risk and water quality problems indicates the potential for a market in avoided costs. Rather than funding hard infrastructure, a proportion of this money could instead fund land management which delivers the same outcomes at equal or lower cost, such as increased protection from flooding, while providing other environmental benefits.

Who is currently paying?

There are currently two approaches to paying farmers to manage land for water.

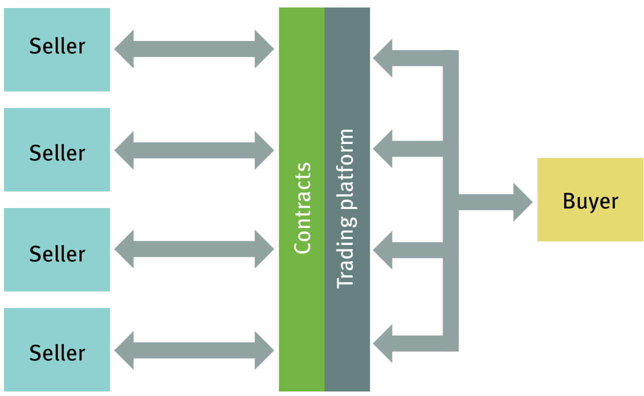
The first is a single purchaser model, in which an organisation, like a water company or the Environment Agency, pays a land manager to implement certain measures on their land. This is generally for one of two purposes: to reduce diffuse water pollution from agriculture, such as nitrates from fertiliser, or to make land available for flooding during extreme weather events.

There are some highly innovative approaches developing in this sphere, most notably EnTrade, an online platform run by Wessex Water. EnTrade uses reverse auctions to pay farmers for land management that reduces nitrate run-off. To date, it has procured measures on more than 3,000 hectares of land, eliminating almost 150 tonnes of nitrogen for its customers. Wessex Water has run five auctions on the platform since June 2016 to protect Poole Harbour, while United Utilities has run an auction for seven safeguard zones in Cheshire.

The second model is a multi-buyer and multi-seller model. This is characterised by collaborative projects delivering multiple environmental outcomes. These are typically brokered by an intermediary, like the Rivers Trust, and frequently use public or charitable grant funding combined with agri-environment subsidy payments.

Paying farmers to manage flooding and water quality: two existing approaches

Model 1: single purchaser



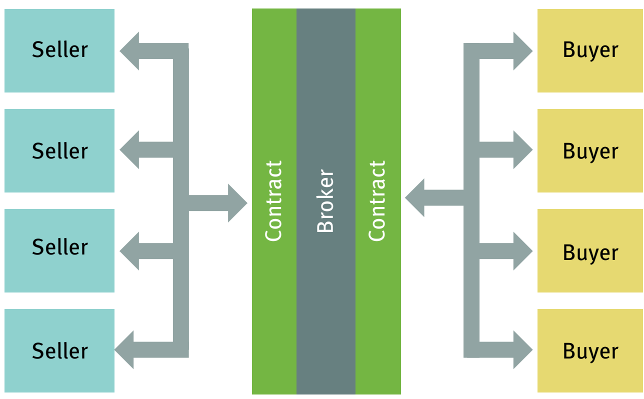
Example: EnTrade

Objectives: reduce nitrate run-off into watercourses

How it works: sellers (farmers) bid via an online trading platform for funding to plant cover crops over winter; it is run as a reverse auction, where sellers bid-in projects, and winners are selected for lowest cost

Buyer/seller model: single purchaser (eg water company) enters into multiple bilateral agreements directly with sellers

Model 2: central broker



Example: Rivers Trust catchment management

Objectives: multiple environmental objectives

How it works: neutral broker pools resources from multiple organisations to support delivery of complex land management projects over a whole catchment

Buyer/seller model: multiple buyers (eg Defra, water companies, Environment Agency, charities) enter into separate agreements with one or more farmers; agreements can be legally binding (eg agri-environment schemes) or more informal

What is different about a NIS market?

There would be two principal differences to most existing models.

1. Farmers are selling a service, not a land management scheme

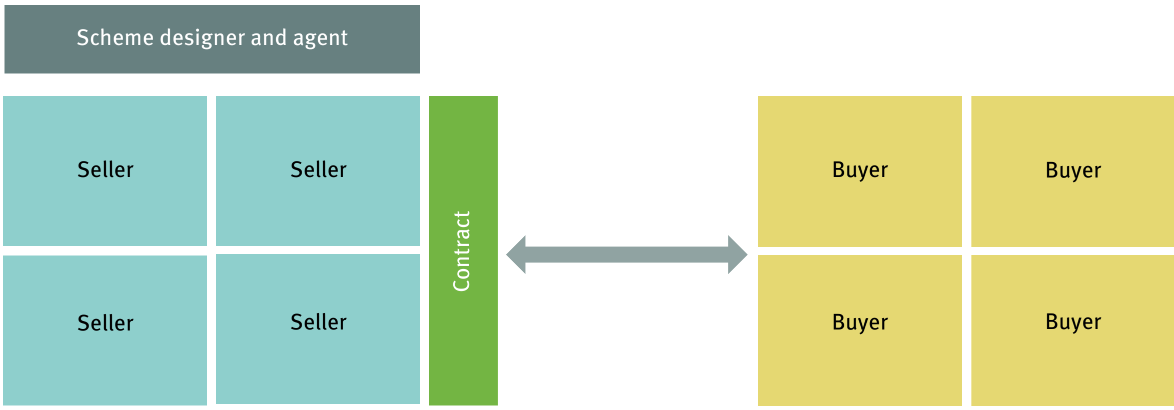
In many current schemes, farmers have no responsibility for the outcomes being sought, whether they are increases to biodiversity, improvements to water quality or flood risk improvements. A functioning market is typically built around sellers competing to deliver what their customers want, and being accountable for whether or not it is achieved.

2. There is a bigger, more diverse set of buyers

The creation of a NIS would benefit a whole range of organisations. Under current models, funding typically only comes from either public agencies like the Environment Agency or water companies. A functioning market would have more of these beneficiaries as paying customers, rather than having some free riding on the investments of others.

Our NIS model is built around these two principles, envisaging a farmer-led process involving consortia of buyers and sellers negotiating directly with one another.

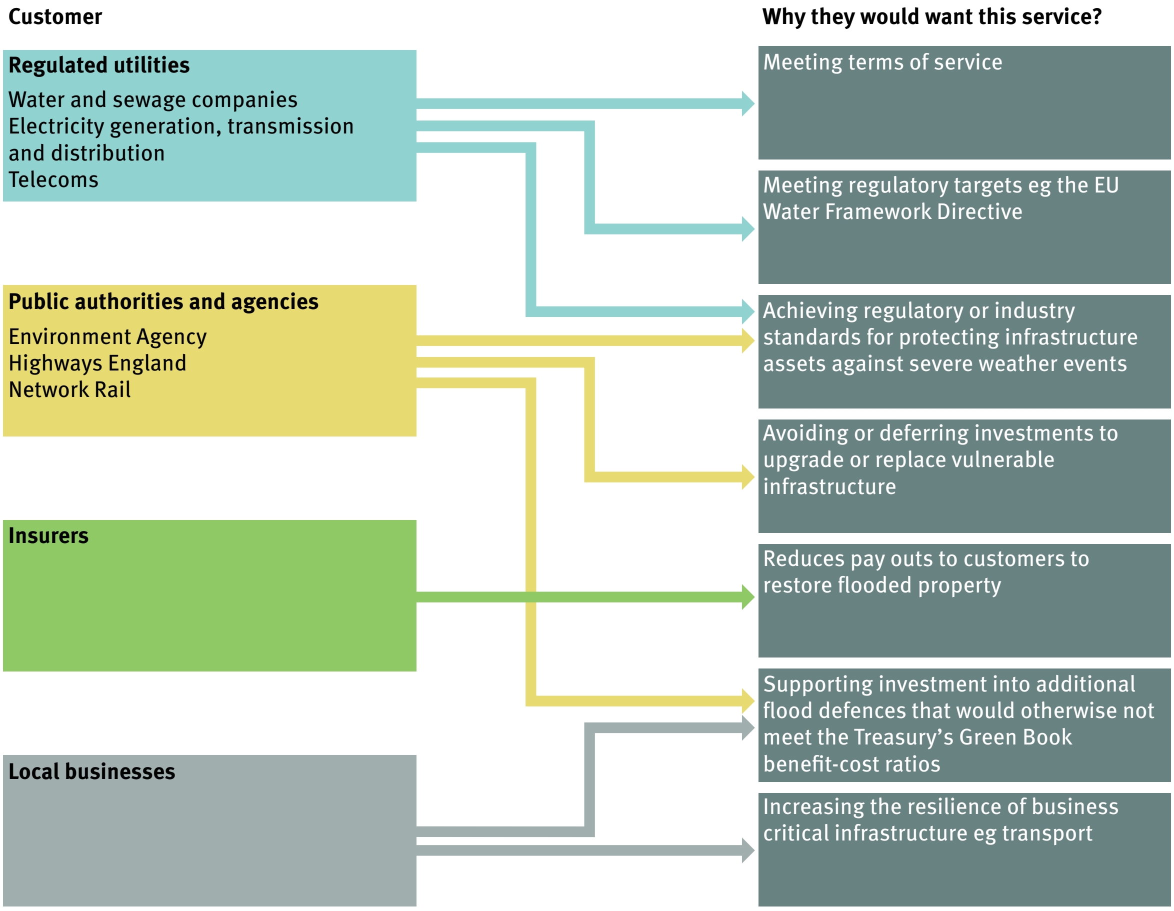
The NIS model: a consortium of land managers sells a service to multiple beneficiaries



Understanding the needs of customers

We have identified four broad categories of customer and mapped out some of their motivations for buying into the scheme:

Four potential customers



All these entities will either be incurring costs related to flooding or water contamination already, or will need to spend significant sums of money to manage them in the short term. They could have one of four financial motivations:

- to increase the resilience of, prolong the life of or improve the performance of existing infrastructure or built environment assets, in the most cost effective way possible;
- to defer or eliminate the need for investment in new infrastructure assets;
- to unlock new, cost beneficial investment;
- to increase the resilience of business critical infrastructure owned by someone else.

The sums of money available, and processes for allocating it, vary considerably by sector. The costs being faced by these sectors frequently run into the millions of pounds, as the summary table shows on page 18.

Network Rail

The rail network has shown itself to be vulnerable to infrastructure failure in the face of even mild flood events: three of the four viaduct or bridge failure incidents between 2003 and 2013 occurred in minor flood events.[12] Instances of earthwork slippage due to water ingress are on a long term upward trend.[13]

Network Rail has to pay compensation to train operating companies for disruption to passenger services caused by flooding. This typically amounts to millions of pounds every year. Furthermore, this excludes the cost of track improvements to address vulnerability to extreme floods. Network Rail's budget for maintaining and improving track drainage, plus earthwork renewals, is £428 million between 2014 and 2019. This reflects the high costs involved; improving track drainage costs £500 per metre, while upgrading electrification to cope with flooding costs £1,000 per metre.[14] An assessment carried out for Cowley Bridge Junction, where periodic severe flooding has repeatedly broken the main line between London and the West Country, costed two options for major resilience works, one at £6.5 million and one at £13 million.[15]

Distribution Network Operators (DNOs)

DNOs have undertaken a thorough assessment of vulnerability to flooding and have plans in place to defend all electricity substations serving populations over 10,000. However, smaller substations, often serving rural communities will, in many instances, be unprotected.

As with rail, the electricity sector is exposed to potentially huge costs for assets which cannot be adequately or cost effectively protected from flood risk by hard flood defences. The cost of raising a small substation by 1.2 metres is £2 million, while relocation would cost £2.7 million. The sector has a £250 million investment programme underway to improve resilience to flooding between 2015 and 2021.

The insurance sector

Insurers have been exposed to huge costs from severe weather events. The insured flood loss from Storm Desmond in 2015 was between £520 and £662 million, resulting from 24,000 property claims.[16] The average cost of repairing or restoring a flooded home is in the range of £20,000-£45,000. These costs will ultimately be passed through to policyholders, but the increases in flood risk, and the higher costs from more severe events has raised questions about the affordability of insurance for some households, or even their ability to access it at all.

As a result, an agreement between the government and the insurance sector led to the creation in 2016 of Flood Re, a reinsurance company with the remit of enabling up to 350,000 households in the most at risk areas to continue to access flood insurance. Flood Re is funded by a levy on insurance policies, to the value of £180 million each year. It has a lifespan of 25 years, with the aim of supporting the transition to a market which better prices in the risks to property.

The water sector

The cost of removing pollutants from water is huge. Water companies are subject to a number of regulations on water quality that drive investment decisions and behaviour. These include Water Framework Directive stipulations regarding the ecological health of water bodies, as well as UK Drinking Water Inspectorate standards for the safety of the public water supply.

The cost of hard infrastructure is starting to drive the development of alternative approaches. For example, Wessex Water developed the EnTrade trading platform as an alternative to building a nitrate removal plant to manage pollution in Poole Harbour. This would have cost £5.5 million, plus £340,000 per year to operate.

Water companies are also liable for many of the costs of overspills from the sewerage system, and invest significant sums in maintaining the resilience of sewers and treatment works to severe weather events. For example, a 3,000 cubic metre overflow storage tank costs in the region of £800,000.[17]

Public roads agencies

Highways England is responsible for the strategic road network but the maintenance of local roads is the responsibility of local authorities. This money may be raised from local taxpayers or funded by central government grants. The costs can be extremely high; in 2013-14, the economic costs of river and groundwater flooding on the road network were £109 million.[18] This covers both the costs of repairing the road surface, as well as impacts on other infrastructure such as bridges. When Pooley Bridge collapsed in Cumbria during Storm Desmond in 2015, Cumbria County Council paid almost £300,000 to install a temporary bridge.[19]

Local businesses

To protect their own assets, where permanent defences are not viewed as cost beneficial, the alternative is to use sandbags or install temporary flood defences, which have a 20 to 30 per cent failure rate. The average cost of installing temporary frame barrier flood defences is £240,000 per site, while the average cost of protection using sandbags is £60,000.

Furthermore, there are precedents for retail and commercial businesses part-funding local flood defences, to defend business critical infrastructure. In Sheffield, a novel scheme created a Business Improvement District, which enables the local authority to use a levy on rates to raise money for flood defences in the Lower Don Valley.

Lower Don Valley flood defence project and Business Improvement District[20]

This flood defence scheme in Sheffield was instigated to increase levels of protection up to a 1 in 100 year event. Uniquely, the funding model makes use of a Business Improvement District mechanism to raise £1.4 million from local businesses. £500,000 is to cover the capital cost of creating the scheme, with the remainder supporting ongoing channel maintenance. The Business Improvement District, which is running from 2014-19, was adopted after a plebiscite amongst local businesses. The funding will be collected as a levy on local rates.

Costs for different sectors run into millions of pounds

Sector	Spending category	Programme budgets	Cost of one-off measures
Power[21]	Electricity sector spending on flood resilience (2015-21)	£250 million	
	Cost of relocating a small substation		£2.75 million
	Cost of raising a small substation 1.2m		£2 million
Rail[22]	Network Rail spending on flood resilience (2014-19): Earthwork renewals Drainage maintenance and improvements for track, earthworks etc	 £100 million £328 million	
	Cost of major resilience works: Enlarge flood relief culvert, install slab track, sheet pile wall to protect slab track Enlarge flood relief culvert, install slab track and lift 500mm, sheet pile wall to protect slab track and lift bridge		 £6.5 million £13.4 million
	Cost per day to Network Rail of mainline tunnel closure due to severe weather event		£264,061
Road[23]	Highways England spending to improve the resilience of the road network to flooding, and to reduce water pollution from road run-off (2015-20)	£78 million	
	Central government spending on resilience of road network to flooding: 100 road schemes to address issues including flooding, carbon emissions, landscape and biodiversity (2015-21) Projects to make roads resilient to flooding, announced in the 2016 autumn statement	 £300 million £100 million	
Insurance[24]	Cost of repairing and restoring a flooded home		£20,000-£45,000
	Flood Re annual revenue, collected as a levy on premiums	£180 million	
Water[25]	Cost of building a new nitrate removal plant		£5.5 million
	Annual running costs for a nitrate removal plant		£340,000
	Cost of major sewer upgrade, involving installation of a 6.5 km waste water pipe		£5 million
	3,000m^3 sewer overflow storage tank		£801,000
All sectors[26]	Installing temporary frame barrier flood defences (average site cost)		£240,000
	Temporary sandbag flood defences (average site cost)		£60,000

Getting the commercial framework right

For NIS transactions to be possible, buyers and sellers will need to enter into binding contracts that are substantially different to existing arrangements.

On the sellers' side, farmers will need to take greater responsibility for delivering environmental services compared to a simpler land management programme. On the buyers' side, infrastructure operators and public agencies will need to evolve the principles that underpin investment decisions, to support the purchase of environmental services from land managers, as well as the construction of hard infrastructure. While there are no direct precedents, there are a number of relevant examples to guide this process.

The key terms the contract will need to specify are:

- What is being bought and sold
- Risks and liabilities
- Payment schedule and structure

What is being bought and sold?

- **Payment for measures:** farmers are paid for implementing an agreed set of land management measures, for example planting cover crops or creating riparian strips adjacent to rivers.

- **Payment for outputs:** this could include, for example, a commitment to creating attenuation features that deliver a guaranteed minimum level of water storage on a specified area of land.

- **Payment for outcomes:** this would require farmers to commit to managing their land to deliver a specific outcome for the buyer and could include protection of an item of infrastructure against a defined level of flood event, or a guarantee that pollutants will not exceed a maximum threshold at a specified point in a river.

Most existing schemes involve payment for measures. However, there are examples of effective projects with contracts that combine payments for outcomes and measures, such as the Pevensey Bay flood defences.

Pevensey Bay flood defences[27]

This is a 25 year flood defence contract between the Environment Agency and a consortium of four companies to protect a 50 kilometre stretch of coastline against a one in 400 year flood event for 25 years.

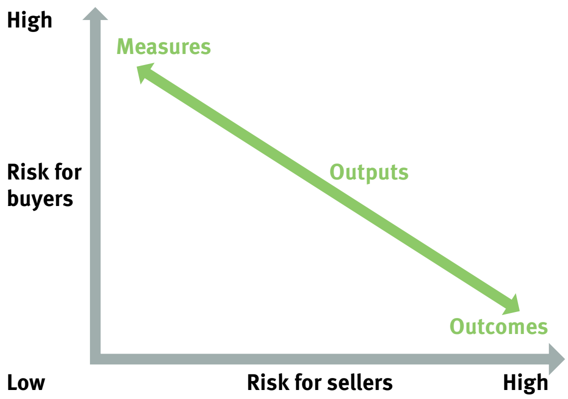
Compliance and liability is determined by the identification of a set of 'key physical features' for 53 sub-sections of the bay, to be monitored monthly.

The value of the contract was £30 million (1999 prices), set against the estimated cost of breaching flood defences of £125 million.

Defining risks and allocating liability

A NIS contract will need to ensure that sellers are not exposed to risks they are unwilling or unable to manage, and that buyers are guaranteed a level of performance to deliver the outcome they want.

In environmental contracting, risk is a zero sum game: in a payment for measures scenario, the risk that the desired outcome will not be achieved sits primarily with the purchasers; provided farmers have maintained the agreed measures on their land, they will be compliant. With payment for outcomes, liability would sit with sellers.



The nature of these risks will change over time. Infrastructure investments are typically measured in decades rather than years. To be competitive with hard infrastructure, catchment management schemes will need to offer guarantees over similar time scales.

Payment schedule and structure

Learning from existing natural flood management and catchment management schemes, the contract would need to address a number of issues, including:

The landlord-tenant split

There have been historical examples of schemes where farmers were not compensated beyond the capital cost of the land. Tenant farmers who faced the loss of yield and income were exposed to costs from increased instances of flooding of their land without any financial benefit (see the Dyffryn Conwy Flood Alleviation Scheme example on page 22). If natural engineering is to become a viable commercial option for farmers, land managers as well as landowners will need to benefit from the income it generates.

Relationship to other funding

While the NIS is a private market, with private contracting arrangements, some of the counterparties will be public entities. For flooding, flood defence projects with a cost benefit ratio of above 8:1 are potentially eligible for Environment Agency funding. The Environment Agency already has a partnership funding model in which other funders contribute to schemes the Agency delivers but would be unable to fund alone. A NIS could take that further and the Environment Agency could become part of a purchasing group for upstream natural engineering.

And while the future of agri-environment schemes is currently uncertain, it is likely there will continue to be money available for measures and projects of this kind up until the early 2020s, and possibly beyond, where the primary objective might not be flood management but grants could support the other environmental benefits delivered as part of a NIS scheme.

Incentives for collaboration and innovation

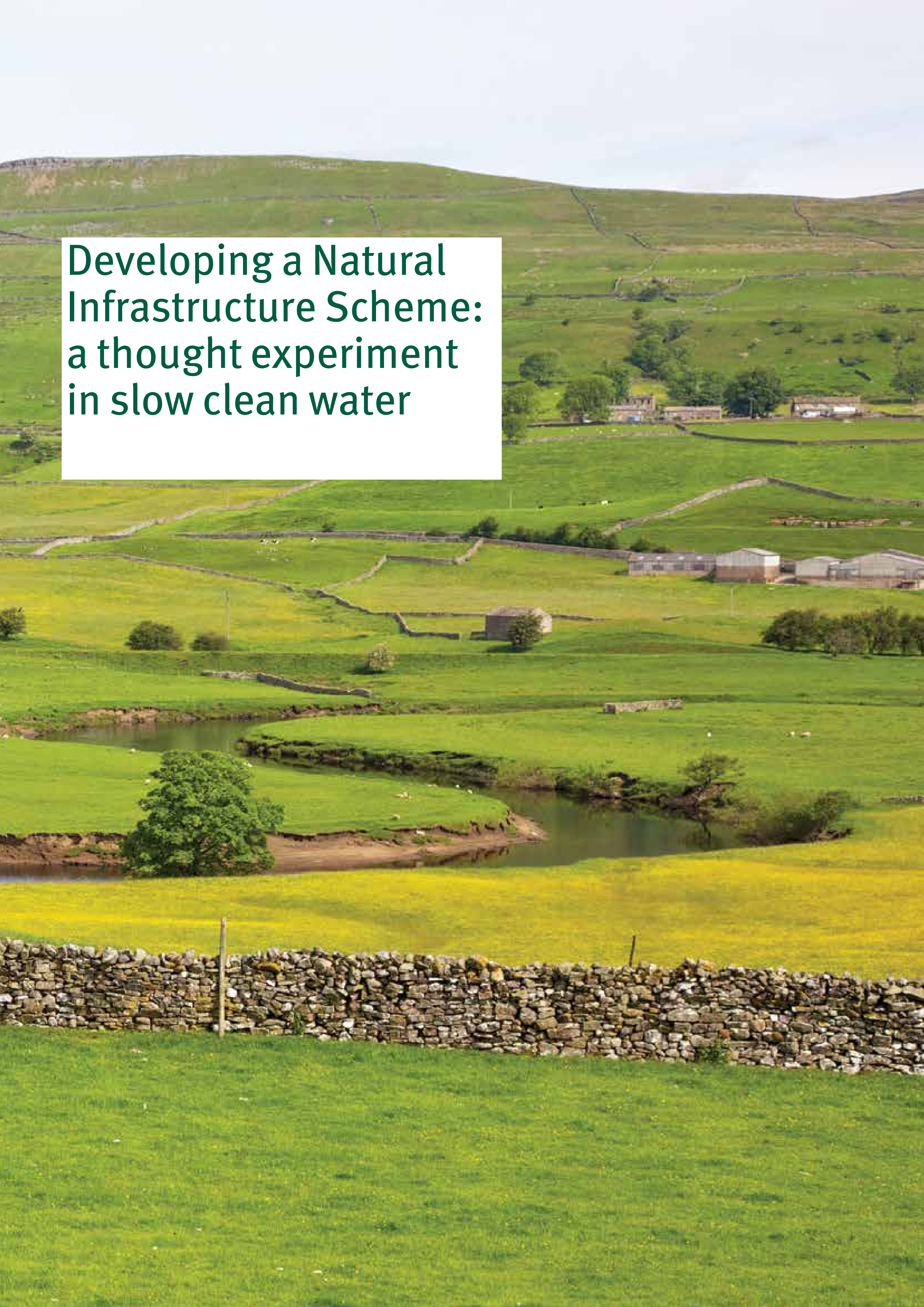
Maximising the benefits of catchment-scale projects will require collaboration between groups of landowners. Smart payment structures would facilitate this and sellers should also be encouraged to innovate. If it is possible to provide the contracted outcome using a smaller land footprint than originally envisaged, freeing up some land for other uses for the benefit of the farmer, or using methods which allow for multiple land uses, this should be supported.

Lessons from the Dyffryn Conwy Flood Alleviation Scheme[28]

This project was led by Environment Agency Wales in 2003 to reduce flood risk to the communities of Llanrwst and Trefriw to a one in 200 year event. It required temporary flooding of 200 acres of land, adjacent to the River Conwy, by lowering existing embankments and building a new embankment to divert water.

All 21 affected landowners entered into legally binding Easement Agreements (right to flood) of 20 years which included a one-off payment. However, tenant farmers did not benefit from this arrangement and incurred significant financial losses during times of peak flooding.

Developing a Natural Infrastructure Scheme: a thought experiment in slow clean water



In principle, a NIS could be applicable more or less anywhere in the country, in both upland and lowland catchments. There are examples of substantial infrastructure spending to address flood and water quality problems in all regions, while nearly three quarters of all UK land is managed for agriculture.

However, to test the approach, we have conducted a thought experiment built around a fictional rural community in north west England that enters into a NIS transaction.

There are three reasons why the model is likely to be particularly cost effective in this part of the country.

The type of farming

The dominant form of farming in the north west is upland livestock grazing, one of the UK's most economically marginal agricultural sectors. On average, upland farmers lose £10,800 per year on their farming business, more than twice the industry average. The sector relies on above average levels of agri-environment subsidy payments to break even. This type of farming accounts for 36 per cent (1,125 out of 3,105) of farms in Cumbria, and 35 per cent (662 out of 1,864) in Lancashire.[29]

Low population density

Traditional flood defences are often judged not to be cost effective in areas of low population density. Cumbria has a population density of 73 per square kilometre compared to a national average of 379.[31] Half the population lives in the main eight urban areas, the three smallest of which (Penrith, Maryport and Ulverston) have populations of between 10-15,000 people each.[32]

Susceptibility to flooding

Cumbria and Lancashire have suffered from a number of devastating flood events in recent years, with significant impacts on local infrastructure.

Power supplies were severely disrupted during the 2015 Boxing Day flood in Greater Manchester, when seven electricity substations were flooded.[33] Considerable sums have since been invested in protecting vital infrastructure against future extreme weather, such as the £4.6 million spent by Electricity North West to protect a substation in Lancaster.[34] But many assets serving smaller communities either have not yet been upgraded or may not be cost effective to protect.

Storms Desmond and Eva impacted 56 wastewater treatment plants in Cumbria. The

Annual farm accounts for an average upland livestock grazing farm in England[30]

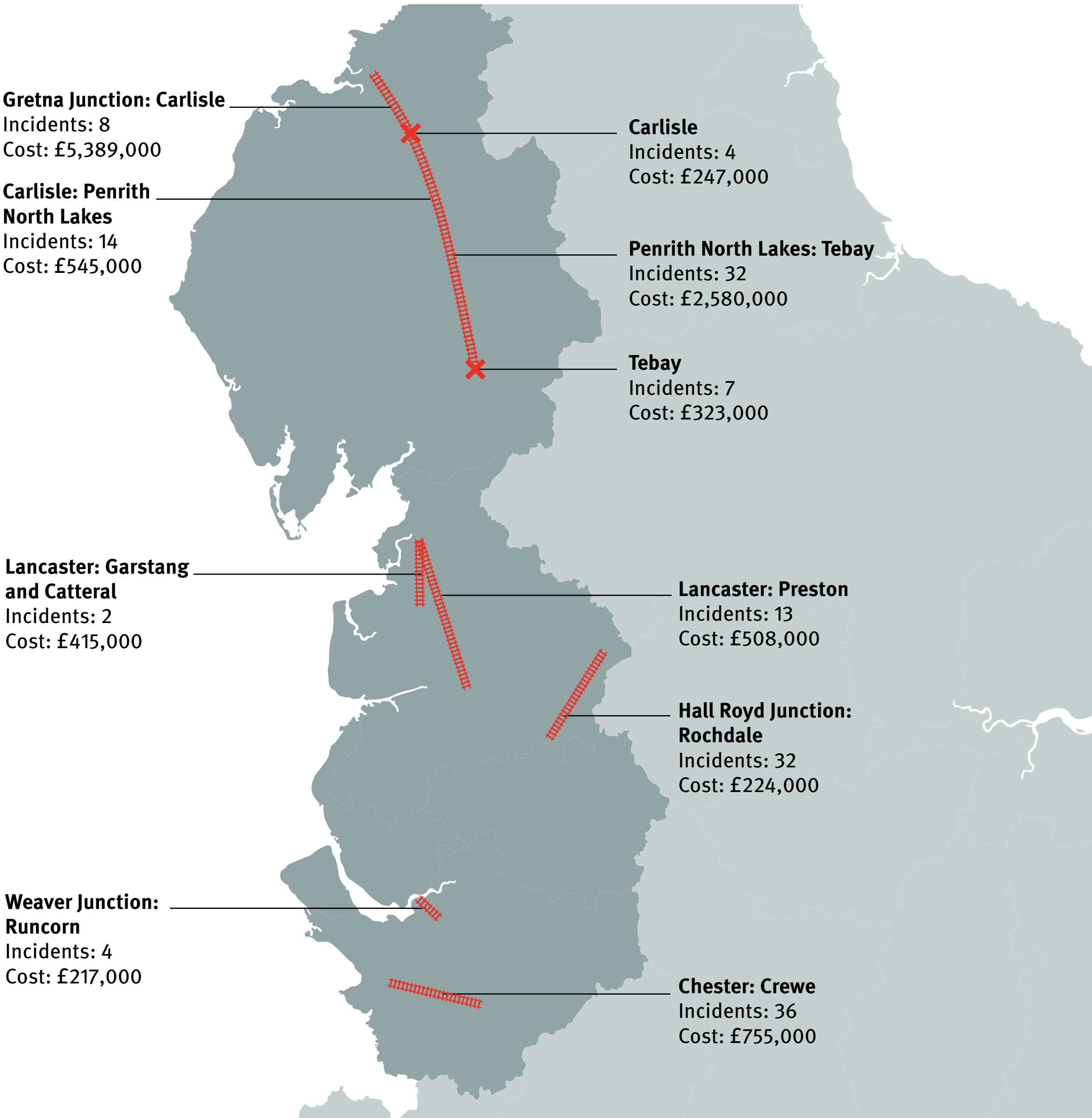
	Agriculture	Agri-environment	Diversification	Basic payment	Totals
Total output	£63,300	£11,900	£4,100	£20,600	£99,900
Total costs	£74,300	£2,100	£1,800	£2,900	£81,200
Profit on machinery and other sales	£300	-	-	-	£300
Farm Business Income (FBI)	**-£10,800**	**£9,800**	**£2,300**	**£17,700**	**£19,000**
Net farm income (FBI minus interest payments, salaries, other costs)					£9,800

subsequent upgrade to the public sewers in Bowness-on-Windermere in the Lake District to prevent them becoming inundated during extreme weather events was reported to have cost £5 million.[35,36]

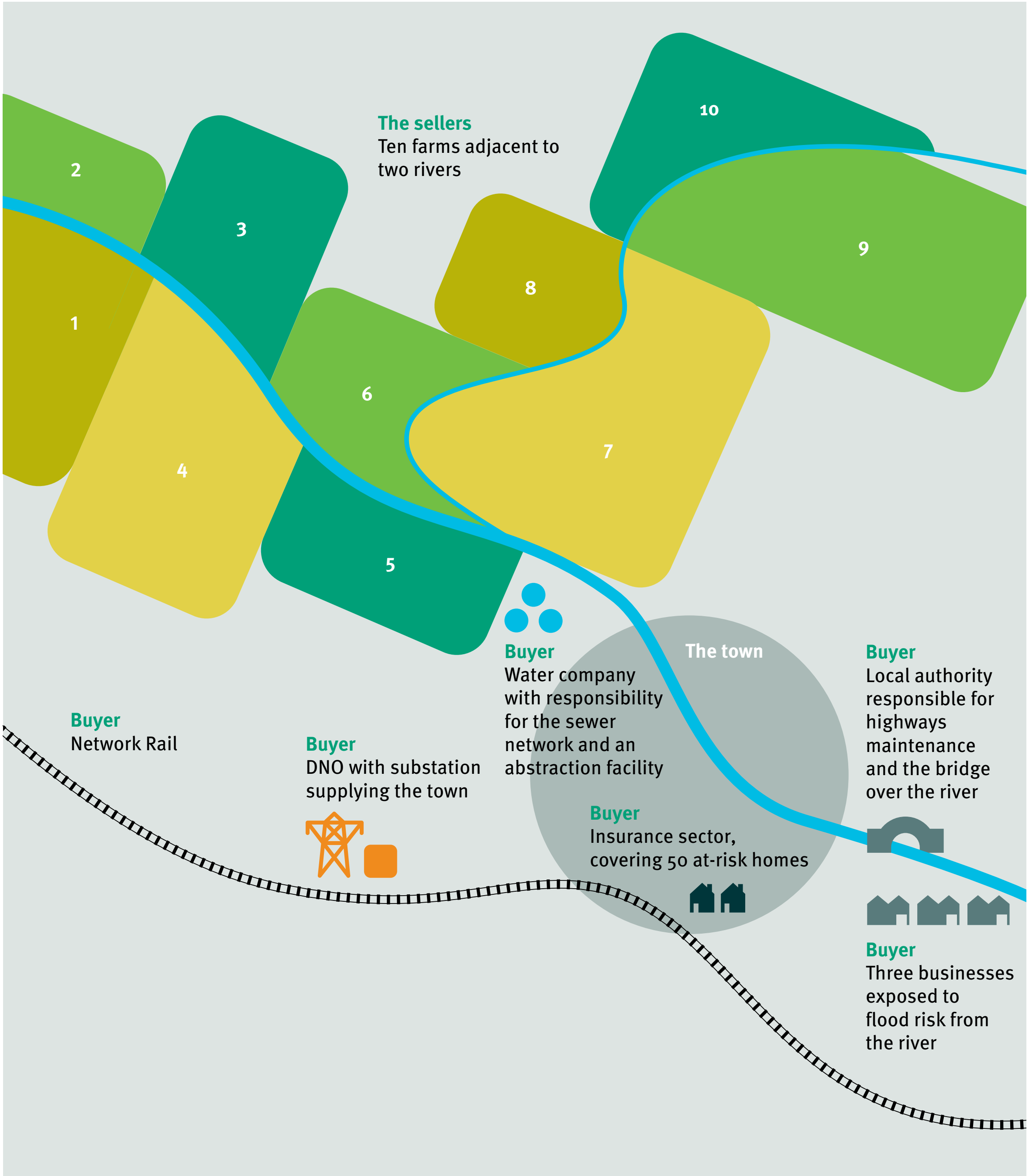
On the road network, across Cumbria over 130 bridges were damaged or temporarily closed in the aftermath of Storm Desmond.[37] In 2015-16, Cumbria County Council spent £1,381,000 on structural maintenance of bridges, with a further £509,000 on structural maintenance of principal roads.[38]

On the railway, quite apart from repair and upgrade costs, disruption to passenger services from flooding requires Network Rail to pay substantial compensation to train operators. In the north west, between 2006 and 2016 this amounted to just under £22.5 million, with a peak during 2015 of over £8.5 million. Over the same period, track subsidence, of which water ingress is a significant cause, required Network Rail to compensate train operators to the tune of £10.4 million.

Number and cost of flood events in the north west for Network Rail, 2006-16[39]



An example scheme in the north west: creating holding capacity for 200,000m³ of water on ten upstream farms



Our example scheme is sited above a town in the north west, downstream from the confluence of two rivers, which flow through grazed uplands. The following organisations are projected to incur significant costs over the next few years arising from the rate of flow and cleanliness in the river.

- **Network Rail:** Investing in measures to improve the integrity of earthworks and track draining, to cope better with severe weather events. Potential for significant compensation payments to the train operating company in the event of service disruption.
- **Distribution Network Operator (DNO):** Raising the height of the electricity substation serving the town to improve protection from anticipated high water levels.
- **Water and sewerage company:** Investing in measures to prevent sewage flooding in the town in the event of severe weather events. Upgrades to water abstraction facility to manage waterborne pathogens from livestock.
- **Insurance sector:** A likelihood of significant pay outs to up to 50 homes in the town at high risk from flooding
- **Local authority:** Faced with the cost of repairing road surfaces after significant flood events, and of maintaining the integrity of the bridge joining the two sides of the town.
- **Local businesses:** Faced with investing in flood protection measures to protect their facilities against future flooding.

Based on the costs set out on page 18, we have calculated that these organisations would be faced with spending in the region of £11.2 million over 15 years dealing with these challenges.

Organisation	Business as usual commitments	Cost
Network Rail	Major resilience engineering	£6,500,000
DNO	Major resilience engineering	£2,000,000
Water company	Improving sewer resilience; upgrading water treatment	£1,200,000
Insurance sector	Restoring 50 houses post-flooding	£1,250,000
Local authority	Road resurfacing or repair; bridge inspection and strengthening	£100,000
Local business	Temporary flood defences (sandbags)	£60,000
Local business	Temporary flood defences (sandbags)	£60,000
Local business	Temporary flood defences (sandbags)	£60,000
Total cost		**£11,230,000**

A natural engineering alternative

A natural engineering approach could deliver the needs of these organisations at lower overall cost. Our scheme would have the following characteristics:

A combination of two land management measures to increase water storage and reduce nutrient run-off

- Bunds to break up the flow of water across fields.
- Attenuation ponds to store water, sediment and nutrients.

A defined level of engineering to ensure customers' needs are met

Our scheme would create 200,000 cubic metres of water storage capacity. Drawing on evidence from existing schemes, this level of water attenuation could be assumed to provide additional flood protection for downstream infrastructure and businesses up to a one in 75 year flood event.[40]

These features would also prevent transmission of pathogens from livestock into the river system. In total, the scheme would cover 100 hectares of agricultural land.

A long term performance guarantee

Participating farmers would be required to maintain the scheme for 15 years, with regular monitoring and reporting. The contract would stipulate from the outset how expectations for climate change mitigation should be incorporated into the scheme's design and maintenance.

The cost to sellers

Experience from similar schemes suggests that developing and building the scheme would cost in the region of £4 million. This is based on a cost of £20 per cubic metre of storage capacity. Evaluation carried out for the Environment Agency of natural flood management projects has demonstrated costs ranging from £2 to £50 per cubic metre, depending on the local context, the scale of the scheme and the measures used.[41]

This would include the cost of designing the scheme, requiring input from a range of specialists, likely to include hydrologists, surveyors and lawyers. This input would be necessary to assure quality of the scheme, ensure its compliance with relevant regulation, and facilitate a robust and enforceable contractual agreement between buyers and sellers.

Given the high upfront costs involved, we have factored in a financing cost of three per cent per year on the capital sum. Using a securitisation model, where value of the future stream of avoided costs is turned into upfront capital to fund the NIS, the capital raised would be paid off in instalments over the contract period. We have, therefore, allowed £1 million as a reasonable figure for interest on the upfront capital over the 15 year period.

We have also assumed the measures would be created across ten individual farm holdings, each of whom would contribute an equal quantity of land (ten hectares) to the scheme. Taking ten hectares of land out of productive use represents roughly nine per cent of the productive area on the average upland farm in the north west.[42] We have, therefore, assumed that it would reduce average agricultural income by nine per cent, equating to £5,697 per farmer per year.

The current system of basic agricultural subsidy payments has been guaranteed up until 2020, and current levels of funding up until 2022. The successor scheme has not been set, and although the government has given firm indications that area-based payments will not continue, we have nevertheless calculated losses based on current payment levels (see page 24). A nine per cent reduction would equate to £1,854 per farmer per year. We have not included agri-environment scheme funding in this calculation.

We have estimated operational costs at ten per cent of the cost of creating the scheme, spread equally across 15 years. This would cover the cost of labour and materials for maintaining the scheme, and the cost of monitoring and compliance. This would come to £400,000 over the contract period.

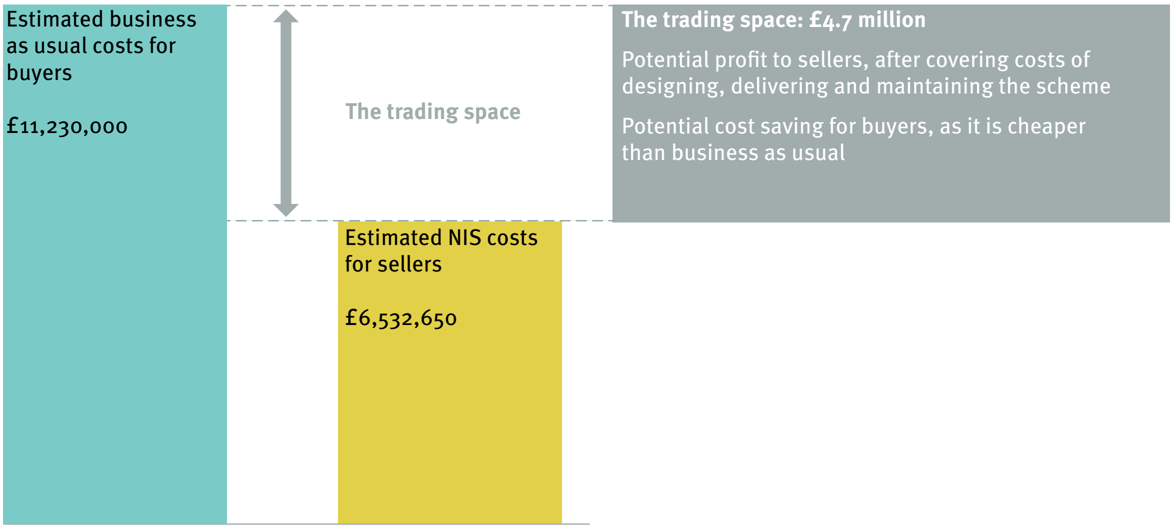
Overall, we calculate that the scheme will cost £6.53 million to deliver.

NIS: ten farms (100 hectares)	Total cost	Average annual cost over 15 years
Capex: upfront cost of creating the scheme	£4,000,000	£266,667
Opex: ongoing operational expenditure. Ten per cent of the cost of creating the scheme, to cover maintenance, labour costs, monitoring and compliance	£400,000	£26,667
Financing costs	£1,000,000	£66,667
Agricultural income foregone	£854,550	£56,970
Basic subsidy payment foregone	£278,100	£18,540
Total costs	**£6,532,650**	**£435,510**

Pricing the transaction

The balance of costs is summarised below.

A new market is possible as Natural Infrastructure Scheme costs are lower



Business as usual costs incurred by buyers		**NIS costs incurred by sellers**	
Cost of investing in reilience of assets or services; costs of restoring infrastructure or services after major flood events	£11,230,000	Capex cost of designing and delivering the scheme	£4,000,000
		Scheme financing costs	£1,000,000
		Opex scheme maintenance costs	£400,000
		Agricultural and subsidy income foregone	£1,132,650
Total business as usual costs over 15 years	**£11,230,000**	**Total costs during 15 year lifetime of scheme**	**£6,532,650**

The space to trade is potentially huge. In this instance, the total costs incurred by sellers are roughly 60 per cent of the cost of the hard infrastructure and damage that would otherwise be incurred.

To determine a price for the transaction, we have considered what a reasonable return on investment for the sellers might look like, beyond covering their costs. As a point of comparison, UK forestry is projected to deliver a four per cent return on investment during 2017.[43]

On page 31 and 32, we set out two options; a 'cost plus' option, in which sellers generate a return of four per cent annually on their capital investment and operational expenditure, and a 'split the difference' option, whereby the price of the contract is the mid-point between seller and buyer costs.[44]

	Value of the contract over 15 years	Total seller profit over 15 years	Total buyer saving over 15 years	Annual profit per farmer
Cost plus Four per cent annual return on capex and opex	£6,708,650	£176,000	£4,521,350	£1,173
Split the difference Trade at the mid point between seller and buyer costs	£8,881,325	£2,348,675	£2,348,675	£15,658

How costs would be shared between buyers under 'split the difference' model

Buyers	Business as usual (BAU) solution	Cost of BAU solution	Contribution to NIS over 15 years	Average annual contribution	Financial saving over 15 years	% saving
Network Rail	Major resilience engineering	£6,500,000	£5,100,000	£340,000	£1,400,000	22%
DNO	Major resilience engineering	£2,000,000	£1,600,000	£106,667	£400,000	20%
Water company	Improving sewer resilience; upgrading water treatment	£1,200,000	£1,000,000	£66,667	£200,000	17%
Insurance sector	Restoring 50 houses post-flooding	£1,250,000	£1,000,000	£66,667	£250,000	20%
Local authority	Road resurfacing or repair; bridge inspection and strengthening	£100,000	£80,000	£5,333	£20,000	20%
Local business 1	Temporary flood defences (sandbags)	£60,000	£40,000	£2,667	£20,000	33%
Local business 2	Temporary flood defences (sandbags)	£60,000	£40,000	£2,667	£20,000	33%
Local business 3	Temporary flood defences (sandbags)	£60,000	£40,000	£2,667	£20,000	33%
Totals		**£11,230,000**	**£8,900,000**	**£593,333**	**£2,330,000**	**21%**

Under the cost plus scenario, each farmer would make a profit of approximately £1,173 per year. Under the higher price, they would each return over £15,000 in profit every year. The contract price would probably lie somewhere between the two.

However, we have tested the viability of this approach by allocating a share of the 'split the difference' higher cost across the group of purchasers listed on page 31, reflecting the fact that they will not be exposed to the same level of costs, or have comparable access to funding. Even under this higher cost scenario, all purchasing organisations end up with a cost that appears fair and affordable, and delivers substantial savings of between 17 and 33 per cent.

Benefits for sellers	
Competitive return on investment	Compelling financial returns relative to both business as usual and other diversification options
Long term revenue certainty	Income from the scheme guaranteed for 15 years
Stronger commercial footing	Diversifies farm business income while leaving over 90 per cent of farmland for agriculture Reduces reliance on subsidy payments Creates a market for environmental services with potential for long term growth
Benefits for buyers	
Increased resilience	Quantifiable reduction in risk based on creation of 200,000 cubic metres of water attenuation capacity
Cost saving	Overall cost reduction in the millions of pounds, with double digit percentage savings for individual buyers

How to facilitate the market: conclusions and recommendations

Our analysis shows that a NIS has the potential to deliver significant financial benefits to farmers and their customers. We have shown that three conditions: technical viability, provable cost savings and a suitable commercial framework, would have to be met to develop a successful NIS market. While there are a number of barriers to meeting these conditions, the problems are not insurmountable and could be overcome well in advance of any future pronounced changes to agricultural subsidies. As such, this is an opportunity worth pursuing to help manage the transition to a new agricultural regime outside the EU.

Recommendations to NIS participants

There are two ways prospective participants could help to kickstart a well functioning market:

Collaborate on example projects to overcome cultural barriers

The basic premise of a market for slow, clean water will feel alien to many prospective buyers and sellers. Farmers typically see their role as being to produce food, and there has been much opposition in evidence to using agricultural land for other purposes. The concept of using natural solutions to manage flooding is viewed as unreliable and risky by many asset owners and operators. Many would not consider it an option, even when there are no other viable or cost effective hard engineering solutions available.

We recommend experimental collaboration between land managers and businesses to develop a small number of exemplar projects and transactions. Demonstrating the efficacy, and income potential of these schemes will enable prospective sellers and buyers to understand how this approach could meet their needs.

Identify the right locations for schemes

The opportunities for greater use of natural engineering are well known and the science behind them is increasingly well understood, but we have yet to see a critical mass of entrepreneurial landowners and land managers wanting to take advantage of them.

We strongly recommend that groups of farmers and land managers, ideally at a catchment scale, conduct research to understand the potential for their land to supply water services to local beneficiaries better. This would need to make use of third party mediation and consultancy, encompassing hydrological studies, and spatial mapping to support design of a Natural Infrastructure Scheme, to identify the location and type of beneficiaries who could buy the services to be provided.

Recommendations to government

The private sector is unlikely to make these schemes happen alone. Without action from government, development of the market is likely to be slow. At worst, it could struggle to get going at all.

The most important private customers; the energy and water utilities and the insurance sector, are highly regulated. The government can work with relevant regulators to facilitate the uptake of schemes. But the main value of government intervention will be to use its soft power to bring potential market participants to the table and support innovation and risk taking. Here are four ways the government can help:

Use smart regulation to remove barriers and encourage behaviour change

Regulation could play a major role in determining the scale of both supply and demand of these schemes.

This is particularly true on the demand side, where approaches vary considerably across sectors. Ofwat's statutory duty for resilience has supported water company investigations into the potential contribution of catchment management. However, Flood Re is currently prevented from investing in resilience projects, with its remit focused on enabling properties in areas of high flood risk to access insurance. In particular, the government should:

- introduce a new reporting requirement for regulated utilities, to report all spending associated with flooding on an area or geographical basis; this includes preventative resilience spending, post flood repairs and any other relevant costs, such as Network Rail compensation payments to train operating companies;

- facilitate the issuing of relevant permits and exemptions by the Environment Agency; for example, for farmers wishing to create natural flood management infrastructure adjacent to rivers;
- require the Environment Agency and other public agencies to make data on water pollution publicly available, and to make it easier for private enterprises to identify local hotspots;
- issue clear guidance that using farmland to provide ecosystem services rather than food will not create tax penalties for farmers, such as losing exemptions for fuel duty and inheritance tax, and, in any transition period, agricultural subsidies;
- expand the remit of Flood Re to enable direct investment into projects that reduce the exposure of homes and other built assets to flood risk.

Improve local planning and procurement of flood risk mitigation

A lack of coherent regional risk mapping and planning is inhibiting action by local bodies. The 2010 Flood and Water Management Act established county and unitary authorities as Lead Local Flood Authorities (LLFAs), charged with managing flood risk from surface and ground water, and local watercourses. But 38 out of 152 LLFAs had not produced their strategy by March 2016, five years after the requirement was introduced, and almost half of LLFAs had not yet developed statutory registers of local flood risk management assets by 2015.[45]

To address the lack of local planning, the government should:

- ensure LLFAs deliver up to date strategies;
- assess whether Catchment Directors or management boards could improve water management, learning from the use of Catchment Directors in Cumbria.

Provide research funding to increase knowledge and reduce costs

To facilitate private sector research and development and example projects, the government should:

- continue to make research and development grants available to fill knowledge gaps regarding the effectiveness of natural flood management at catchment scale, building on the £15 million allocated in 2016;
- make funding available to support the provision of large scale catchment management projects by farmers; this could include support for scoping studies across multiple private landholdings, or the development of standardised contract and payment terms to reduce the cost and risk of private transactions.

Introduce quantifiable long term objectives for environmental restoration

This could be done, for example, through the government's forthcoming 25 year plan for the environment. This will facilitate market creation in several ways. It will align private creation of natural infrastructure with public policy goals that extend beyond the lifetime of the contract, reducing the policy risk associated with new markets and financing arrangements. This should facilitate the availability of private finance for the NIS, as well as potentially reducing the financing costs. It should also increase the possibility of accessing public money to support the delivery of large scale NIS projects.

Endnotes

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41 The Environment Agency's Working with Natural Processes (WWNP) programme is assembling the evidence base for the efficacy of natural flood management. The projects summarised online demonstrate a wide range of costs to date, ranging from as little as £2 per cubic metre of storage capacity to over £70 per cubic metre. Based on the measures proposed, we have chosen £20 per cubic metre as the basis for our analysis. The WWNP summary is available here: http://naturalprocesses.jbahosting.com/#6/54.188/-1.945

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