ASSESSMENT OF ECONOMIC VALUE OF NATIONAL ASSETS AT RISK FROM FLOODING AND COASTAL EROSION

Conference Paper · July 2000

CITATIONS
4

READS
43

5 authors, including:

Paul Graham Samuels
HR Wallingford
93 PUBLICATIONS **760** CITATIONS
SEE PROFILE

Edmund C. Penning-Rowsell
Middlesex University, UK
157 PUBLICATIONS **2,966** CITATIONS
SEE PROFILE

ASSESSMENT OF ECONOMIC VALUE OF NATIONAL ASSETS AT RISK FROM FLOODING AND COASTAL EROSION

KEVIN BURGESS[†], Dr PAUL SAMUELS[*], JOHN CHATTERTON[#], Professor EDMUND PENNING-ROWSELL[#] and ROBERT DEAKIN[†]
[†]Halcrow Maritime, UK, [*]HR Wallingford Ltd, UK,
[#]Flood Hazard Research Centre, Middlesex University, UK

SUMMARY

This paper describes policy-related research commissioned by MAFF to inform decisions on future expenditure on flood and coastal defence. The principal objective was to refine the broad-brush estimates of the national assets at risk from flooding and coastal erosion that MAFF made for the Comprehensive Spending Review in 1998. The project team used readily available information to determine the areas of hazard from flooding and coastal erosion and the valuation of assets in the within these areas. Information was obtained on current expenditure on capital and maintenance of flood and coastal defences and typical costs of construction of the elements of defences. Several future investment scenarios were examined: do nothing, maintain the current expenditure, maintain the current standard of defences and provide indicative standard of defences. The results indicate that some difficult decisions lie ahead in the provision of national flood and coastal defence; some key findings of the project are that:

- the value of the assets at risk is approximately £214 billion,
- the potential annual average damages (without defences) are about £2.8 billion,
- the current annual average damages are about £600 million, and
- the current expenditure is about half that required to maintain current standards.

1 INTRODUCTION

In 1998 MAFF produced a paper for the Treasury on the risks of flooding and coastal erosion in England and levels of resources needed, as part of the Governments Comprehensive Spending Review (CSR). This reviewed the potential economic impact of these risks, the impact of man in reducing the risks, the current level of expenditure in defending against these risks, the long-term requirements for expenditure and future exposure to risk. The assessment for the CSR necessarily contained many assumptions and consequently significant ranges of uncertainty were quoted on key results. It was recognised that better quality information could reduce the uncertainties in the estimates and MAFF commissioned research in 1999 to refine the estimates. A project team comprising Halcrow Maritime, HR Wallingford and Middlesex University Flood Hazard Research Centre (FHRC) was commissioned to undertake jointly this project through the Ministry's research commission contract at HR Wallingford. The objectives of the research project were to:

- gather information on the extent of the areas at risk and the assets in those areas,
- update and improve the 1998 CSR valuation of the risks,
- consider a range of scenarios for future investment, and
- recommend potential future improvements to the analysis.

A steering committee was set up from MAFF FCDE Division, the Environment Agency and the project team. The steering committee reviewed the progress of the research and the implications of the findings. A full report on the project is in preparation (Burgess *et al*, 2000). Throughout this paper, the now common definition of £1 billion as £1,000 million is used.

2 APPROACH

The approach to the research involved the compilation of a national coverage for England of all relevant information within a GIS to compare the areas of hazard with the vulnerability of the assets in those areas and to enable different future scenarios to be evaluated. The main steps in the assessment were as follows.

2.1 Identify the area affected by the hazards

The areas of hazard (floodplain and erosion limits) were identified from sources of readily available information including:

- the indicative flood mapping compiled by the Environment Agency
- areas of coastal flood hazard from previous work for the Association of British Insurers and
- areas of coastal erosion from Shoreline Management Plans

It was recognised that the sources of information did not represent a uniform approach to the estimation of the hazards. For example, the indicative flood plain maps were based upon a combination of detailed Section 105 survey assessments, historic flood limits of unknown probability of occurrence and broad based mapping by the Institute of Hydrology. Nevertheless, it was assumed that the river flood plain data available generally represented the limit of the 1 in 100 year event (annual probability of occurrence of 0.01).

2.2 Identify the assets lying within the areas of hazard

The number of properties, other facilities and land use were compiled from a variety of sources including the:

- OS Address Point (OS-AP) database,
- MAFF agricultural land classification, and
- MAFF Coast Protection Survey of England (CPSE).

The information did not differentiate between the nature of assets in broad classes to the degree which ideally would be needed for detailed economic assessment of, say, a flood defence scheme. Thus some uncertainty is inevitable in the project results because of the broad-banded information which was available.

2.3 Estimate the economic value of the assets

The asset values and potential damage and loss values for flooding and coastal erosion were estimated using information from several sources including:

- regional house price surveys,
- agricultural land values,
- the FLAIR database from the FHRC (this was updated as part of the project)), and
- a national database of rating valuations for commercial property.

The valuations followed the principles of the recently issued FCDPAG3 (MAFF, 1999) in determining Annual Average Damages (AAD's) for any flood plain, from property data counts within these pre-defined areas using FDCalc. It should be noted that all damages and losses have been calculated as AAD's rather than discounted Present Values. This was appropriate because the damages and investment needs were considered as part of a rolling programme of schemes that would be implemented on an annual basis over a 50-year period. This obviated the need to assess the timing of defence breaches and losses and also the

expenditure on works. Certain categories of loss have not been included in the estimates (e.g. impacts on transport and other major infrastructure and "intangible" impacts on health, recreation and the natural environment). Thus the damage figures may still be somewhat conservative.

2.4 Assess the standard of service given by existing flood and coastal defences

Defence locations were obtained as far as possible from the Flood Defence Management System (FDMS) and the CPSE. These databases also have the facility to contain information on defence standard and residual life. Where this information was not recorded, a probabilistic approach was adopted to estimate defence standard, and default assumptions were made regarding residual life. For example, where the current standard of service for fluvial defences was not available in FDMS for the research, surrogates were developed. The House Equivalent (HE) values of land use and Standard of Service (HE/km/pa) provided by the existing defences were assessed by comparison of nationally available data from the OS-AP database and the regional records as available. The surrogates were used only where detailed records were not available and included measures of uncertainty in the estimates.

2.5 Estimate costs and benefits

Replacement and maintenance costs for defence structures were obtained through consultation with each of the regions of the Environment Agency and a selection of local authorities. There were regional variations in the indicative costs of elements of a defence scheme but no attempt was made to resolve these. The costs are based upon different types of defence, from which average values for different generic location types have been generated (i.e. fluvial, tidal, coastal and coast protection). The costs of and benefits from different investment scenarios were assessed, broadly these were to:

- do nothing (i.e. walk away from all defences and without maintenance or repair),
- maintain the current expenditure on maintenance and renewal of asset,
- maintain the current standard of defences and
- provide indicative standard of defences where the current standard falls below the indicative standard in FCDPAG3.

3 OVERALL ASSESSMENT OF VULNERABILITY AND RISKS

The hazards from fluvial, tidal or coastal flooding, and coastal erosion, and the consequent risks are often not recognised by the general public, or even in the past by local planning authorities. A measure of the potential risk to the nation can be readily appreciated from examination of the number of residential and commercial properties that are located within these areas. Some "headline" statistics from this research for the vulnerability of assets are that, in the areas of England liable to fluvial or coastal flooding and to coastal erosion, there are:

- over 1.7 million residential properties,
- approximately 130,000 commercial properties,
- between 4 and 5 million people who could potentially be affected,
- in total, approximately 1.3 million hectares of agricultural land, including
- 218,000 ha of Grade 1 land (i.e. 61% of the total Grade 1 land in England - 49% lying in East Anglia alone).

Thus the total capital value of the assets potentially at risk amounts to approximately £214 billion. Even though, as a proportion of national assets, the values above are less than in

some other countries (notably the Netherlands, see Jorrisen (1998)), the potential for losses is substantial.

4 ASSESSMENT OF ECONOMIC DAMAGES AND INVESTMENT NEEDS

4.1 Do-Nothing

The total capital value of assets at risk, presented in Section 3 above, assumes that no defences have been constructed. A more realistic picture of present-day risks must take into account that defences are in place and, even if they were not maintained or replaced, would continue to offer some residual protection for some years to come. These values are presented in table 1. The total potential Annual Average Damages have been calculated to be nearly £2.8 billion per year. This is the cost to the nation if flood and coastal defences did not exist. These damages are mostly associated with properties affected by flooding, and are relatively evenly spread between fluvial and tidal-sea areas (43% and 49% respectively). Agricultural land losses make up only 5% of the total, the majority of these being within Anglian Region, whilst coastal erosion losses are less than 3%.

Thames Region alone constitutes approximately 34% of the total do-nothing damages, with £419 million AAD of this within the London tidal area upstream of the Thames Barrier, some 15% of the national total. However, care should be taken in seeking to draw too many definitive conclusions at a regional level, because of the variability in data quality, in particular regarding defence standards of service. Whilst the national totals are considered to be of the right order, regional values should be treated as indicative of the order of magnitude of damages, not as definitive values.

4.2 Maintain Current Standards

This analysis tested the resultant damages if defences were maintained and replaced to continue to provide their present standards of protection against flooding and erosion, and the investment needed to achieve this.

4.2.1 Economic Damages

With present levels of protection, some economic damages must be expected as a result of events that exceed the design thresholds for the defences. The resultant average property damages from this scenario total approximately £640 million per annum, 95% of the total calculated damages for this option.

The damage averted by providing this level of protection can be established from comparison with the do-nothing damages, see Table 2. These benefits total almost £2 billion; 97% relating to the protection of flood risk areas, with coast protection accounting for only 3%. Again, protection provided within Thames Region yields a total of 34% of the benefits, with tidal areas in London upstream of the Thames Barrier producing approximately 20% of the total (£397 million). Indeed the total benefits for London should probably be slightly higher as the Barrier provides a 1 in 1000-year (0.001) standard of protection against tidal flooding whereas the default maximum for calculating damage values used in this analysis was 1 in 200 years (0.005).

4.2.2 Investment Needs

Table 4 presents the annual average investment required to maintain present defence standards, based upon returns from the Environment Agency and a selection of local authorities. This indicates a required spend of approximately £300 million per year on replacement works, with a further £115 million per year on maintenance work, producing an

overall investment needs total of over £415 million per year. Again, these values exclude any costs associated with major barrages such as the Thames Barrier.

It should be noted that a wide range of unit cost estimates have been produced by different sources, as well as some questionable details regarding defence lengths. Therefore sensitivity tests were performed, applying highest and lowest quoted values for different types of work across all defences in all regions. This produces a range of costs between £250 and £480 million. The conclusion reached from this exercise was that confidence in the accuracy of the total replacement cost estimate is ± £ 55 million, i.e. 15% of the total estimated value. This also excludes any adjustments that may be appropriate as a result of potentially uncertain data which might reduce costs by up to a further £ 40 to 60 million.

Even considering all three of the above points, it can be concluded that, as a lowest possible investment scenario, average expenditure of the order £300 to £350 million per annum is still required to maintain current standards of defence.

4.3 Meeting Indicative Standards

Indicative standards of protection are given in FCDPAG3 (MAFF 1999) and it is recognised that not all defences meet these standards and indeed some exceed them. This scenario has examined the changes in investment needs and resultant damages if indicative standards are to be met uniformly.

4.3.1 Economic Damages

It is estimated that provision of defences to indicative standards will reduce annual average damages to less than £200 million, and thus provide and annual economic benefit of over £2.4 billion, an increase of some £450 million compared to present day protection levels (see Table 3). However, it must be recognised that these values are based upon probabilistic estimates (see Section 2.4) for the likely defence standards in many areas where the actual data on defence standards is currently lacking. Consequently, without firm data in all areas, it is not recommended that these values should be adopted for any other purpose than indicating that there is scope to further reduce damages.

4.3.2 Investment Needed

The changes to defences, and thus investment needed to meet indicative standards, is also difficult to ascertain given the level of information available to this study. Therefore the two extremes of investment needs have been calculated as national totals, i.e. assuming either that all defences are either above or below standard. The results of this analysis are presented in Table 5. As there is no reliable mechanism for calculating any change in maintenance costs, nor other control structure needs, analysis has been made on capital replacement costs alone and other costs have been assumed to remain the same. Indeed it is reasonable to assume that the maintenance needs will vary little, as it is only the size of the defence which would change.

If these assumptions are correct, then the additional investment needed to meet these standards over that needed to maintain present standards could be less than £30 million per year. However, this would cover only the change in standards for those defences that were due for replacement and would not, for example, cover any additional replacements that would be required to achieve increased standards for whole flood compartments. It should also be noted that the current decision process set out in FCDPAG3 (MAFF, 1999) aims to

maximise standards commensurate with economic efficiency and this result would appear to endorse that policy.

4.4 Maintaining Present Investment Levels

4.4.1 Investment

Annual investment in flood and coastal defence presently averages approximately £200 million per year, with approximately £110 to £120 million spent on capital works and the balance (£80 to £90 million per year) on maintenance. It is clear from the results presented in the preceding sections that a substantially higher level of investment is required if deterioration in the current defence standards is to be avoided. This higher level of investment has been calculated as a further £180 million per year on capital works and approximately £30 million per year on maintenance. Even taking account of the major uncertainties and sensitivities in the assessments, a 50% increase in overall expenditure has been identified, with the most substantial increase for capital investment.

4.4.2 Economic Damages

With the information currently available it has not been possible to accurately establish the extent of damages or benefits if present investment levels are not increased. However, some general observations can be made. It may be argued that at the present time residual damages are closer to the lower value of £0.6 billion per annum but, with defences deteriorating and not being replaced. If investment remains at its current level then the annual average damages will increase year upon year. The rate of increase is uncertain since it is affected by the (unknown) residual life of the defences and by the effectiveness of future maintenance. Assuming an average residual life of 50 years would suggest an annual increase of about £20 million per year, with higher values arising from lower estimates of the residual life.

4.4.3 Future Policy

It is clear that adopting a minimum defence scenario, i.e. providing widespread defences but to only low standards is not a solution as this still requires investment of the order of 90% of that estimated to maintain the current standard. Therefore, to maximise benefits given current levels of investment it will be necessary to target protection of particular areas of high vulnerability and abandon others. If present investment levels are not increased substantially, this may need to be considered as the sustainable long-term defence policy.

It was not possible within this research project to analyse specifically which areas, or how many areas should be protected or abandoned to obtain best value. It was not appropriate to do so, given the paucity of information in certain regions. Whilst the research has provided a broad assessment of the relative merits of protecting against different risks, it is most likely that some combination of fluvial, tidal and coastal defence, concentrated upon urbanised areas, will yield greatest return on investment. It is perhaps in this area that future studies will need to be focussed.

5 POTENTIAL IMPROVEMENTS AND DEVELOPMENTS

The importance of good data cannot be over-stressed and future data collection should be integrated with the strategic assessment needs. It is important to overcome the regional variations that have been apparent from this study in the form of different levels of data collection, recording, storage and accessibility, and inconsistencies in the information provided, particularly with regard to defence costs. Resolving many of these issues would offer a considerable step forward in determining how, where and when to invest. Accuracy of analysis and the ability to analyse strategic options will improve with time as better

resolution and consistency in the data develops. In particular, better data should be gathered on defence construction and maintenance costs and related to structure types and conditions, to enable more accurate assessments of investment for forward planning.

The effectiveness of investing in different ways should be researched. For example, the merits of spending less or more on maintenance work with regard to changing whole life costs and effective defence life ought to be explored. A strategic analysis framework could be established to facilitate decision making which is both informed and consistent by responding to questions such as:

- What is the return on investment in specific areas?
- How much will that return change if investment is increased or decreased for those areas?
- What are the implications for these areas of spending less or more on maintenance, bringing forward or delaying works etc, and what are the true whole life costs for schemes?
- How does the vulnerability of assets at risk in these areas change if investment in increased or decreased? Where are the 'hotspots'?
- Where are other key infrastructure located, for example major transport routes and communication networks, particularly vulnerable industry/commerce, schools and hospitals at risk etc, or 'headline' risks located, such as major concentrations of population at risk?
- What are the overall priorities in terms of long term decisions on where to invest, and which areas should be considered for abandonment? On what basis will priorities be determined and policy be set?
- How long will it be economically viable to maintain a given line of defence especially where sea level is rising and coastal sediment processes are changing, at what point does abandonment become the preferred option?
- What is the appropriate level of assessment required in different areas, i.e. how much should be invested in improving data and analysis and where should this be targeted?

6 CONCLUSIONS

This research study has combined data sets from a variety of sources, compiled the information spatially in a GIS and established an analytical framework for assessing investment needs and developing strategies. The principal conclusions from this research project are as follows:

- Approximately 10% of the population of England live within areas potentially at risk from flooding or coastal erosion, whilst approximately 12% of the agricultural land in England (including 61% of the country's Grade 1 agricultural land) is also located in these areas,
- Property worth over £200 billion and agricultural land worth approximately £7 billion is located within these areas potentially at risk,
- Without any flood and coastal defences, the annual average economic damage from flooding and coastal erosion would be over £2.6 billion per year,
- The investment needed to continue to provide and maintain present defence standards is substantially more than current expenditure, and could be approximately double that

currently invested. This level of investment would maintain damages at approximately £0.6 billion per year; and

- Continuing to invest at present levels of approximately £0.2 billion per year will result in increasing annual average damage eventually exceeding £1.6 billion per year.

The current study has involved some broad-based assumptions and there is scope to further improve upon the accuracy of the analysis. However, there is sufficient confidence in the order of magnitude of the results to re-affirm that there is probably a long-term need to reappraise existing practices for undertaking and funding flood and coastal defence. If investment is maintained at or around present levels, it may only be possible to provide effective protection to selected areas of the country and a conscious decision would be required to abandon defences to many areas.

Although definitive arguments regarding how and where to invest should not be drawn from this study, there is little doubt that there is a clear need to substantially increase expenditure on flood and coastal defence if the same levels of protection as that which currently exists are to be maintained. Failure to do so will inevitably lead to an increase in economic damages year by year.

Given the conclusions of this study, and the possibility that investment to maintain or improve current defence standards throughout will not be forthcoming, there is a very real need for a strategic framework to obtain the best value from available funds. The work already undertaken for this study forms the basic building block for development of this tool.

7 ACKNOWLEDGEMENTS

The authors thank the members of the project steering committee for their advice and support during the research. In particular, we are grateful to David Richardson of MAFF for his helpful comments on the draft of this paper.

8 REFERENCES

1. Burgess K A, Chatterton J B, Samuels P G, Penning-Rowsell E & Deakin R (2000), *National Appraisal of Assets at Risk from flooding and Coastal Erosion,* Project report on Commission FD1702, HR Wallingford, (to appear)
2. Jorissen R E (1998), *Safety, risk and flood protection*, Proceedings of the RIBAMOD Workshop 1 on Current Policy and Practice in Flood Management, Eds R Casale, G B M Pedroli & P G Samuels, published by the Directorate General for Research and Development, European Commission, Luxembourg, ISBN 92-828-2002-5 (1998)
3. MAFF (1999), *Flood and Coastal Defence Project Appraisal Guidance – Economic Appraisal*, Document FCDPAG3, MAFF Publications, Admail 6000, LONDON.

	Anglian	Midland	North East	North West	South West	Southern	Thames	Total
Fluvial	268.5	293.5	165.3	60.6	86.2	70.5	349.4	1,294.1
Sea and Tidal	167.2	42.8	192.1	133.7	60.0	227.0	571.2	1,394.0
Coastal Protection	6.0	0.0	13.0	5.0	16.0	32.0	0.0	71.0
Total	**441.8**	**336.4**	**370.3**	**199.5**	**162.2**	**329.6**	**920.6**	**2,759.5**

Table 1 Do-Nothing Annual Average Damages (£ million per year)

	Anglian	Midland	North East	North West	South West	Southern	Thames	Total
Fluvial	155.9	241.3	109.3	38.4	49.4	52.3	142.2	788.8
Sea and Tidal	132.2	32.4	125.7	110.1	48.6	177.3	512.2	1,138.4
Coastal Protection	4.8	0.0	10.4	4.0	12.8	25.6	0.0	56.8
Total	**292.9**	**273.7**	**245.4**	**152.5**	**110.8**	**255.2**	**654.3**	**1,984.0**

Table 2 Annual Average Damages Avoided to Property by Maintaining Present Levels of Protection (£ million per year)

	Anglian	Midland	North East	North West	South West	Southern	Thames	Total
Fluvial	179.5	253.5	133.9	50.6	69.0	60.2	313.4	1,059.8
Sea and Tidal	145.6	35.8	166.2	126.2	58.0	217.9	562.3	1,311.7
Coastal Protection	5.4	0.0	11.7	4.5	14.4	28.8	0.0	63.9
Total	**330.5**	**289.3**	**311.8**	**181.3**	**141.4**	**306.9**	**875.7**	**2,435.6**

Table 3 Annual Average Damages Avoided to Property by meeting Indicative Standards (£ million per year)

	Totals (£ million per year)		
	Maintain	**Replace**	**Total**
Fluvial	48.18	126.78	174.96
Sea	10.03	26.40	36.43
Tidal	26.91	70.82	97.73
Others	8.32	21.89	30.21
Total flood defence	93.44	245.89	339.33
Coastal Protection	21.21	55.82	77.03
Overall Totals	114.65	301.71	416.36

Table 4 National Investment Needs to Maintain Present Standards

	Maintain	**Meet Indicative (Lower Bound)**	**Meet Indicative (Upper Bound)**
Fluvial	126.78	114.10	139.45
Sea	26.40	23.50	29.31
Tidal	70.82	64.45	77.19
Coastal Protection	55.82	48.56	63.07
Total Replacement	279.82	250.60	309.02
Maintenance	114.65	Not Established	Not Established
Other Structures	21.88	Not Established	Not Established
Total	**416.35**	**387.13***	**445.55***

*assumes no change to maintenance costs or other structures

Table 5 National Investment Needs to meet Indicative Standards (£ million per year)