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Long-term Investment Requirements for Flood Defences in Wales

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List of Abbreviations

Acronyms used throughout this report:

AEP - Annual Exceedance Probability

AMX – Asset Management eXpert (Flood risk asset database)

BCR – Benefit Cost Ratio

CaRR – Community at Risk Register

ETS – Economic Tool Set

FCERM – Flood and Coastal Erosion Risk Management

FFIW – Future Flooding in Wales (report)

FRAW – Flood Risk Assessment Wales

LA – Local Authority

LTIR - Long-Term Investment Requirements

NRW - Natural Resources Wales

PVs - Present Values (the capitalised value of a stream of future costs or benefits)

RMA – Risk Management Authority

SoP – Standard of Protection

Foreword

The impacts of flooding are devastating. We have seen numerous examples of major flooding both in Wales and across the world in recent years. The floods in Germany and Belgium in summer 2021, with significant loss of life, were an unwelcome reminder of the force of nature and the impacts of flooding. Residents of Wales will need no reminders of recent floods closer to home, be that from Storm Dennis in 2020 or any of a host of other storms and floods that have happened in recent years.

Unfortunately, flooding on this scale will continue to happen in the future and is set to get worse. The Inter-Governmental Panel on Climate Change reports published in recent years are categoric in showing that we are experiencing more frequent and more extreme weather events, with the inevitability of more and more severe floods in the future.

The need for managing flood risk is an issue for the long term. We need to understand the investment requirements so that we can plan effectively, and so that we can act to manage the risks from flooding.

This report looks at the long term investment requirements required for flood defences in Wales (with some caveats, as explained in the report). Flood defences are key part of the toolkit of measures we need to take to manage flood risk. Flood defences reduce the probability of flooding, but they are not a guarantee of being flood-free. Defences can be overtopped, or they can fail. They also need to keep pace with climate change if they are to continue to provide the same standard of protection. This means they will need to be higher and stronger, and maintained to be fit for purpose. But building defences ever higher and higher is not going to be feasible or economic, in all locations. We need to understand what is possible – and desirable – over the long term. We need to understand the long term investment requirements, and this why we have produced this report.

We also know that we cannot defend everywhere or rely on defences only to manage the risks. It is absolutely vital that we also plan for and invest in a range of other flood risk management tools and techniques, as we respond to the rapidly changing climate and the impacts it will bring. The need for this wider investment and utilisation of a range of measures, and investment in adaptation and resilience measures, is spelt out in other NRW publications, such as our 2023 Flood Risk Management Plan (available on our website). We intend to produce other reports in the future about investment requirements for other areas of flood risk management (such as flood forecasting and warning, planning, or working with nature and catchment approaches). By producing this report on defences we are definitely not saying investing in defences is the only investment needed; but we are saying it is a key component.

Of course, levels of investment is primarily a matter for Government, and it is intended that this report will help Welsh Government in its consideration of the choices. It will also be of strong interest to all policy makers and practitioners in the sector.

Jeremy Parr, Head of Flood and Incident Risk Management, Natural Resources Wales, January 2024

Executive Summary

This report sets out the findings of the Long-Term Investment Requirements (LTIR) analysis undertaken to date, utilising the latest information from the Flood Risk Assessment Wales (FRAW) project and the Asset Management eXpert (AMX) flood asset database. Using an economic tool to assess different investment scenarios, the likely costs and benefits of different policy decisions have been set out to further inform decision making and budget planning for Flood Risk Management (FRM) in Wales.

Purpose and methodology

Four different investment scenarios, coupled with a range of different climate change predictions, have been utilised to assess the levels of investment required in building and maintaining raised flood defences, on a national scale. Raised defences are classified as embankments, walls and demountable structures. Other asset types such as culverts, outfalls, open channels, trash screens etc. are not included in this assessment but are factored into the final results to provide a complete picture of our capital requirements.

The scenarios are:

Scenario A – All assets will keep pace with climate change with no financial limits imposed. Defence crest levels are raised to maintain current standard of protection and condition grades remain at a set standard.

Scenario B – If it is economically viable to do so (Benefit Cost Ratio (BCR)>1), assets will keep pace with climate change. For those that are not viable to keep pace with climate change, we will maintain them if it is economically viable to do so. ‘Maintain’ is defined as ‘defence crest levels won’t change but condition grades remain at a set standard.’ For all other assets, there will be no intervention therefore crest levels will not change and condition changes according to deterioration.

Scenario C – All assets located within the top 100 communities identified in the Climate Change Community at Risk Register (CaRR) will keep pace with climate change. All remaining assets will not be invested in therefore crest levels will not change and condition changes according to deterioration.

Scenario D – All assets will be maintained. Following this, as many assets as possible (ranked by economic viability) will keep pace with climate change until there is no funding available.

The analysis uses Natural Resources Wales’s (NRW) latest national modelling (Flood Risk Assessment Wales, or FRAW) on the present-day and future risk from fluvial, tidal and pluvial sources; along with information on assets including defence condition, length and type. It evaluates the relationship between investment and risk and how this relationship changes over time and as various measures are applied to flood risk defences.

This study uses national scale modelling, and its findings will be reported on a national basis. The analysis undertaken cannot be used to identify specific locations requiring

investment. Its purpose is to provide the evidence base required to secure future investment in flood risk management at a strategic and national level.

Costs

All costs in this study are present day capital costs related to the maintenance and improvement of raised defences (walls, embankments and demountable structures). The investment profiles within the study will not be uniform as defences across Wales will be in different conditions, offering various standards of protection and are of varying ages. A 100-year appraisal period has been used to capture the full effects of climate change projections and to ensure that full asset life cycles are considered. But it has also been used to enable production of an averaged out estimate of annual investment requirements which removes the large peaks and troughs that will inevitably arise with this type of study.

Some of the costs will be associated with assets not owned by NRW. There are Local Authority (LA) maintained assets providing protection from flooding included within the study, but this is not a complete dataset. For fluvial and tidal flooding, the assets included are ones which are included within NRW's asset database. These assets will have been historically inspected by NRW. This is likely to include relatively good coverage of coastal assets but limited coverage in other areas especially away from Main Rivers.

Economic Baseline

The baseline used for the economic appraisal is the Do Nothing with defences in place. The damages would be far greater if the undefended scenario was used but this has been deemed unrealistic. It is important to recognise the many decades of investment that has already been made to create and maintain the flood risk infrastructure currently in place across Wales. All of this investment and therefore the value of the existing network is acknowledged in the Do Nothing (defences in place) scenario. Using the undefended scenario as our baseline would mean demolishing/ignoring all current defences and give a false impression of current risk.

Key Findings

Scenario	Total Benefits	Total Cost	Annual Cost	Properties remaining at high risk	Reduction of properties at high risk	Benefit for every £1 spent
A	£26.6bn	£5bn	£50m	42,464	63,811	£2.80
B	£26.3bn	£2.20bn	£22.0m	52,884	53,390	£11.90
C	£26.2bn	£2.38bn	£23.8m	49,146	57,129	£5.30

Scenario	Total Benefits	Total Cost	Annual Cost	Properties remaining at high risk	Reduction of properties at high risk	Benefit for every £1 spent
D	£25.9bn	£1.97bn	£19.7m	60,553	45,721	£13.10

As the main body of the report explains, all elements of the results must be assessed together as some may be misleading when looked at individually. Care is needed in interpreting these results, and in understanding what is included and what is not in each figure. For example, the 'benefit for every £1 spent' is not simply the ratio of the total benefits figure in this table divided by the total costs figure, because of the various other necessary assumptions that have been factored into the analysis. Note, pluvial flooding is not included in the figures in this table, as is explained in the main body of the report.

The main conclusions, on a national scale, are:

- Investing in flood risk defences results in significant amounts of economic benefits over the appraisal period. The economic benefit of the investment far outweighs the costs of delivering the work for all scenarios. All 4 scenarios are cost beneficial ranging from a 2.8 - 13.1 to 1 return on investment.
- The scenario for keeping pace with climate change everywhere results in the greatest reduction in properties at risk.
- The scenario of keeping funding at current levels results in over 18,000 additional properties remaining at High Risk and Residual damages increasing by £800m over the appraisal period.
- Keeping pace with climate change everywhere comes at a significant cost, as this scenario requires 3.4 times current funding levels.
- Whilst the overall investment at a national level is strongly cost-beneficial, at a community level, many communities across Wales will be uneconomical (i.e. not cost-beneficial) to invest in over the next 100 years. When investment is focussed solely on locations that are economical to do so, only 13% of defended areas are proven to be economically viable to keep pace with climate change. However, 70% of the total properties at risk across Wales are located within these defended areas.
- High-risk locations in Wales will always be beneficial to invest in as the bulk of the properties at risk are within them. However, over 22,000 properties are uneconomical to invest in when assessed nationally.
- Regardless of the scenario implemented across the appraisal period, residual damages remain. This shows that flooding cannot be stopped, only managed. Although ensuring that flood defences keep pace with climate change has a large part to play in protecting communities, they cannot be the sole focus.

Introduction

This report summarises the assessment undertaken by NRW of the Long-Term Investment Requirements (LTIR) for managing the flood defence asset base in Wales[1]. Four different scenarios, plus a range of climate change projections, have been assessed, and conclusions drawn.

The assessments made use the latest understanding of flood risk in Wales on a national basis to model different scenarios. It uses the newly available Flood Risk Assessment Wales (FRAW), and in particular the new Economic Tool Set (ETS) that has been developed as part of the FRAW project.

The need for and desirability of this new assessment is recognised in Welsh Government's National Flood and Coastal Erosion Risk Management Strategy (FCERM Strategy)[2]. Para 319 states:

> In 2010, Environment Agency Wales published their Future Flooding in Wales [FFIW] report, which helped to inform the level of investment needed to manage flood and coastal erosion risk. We want to see this updated using the latest climate change projections and FRAW to inform future investment needs for all sources of flooding and coastal erosion.

And the objective and action are captured in Measure 23:

> We [WG] want to update our long-term investment requirements utilising the latest risk data and climate change projections.
>
> Measure 23: NRW will work with Local Authorities and Welsh Government to publish long-term investment requirements for FCERM, complementing Flood Risk Assessment Wales, by the end of 2021.

Whilst the 2010 FFIW and this 2023 LTIR work both assess the long-term investment requirements of maintaining flood defence assets, they use different methodologies and datasets, and so are not directly comparable. Therefore, this LTIR work is not a direct "update" as such of the FFIW assessment work, but the LTIR work is a progression from that original FFIW assessment. Whilst delivering against the requirements of the FCERM Strategy it is also recognised that developing a strong investment case around all aspects of Flood Risk Management (FRM) is required. Therefore the work presented in this report is recognised as only explaining part of the Long-Term Investment Requirements for FRM, significant further work will be required to build on this evidence base.

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[1] The assessment and results are for capital work (new or replacement defences and capital maintenance, for assets that are contained in Flood Risk Assessment Wales. This is NRW assets, and Local Authority or 3rd party assets, where the data is known. It does not include any revenue funded activities. See section "Future Updates" for more information on the scope and limitations

[2] National Strategy for Flood and Coastal Erosion Risk Management in Wales | GOV.WALES

Background and Methodology

What is Flood Risk?

Flood risk is the combination of likelihood and consequence. Flood defences reduce the likelihood of flooding, but the consequences remain. The flood damages that remain after interventions have been considered are known as the residual damages. Although defences reduce the likelihood of flooding, action must also be considered to try and reduce these consequences through measures such as adaptation and resilience.

Consequences of flooding

Flooding poses a high risk to life and can devastate homes, businesses, and communities; affected areas and properties can take a long time to recover. Flooding can devastate people, their property and businesses. It can also have a significant impact on the environment, the wider community and the infrastructure and essential services that they rely on. This can lead to significant effects on people's mental and physical wellbeing.

Wales has experienced significant flood events in the recent past – notably; during the winter storms of 2013/14 (305 properties flooded), October 1998 (750 properties flooded) and previously back in December 1979 where over 3,000 properties flooded in Cardiff alone. Storm Dennis, during February 2020, was one of the most significant weather events to hit Wales in over a generation. During this devasting storm 2,765 properties flooded, including 2,200 households and 565 non-residential properties. It is estimated the flood damage to households alone was in excess of £80million[3].

Likelihood of flooding

The likelihood of flooding occurring in any one year can be expressed as a return period, percentage, or a probability. The risk categories referred to in this report are as follows:

Table 1 - Likelihood of fluvial and pluvial flooding in any given year

Category	Return Period	Percentage
Low	1 in 1000 – 1 in 100	0.1 – 1%
Medium	1 in 100 – 1 in 30	1 – 3.33%
High	<1 in 30	3.33 – 100%

[3] February 2020 Floods in Wales: Flood Event Data Summary

Table 2 - Likelihood of tidal flooding in any given year

Category	Return Period	Percentage
Low	1 in 1000 – 1 in 200	0.1 – 2%
Medium	1 in 200 – 1 in 30	2 – 3.33%
High	<1 in 30	3.33 – 100%

Calculating flood risk

This study is based on the most accurate and up to date national scale modelling for Wales – FRAW. The data within this modelling is presented in flood risk likelihood categories which indicate the chance of flooding in any given year. The fluvial modelling is for the undefended scenario with flood flows and design hydrographs calculated at around 31,000 locations.

Tidal modelling is based on projection mapping and utilises new extreme water level estimates along the coastline and up key estuaries. The tidal figures within the report should be treated with caution as the tidal modelling is based on projection mapping. This indicates the worst-case scenario, it is not dynamic and does not look at volumes. It is simply still water projections inland. As the figures later in the report will show, the numbers of properties at risk are significantly larger than fluvial. This is the most accurate modelling currently available to us at this point. It still gives us a very good indication of risk, but it must be stated that it is not as accurate as the fluvial modelling.

Pluvial hazard modelling uses a direct rainfall approach and provides flood mapping for surface water and small watercourses. Only the defended scenario for pluvial flooding exists within FRAW therefore the economic viability of pluvial defences, and how they impact on property numbers are not assessed in this study.

The FRAW ETS builds on this modelling by introducing defended area polygons (for fluvial and tidal) and explores the impacts of flooding under future climate scenarios and how the impacts can be mitigated by a range of measures.

The ETS provides NRW with a range of options and opportunities to assess its future investment requirements.

There are 3 main variations available, and the scenarios within our new Long-Term Investment Requirements will be based on various combinations of these:

- Do nothing – crest levels do not change and condition changes according to deterioration.
- Maintain only – Defence crest levels do not change but condition grades remain at a set standard.

- Keep pace with climate change – Defence crest levels are raised to maintain current standard of protection and condition grades remain at a set standard.

Standard of Protection and Condition Grades

Flood defences provide specific areas (Defended Areas) with a Standard of Protection (SoP). For example, an area with a 1 in 100 SoP would be expected to provide protection from all floods up to and including the 1 in 100-year Annual Exceedance Probability (AEP) Event. AEP is the probability of a flood event occurring annually. However, it is important to note that this flood might not happen for 200 years yet could also occur twice over the next 20 years. The asset should then be maintained to ensure that the defence does not degrade and weaken which would increase the likelihood of flooding.

Each asset is also given a target condition grade (defined by industry standards) and maintenance work will seek to ensure that this condition grade is sustained. The Welsh Government FCERM Strategy states that "There is no fixed standard of protection; however the Welsh Government encourages alleviation schemes which remove homes from high or medium risk (less than a 1% risk of fluvial flooding or 0.5% risk of coastal flooding). This helps FCERM policy to align with planning and insurance standards."

Flood alleviation schemes have to be appraised under the principles set out in both UK Treasury and Welsh Government guidance on Business Cases[4], which means they have to take account of economic, technical and environmental factors when determining scheme design and the standard of protection a scheme may deliver.

All of the damages, benefits and costs within this report have been converted into Present Values (PVs) as it is standard practice in economic appraisal to use PV's when assessing the whole-life benefits and costs of flood defences.

Managing the consequences of flooding

The flood defences that Risk Management Authorities manage are maintained through a range of maintenance activities. These include maintaining conveyance (weed and grass control, tree work, obstruction removal, dredging, sea outfall management etc); vegetation management, access management, beach recharge, concrete and masonry repairs and a host of other activities up to and including significant refurbishment and replacement work.

The assets that are included within the FRAW ETS are classed as Raised Defences. This includes walls, embankments and demountable structures. Assets such as culverts, open channels, high ground and outfalls are not included within the ETS but are covered in the *Investing in flood defences* section of this report, as these assets all require varying levels of maintenance and therefore have associated costs. Below is a definition of the assets that are included within the Raised Defences classification:

[4] Flood and coastal erosion risk management (FCERM): business case guidance

An embankment is an earthen structure used in the fluvial, tidal and costal environments for flood defence and/or erosion protection. In the fluvial environment, embankments that are raised soft defences may be located close to channels or may be set back from channels.

A wall is a raised structure used in the fluvial, tidal and costal environments for flood defence and/or erosion protection. Concrete, steel & brick walls of different heights and widths and located in different types of environment are covered.

A demountable structure is a temporary defence that is brought to, or stored on, site and erected when necessary to form a flood defence.

This report focusses on maintaining existing assets and building new ones and analysing the cost and benefit of doing so. However, it is important to acknowledge that there are many other activities and work areas involved in flood risk management that are not included in this report. These will all play an important role in the future and will all have a cost. These include flood warning and forecasting systems, flood awareness, mapping and modelling, planning and development control, delivering Property Flood Resistance and Resilience measures, as well as more long-term strategic work such as climate change adaptation planning.

Quantifying flood risk

“The benefits of flood risk management comprise the flood damage averted in the future as a result of schemes to reduce the frequency of flooding or reduce the impact of that flooding on the property and economic activity affected, or a combination of both”[5]

There are various terms used both within this report and the analysis undertaken in regard to flood “damages”:

Damages – The damages caused by a flood event. For the purpose of this report, this includes damage to all types of property (residential and non-residential) and their contents, and indirect damages (communications, emergency services, evacuation costs, vehicles etc).

Undefended Damages – This is used as a reference and is classed as the worst-case situation where there are no defences in place.

Breaching Damages – This is the scenario where all defences are in place, but the condition grade of each defence is taken into consideration. Assets with lower condition grades will lead to increased damages due to their increased likelihood of failure.

Residual Damages – There will always be a possibility of a defence being overtopped by a flood event greater than its SoP. These remaining damages after interventions have been considered are the residual damages.

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[5] Flood and Coastal Erosion Risk Management: A Manual for Economic Appraisal

Benefits – Also referred to as the damages avoided. In its simplest form, these are the difference between the undefended and defended scenarios. Subtracting one from the other gives us the benefit of a defence being in place. For this study, the benefits are calculated by subtracting the damages for various scenarios from the damages in the breaching scenario (defences in place but condition grade taken into consideration).

Benefit Cost Ratio – An assessment undertaken to determine economic viability by comparing the benefit of something by its cost. If the ratio is greater than one, then it is deemed economically viable.

All of the damages, benefits and costs within this report have been converted into Present Values (PVs) as it is standard practice in economic appraisal to use PV's when assessing the whole-life benefits and costs of flood defences.

Current Flood Risk in Wales

According to FRAW, there are currently 290,844 properties at risk from the different sources of flooding (fluvial, tidal, pluvial) across Wales (not taking defences into account – undefended) as shown in Table 3. This changes to 245,00 when you consider a property may be at risk from more than one source. Figure 1 shows how these properties are distributed across the risk bands.

Table 3 - Properties at risk from various sources across Wales in the present day – undefended scenario

Source of flooding	Metric	Low Risk	Medium Risk	High Risk	Total
Fluvial	Residential	40,954	14,920	21,944	77,818
Fluvial	Non-Residential	6,760	2,343	3,168	12,271
Fluvial	Total	47,714	17,263	25,112	90,089
Tidal	Residential	17,822	2,102	42,163	62,087
Tidal	Non-Residential	3,128	399	5,208	8,735
Tidal	Total	20,950	2,501	47,371	70,822
Pluvial	Residential	68,121	16,438	31,192	115,751
Pluvial	Non-Residential	7,836	2,247	4,099	14,182
Pluvial	Total	75,957	18,685	35,291	129,933
All sources	Total Properties	144,621	38,449	107,774	290,844

Figure 1 - Properties at undefended risk from fluvial and tidal flooding across Wales

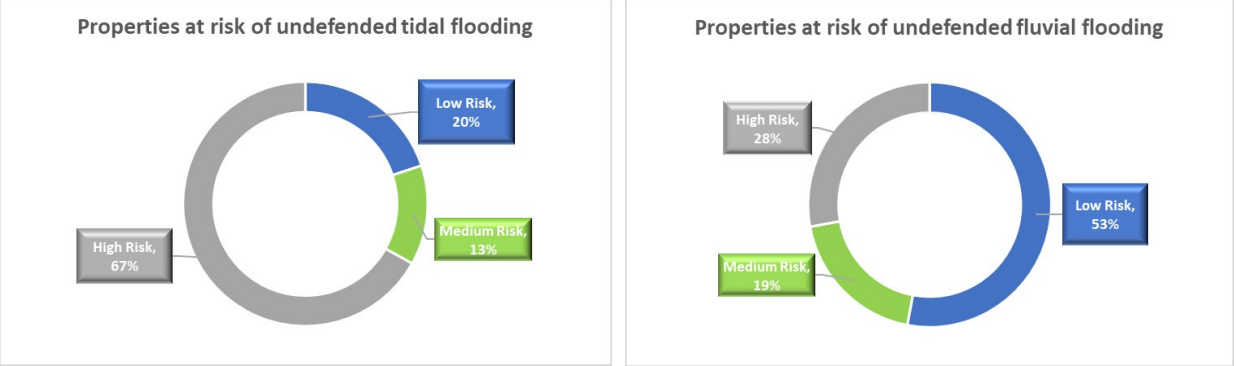


Table 4 below shows how defences currently reduce the number of properties at High risk across Wales. The defended figures below take account of the physical condition of the assets and factor in the likelihood of breaching based on that condition.

Table 4- Properties at risk in the undefended and defended scenarios

Source of flooding	Metric	Undefended High Risk	Defended High Risk	Reduction in properties at High Risk	% difference
Fluvial	Residential	21,944	8,346	13,598	62%
Fluvial	Non-Residential	3,168	1,300	1,868	59%
Fluvial	Total	25,112	9,646	15,467	62%
Tidal	Residential	42,163	1,805	40,358	96%
Tidal	Non-Residential	5,208	485	4,723	91%
Tidal	Total	47,371	2,290	45,082	95%

With defences in place, the number of properties within the High-risk category reduces whilst the number or properties within the Low and Medium risk categories increase. This is due to properties moving out of the High-risk category and into the lower risk categories. This is particularly apparent in the tidal scenario. This shows the importance of flood defence assets particularly in tidal locations. The importance of maintaining these assets will be discussed later in the report.

Future Flood Risk in Wales

Climate Change within FRAW

All climate change projections within FRAW and this study are based on the WG guidance which was available at the time the FRAW project was developed in January 2018. Changes since then will not be reflected in this study, however, they will be included in future updates.

The FRAW project modelled Present Day, Central Climate Change and Upper Climate Change using Welsh Government guidance[6]. This guidance does not include a Lower scenario. However, the Lower scenario has been added to the ETS for full flexibility but is not something that NRW report against and is not based on any formal guidance. The methods used by the ETS to adjust for climate change for the three flood sources – fluvial, tidal and pluvial are summarised below:

Fluvial - Uplifts for fluvial flows are taken from Welsh Government guidance, which splits the country into 3 River Basin Districts and provides a central and upper percentage uplift for the 2020s, 2050s and 2080s for each of these. Lower uplifts are also used in the ETS and are taken as half of the central uplift.

Tidal - Uplifts for tidal sources are also taken from Welsh Government guidance, which are in the form of mm/yr rises to be applied nationally. The upper scenario is taken as the H++ uplifts given in the guidance, and the lower scenario uplifts are half the central uplifts.

Pluvial - Uplifts for pluvial sources are again taken from Welsh Government guidance, which are in the form of percentage rises to be applied nationally. The lower values are taken as half the central values. The baseline for these uplifts is 1961-1990, and a similar process to that for fluvial is used to calculate uplifts from the 2020 baseline used in FRAW.

The Flood Map for Planning shows how climate change will affect flood risk extents over the next century. The map shows the potential extent of flooding assuming no defences are in place and represents the best available information we have on flood risk in Wales. The Flood Map for Planning is based on the Central Climate Change scenario, therefore, for consistency the central uplift figures are used within this report.

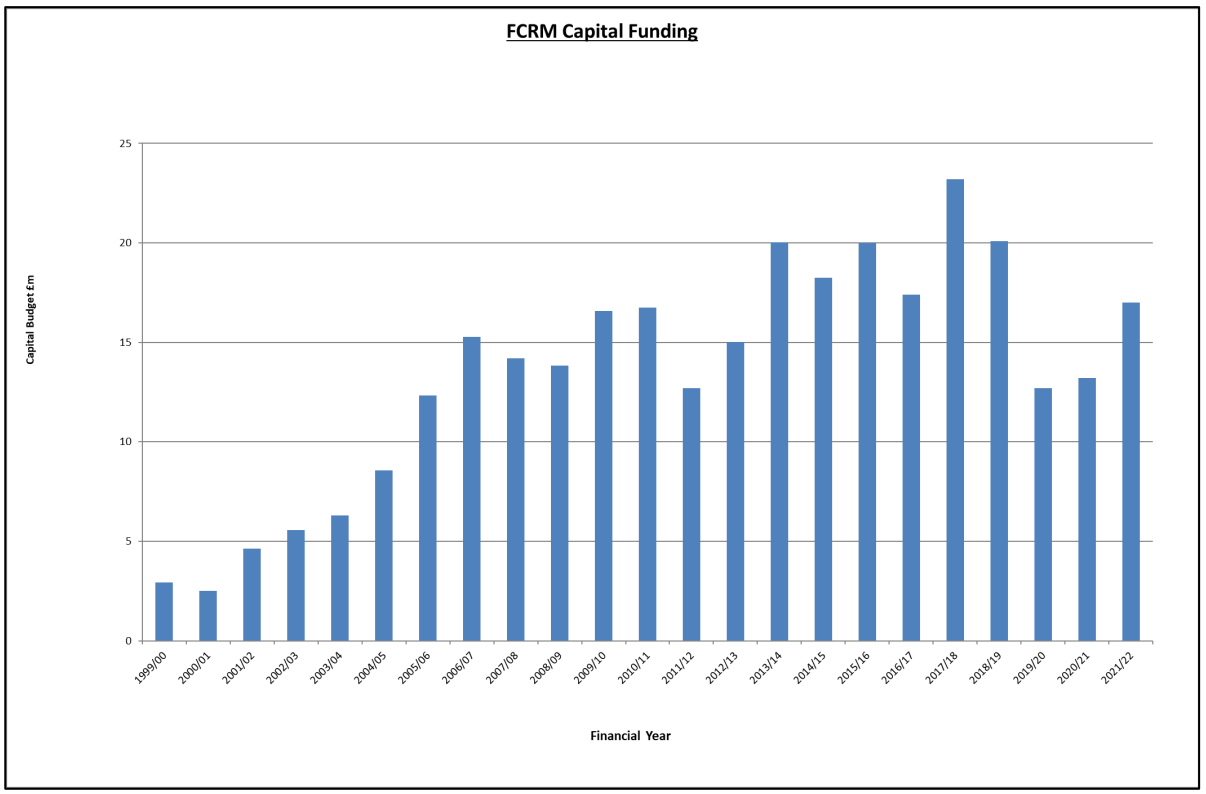
[6] Flood and coastal erosion risk management: adapting to climate change | GOV.WALES

Investing in flood defences

Current investment in flood defence maintenance and construction

Projects within the NRW Flood Capital Programme receive their funding via Welsh Government's single investment programme overseen by the Flood and Coastal Risk Programme Board. All NRW and LA proposed schemes (above a set value of £100k) are submitted to Welsh Government and are subsequently assessed against specific criteria including communities at risk register ranking, flood events (frequency and number of homes flooded) and the number of homes benefitting from the scheme**.** Figure 2 shows how NRW capital funding from WG has increased over the last 20 years and how it fluctuates annually, depending on the projects being planned by NRW.

Figure 2– NRW Flood Risk Management capital funding 1999-2022



The NRW FRM Capital Programme can include anywhere between 200-300 projects each year and it delivers outcomes such as *properties benefiting from a reduced risk of flooding* which fluctuate annually. When assessing the previous 10 years, on average the NRW FRM capital programme has moved over 700 properties per year into a lower risk category. Over that period approximately 5,700 homes and 1,300 businesses have benefitted from a project investment of approximately £70 million. This equates to an average spend of approximately £9,700 per property benefitting.

When considering the Programme as a whole though, the vast majority, by volume of projects, are maintenance projects and can be relatively small and simple (de-shoaling, access improvements, embankment repairs etc) through to more complex refurbishments.

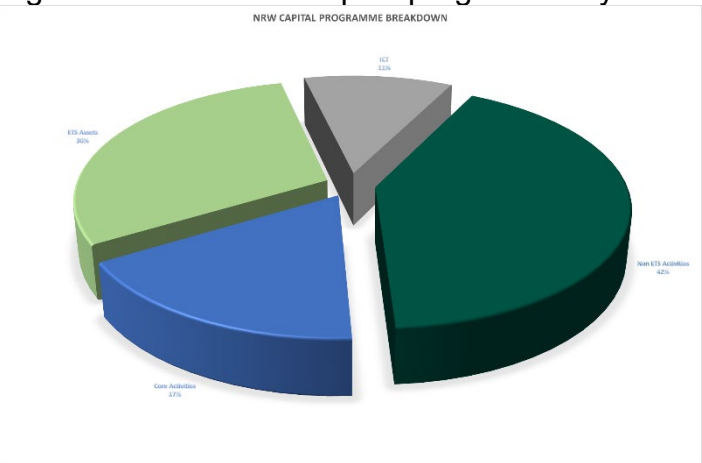
By spend however, a significant proportion of the funding each year is utilised on large scale flood alleviation schemes such as (in recent years) St Asaph (Denbighshire), Roath (Cardiff) and Crindau (Newport).

Other elements of the programme include

- mapping and modelling projects
- investing in our ICT systems, enhancing and improving critical FRM systems
- investing in the hydrometric network
- fleet replacement programme
- Coastal adaptation projects and the delivery of compensatory habitat

For the purpose of this study an average capital budget of £17.6m has been calculated, based on the capital budgets NRW has received from WG over the last 10 years.

Figure 3– NRW FRM capital programme by activity type



As stated earlier in the report, there are only certain types of assets included within the ETS – raised defences. The activities carried out by NRW on existing raised defences account for approximately 30% of its annual capital programme. The economic analysis carried out using the ETS is therefore focussed on these activities.

In order to get the full picture on future funding requirements, assumptions must be made on the remaining elements of capital spend. These include Core Activities (capital salaries and fleet management); ICT, maintenance of non ETS assets (hydrometric network, outfalls, screens, culverts) and the construction of new defences.

Assessing the make-up of the capital programme over the previous 10 years and evaluating the types of schemes within the Medium-Term Plan has enabled a fixed figure to be developed to incorporate into our scenarios. It is estimated that the remaining activities will cost in the region of £12m per year, using present day costs, although asset replacement and new build assets could lead to widely varying costs if considered on a scheme-by-scheme level.

The main assets and activities affected by rising river and sea levels due to climate change are those included within the ETS. The activities included within the £12m will also inevitably be affected by climate change in future, but not to the same extent and are therefore more suitable to be extrapolated in this way. Even though assets such as outfalls, sluice gates and hydrometric monitoring stations are not included within the ETS, the benefits associated with them will be included (on the whole) as the majority of these assets will either be within defended areas or directly linked to them. This gives confidence that they can be accurately included in the economic calculations.

The ETS evaluates the costs and benefits of maintaining and improving existing assets. As new schemes are developed, they will be included in future updates of LTIR. Therefore, as the report is updated over time, the benefit and economic viability of WG investment will continually be updated. Building new defences and creating new defended areas is not included in this analysis. Therefore the average cost of this (based on previous capital programmes) is included in the £12m figure.

However, as NRW's Medium Term Plan suggests, the number of sustain projects (projects sustaining an assets designed height and condition grade) is on the increase. We estimate that over the appraisal period, sustain projects will dominate the programme and the creation of new assets will decrease. Therefore, over time, capital expenditure on the asset types within the ETS will increase significantly. This has been factored in *to* the £12m estimate.

Flooding in Wales: A national assessment of flood risk[7] released in 2009, estimated that the cost of replacing all of our flood defence assets would exceed £2 billion. This was calculated by using the average cost of building each of the different types of flood defence and applying it to our database of assets. This remains the most accurate estimate available of the rebuild costs of NRW assets across Wales and is used when estimating the whole life costs of each investment scenario.

Investment scenario modelling

The results for each scenario include:

- The total benefit provided by defences (and the measures applied) over the appraisal period.
- The residual damages remaining despite defences being in place, over the appraisal period.
- The reduction in the number of properties within the High-Risk category (return period <1 in 30).
- The annual investment requirement to deliver the scenario. This figure is calculated using the 100-year appraisal period and factored down.
- A cost profile for the next 100 years showing the total amount of investment required each year and how this fluctuates over time.

[7] Flooding in Wales: A National Assessment of Flood Risk, Environment Agency Wales, 2009

- The percentage of properties at flood risk in 100 years' time within each flood category. Each scenario is compared with the Do Nothing and Maintain Only scenarios.

The scenario modelling is focussed on assets included within the ETS. The additional costs highlighted in the Investing in flood defences section (rebuild costs and other activities) are then added to the modelled outputs to produce an annual investment requirement.

The scenarios consider fluvial and tidal flooding only.

All of the economic benefits gained from maintaining assets or keeping pace with climate change, use the Do-Nothing Breaching scenario as the baseline. This is where defences are in place but not maintained, with a presumption that breaching will take place depending on condition grade.

All costs are based on present day and therefore no allowance has been made for inflation.

Costs are based on a per asset basis and the approach deployed assumes a standard defence height for a given Standard of Protection (SoP). The SoP is defined from the Defended Area dataset to give a consistent value over multiple assets protecting the same area. The ETS selects an appropriate unit cost from the unit cost database for each asset type (wall, embankment, demountable) and multiplies it by the asset length.

All calculations have been assessed using a 100-year appraisal period.

Investment Scenarios

4 scenarios have been identified to assess the impacts of various investment options. Each is assessed across a 100-year appraisal period with Central Climate Change projections being applied.

Scenario A

Keeping pace with climate change.

Defence crest levels for all assets across Wales are raised to maintain current SoP and condition grades remain at a set standard.

Scenario B

Investing in economic assets only.

All assets to be provided with the most economical service: keep pace, maintain only or do nothing, dependant on economic viability.

Scenario A – All assets will keep pace with climate change with no financial limits imposed. Defence crest levels are raised to maintain current SoP and condition grades remain at a set standard.

Scenario B – If it is economically viable to do so (BCR>1), assets will keep pace with climate change. For those that are not viable to keep pace with climate change, we will maintain them if it is economically viable to do so. For these assets, defence crest levels will not change but condition grades remain at a set standard. For all other assets, there will be no intervention therefore crest levels will not change and condition changes according to deterioration.

Scenario C – All assets located within the top 100 communities identified in the Climate Change CaRR will keep pace with climate change. All remaining assets will not be invested in therefore crest levels will not change and condition changes according to deterioration.

Scenario D – All assets will be maintained. Following this, as many assets as possible (ranked by economic viability) will keep pace with climate change until there is no funding available.

Scenario A is the only scenario that has no constraints and looks at providing the best possible standard of service to all assets within the study. This scenario will give perspective to the outcomes of the other scenarios. Scenarios B and C build on Scenario A by introducing economic and strategic requirements. Scenario B provides funding based on benefit cost ratios, while Scenario C is based on impacts. The final scenario (D) is based on current funding levels.

All scenarios are assessed over a 100-year appraisal period. This is critical in ensuring the full effects of climate change are established for each scenario and that full asset life cycles are considered.

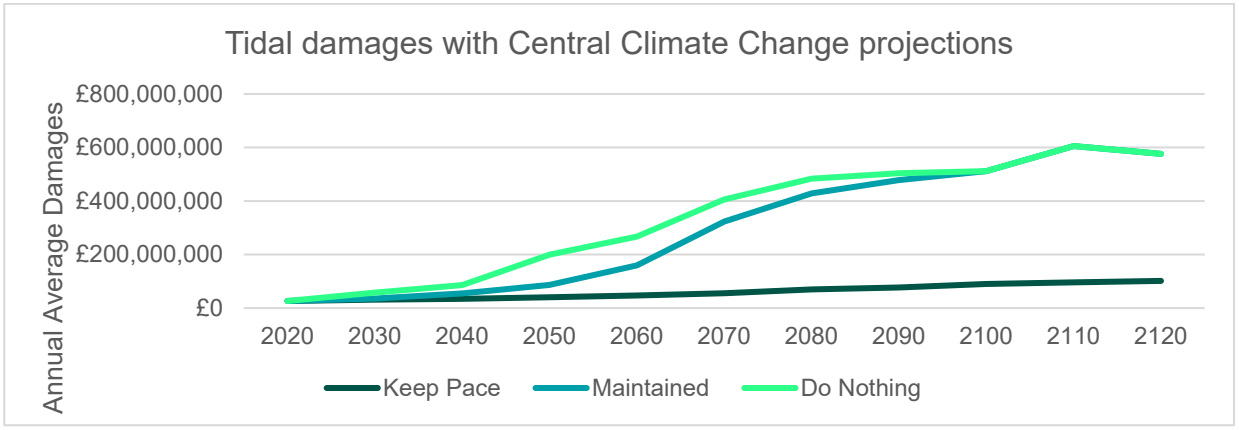
The results for annual average damages over the 100-year period are shown in Figure 4. This clearly shows when (in around 2040) the full effects of the ‘keep pace’ scenario begins to take effect. It also shows how eventually there is no tangible difference between maintaining assets and doing nothing in future years. This is due to the fact that at a

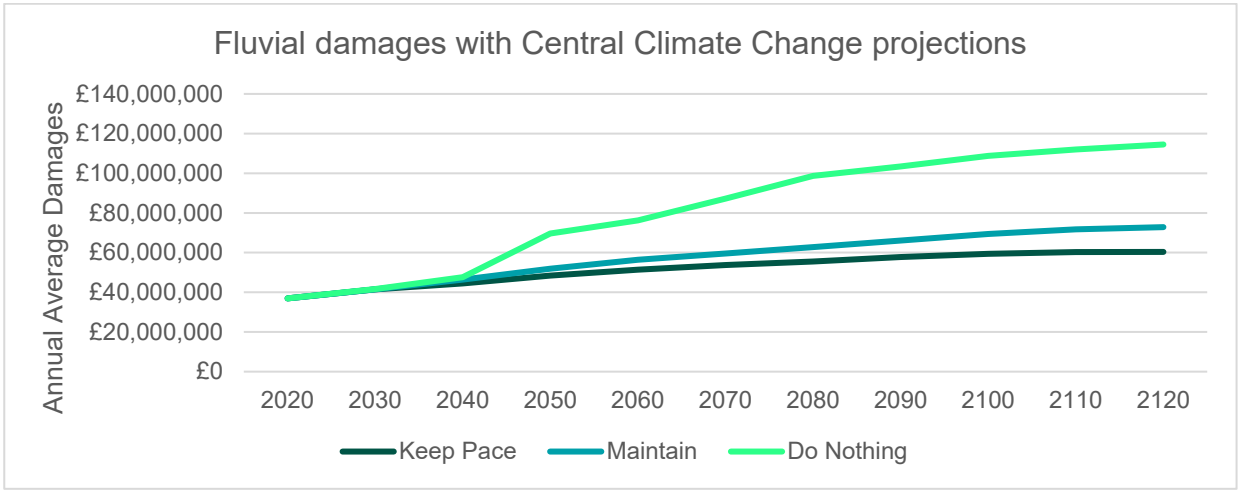
certain point in the future, defences at their current height will be overtopped so regularly, they would become insignificant.

Many high-risk locations are not viable for investment over a 25-year appraisal period as damages begin to take place later due to climate change and the good condition of the majority of assets due to historical maintenance spending. It is highly unlikely that a community would not receive investment based on a 25-year assessment and therefore this study focusses on the 100-year timeline but uses this to create an annual investment requirement. This can then be scaled up into any appraisal period (such as 25 years) required, ensuring that all viable locations are fully assessed.

Figure 4 also shows that the impacts of climate change are clearly more significant in the coastal zone (tidal damages), and this is to be expected as the majority of the most at-risk locations according to the Community at Risk Register are coastal. There are significant numbers of properties at risk in the coastal zone and the difference in damages between tidal and fluvial damages in future clearly demonstrate this.

Figure 4 – Damages from fluvial and tidal sources over the appraisal period per measure





Exclusions from scope

Local Authority Assets

This report focusses on capital work (replacement defences and capital maintenance), for assets that are included in Flood Risk Assessment Wales. This includes NRW, LA and in some cases third party assets, where the data is known.

There are LA maintained assets providing protection from flooding included within the ETS, but this is not a complete dataset. As part of WG's FCERM Grant Memorandum[8], key details on all new LA flood schemes (new or improvements) must be supplied to NRW within 6 months of completion. This data will provide NRW with the required information to enable new Defended Areas to be created. This work will help develop the National Asset Database and in turn, allow us to continually improve LTIR in future.

For fluvial and tidal flooding, the assets included are ones which are included within NRW's asset database. These assets will have been historically inspected by NRW. As is the case for NRW, the only assets included are raised defences. Any LA assets that are within the ETS, will be included in the economic analysis presented within this report.

Pluvial Flooding

The report looks at fluvial and tidal flooding only. The situation is different for surface water (pluvial) flooding. FRAW flood maps only include the defended scenario for pluvial flooding. During the development of FRAW, work was undertaken to try and develop an undefended scenario including modelling of various blockage scenarios. This was unsuccessful and it was deemed unviable due to the lack of asset information and modelling available. To develop an undefended scenario would require a FRAW scale project, remodelling the whole of Wales to show the extent of the benefits provided by pluvial defences (culverts, trash screens etc).

Due to the fact that there is currently no record of the costs associated with maintaining pluvial defences within the ETS, and that there is no undefended scenario modelled within FRAW, it is not possible to undertake any economical assessment looking at costs and benefit at this stage.

Addressing potential updates

Whilst delivering against the requirements of the FCERM Strategy it is also recognised that developing a strong investment case around all aspects of Flood Risk Management (FRM) is required. Therefore the work presented in this report is recognised as only explaining part of the Long-Term Investment Requirements for FRM, significant further work will be required to build on this evidence base including further assessment of other capital funded activities as well as future revenue requirements.

[8] Welsh Government Grant Memorandum - Flood & Coastal Erosion Risk Management

There are projects and key activities on-going to address several potential updates highlighted in this section. Future versions of LTIR will then be able to use the information gathered through these projects and activities. Table 5 details how each update is currently being addressed:

Table 5- On-going strategic projects that will support future versions of LTIR

Item	Potential Update Areas	Project addressing potential updates	Comment
1	Local Authorities (LA) fluvial and tidal assets not all represented within the FRAW mapping and not featuring in the ETS	Wales Flood Map updates	NRW have advised that LAs should be identifying gaps in the FRAW maps and providing additional information on flood defences. This will then enable new defended areas (and the associated economics) to be created and included in future updates of LTIR.
2	New LA defences need to be included in future	National Asset Database – FCERM Grant Memorandum	As part of WG's FCERM Grant Memorandum, key details on all new LA flood schemes (new or improvements) must be supplied to NRW within 6 months of completion. This data will provide NRW with the required information to enable new Defended Areas to be created.
3	Improvements needed to LA data featured within NRW flood maps	LA Regional Flood Groups	NRW active engagement with LAs via Flood Groups requesting better information. LAs to also contact NRW directly where they know information is incomplete.
4	NRW Revenue Maintenance Requirements	Risk Based Revenue Allocation Model (RBRAM)	New project developing an improved risk-based approach to NRW routine asset maintenance revenue allocations. Outputs will allow NRW to quantify future revenue requirements.

Results and Findings

FRAW future predictions for fluvial and tidal flood risk

Table 6- Properties at risk in the present day and future in the undefended scenario

	Low Risk	Medium Risk	High Risk	Total
Fluvial Present Day	47,714	17,263	25,112	90,089
Fluvial 2120	47,811	20,643	43,122	111,576
Tidal Present Day	14,110	9,341	47,371	70,822
Tidal 2120	13,861	2,330	87,803	103,994

Table 6 above displays how climate change projections affect the figures from Table 3 in the Current Risk section of the study. As Central Climate Change projections are applied, we see the number of properties at High Risk increasing significantly by the year 2120 in the undefended scenario. The total number of properties at risk of fluvial flooding also increases by over 21,000 and over 33,000 from tidal sources.

The FRAW ETS builds on the defended and undefended scenarios, using the measures listed earlier (Do Nothing, Maintain Only, Keep Pace with Climate Change). Table 7 and Figure 5 below detail how these adaption measures affect the number of properties at risk from fluvial and tidal flooding in the future (next 100 years), applying central climate change projections. These figures are with defences in place and should not be compared to the undefended figures above in Table 6.

Table 7– Properties at risk in 2120 with measures applied to the defences in place

Source of flooding	Do Nothing	Maintain Only	Keep Pace with CC
Fluvial	42,995	35,132	19,038
Tidal	87,803	87,803	38,079

Figure 5 - Properties at risk within the 25- and 100-year appraisal periods under various measures.

The differences are amplified when using Upper Climate Change projections and negated when not applying any climate change. When focussing on Central Climate Change, Figure 5 show us that over the first 25 years, there is limited change between the three measures. The damages caused by climate change are yet to take place. When assessing the 100-year appraisal period, it is clear that the only way of reducing properties at risk is to keep pace with climate change. By 2120, whether using Upper or Central Climate Change, both Do Nothing and Maintain Only give similar results.

Therefore in future, maintaining our defences to current standards will not be sufficient

Pluvial Flooding

The limitations with pluvial flooding and the reasoning around these are detailed within the above Exclusions from scope section of this report. However, the ETS is still able to provide valuable information on the risk posed by pluvial flooding for the present day and how climate change projections influence this in the future.

Table 8 uses central climate change projections and clearly displays the additional risks posed by climate change for pluvial sources over a 100-year appraisal period.

Table 8- Properties at risk from Pluvial flooding across Wales

Appraisal Period	Source of flooding	Low Risk	Medium Risk	High Risk	Total
Present Day	Pluvial	75,957	18,685	35,291	129,933
2120	Pluvial	98,068	26,291	49,260	173,619

Figure 6- Properties classified as High Risk from pluvial flooding

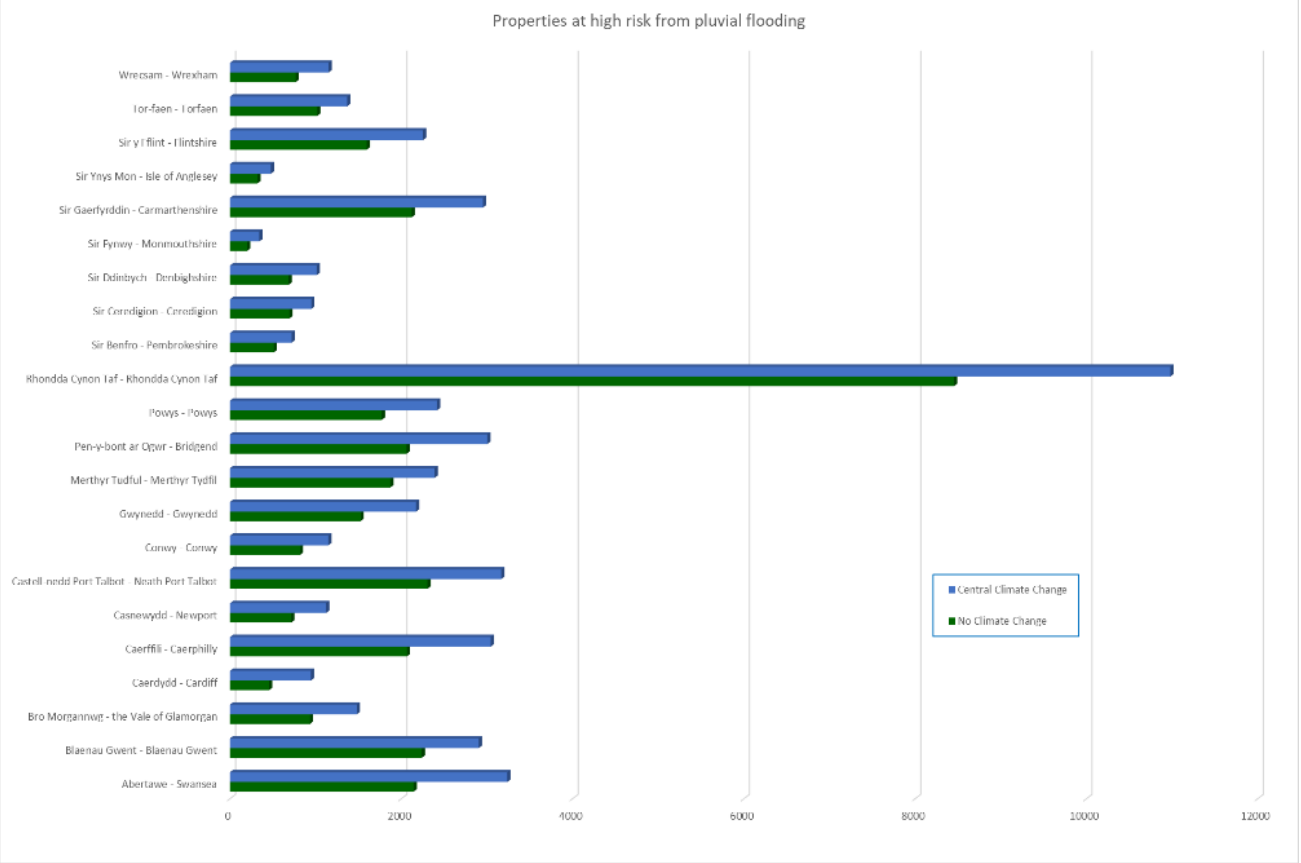
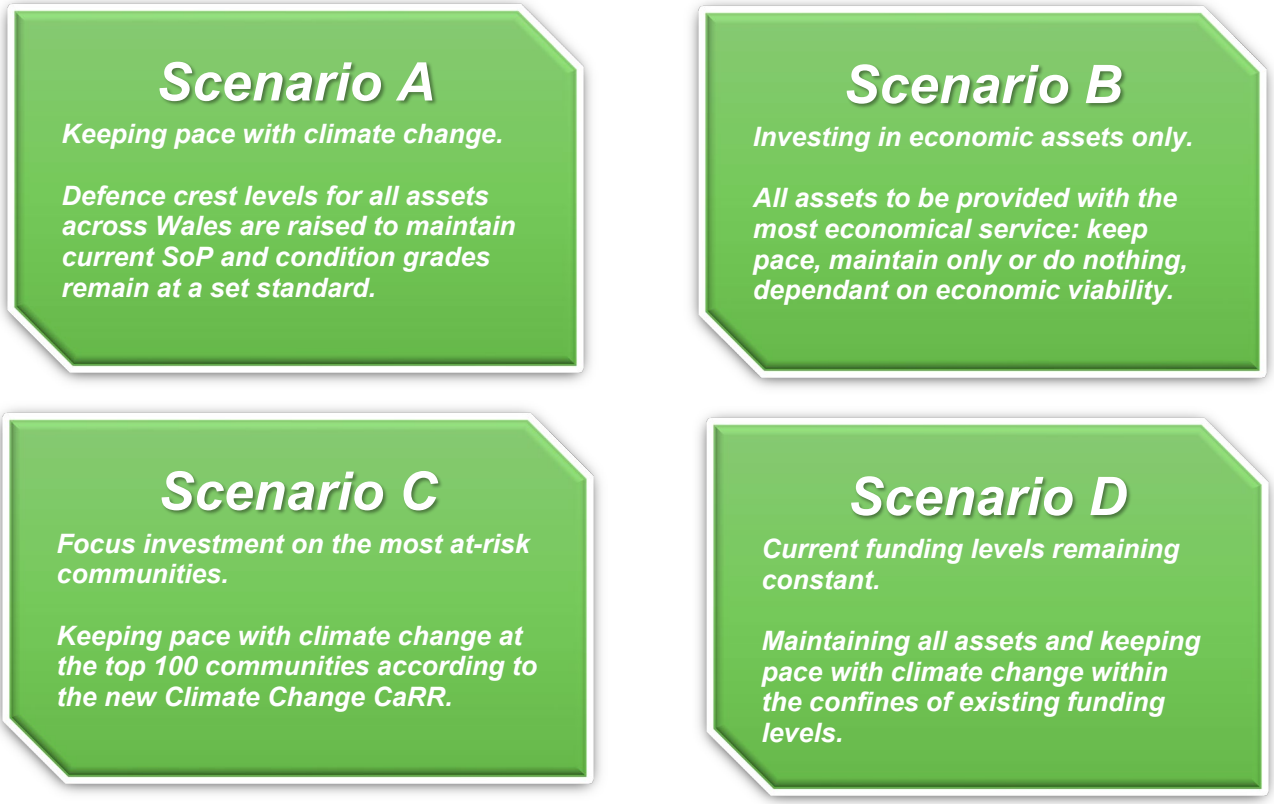


Figure 6 focuses on properties within the high-risk category and shows how central climate change projections affect property numbers over the next 100 years, compared to the no climate change scenario. It also shows us how the risk is distributed across Wales.

Even though the ETS cannot demonstrate the economic benefit provided by pluvial defences, it does provide information on the damages associated with pluvial flooding and how this is affected by climate change. Over a 100-year appraisal period with central climate change projections, the total damages across Wales from pluvial flooding reaches in excess of £11.9bn. These are the damages with defences in place – residual damages. The distribution of these damages follows the same pattern as shown in Figure 6.

Consequences and benefits for flood risk from different scenarios



This section summarises the results of each modelled scenario. More detailed information on each scenario is included in Appendix 1.

Table 9- Summary results of each Investment Scenario

Scenario	Benefits	Total Cost	Annual Cost	Properties remaining at high risk	Reduction of properties at high risk	Benefit for every £1 spent
A	£26.6bn	£5bn	£50m	42,464	63,811	£2.80
B	£26.3bn	£2.20bn	£22.0m	52,884	53,390	£11.90
C	£26.2bn	£2.38bn	£23.8m	49,146	57,129	£5.30
D	£25.9bn	£1.97bn	£19.7m	60,553	45,721	£13.10

Comparing Scenarios - Properties at risk

Figure 7 shows the percentage of properties within each risk category over the appraisal period for every Investment Scenario along with the Do-Nothing Scenario (no future investment). It also shows the Present-Day Scenario and how things will change as climate change projections are applied regardless of which scenario is looked at. Every scenario is clearly an improvement when compared to Do Nothing.

The figures clearly show that ceasing future investment in flood defences would lead to a significant increase in properties at High Risk.

Scenario A has the most impact on property numbers and shows the greatest reduction to property numbers at High Risk.

Keeping pace with climate change everywhere is the highest level of service that can be modelled within this assessment. Comparing Scenario A with Scenario D results in 18,089 properties remaining at High Risk and Residual damages increasing by £820m over the appraisal period. All scenarios have a greater impact on the number of properties at high risk than current funding does. Figure 8 clearly shows that increased expenditure results in a reduction in properties at risk.

Figure 7 - Investment Scenarios - Categorisation of properties at risk

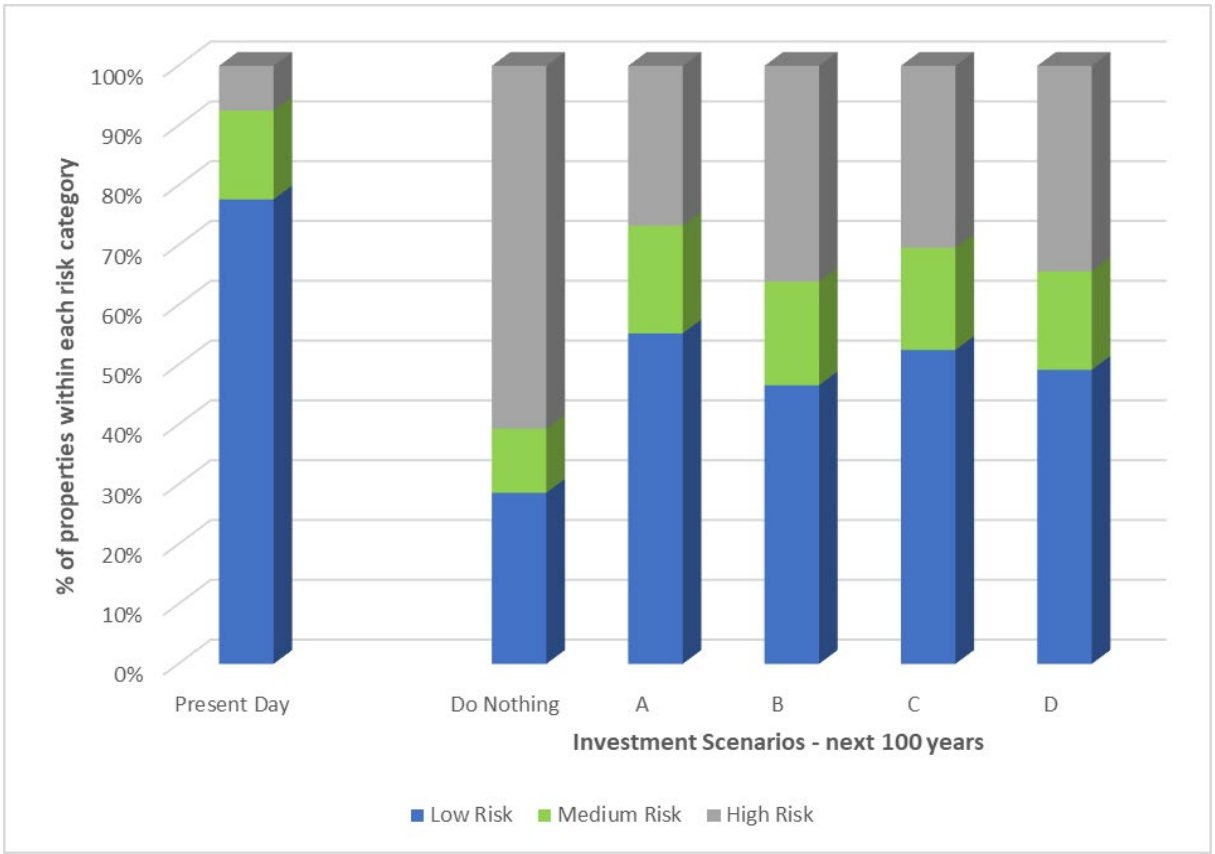
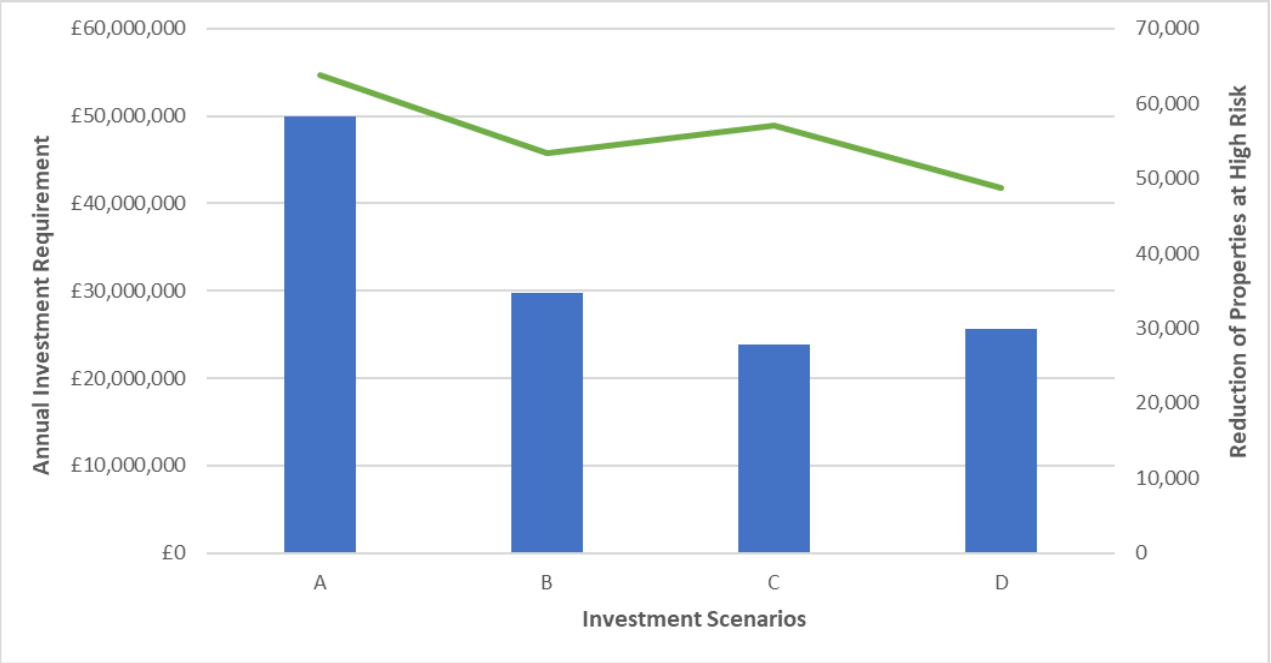


Figure 8- Investment Scenarios - Annual investment requirements and the reduction of properties at high risk.



Comparing Scenarios – Economics

Every scenario assessed is economically viable to implement. The benefit of the investment significantly outweighs the costs with every £1 spent returning between £2.80 and £13.10 of benefit depending on which scenario is implemented.

The ETS identifies £1.8bn costs across the appraisal period for Scenario A. For assets within the ETS, £1bn of the Scenario A costs are on defended areas which are not economically viable, but they would protect over 33,000 properties.

Scenario A requires 3.4 times current funding levels.

There are challenges to keeping pace with climate change everywhere as there are many defended areas (79) where there are no properties benefitting. Plus, an additional 163 that only have between 1 and 10 properties within them. These defences are included in the costs and total almost £300m across the appraisal period.

If the funding is not made available for keeping pace everywhere, we begin to look at Scenarios B and C, both of which limit investment either by assessing economics (B) or the likely impacts (C). Both scenarios lead to an increased number of properties remaining in the high-risk category (B – 10,420 C – 6,682) and an increase (~£450m) in residual damages when compared to Scenario A.

For Scenario B, only 13% of defended areas are proven to be economically viable to keep pace with climate change. However, these assets protect 81,985 properties

which is over 70% of the total properties at risk. Where it is not viable to keep pace with climate change, it is deemed economically viable to maintain defences at 39% of defended areas (10,970 properties).

For the remaining 48% of defended areas (22,343 properties), no funding is provided as it is uneconomical to do so in this scenario.

For assets within the ETS, Scenario B requires a 40% increase on current funding levels.

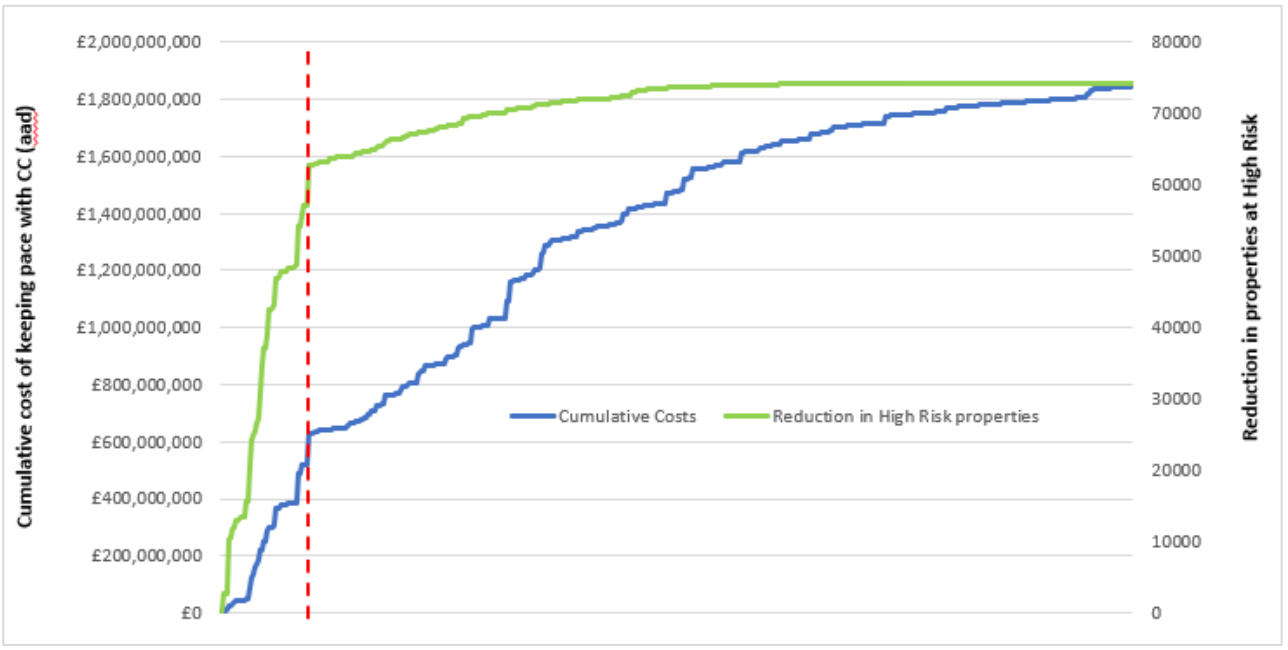
Scenario C provides slightly better results than Scenario B. But this scenario has similar disadvantages as Scenario A in that communities keep pace with climate change regardless of economics. These communities will be the most at risk by the end of the appraisal period, but they are not all economical to keep pace with climate change.

Scenario D assess what could be done using current funding levels across the appraisal period. NRW would prioritise its funding to maintain existing assets before looking at increasing protection. Scenario D therefore maintains all assets, and then uses the remaining funding to keep pace with climate change where possible. In Scenario D, 12% of assets are given the required funding in order to keep pace with climate change. Defence crest levels are raised to maintain current SoP and condition grades remain at a set standard. These assets protect 62% of the total properties at risk within defended areas.

When comparing current funding levels with the most favourable scenario (A), an additional 18,089 properties will remain at High Risk, with an increase of approximately £800m in residual damages.

Figure 9 shows a clear change in the relationship between costs and the reduction of properties at risk. On the left-hand side, approximately £600m is required to reduce the number of properties at high risk by almost 60,000. However, as the right-hand side illustrates, in order to reduce the risk to the next 10,000 properties, a further £1bn of investment is required.

Figure 9 - Investment requirements and the reduction of properties at high risk due to keeping pace with climate change (with defended areas ranked by risk)



Conclusions

Flood defences play a vital role in protecting communities from flood risk and the future effects of climate change. The results demonstrate how essential maintaining and improving assets is, and that in future, keeping pace with climate change is the most effective way of reducing properties at risk.

Addressing the flood risk created by future climate change projections across Wales will require a 3.4 increase to current funding levels.

If these funding levels are not achievable, then certain criteria such as economics and risk can be applied to prioritise efforts and reduce the cost. However, reducing the investment inherently leads to a greater number of properties at risk.

Investing in economical assets only, would require a 40% increase in funding levels. Focussing investment in the most at-risk communities only is another option that could be introduced. It would require a similar increase in investment, however some of the communities in question would not be economical to invest in.

Although a marked improvement from the Do-Nothing scenario, continuing with current funding levels into the next 100-years would lead to thousands of homes becoming high risk from tidal and fluvial flooding.

All of the Investment Scenarios evaluated within this study are economically viable as the benefits significantly outweigh the costs of implementing them. But caution must be taken when looking at the benefits. The most at-risk locations with the highest numbers of properties always receive investment regardless of the scenario implemented. These locations account for a large proportion of the properties at risk (and therefore economic benefits), and this leads to the benefits of every scenario being very similar. Therefore, the main difference between the scenarios is what to do with the remaining defended areas with limited properties and economic benefits.

Only 13% of defended areas are proven to be economically viable to keep pace with climate change, yet these assets protect 82,000 properties (70% of the total properties at risk). Further, it is deemed economically viable to maintain defences at 39% of defended areas and these assets protect 10,970 properties (10% of the total properties at risk). The remaining 48% of defended areas protect 22,343 properties (20% of total risk) but are uneconomical when assessed nationally.

With defended areas ranked by risk (Figure 9), the first £600m of investment will reduce the number of properties at high risk by approximately 60,000. The next £1bn only adds 10,000 properties to this. This is why the results of the scenarios are so similar. The high-risk locations will always be beneficial to invest in as the bulk of the properties at risk are within them.

The decisions lie with how to address the risk posed to the remaining properties (the 22,343 mentioned above) that do not have the same economical backing. Given the

geography of Wales, with many isolated rural communities and a lack of big urban areas with commerce and industry (and therefore economic damages), we are left with decisions to make on defended areas that are economically unviable. Other options to address the risk such as relocating residents would be extremely costly and politically sensitive but should also be considered alongside the cost and benefits of this option.

All elements of the results must be assessed together as some may be misleading when looked at individually. For example, Scenario D (current funding levels) has the highest benefit for every £1 spent, but it also has the highest number of properties left at high risk. Scenario A is overall cost beneficial, yet hundreds of uneconomical assets will receive funding based on the benefits of defending highly populated areas elsewhere.

It is important to recognise the benefits provided by the Do-Nothing baseline. The majority of assets are currently in good condition. For the first 20-25 years of this appraisal, there is limited variance between the three measures. The chances of a breach, whilst possible, are not high and therefore until climate change is applied and begins to reduce the SoP of defences, Do Nothing is not significantly worse than the other measures. Recent floods corroborate this as we rarely see breaches, only overtopping. This would not be the case if assets were starting the appraisal period at a lower condition grade and therefore previous investment to date should be acknowledged.

Although the data shows that Climate Change does not have a significant impact on damages until later in the appraisal period, it is important to clarify that this does not mean that we can wait. Large scale construction schemes and adaptation strategies take years of planning, as does securing long term budgets. Work will need to be staged, otherwise in the later stages of the appraisal period, we will be faced with a substantial programme of projects all requiring funding at the same time.

Regardless of the scenario, residual damages remain. This shows that flooding cannot be stopped, only managed. Although flood defences have a large part to play in protecting communities, they cannot be the sole focus. A range of other activities are necessary to complement the benefits provided by flood defences.

Some of the main conclusions are summarised in the infographic in Appendix 1.

Appendix 1 – Infographics: Main Conclusions and Scenario Results

Long term investment requirements

Keeping pace with climate change and continuing to maintain and invest in flood defences will be the most effective way of reducing the number of properties at risk of flooding in Wales over the next century, but some locations may not be economical to defend.

Cyfoeth Naturiol Cymru
Natural Resources Wales

Over the next 100 years

3.4
times current funding levels would be required to keep pace with climate change

£2.80 to £13.10
return on every £1 invested across all scenarios

13%
of defences are proven to be economically viable to keep pace with climate change

70% (81,985)
of the total properties at risk would be protected by the 13% of economically viable areas

22,000
properties would be uneconomical to invest in

While the work will come at a cost, the economic benefit of investment outweighs the costs of delivering the work.

Every £1 spent returns between £2.80 and £13.10 of benefit depending on which scenario is implemented.

High-risk locations in Wales will always be beneficial to invest in as the bulk of the properties at risk are located in these areas.

However, over 22,000 properties are uneconomical to invest in over the next 100 years.

Certain locations may not be cost-effective to invest in over the next 100 years. When investment is focused solely on economical locations, only 13% of defended areas are proven to be economically viable to keep pace with climate change.

However, 70% (81,985) of the total properties at risk across Wales are located within these defended areas.

Regardless of the scenario implemented across the 100-year appraisal period, residual damages remain. Flooding cannot be stopped, only managed.

While maintaining and investing in flood defences to keep pace with climate change has a large part to play in reducing the risk to these communities, they cannot be the sole focus. Wales will need to look at a multi-faceted approach to manage increasing flood risk in the future.

Nature and people thriving together

Scenario A

Keeping pace with climate change everywhere

In this scenario, there are no limitations on funding. All assets would keep pace with climate change. Implementing this scenario would require a total investment of £5bn over the next 100 years.

Cyfoeth Naturiol Cymru
Natural Resources Wales

£26.6bn
benefits (the economic damages avoided due to flood defences being in place)

63,811
reduction of properties at high risk

£7.2bn
residual damages (the remaining economic damages after interventions have been put in place)

£50m
annual investment requirement

3.4
times current funding levels required to implement this scenario

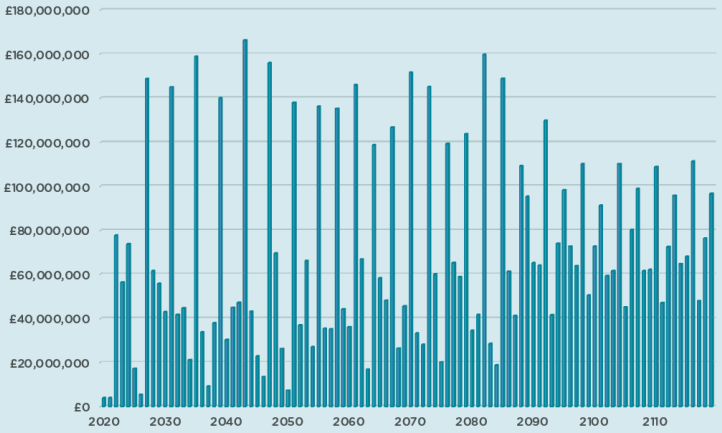
56%
of costs are invested in defended areas that are not economically viable to do so

£100m
is spent on defences that aren't protecting any properties

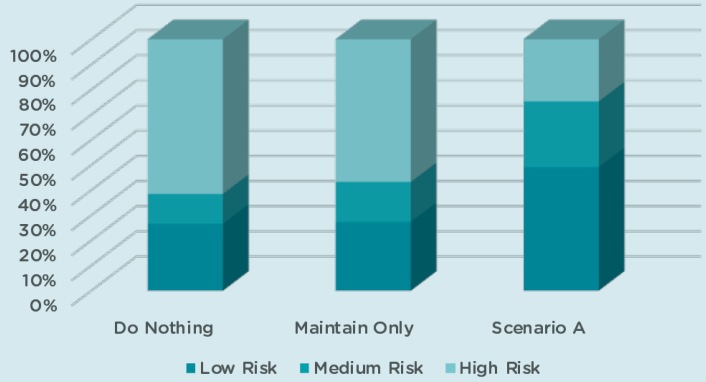
33,000
properties that are deemed uneconomic are still being protected in this scenario

£2.80
of economic benefit for every £1 spent

Cost profile



Likely flooding to residential properties



Scenario B
Investing in economic assets only

In this scenario, funding is focused on economics. Only 13% of defended areas are economically viable to keep pace with climate change. However, these defences protect 70% of the properties at risk across Wales. Implementing this scenario would require a total investment of £2.2bn over the next 100 years.

Cyfoeth Naturiol Cymru Natural Resources Wales

£26.32bn
benefits (the economic damages avoided due to flood defences being in place)

53,390
reduction of properties at high risk

£7.6bn
residual damages (the remaining economic damages after interventions have been put in place)

£22m
annual investment requirement

40%
required increase on current funding levels for defences within the FRAW Economic Tool Set

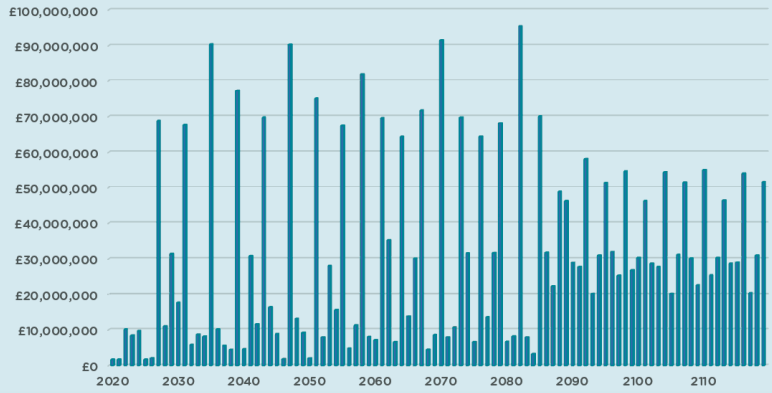
13%
of defences are proven to be economically viable to keep pace with climate change.

48%
of defences would receive no funding as it's uneconomical to do so. These defences protect 22,343 properties

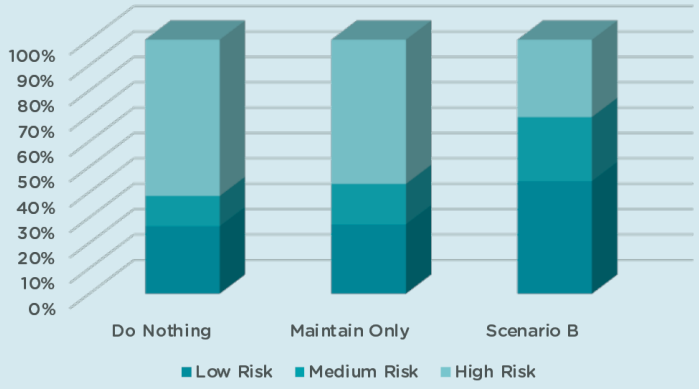
70%
of the total properties at risk across Wales (81,985) are protected

£11.90
of economic benefit for every £1 spent

Cost profile



Likely flooding to residential properties



Scenario C

Focusing investment on the most at risk communities

In this scenario, funding is focused on risk. Only the 100 most at-risk communities are invested in, however these protect 74% of the properties at risk across Wales. Implementing this scenario would require a total investment of £3.1bn over the next 100 years

Cyfoeth Naturiol Cymru Natural Resources Wales

£26.2bn
benefits (the economic damages avoided due to flood defences being in place)

57,129
reduction of properties at high risk

£7.6bn
residual damages (the remaining economic damages after interventions have been put in place)

£23.8m
annual investment requirement

70%
required increase on current funding levels for defences within the FRAW Economic Tool Set

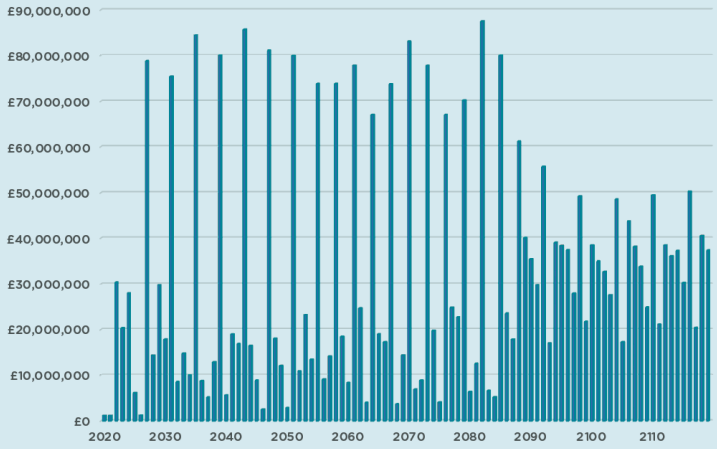
14%
of communities at risk areas are given the funding to keep pace with climate change

128,000
properties would keep pace with climate change

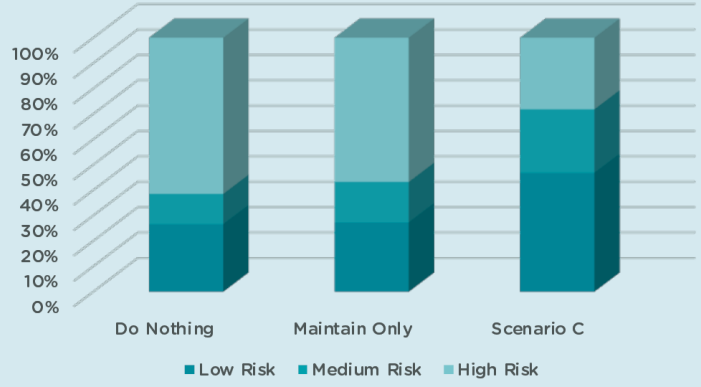
44,581
properties across Wales would not benefit from any investment

£5.30
of economic benefit for every £1 spent

Cost profile



Likely flooding to residential properties



Scenario D

Current funding levels remaining constant

This scenario is focussed on current funding levels being applied across the appraisal period. Only 12% of defended areas are given funding to keep pace with climate change. These protect 62% of the properties at risk across Wales. Continuing with current funding levels requires £1.97bn of investment over the next 100 years.

Cyfoeth Naturiol Cymru Natural Resources Wales

£25.9bn
benefits (the economic damages avoided due to flood defences being in place)

45,721
reduction of properties at high risk

£8bn
residual damages (the remaining economic damages after interventions have been put in place)

£19.7m
annual investment requirement

12%
of defences are funded to keep pace with climate change

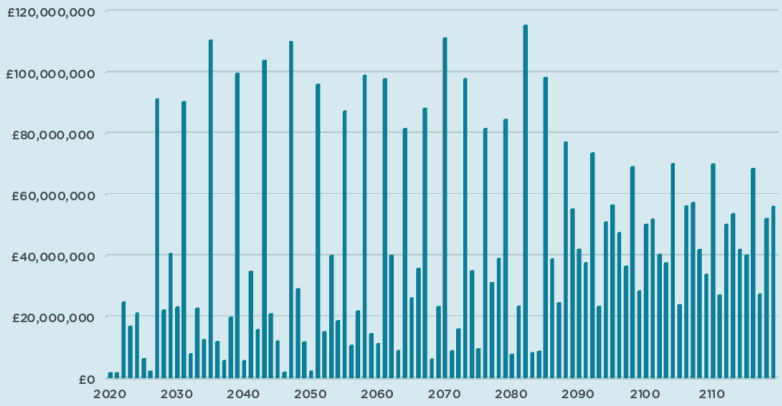
62%
of properties at risk nationally are protected.

18,809
properties would remain at high risk when compared to the most favourable scenario (A)

60,553
properties would remain at high risk (the most of all the scenarios)

£13.10
of economic benefit for every £1 spent

Cost profile



Likely flooding to residential properties