The use of economic valuation to activate alternative financing mechanisms for flood protection

The case of Partnership Funding

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In the past flood defence projects in England were funded largely from the national budget. In 2011, Partnership Funding (PF) was introduced as a new approach to the financing of projects to reduce flood and coastal erosion risks. The new policy encourages the sharing of project costs between national and local public sources and uses an economic assessment to provide guidance on the level of funding that should be sought from third parties. By making explicit the beneficiaries of flood protection policies, economic valuation might, increasingly, affect not only the concrete actions introduced to meet policy objectives (the "what" of policy making) but also the actors implementing these measures (the "who") and the sharing of the financial burden among the affected parties (the "how"). We conduct an in-depth policy review that combines qualitative analysis of policy relevant information (including legislation, guidance notes and information on specific projects) with quantitative analysis of (publicly available) project data. Our analysis shows that although since PF was introduced local contributions have increased compared to previous years, the majority of funding still comes from central government. We suggest that disadvantaged areas should be better targeted.

1 Introduction

Recent extreme flood events (particularly in 2007, 2012 and 2014) have boosted debate on how to improve the flood management practices in the United Kingdom. It is estimated that the annual cost of flood damage amounts to £1.1 billion (Priestley, 2017) and that around 5.4 million properties (in England alone) are at risk of flooding. In the last few years, the country has been hit particularly severely, with economic damage estimated at between £1billion and £1.5 billion (for the 2013-14 floods) and between £5 billion and £5.8 billion (for the 2015-16 floods). In addition to maintaining and improving the existing infrastructure, to tackle the effects of climate change and population growth, which are expected to increase exposure to flood risk, other measures are needed, ranging from improved warning systems to innovative management practices using natural processes (EA, 2014). In particular, the Pitt Review (2008) highlighted the need for more extensive flood protection. It noted also that the necessary resources should come from other sources than national government. In particular, it recommended that "Government should develop a scheme which allows and encourages local communities to invest in flood risk management measures" (Recommendation n. 24). In 2010, in response to the Pitt Review, a new Flood and Water Management Act was introduced.

As a result, flood management policies were reformed. The introduction of Partnership Funding (PF) in 2011 marked a turning point in the way investments in flood protection are financed in England. Previously, flood risk management

works were funded mainly from the central government budget and were prioritised according to the benefits they provided to the nation. The new approach encourages the sharing of project costs between national and local public sources with the contribution from local sources determined by considering the whole life net benefits of the project. A funding calculator, developed by the Environment Agency (EA) for England and Wales, considers project costs and project benefits to quantify the maximum size of the Flood Defence Grant in Aid contribution to any project.

In 2013 two independent reviews of the PF mechanism were conducted (EFRA, 2013 and Defra, 2014). In 2016, as a result of recent previous flood events, another review was commissioned and published (HM Government, 2016). It focuses on increasing the resilience of key infrastructures and recommended additional funding for resilience measures. Results will be published in 2018.

Thus, flood protection policies in England are a good example of how economic valuation might shape public policy by affecting its outcome, in terms of concrete actions introduced to meet policy objectives (the "what" of policy making), the actors that implement these measures (the "who"), and the sharing of the financial burden among affected parties (the "how").

This paper aims to:

- » explain how economic valuation affects flood management policy decisions in England and Wales;
- » discuss how economic assessment, in practice, can influence public investments, by highlighting the importance of local versus national benefits from flood protection;
- » assess to what extent the introduction of PF has been successful for mobilising alternative sources of funding.

To address these research questions, we conduct an in-depth policy review that combines qualitative analysis of all policy relevant information (including legislation, guidance notes and information on specific projects), with quantitative analysis of (publicly available) project data.

The paper is structured as follows. Section 2 reprises the theoretical (economic) justification for funding flood defence works from centralised as opposed to local sources and makes the case for economic assessment to understand the boundaries between local and central provision of flood defences. Section 3 discusses the use of economic assessment in the context of flood protection policies in England, the PF mechanism and the rationale for its introduction. Section 4 provides a quantitative analysis of past and future investments, to check the extent of the success of the PF approach for attracting alternative finance and targeting high flood risk prone areas. Section 5 presents the results and discusses some implications for policy.

2 Provision of flood protection interventions according to economic theory: national vs local approaches

From a theoretical point of view, public provision of flood defences is justified by their public good nature and their positive externalities (Cornes and Sandler, 1996; Derevell, 2015). Flood defences can be considered a classic example of a public good since they are non-rivalrous and non-exclusive. For example, once a flood wall is built, everyone within the protected area benefits from its construction, and it is neither possible nor sensible to exclude these individuals from enjoying the improved flood defences (non-excludability). Moreover, the protection enjoyed by one individual or group does not prevent others from experiencing the same benefit (non-rivalry). The consequent free-riding problem justifies the public provision of flood protection since private agents have little incentive voluntary to provide this good. In addition, flood protection creates positive externalities if it is provided in conjunction with other environmental goods, such as buffer zones, which improve water purity or local amenities (e.g. coastal promenades). From an economic perspective, therefore, it constitutes a market failure and justifies government intervention in the financing and provision of this public good, which would be under-provided by the free market. However, there are certain cases when the existence of one or a few beneficiaries can justify provision by a private entity, but such cases are rare (e.g., a large, privately-owned power plant). A decentralised solution is not feasible if its benefits accrue to several individuals or businesses, spread over a large (either rural or urban) area, which makes it difficult to achieve a bargaining solution.

Alongside the issue of private versus public provision of flood defences, economic theory provides useful insights into the level of central government involvement. Central government provision might be justified on redistributive grounds (Feidler and Staal, 2012). General taxation acts as a risk sharing mechanism, since the costs that otherwise would be borne by those most at risk, are shared with the rest of society, and also solves the free-riding problem. Therefore, achieving optimal provision could counter the inefficiencies brought by redistribution (Boadway and Marchand, 1995).

Despite centralised provision, local authorities can also be responsible for flood management. In some cases, certain types of flood management interventions, typically minor schemes, are impure public goods and their provision might be left to individuals or associations (Olson, 1969; Buchanan, 1965). In the case of local environmental public goods (i.e., public goods whose benefits accrue only to a small jurisdiction, such as a municipality or a town), beneficiaries can form voluntary groups to share either the

costs or the benefits deriving from public good provision. Examples of local environmental public goods are waste disposal, water purification and transport of nutrients. The local provision of public good has two rationales: first, local representatives are likely to be more knowledgeable about what the local community wants compared to a centralised, fit-for-all solution; second, if most of the cost is borne by the taxpayer, there is little incentive for local action or innovation to achieve multiple benefits (Defra, 2014).

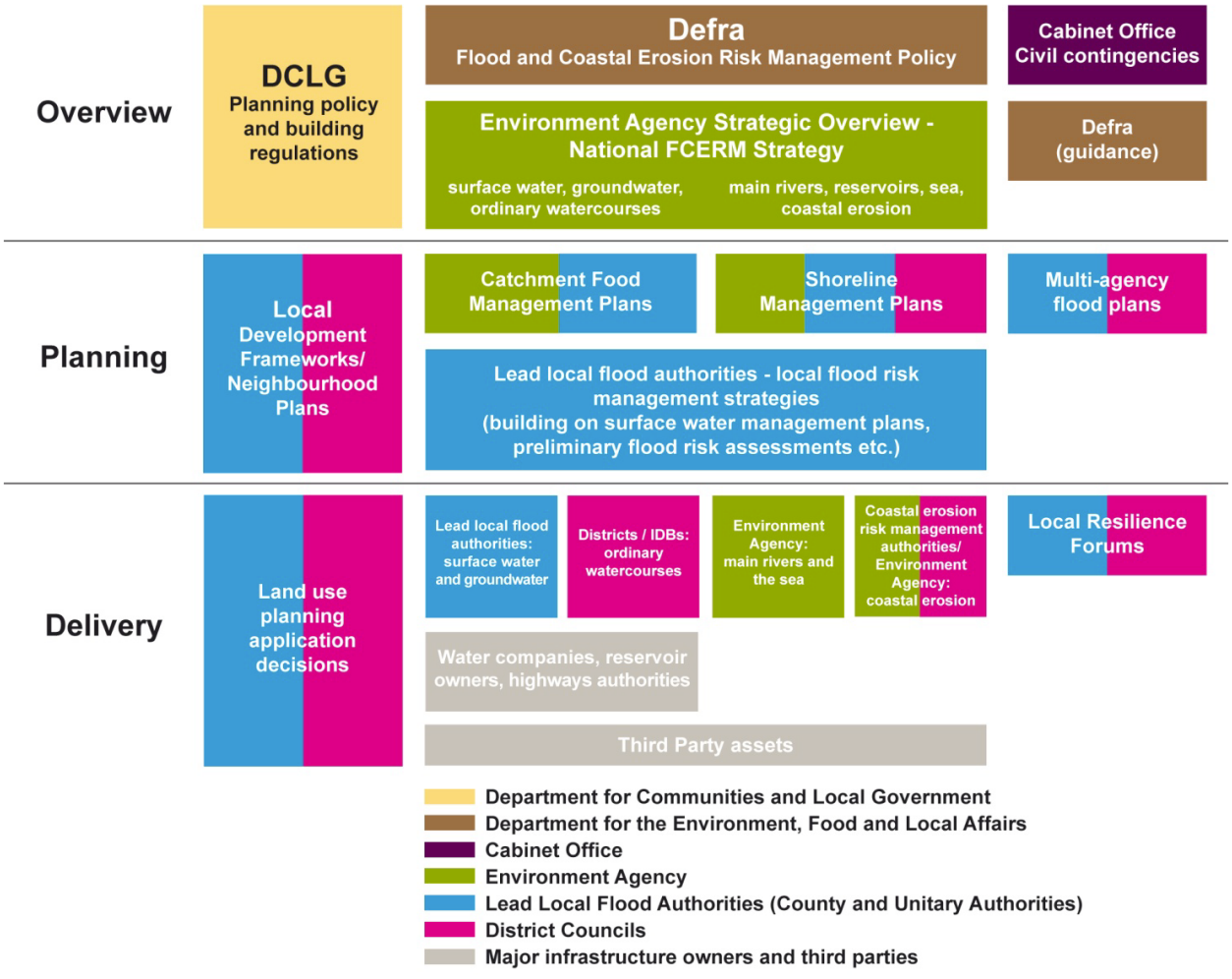
Another major drawback of centralised funding of flood defences is that it could prioritize investment in high flood risk areas, which might be able to finance its defences from its local budgets. London is a classic example of this type of redistributive issue.

Finally, even with increased levels of funding, climate changes is expected to increase the number of homes at risk of flooding and "Concerted efforts will also be needed by local authorities and partner organisations to improve the management of catchments, the coast, and urban areas in ways that alleviate the potential for flooding" (Committee on Climate Change Adaptation Sub-committee (2015: 10).

These economic principles are acknowledged in the definition of flood protection policies in England, where the central government, through the EA, is responsible for planning flood management interventions. However, it should be noted that all powers relating to flooding and land drainage are permissive and, therefore, the various bodies have no statutory responsibility or duty to take action (Priestley, 2017). Responsibilities are shared as follows (Priestley, 2017):

» Defra (Department for Environment, Food and Rural Affairs) provides most of its Flood and Coastal Erosion Risk Management (FCERM) funding to the Environment Agency as FDGiA. Defra also spends some funding directly on ad-hoc programmes;

Figure 1: Responsibilities for FCERM planning and management in England and Wales



Source: EA (2014: 8)

- » the EA is an executive, non-departmental public body, sponsored by Defra. The EA receives FDGiA funding from Defra which it spends directly or passes on in the form of grants to risk management authorities;
- » Regional Flood and Coastal Committees (RFCCs) are established by the EA to oversee flood risk management decisions in the regions. They are comprised of EA members, the Lead Local Flood Authorities (LLFA) and independent members with relevant experience;
- » LLFA are responsible for developing, maintaining and applying local flood risk management strategies in their areas;
- » other competent bodies: local authorities (unitary, county or district councils) have permissive powers to undertake flood defence works; Internal Drainage Boards (IDBs) are independent public bodies involved in water level management in low lying areas; water and sewerage companies are responsible for managing flood risks from public sewer systems.

Figure 1 provides an overview of the responsibilities for planning and delivering flood risk and coastal erosion management policies in England and Wales.

The shift from a centralised national policy to localism has been address in the public policy literature. Debate over localism has influenced the evolution of public policy in England (Thaler and Priest, 2016), and flood risk management is no exception (Meijerink and Dicke, 2008). In their qualitative policy analysis, Thaler and Priest (2016) note that the introduction of PF changed the governance of flood risk management in England, by increasing the number of actors involved in decision-making practices and changing the way actors interact. In particular, they note that the implementation process is more dependent on local actors' interests and political will, although technical experts, primarily the EA, continue to play an important role in policy making.

3 Economic valuation and flood management policy decisions in England and Wales

Economic assessment for FCERM policies in England and Wales is carried out at two levels: local and national.

At the local level, FCERM projects or strategies require EA technical and financial approval in order to obtain FDGiA, or Exchequer funding, which is awarded based on a project business case and must include an economic assessment of whole-life project costs and benefits. The relative costs are covered mainly by general taxation, but local funding sources also play a part. Flood risk, and the costs and benefits related to feasible policy options, are estimated following an Appraisal Guidance (EA, 2010). Benefit-cost analysis is applied to identify the preferred option. This generally is the scheme with the highest B-C ratio, which ensures that only the most cost-beneficial scheme goes forward.

As benefit assessment is a requirement for approvals to obtain funding for projects or other FCERM measures, beneficiaries are identified during the planning process. Moreover, since the introduction of the PF mechanism, in some cases, these beneficiaries are required to contribute to the financing of the FCRM intervention.

The approach applied in England to estimate the benefits of flood risk management options differs from those adopted in other European countries (US Army Corps of Engineers et al., 2011). Whilst all approaches adopt a common definition of risk (as the product of the probability of flooding and the impact of flooding), the methods used to assess economic damage differ, according to how damage functions are calculated and how uncertainty is tackled. In this respect, approaches to the assessment of economic damage fall into two broad categories according to how damage functions are defined (Meyer and Messner, 2005):

- » Relative damage function approaches (used in continental Europe), where the total value of the receptor at risk (e.g., a house) is considered, and economic damage is expressed as a fraction of that value;
- » absolute damage function approaches (used in the UK and the US), where damage is computed by looking at the absolute damage relative to flood conditions (i.e., flood depth)

Then, the unit values so derived can be aggregated in various ways, depending on the way that uncertainty is incorporated in the analysis. For instance, in the Netherlands, the appropriate level of protection is defined by law as the level that guarantees against extreme events (1 in 10,000 years). Therefore, economic damage is assessed considering only that standard of protection. However, in the UK, where the definition of risk reduction objectives is informed by flood risk management principles, flood risk is defined as expected flood damage for a given likelihood of flooding. The National Flood Risk Assessment (NaFRA) assesses the likelihood of flooding for England and Wales. The data is presented in flood risk likelihood categories, which indicate the chance of flooding in any given year. It estimates the probability of flooding from rivers and the sea, considering location, type and condition of defences, which it maps on a 50m x 50m grid for four flood-likelihood categories:

- » High: greater than or equal to 1 in 30 (3.3%) chance in any given year;
- » Medium: less than 1 in 30 (3.3%), but greater than or equal to 1 in 100 (1%) chance in any given year;

» Low: less than 1 in 100 (1%), but greater than or equal to 1 in 1,000 (0.1%) chance of flooding in any given year;
» Very low: less than 1 in 1,000 (0.1%) chance in any given year.

Whilst flood maps indicate the risk to a property of flooding, NaFRA describes the overall risk, rather than the risk associated to a specific event or scenario. Unlike flood maps, NaFRA takes account of the presence and condition of flood defences and their effect on flooding.

Economic assessment is used also to determine the optimal level of investment in FCERM measures at the national level. In 2014, the EA developed a Long Term Investment Strategy (LTIS) for England that determines the optimal level of investment by analysing current and future levels of risk (EA, 2014). This is defined as the FCERM investment at which net annual benefits are maximised. Above that level, it would not be beneficial to continue investing in flood defences; an additional pound spent on flood protection would not be justified since the benefits would not cover the relative costs (see Figure 2).

Table 1: Benefit categories considered in Economic Appraisal

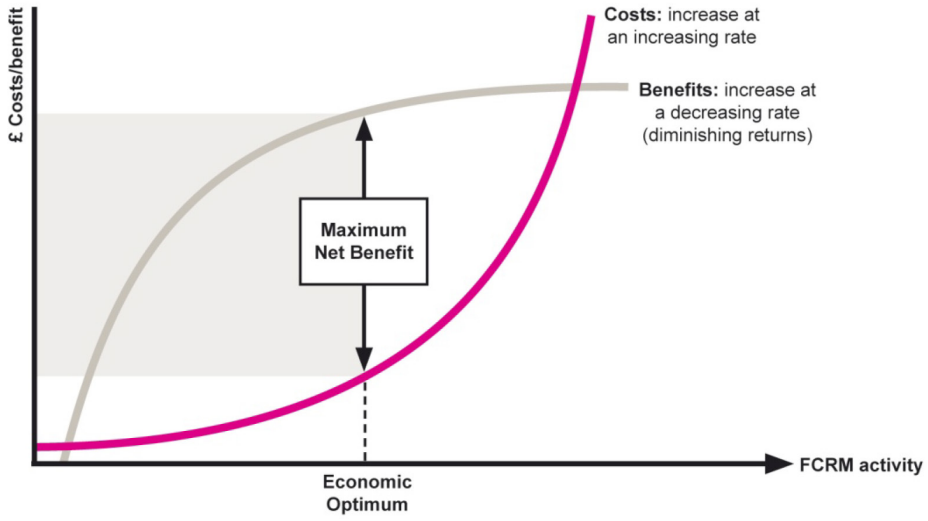
Benefit Categories	Benefit estimation Approach
Residential Properties	Avoided damage to buildings, vehicles and other intangible effects, such as impacts on health
Non-residential properties	Avoided damage to buildings, stock and indirect losses such as production disruptions
Damages to Agricultural Land	Damage to crops
Recreational Impacts	Value transfer from contingent valuation studies
Environmental Impacts	Value of ecosystem services
Infrastructure impacts	Avoided damage (replacement costs)
Avoided road and rail disruption and emergency costs	Additional time costs and additional resources costs

Source: Adapted from Penning-Rowsell et al. (2013)

In England and Wales, economic damage from flooding to residential and non-residential properties is assessed using the WAAD (Weighted Annual Average Damages) method. The calculation is based on the likely flood depth of each flood probability, and the cost of the damage at that flood depth for a given category of property. This risk is converted into flood damage costs averaged by year. The economic appraisal also considers other benefit categories (Penning-Rowsell et al., 2013). Table 1 summarises the estimation approaches.

The analysis considers six investment scenarios, defined by considering climate change scenarios and the level of flood plain development. The optimal level of investment is determined by adding investments ordered according to their BC ratio (i.e., according to which investments bring the most benefit in relation to costs) until net benefits are maximised and the optimum level is reached. The model considers an investment ceiling, that is, a maximum annual budget for FCERM investments, and identifies the most efficient combination of measures given this budget constraint.

Figure 2: Decision rule for LTIS

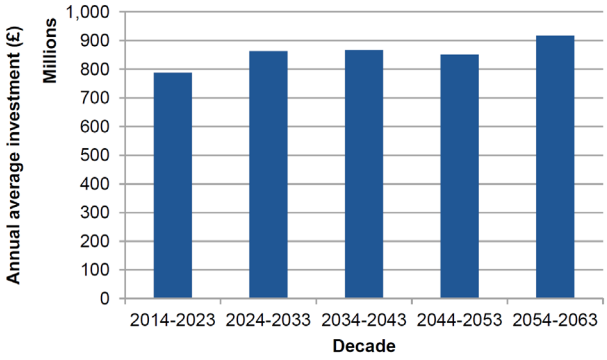


Source: EA (2014: 49)

The LTIS suggests that the optimum level of investment in the long term is £860 million per year on average (in the range £790 million to £920 million). The whole life net economic benefits of the preferred option are estimated at £102 billion, giving a BC ratio of about 5:1. This figure includes both expanding and maintaining the existing infrastructure, and other FCERM measures such as flood forecasting and flood warnings, data and mapping and development control (EA, 2014). In the long run, investments are expected to rise above £900 million per year due to

replacement of aging infrastructure and the effects of climate change (see Figure 3).

Figure 3: Long term investment level over 50 years for England



Source: EA (2014: 20)

It should be noted that this assessment does not consider funding, but acknowledges that "activities could be funded by central government, local government, households or businesses that would benefit" (EA, 2014: 16).

4 The financing of flood defence interventions: partnership funding mechanism

Funding for FCERM measures in England comes mainly from central government. Table 2 summarises how funding streams are allocated among different entities and the organisation responsible for investing.

Flood and Coastal Erosion Resilience Partnership Funding (or PF) was introduced by Defra in May 2011 to encourage an increase in total investment beyond levels affordable by central government alone, and to combine centralised provision of flood defences with local choice. The rationale for this policy reform was increasing the number of projects financed: rather than guaranteeing total funding for a small number of projects, when complementary funding sources could be identified, the new approach made it possible to provide funding for projects that did not qualify for total funding previously. The funding system was reformed to tackle some major shortcomings in the previous funding mechanism (Defra, 2014), namely:

- limited possibilities for local choice;
- small number of projects funded since capital rationing meant some worthwhile projects were not funded; and
- few incentives to seek external financing since central government funding was guaranteed for cost-beneficial projects.

Under the new policy, any flood and coastal erosion risk management project whose benefits are greater than its costs over its useful life, is eligible for central government funding (EA, 2012). The new policy follows an outcome-based approach, in which funding levels for each project are related to the benefits of the proposed scheme in terms of avoided damage, number of households protected and other benefits such as environmental benefits. As before, all potential benefits of a project are considered, including flood protection to businesses, agriculture, infrastructure and residential premises, but funding is commensurate with those benefits. The amount of FDGiA will depend on the outcomes and benefits of the proposed interventions. If central government funding is insufficient to cover

Table 2: Government and external funding in England

Type of Funding	Responsible entity	Description
Government Funding	Defra	Defra retains a small proportion of the money it receives from HM Treasury for flood and coastal erosion risk management for schemes such as the Community Pathfinder projects
	Lead Local Flood Authority (LLFA)	Provided to LLFAs by Defra to support their new roles under the 2010 Flood and Water Management Act
	Local authorities	Expenditure by local authorities to manage the flood and coastal defence assets for which they are responsible. Excludes levies to manage land drainage
	Environment Agency - revenue	Grant in Aid from Defra to support Environment Agency roles, including maintaining defences and other flood related roles.
	Environment Agency - capital	Grant in Aid from Defra for the EA, local authorities and internal drainage boards to provide new and improved flood defences
External Contributions	Local levy	Locally raised monies to supplement Defra funding, responding to local priorities, including contributions to new flood defences
	Partnership funding	Contributions from third parties towards new and improved flood defences (not including the above levy funding)

Source: Adapted from EA (2014)

project costs, securing additional contributions from local sources is a condition for receiving the allocated FDGiA. This mechanism makes it possible to consider local choices in the definition of FCERM actions and the desired level of protection. Thus, provided that local beneficiaries fund the extra costs associated to the increased flood protection, the local community could achieve a level of flood protection greater than that allowed by the national policy. It also requires private beneficiaries (e.g., developers) to contribute, in all cases where they enjoy direct benefits from improvements to flood defences. Although there are no rules about how much external parties should contribute, EA (2012) states that "private or third sector contributors should be encouraged to contribute in proportion to the benefits that they will receive". In cases where there is no existing flood defence, the developers are responsible for funding the entire cost of the scheme (development, design, construction and maintenance).

Local authorities or other lead authorities can use the PF calculator (EA, 2014) to determine the amount of FDGiA for which the project is eligible.[1] This is a spreadsheet tool developed by the EA, which calculates the maximum available funding based on (EA, 2014):

- Present value benefits;
- present value costs of appraisal, construction and maintenance of flood works;
- duration of benefits;
- number of households in different flood risk bands before and after the investment (split by 3 levels of deprivation) and/or number of households in different erosion risk bands before and after the investment (split by 3 levels of deprivation);
- area (in hectares) of water-dependent habitat being created or improved;
- area (in hectares) of new inter-tidal habitat created;
- length (in kilometres) of protected river improved;

The maximum amount of funding available to a project is calculated by multiplying the expected benefits by a set of payment rates (see Table 3). These payment rates will be higher for deprived areas, thus giving more central government support per unit of realised benefits to the poorest areas. The share of total costs by central government is calculated according to the formula (Defra, 2011)

$$S = \frac{(H + B + E) * P}{F}$$

where:
S = share of total costs funded by Defra
H = households benefits
B = other benefits
E = environmental outcomes
P = fixed payment rates
F = amount of funding required.

Defra established payment rates in 2014, considering the value of the flood damage avoided (see Table 3). The assumption was that, on average, a flood event causes £30,000 of damage (based on insurance claims after the 2007 floods). Defra (2011) clarified that central government will pay FDGiA contributions equal to one-fifth of the expected benefits[2] for better protected residential properties.

5 Defra's evaluation of Partnership Funding application

In July 2013, the Environmental, Food and Rural Affairs (EFRA) Committee highlighted concern that only a small proportion of funding from external contributions came

Table 3: Payment rates per £1 of qualifying benefits

Benefit Category	Payment Rate (£)	Unit
Household damage	0.20	Per £ of present value (PV) whole-life benefit
Household damage (most deprived areas)	0.45	Per £ of PV whole-life benefit
Other benefits* (excl. environmental benefits)	0.0556	Per £ of PV whole-life benefit
Habitat created	15,000	Per hectare
Inter-tidal habitat	50,000	Per hectare
River habitat	80,000	Per km of river bed

** This includes protection of businesses, agricultural land, important national and local infrastructure, public buildings and cultural heritage sites.*
Source: Adapted from Defra (2011b)

[1] https://www.gov.uk/government/publications/fcrm-partnership-funding-calculator

[2] This decision was based on the evidence that "projects typically deliver benefits worth at least five times the costs involved" (Defra, 2011b)

from the private sector and, therefore, funding from non-governmental sources remained low (EFRA, 2013).

That same year, Defra commissioned an independent evaluation of the implementation of the PF approach in England (Defra, 2014). The research was carried out between March and October 2013 and involved consultation with 160 individuals from national, regional and local stakeholders involved in PF implementation and review of 849 business cases.

It should be noted that FCRM schemes take between two and three years to develop and implement, and that a large proportion of funding is allocated to projects already under construction. Therefore, the 2013 review related to a very early implementation stage of the new approach. It looked at both the process and the results of PF implementation and included new projects within the medium term plans for the two years before and after the introduction of PF. The main results of the evaluation can be summarised as follows (Defra,2014):

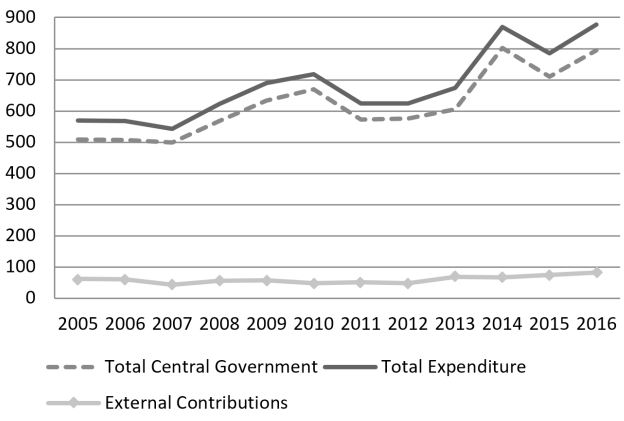
- investment in the form of both FDGiA and external funding (in relative and absolute terms) increased since introduction of PF. In particular, for the projects reviewed, contributions increased from £34 million (in the two years before introduction of the new approach) to £120 million (in the two years after its introduction);
- PV benefits decreased significantly over time, as the number of households moved to a low level of risk (from 30,861 in 2010 to 25,589 in 2013);
- over the four-year period, the number of better protected households in deprived areas decreased (from 7,205 to 3,915);
- overall 75% of external funding was from public sector sources (including RFCC local levies) and 25% from private sector donors;
- the BC ratio for the whole programme decreased from 17:1 in 2010 to 10:1 in 2013. Similarly, average BCR at scheme level dropped to 10:1 in 2013, from 23:1 in 2010. Schemes in high risk areas and high levels of deprivation achieved the highest BCRs;
- only a minority of schemes targeted properties at high risk of flooding and in very deprived areas (less than 10%), despite most deprived areas in England and Wales being located in high flood risk prone areas (EA, 2006);
- whilst the proportion of urban schemes remained the same (at around 50%), the proportion of rural schemes increased constantly over the four years considered, from 11% in 2010 to 23% in 2013. This suggests that PF might have incentivised investment in flood defences in rural areas that, previously, did not qualify for full funding.

The above results suggest that the overall efficiency of the FCRM programme may have been affected by the introduction of PF. This would seem to be confirmed by the fact that 70% of the schemes funded in the two years following implementation of PF would not have been fully funded under the previous system. However, the new approach does not target disadvantaged communities effectively. In 2017, Defra commissioned a full post-implementation review; the results will be published in 2018.

6 Past and future investments in FCRM in England and Wales

Data published by Defra (2017: 8) show that between 2005-6 and 2016-17, total investment in flood defences in England, rose from £570 million to £877 million (the highest since the 2014 figure of £870 million spent on FCERM). Total external contributions for this period were £714 million and total central government expenditure on flood defences was circa £7,450 million. Thus, the share of external contributions from local sources in total expenditure over this period was around 8.7%. After 2012, contributions increased in absolute terms (from £47.4 million in 2012 to £82.1 million in 2015), but, relative to total government expenditure, they remained at around 10%. The share of central government expenditure in total FCRM expenditure has been above 90% in most of the years considered with the exception of 2005, 2006 and 2013. Total government expenditure increased between 2008 and 2010, and between 2013 and 2016, in response to major flood events in 2007, 2012 and 2014. In 2014, an additional £270 million was allocated to repair damaged defences, £35 million of which went on maintenance (Priestley, 2017). In 2016, overall about £200 million additional investment was announced to aid recovery from the flooding in winter 2015-16. These additional spending allocations explain the expenditure peaks in 2014 and 2016.

Figure 4: Total FCRM expenditure between 2005 and 2016 (£ millions)



Source: Own elaboration of Defra (2017)

Table 4: Total project costs and funding of 2017-21 FCRM Programme of Work (£K)

Development Stage	Total Project Cost	Total FDGiA	Total Contributions
Construction	2,987,179	2,640,207	346,971
Development	2,608,411	1,514,249	1,094,162
Pipeline	426,217	217,892	208,325
Total	**6,021,806**	**4,372,348**	**1,649,458**

Source: Own elaboration of Defra (2017)

In April 2017, Defra announced investment of more than £2.5 billion, to reduce flood and coastal risks, through 1,500 schemes to be financed between April 2017 and March 2021. Data are available for 1,135 programmes of work, classified according to their stage of development[3]: 1) projects already in construction (190); 2) projects in development (853) to be constructed in the future depending on approval of the full business case; and 3) Pipeline (92), i.e. projects likely to qualify for funding before 2021, for which sufficient contributions have yet to be identified, or which lack a well-developed business case, or which have not yet entered the development phase.

For each scheme, information is available on: location (including local authority, EA region and parliamentary constituency), total project costs, total FDGiA and contributions, dates of construction start and completion, and total number of homes better protected from flooding and coastal erosion.

Table 4 summarises the total anticipated project costs, FDGiA and contributions for these schemes. It shows that contributions average 27% of total project costs, but cover only 12% of the total costs of schemes already under construction. Therefore, the share of total contributions in total expenditure is continuing to increase following introduction of PF. This share increases to 42% and 49% respectively for projects in development and in the pipeline. The lower share of contributions for projects under construction might be explained by the fact that, at that stage, many contributions promised in previous phases did not materialise. Therefore, the share of contributions for schemes under development or in the pipeline might be an overestimation of contributions eventually realised in the construction phase.

For projects under construction or in development, the average total cost is £5,365,000 (median £497,000 and the average contributions are £1,382,000 (median £60,000). The percentage of external contributions does not change considerably in relation to the project size, as shown in Table 5.

If we consider administrative regions (Table 6), it can be seen that only four regions secured contributions greater than a third of project costs, namely East England, North-East England, South-West England and Yorkshire. London, in particular, is expected to raise less than £44 million from non-governmental sources, that is, 96% of its project costs will be covered by central government budget. This is because the PF calculator computes the FDGiA by considering the number of households better protected, which, in the case of London, is so high that it ensures almost total coverage of anticipated costs from central budget. Although some London boroughs are ranked areas of high deprivation (UK Parliament, 2015), this raises some distributional concerns since tax-payers' money is being spent on protecting the richest areas of the country, which might be able to contribute to their defences via cross-subsidies among local tax-payers.

Table 5: Total contributions as % of project size – all projects (£k)

Project size	Total Project Cost	Total Contributions	% Total Contributions on Total Project Costs
Big (Project cost > £2,500k)	5,516,897	1,495,233	27%
Medium (Project cost above £250K and below £2,500k)	463,144	143,063	31%
Small (Project cost < £250k)	41,765	11,162	27%
Total	**6,021,806**	**1,649,458**	**27%**

Source: Own elaboration on Defra (2017)

[3] Available at https://www.gov.uk/government/publications/programme-of-flood-and-coastal-erosion-risk-management-schemes (accessed 25/09/2017).

Table 6: Details of project costs and contributions at the regional level (£k) – all projects

ONS Region	Total Project Cost	Total Contributions	% total contributions on total project costs
East Midlands	364,525	97,529	27%
East of England	391,101	153,713	39%
London	1,055,514	43,687	4%
North East	158,025	71,822	45%
North West	403,899	41,772	10%
South East	2,298,673	684,897	30%
South West	530,840	264,417	50%
West Midlands	109,096	31,075	28%
Yorkshire & Humberside	710,134	260,546	37%
Total	**6,021,806**	**1,649,458**	**27%**

Source: Own elaboration of Defra (2017)

To check whether the number of houses better protected influences the amount of FDGiA granted to each project, we compute the correlation between the number of homes better protected and total FDGiA. This is r = 0.7794 for projects under development or construction, indicating a strong positive correlation between the number houses that are better protected and the amount of centralised budget available.

Finally, we consider construction projects data to check whether the amount of contributions varies between urban and rural areas. Table 7 shows that, in rural areas, contributions amount to almost a quarter (24%) of total project costs, compared to 9% in urban areas.

Table 7: Total contributions (£k) and their share on total costs – construction projects

Location	Project Costs	Contributions	%
Urban	2,529,690	236,746	9
Rural	457,488	110,225	24
Total	**2,987,179**	**346,971**	12

Source: Own elaboration on Defra (2017) and ONS (2016)

7 Conclusions and policy implications

Although the introduction of the PF mechanism has increased the absolute level of non-government, local contributions, central government budget also increased after the introduction of PF, mainly in response to major flooding events, and, thus, the percentage of external contributions in total FCERM expenditure has remained below 10%.Analysis of publicly available information on projects due to receive funding in the next few years, suggests a slight increase in the share of external contributions in total costs for projects under construction (from 9% to 12%). It should be noted that, although the PF calculator includes other benefits, the high payment rates attached to the number of households better protected, ensure that FDGiA is available for projects targeting high flood risk prone areas within urban settlements. This might explain why the share of external contributions increases to 24% in rural areas, indicating that these areas might be able to attract more external funding, probably because the projects would not be fully funded by central government budget. This might affect the overall efficiency of the FCERM expenditure, since the same projects might not have been funded before the policy change. The 2013 Defra review confirms this, recording a decrease in the overall BC ratio of selected projects before and after introduction of PF. As FCERM expenditure is predicted to increase in future decades to tackle climate change effects, under public finance constraints it might be necessary to prioritise the more cost-beneficial options (and apply an annual ranking similar to that applied to definition of the optimal investment level in a long term investment strategy, i.e. net present value benefits).

Redistributive concerns should be addressed in more detail in future work. The 2013 review highlights that the new PF mechanism might not target deprived areas effectively. Deprived areas should be supported by central government funding. Our dataset indicates that for some projects, in 10% of deprived areas significant contributions will be secured. This might be because some private beneficiaries (e.g. industrial parks) in some of these areas have been asked to contribute; however, we do not have sufficient data to conduct a robust analysis. Moreover, there is no public information on the wider economic benefits from FCERM projects.

Finally, whilst the UK's decision to exit the EU does not affect flooding funding per se since it comes from national taxpayers, the consequent necessary reform of UK agricultural policy might affect flood funding decisions. It has been suggested that future support could increasingly be linked to environmental measures, including the area of flood protection (Priestley, 2017). Farmers then would be paid for providing public goods, such as holding flood water on their land. Were this to be implemented, the trends highlighted above might change.

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