BASE BOTTOM-UP CLIMATE ADAPTATION STRATEGIES TOWARDS A SUSTAINABLE EUROPE

SEVENTH FRAMEWORK PROGRAMME

UNIVERSITY OF EXETER

Subgroup: Coastal cases

Case-study: South Devon Coast

(University of Exeter, UK)

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Purpose of this document:

"The Case Studies Living Document (CSLD) will be the document that each case study leader will use to share the information that (i) characterize and give context to its case study, (ii) the goals within BASE, (iii) the methods used and mainly (iv) a synthesis of the results that that case study is providing to BASE project. This will allow the CS leader to understand how its own case is going (having a good overview), but also (v) will allow the sub-group to which the case study belong to know what is happening and what can be done (mainly on synergies and so on) as well as to (vi) WP4 & 5 coordinators to use that information to report (including each WP task leaders). These living document will also (vii) allow WP6 & 7 partner to know the information."

Index

1. General Case Study Description

A. Location

The location is in the Southwest of England, at the coast along South Devon from the town of Teignmouth (at the relative southwest), including the town of Dawlish, through Dawlish Warren (at the relative northeast). The geographical coordinates of Dawlish are: latitude 50°34.8708' N, longitude: 3°27.9864' W.

GPS: N 50°34.8708 / W 3°27.9864'
Area: the coast along about 10 km

B. Case Study Summary

(Máx 500 words)

The South Devon Coast, located in the South West of England, is an important area for tourism; it includes sites with heritage and nature conservation, and it provides some sites with exclusive housing/residential areas. In addition, it includes some important infrastructure connecting the South West of England to larger cities such as London. This study focuses at the coastal area stretching from the town of Teignmouth (at the relative southwest), including the town of Dawlish, through Dawlish Warren (at the relative northwest); covering a length of about 10km. Provision of housing/residential areas, infrastructure and tourism, and heritage and nature conservation are already under pressure from coastal erosion and sea and river flooding (e.g. the town of Teignmouth is located at the mouth of the river Teign), a situation which will be exacerbated by climate change.

The recent extreme events at the coast at Dawlish (February 2014), which severely damaged the sea wall and the railway, increased the risk of flooding for the houses behind the sea wall, and disconnected the railway connection of the southwest of England to the rest of the country, demonstrate these pressures. Moreover, due to the geomorphological setting of rocky/cliff shores at the South Devon coast, options for managed flood plains, or for example dikes, or managed realignment of the coast are limited which presents further challenges when considering and developing climate change adaptation pathways. Climate change adaptation at the Dawlish coast has been topic of discussion. As adaptation it is a very complex issue at this location, several groups have formally and informally attempted to outline the main issues and several options. But a formal adaptation strategy has so far been absent. In general, after the recent extreme events at the Dawlish coast, we can diagnose that – as far as there have adaptation actions – these have been clearly insufficient to prevent severe disruptions such as severe flood risks and infrastructure disconnections.

C. Context

(Máx 500 words) *If relevant to the understanding of the Case Study , please provide any contextual information of the region, history, etc of the case study*

In order to increase our understanding of barriers and enablers to climate change adaption, we will study two local case studies of climate change adaption in Southwest England. In one of our two case studies, i.e. Dartmoor National Park, a climate change strategy has been developed in 2011. In the other case study, i.e. the South Devon Coast from Dawlish Warren to Teignmouth, this has not been done yet. This study focuses on identifying

current discussions on climate change adaptation in this area, identifying who is involved in which way, identifying which potential risks and vulnerabilities are discussed and which not yet, and who is and/or will be in charge for which type of adaptations. We will focus on the understanding of barriers and enablers in:

- the relationship/dynamics between local initiatives and higher level policy frameworks;
- the relationship with other relevant policy fields (e.g. is climate change adaption integrated in other relevant policy topics such as nature conservation, agriculture and infrastructure, and if so, how?);
- the role of participation (i.e. of local/regional non-state actors in policy making for collective goals);
- the role of knowledge use (e.g. to deal with uncertainties due to variability or due to lack of knowledge).

Also included in our study are evaluating the role/relevance of economic assessments (e.g. does insight in cost-benefit analysis help in decision-making on climate change adaption?), and the role/relevance of adaption pathways (e.g. does insight in adaption choices help in decision-making on climate change adaption?).

D. Brief General Information on Climate CHANGE and related issues

(Máx 2000 words) *Please state which is the European climate zone of the case study and insert any information regarding the current available information regarding the case-study, namely expected impacts, scenarios.*

The current climate for the Southwest of England depends on several factors including altitude and distance to the sea. The Met Office keeps records of climate characteristics such as rainfall, sunshine and temperature. Information can be found here:

- http://www.metoffice.gov.uk/climate/uk/regional-climates/sw
- http://www.metoffice.gov.uk/media/pdf/n/9/Fact_sheet_No._14.pdf

>> Current climate for the coastal area to be summarise here.

The regional government is expecting climate change impacts for this area. Recent trends of temperature rise – resulting into milder, wetter winters, and hotter, dryer summers – and of sea level rise are expected to continue for this region (http://www.devon.gov.uk/index/environmentplanning/climatechange/climate-strategy.htm).

Climate Predictions

The main climate changes for the region are forecast to be longer, warmer summers (with a longer tourist season), and milder winters (CSW 2010).However, the region is also predicted to be more susceptible to episodes of extreme weather events from longer and more frequent periods of drought, to more intense precipitation events associated with more intense winter storms, and longer and hotter heat wave events (Devon County Council, 2005). Modelling suggests 1 in 100 year storm surges events on parts of the South Devon coast could increase to a 1 in 20 year

probability by the latter half of this century,due to rising sea levels and predicted increases in winter storm intensity (Devon County Council, 2005).

According to Climate South West (2010) there is already some evidence of climate change in the region. Between 1961 and 2006, for example, average daily temperatures increased by 1.37°C, with the number of days of air frost decreasing by 20.9 days. Over the last couple of decades there have also been several episodes of extreme high temperatures. In addition there has been a small reduction in total summer precipitation of 8.8% in the same period. Further changes include a 5% increase in total winter precipitation stemming from heavy precipitation events, and increased frequency of floods and droughts. Finally sea level in the region (corrected for land movement) has risen by around 1 mm/yr over the 20th century, with some indications that the rate of increase has become more pronounced since the1990s. The isostatic sinking of the South West land mass (where land levels are generally getting lower through time) is likely to exacerbate the effects of a rising sea level.

Climate impacts

The coastal line if the South West is a vital asset to the region. It helps to attract over 21 million tourists a year to the region, comprising as it does of approximately half of the UK's designated bathing beaches. Tourism is a main pillar of the region's economy, with visitors spending over spending over £9 Billion a year and supporting about 200,000 full-time jobs in the South West (CSW 2010). A survey of tourism businesses in the South West found that 56% had been affected by extreme weather events in the past (CSW 2010).

According to Climate South West (2010) and Devon County Council (2005) key projected climate impacts on the coast are:

- Rising sea levels, and changes to coastal dynamics with the potential for increased wave heights which will increase coastal erosion and damage coastal amenities.
- Natural assets such as beaches, wetlands, mudflats, salt marshes and dunes will be more vulnerable to loss and damage including associated flora and fauna.
- Protecting or relocating coastal assets may be too costly. However, due to the hard geology and steep topology of the coast, there are few opportunities for managed retreat.
- Heavy rainfall can mean that harmful organisms and chemicals can be rapidly washed into the sea which may impact upon bathing water quality.
- Predicted extreme high temperatures in Mediterranean and other overseas tourism destination could boast domestic and international tourism to the South West as visitors look for a more comfortable climate for their holidays. While providing a positive boast to the local economy, the extra visitor numbers will increase pressures on the natural environment, attractions, services and utilities

E. Existing Information on Case Study's adaptation history

(Máx 2000 words) *Please insert a Short resume of the Case study existing information related to Climate Change Adaptation (major goals, plans, measures and timelines already defined or implemented), important Milestones in its "Adaptation Journey" as well as relevant state-of the art regarding the implementation of Adaptation Strategies and Specific Measure*

A formal climate change adaptation strategy to deal with the issues at the South Devon Coast has so far been absent. In general, after the recent extreme events at the Dawlish coast (in February 2014 – see below), we can diagnose that – as far as there have adaptation actions – these have been clearly insufficient to prevent severe disruptions such as severe flood risks and infrastructure disconnections.

Adaptation at the South Devon Coast is currently (i.e. February-March 2014) a hot topic of dicussion, though not under the heading of climate change adaptation, rather under the discourse of responding to coastal dynamics. Overal, the current discussion mostly focuses on advantages and disadvantages of options to reroute the railway, which links the South West of England to London and which currently runs along the cliff base. Flood risk management appears to be a minor issue in the current discussion in comparison to the attention that is given to the infrastructure connection. Although flood risk management is not a hot topic in the current discussion about this part of the coast, there are several management plans that address the flood risks in the area of our case study. In terms of addressing issues under the heading of climate change adaptation, a strategy was developed for the county of Devon in 2005 by the Devon County Council. In principle, this climate change adaptation strategy includes the coastal area between Dawlish Warren and Teignmouth, but this strategy is proposed in general terms for the whole county of Devon, and not specified to different locations.

Railway connection

The railway line along the coast at Dawlish provides an important infrastructure connection between Cornwall and the west of Devon, and London and the rest of England. It's usual that the railway is closed every year in winter for a short while to repair damages due to high and strong waves, and the discussion of how to adapt this part of the railway has been ongoing for several years and focuses on options of rerouting and/or maintaining the current train line.

However, this years' storms (in February 2014) have led to very heavy damage to the railway rendering it unusable, with repairs expected to take more than two months (until Easter 2014). The vulnerability of this part of the railway has been exposed as the Achilles's heel in the connection between Cornwall and London. A BBC news item mentions that according to the Chambers of Commerce in the region, "the South West Economy is losing £20 a day as a result of the track being destroyed" (http://www.bbc.co.uk/news/uk-england-26349928).

This years' severe damage to the railway has sparked the discussion again on the long term viability of the railway. The current discussion does not relate the impacts or the options to climate change, or connect it to flood risk management, despite the obvious connections. The Department for Transport, Network Rail (the government owned company in charge of managing the UK's railway infrastructure), various transport experts and the Devon County Council play an important role in the current discussion.

A news item from 2 March 2014 from the BBC mentions that the Department for Transport has asked Network Rail "to look at options for Dawlish including a review for securing the coastal line and the feasibility of

alternative routes" (http://www.bbc.co.uk/news/uk-england-26407806). Network Rail is expected to report back a first proposal around June/July 2014, and formally in autumn 2014. On 19 February 2014, Network Rail preliminary/tentatively identified the following options:

a) "Reinstate the Okehampton line (between Plymouth-Exeter, via Okehampton), which closed in 1967

b) Create a new line connecting existing freight lines from Alphington (near Exeter) and Heathfield (near Newton Abbot)

c) Options between Newton Abbot and Exeter (with new tunnels) – but current level of trains via Dawlish route could be maintained

i) Exminster – Newton Abbot

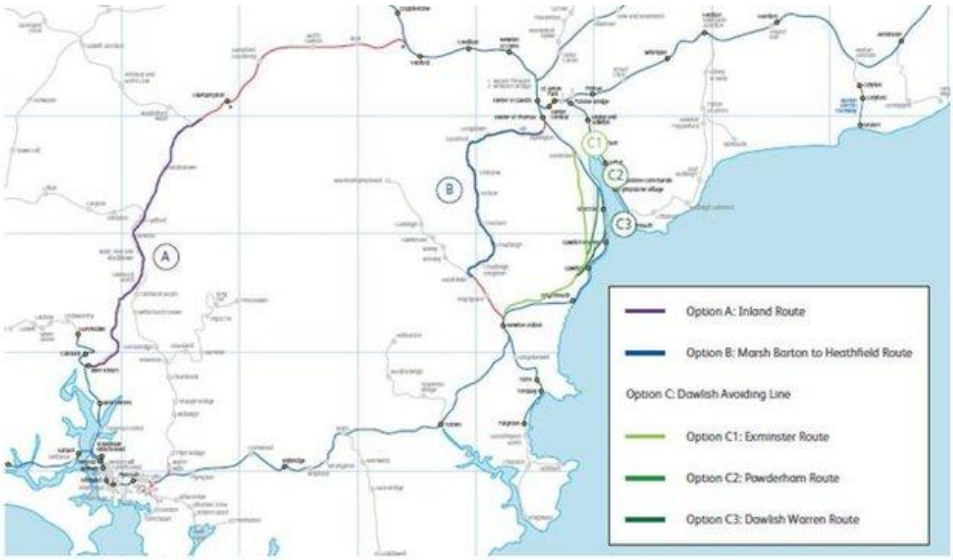
ii) Starcross – Newton Abbot

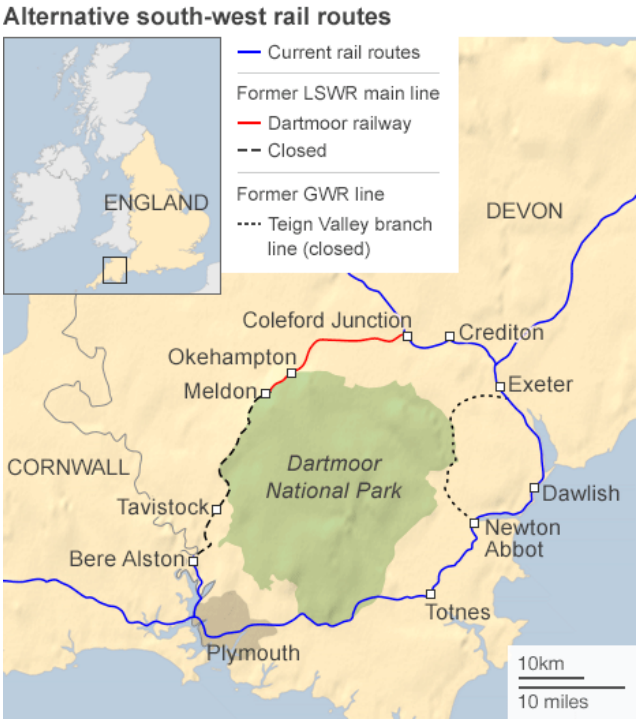
iii) Dawlish Warren – Newton Abbot

d) Make the coastal railway more resilient"

(http://news.bbc.co.uk/1/shared/bsp/hi/pdfs/26_02_14_dawlish_jmo.pdf)

The two figures below are used in the discussion of the future of the Dawlish railway line and sketch the different options (the pictures below are taken form this BBC website, original sources unknown: http://www.bbc.co.uk/news/uk-england-26349928).





Floodrisk management

A "Shoreline Management Plan 2" should be in place for the coast from Durlston Head in Dorset through Rame Head in Devon, which includes the piece of coast between Dawlish Warren through Teignmouth. The Environment Agency is the responsable authority for the Shoreline Management Plans. A draft of this Shoreline Management Plan 2 (the Shoreline Management Plans 2 are updates of the Shoreline Management Plans 1) has been proposed in September 2010. The current status of this Shoreline Management Plan 2 is not entirely clear. In the draft from 2010, 2 types of action are proposed for the area between Dawlish Warren and Teignmouth, whereby proposed types of action may change over three time periods, i.e. short term to 2025, medium term to 2055, and long term to 2105 (SDCADCAG, 2010, pp. 21-22):

- "Hold the existing defence", i.e. maintain or change the level of protection provided by defences in their present location.
- "Managed realignment", i.e. allowing the shoreline position to move backwards (or forwards) with management to control or limit movement.

For most of the locations between Dawlish Warren and Teignmouth, the action of "hold the defence line" is proposed in this plan (i.e. "policy unit 6b20" through "policy unit 6b30"). For 3 sites at Dawlish Warren (policy units 6b20, 6b21 and 6b22), and 1 site in Teignmouth (policy unit 6b29) "hold the defence line" or "managed realignment" are proposed for the medium and long term time periods.

The options of "Advance the existing defence, i.e. build new defences on the seaward side of the existing defence line to reclaim land" and "No active intervention, i.e. a decision not to invest in providing or maintaining defences" are not proposed for the area between Dawlish Warren and Teignmouth.

Two river basin flood risk plans address parts of our case study. The first is a flood risk management plan for the "South Devon Catchment" that has been issued by the Environment Agency (issued in December 2009). This flood risk plan proposes preferred policies for several sub-areas; in one of the sub-area the town of Teignmouth

is included (which is the western tip of the stretch of coast we study). Concerning the area which covers Teignmouth, this plan refers to the need to adapt to anticipate climate change impacts, which is expected to lead to sea level rise and increasing frequency and depth of future flooding (Environment Agency, 2009). It also refers to the Shoreline Management Plan to reduce flood risk overall. For the area which includes Teignmouth, the plan proposes the following "...actions to implement the preferred policy:
- System Asset Management plans and performance specifications will be produced for all our flood risk systems and major assets. These will assess flood risk maintenance with the aim to reduce flood risk in the policy unit and will include environmental constraints and targets.
- We will investigate options to reduce flood risk to settlements around the estuaries. This should include habitat creation or enhancement to contribute to Devon's Biodiversity Action Plan targets.
- We will identify locations where tidelocking of tributaries is causing problems. We will investigate, and where appropriate implement solutions (for example at Bitton and Brimley Brooks in Teignmouth).
- Produce community flood action plans in Dartmouth and Kingsbridge to reduce flood risk through engagement of the local community." (Environment Agency, 2009, p. 21).

The second is a flood risk management plan for the Exe Estuary that has been proposed by a consortium of partners including the Environment Agency (drafted in August 2013). This plan proposes flood risk strategies for several sub-areas, including Dawlish Warren and the town of Dawlish (which are located at the eastern part of our case study area). For the sub-area of Dawlish Warren, the plan proposes: "Continued maintenance of the coastal revetment and wave wall at the near end. Groyne maintenance, local ground raising and removal of some existing gabions are alsoecommended in the period up to 2030. This will provide protection for Dawlish Warren village and for the tourist and environmental interests. Beach recharge and recycling will improve the quality of the beach and help it to act as a natural wave barrier into the medium term (towards 2060). Between 2030-2110 the coastal revetment will need to be maintained and improved, with the sand spit being allowed to evolve naturally." (Environment Agency, 2013, 15). It also includes the following consideration: "It is predicted that that towards 2060 continued engineered control of the sand spit will become too difficult and costly. We also then expect the sand spit will partly lose its sheltering function, requiring further defence improvements within the estuary. Some of this work will require local partnership funding." (Environment Agency, 2013, p. 15). And it also refers to coordination with the Shoreline Management Plan: "The Strategy agrees with the South Devon and Dorset Shoreline Management Plan 2 policy for Policy Units 6b19 in the short term and extends it to the medium and long terms. For Policy Units 6b20 and 6b21 the Strategy changes the policy from Hold the Line in the short term to Managed Realignment. The policies for the medium and long terms are now Managed Realignment and No Active Intervention respectively. (Note that policies for Dawlish Warren sand spit for the medium and long terms were not previously determined)." (Environment Agency, 2013, p.15).

For the sub-area that covers the town of Dawlish, this flood risk plan proposes: "Improvements to the mainline railway revetment in the short term. Network Rail is carrying out its own studies to develop the approach to this, which the Strategy supports. Resilience works for local properties, adjacent to where Dawlish Water discharges to the sea, will be required between 2030-2110 to keep pace with climate change. The improvement works would improve protection and reduce operational impacts on the mainline railway, and limit tidal flood risk to property into the future." (Environment Agency, 2013, p. 16). It also gives a consideration: "The drainage of low-lying areas, particularly during tide-lock, and the flood risk to properties due to groundwater are also of concern, and the Strategy recommends further detailed studies on these." (Environment Agency, 2013, p. 16). And as coordination to the Shoreline Management Plan, it says: "The

Strategy agrees with the South Devon and Dorset Shoreline Management Plan 2 policy in the short to long term of Hold the Line for Policy Units 6b22 to 6b23." (Environment Agency, 2013, p. 16).

Climate change

The climate change adaptation strategy for the county of Devon included objectives such as: to undertake a climate impact assessment for Devon for the short and medium term; to review and update the Council's emergency/contingency plans for all vulnerable locations in the light of recently experienced weather-related hazards; to ensure that when unexpected, unusual or extreme weather events cause problems the post hoc restoration is climate-proofed for the next 50 years against potentially more extreme events and the lessons learned are applied where practicable to similar locations countywide; and, to climate-proof strategies, policies, programmes and plans that come up for review, infrastructure upgrades, maintenance regimes and new fixed infrastructure that has a life of 20 years or more against projected changes in climate over the next 50 years (Devon County Council, 2005, p. 80). It further proposed 5 adaptation principles (Devon County Council, 2005, p. A5-6): 1. adaptation should focus on seasonal extremes and short duration hazards for the period to 2040; 2. climate events of the recent past should be used to identify potential adaptations required over the next 20 years; 3. all adaptation measures should be climate-proofed for a minimum of 50 years; 4. long-term business/investment decisions (i.e. + 30 years) must take into account changes in mean climate; and 5. the business case for long term adaptations must use the precautionary principle as the basis for action.

Noticeable is that it states about storm surge events: "There is no evidence for a long-term change in UK storm surge statistics." (Devon County Council, 2005, p. 23) as well as "Whilst the tidal range will continue to be highest on the north coast, higher storm surges are likely to occur on the south coast increasing in height in an easterly direction. For Start Bay a current 1 in 200 year extreme storm surge event will become a 1 in 20 year probability by the end of the century." (Devon County Council, 2005, p. 50). And that it expects relative more sea level rise at the coast: "For the South West the present rate of subsidence is estimated at between 0.1 and 1.4 mm/year. Therefore, it is likely that relative sea level rise along the coasts of Devon has been greater than the average sea level rise around the coast of Britain over the 20th century i.e. +0.1 metre." (Devon County Council, 2005, p. 31).

The Environment Agency in Exeter hosts and facilitates an initiative on climate change adaptation called 'Climate SouthWest' (started in early 2010, which succceeded the South West Climate Change Impacts Partnership whihc started in 2001). Climate SouthWest aims: "to raise awareness of the impacts of climate change, inform and advise on the challenges and opportunities of climate change in SW England, and develop practical adaptation responses. Our focus is to look at the effects and impacts of climate change in the South West and develop adaptation responses across a number of priority sectors. We influence the strategies and plans of key partners and work with stakeholders to enhance the region's resilience to the impacts of climate change." (quote from their website http://climatesouthwest.org/about). They identify that coastal change is one of the five key themes in climate change impacts in the region, and state that coastal change is expected in terms of "sea level rise and erosion impacting on business, people, property, transport (e.g. coastal railway at Dawlish) and wildlife" (quoted from: http://climatesouthwest.org/impact-on-the-south-west). Though, as far as their website informs, they don't run or plan to run a coastal project.

Summary

In summary, climate change adaptation of this coastal area is addressed in a fragmented way. The current discussion about how to adapt this coastal area to current and expected challenges focuses on adaptation of the railway connection, and does not link it climate change and flood risk management. Several options to adapt the railway are currently being considered and a decision about it has not yet been made. Although not part of the current discussion, flood risk management is being addressed by several flood risk management in this area plans developed by the Environment Agency, such as the flood risk plans for the Exe Estuary, the South Devon Catchment and a Shoreline Management Plan. Furthermore, two policy initiatives (one by the Devon County Council and one by the Environment Agency) address climate change adaptation in the Devon area, and mention coastal issues, but are not specified to adaptation around the Dawlish coastal area.

F. Connection with other research projects:

(Please list and shortly describe previous or ongoing research projects directly related with the Case Study) Please write the name and summary of the project, relevant partner institutions, year of beginning and end of project)

There are no immediate relations with other ongoing research projects. It does build onwards on the work of David Dawson (2012), who wrote a dissertation on the impact of sea-level rise on the London-Penzance railway line. It might also connect to the "MAGIC" project, which looks at multi-scale adaptation to global change at the coast, and includes a case study in North Cornwall.

G. Case ID, Typologies and Dimensions

Having in mind the following BASE Objectives; Categories of Case Studies, please fill in the following table.

BASE OBJECTIVES
1. Compile and analyze data and information on adaptation measures, their effectiveness. (…)
2. Improve current, develop new and integrate methods and tools to assess climate impacts, vulnerability, risks and adaptation policies (…).
3. Identify conflicts and synergies of adaptation policies at different levels of policy making with other policies (including climate mitigation) within and between sectors. (…)

4. Assess the effectiveness and full costs and benefits of adaptation strategies to be undertaken at local, regional, and national scales using innovative approaches (mainly by integrating bottom-up knowledge/assessment and top-down dynamics/processes) with particular attention on sectors of high social and economic importance.

5. Bridge the gap between specific assessments of adaptation measures and top-down implementation of comprehensive and integrated strategies.

6. Use and develop novel participatory and deliberative tools to enhance the effective use of local contextualized knowledge in adaptation strategies to assess perceptions of adaptation pathways and their co-design by citizens and stakeholders.

7. Disseminate findings by sharing the results of the project with policy-makers, practitioners and other stakeholders. (…)

CASE STUDIES CATEGORIES

A. Public administration (municipality, regional, national, european)
B. Research and education Centres (universities, research centres, projects and groups, schools)
C. Public companies
D. Companies (farms, SMEs, big businesses)
E. Social enterprises (cooperatives, non profit companies, woofing farms, etc)
F. Consortiums (partnerships, campaigns),
G. NGOs (environmental NGO, local development NGO, charities, etc)
H. Transition Initiative
I. Ecovillage
J. Informal groups, Movements

Case ID			Typologies and characterization				
Country & Name of CS	BASE Objectives to be answered by the CS	Category of case study	Territorial zones	Scale	Process Direction	Temporal Definition	Timescale[1]
UK, South Devon Coastal Case	[v] Objective 1 [ ] Objective 2 [v] Objective 3 [V] Objective 4 [ ] Objective 5 [ ] Objective 6 [V] Objective 7	A. Public administration (municipality e.g. Teignbridge District Council, regional/county such as Devon County Council, national) C. Public companies (Environmental Agency) D. Companies (First Great Western, Network Rail, tourism sector)	[ ] Rural [ ] Urban [v] Coastal [ ] River Basin	[v] Local [v] Regional [v] National [ ] Transnational [ ] European /Global	[v] Bottom-Up [v] Top-Down	[ ] Retrospective [v] Prospective	2004 (start of Devon County Council Climate Strategy) – 2060??? (forecast Dawlish Warren)

[1] Please insert year of start and year of end of case study.

		G. NGOs (Devon Wildlife Trust)					

H. Impacts, Sectors and Implementation

Please tick the relevant boxes for impacts and implementation and insert the number 1 for primary sector and the number 2 for secondary sector.

Impacts		Sectors		Implementation	
Primary CC Impacts (Climate-Adapt)	Primary CC Impacts (BASE)	Primary and Secondary Sector (Climate Adapt)	Primary and secondary Sector (BASE)	Implemented[2]	Phase of Implementation[2]
[v] Temperatures [ ] Water Scarcity [v] Flooding [v] Sea level Rise [ ] Droughts [v] Storms [ ] Ice and Snow	[ ] Extreme temperatures [ ] Water scarcity [v] Flooding [v] Coastal Erosion [ ] Droughts [v] Soil Erosion [ ] Vector Borne Diseases [v] Damages from extreme weather related events (storms, ice and snow)	[ ] Agriculture and forest [ ] Biodiversity [1] Coastal Areas [ ] Disaster risk reduction [ ] Financial [ ] Health [2] Infrastructure [ ] Marine and Fisheries [ ] Water Management [ ] Urban	[ ] Agriculture [ ] Biodiversity & Ecosystems [1] Coastal and Marine systems [ ] Energy [ ] Health and Social Policies [2] Transport [ ] Production Systems and Physical Infrastructures [ ] Water resources [3] Tourism	[ ] Yes [ ] Ongoing [v] No	[v] Assessment [v] Planning [ ] Implementation [ ] Monitoring [ ] Evaluation

I. Importance and Relevance of Adaptation

Please tick the relevant box for the case study.

[ ] Case developed and implemented as a climate change adaptation measure

[v] Case developed and implemented and partially funded as a climate change adaptation measure

[v] Case mainly developed and implemented because of other policy objectives, but with significant consideration on climate change adaptation aspects

[2] When the case study consists of a public administration with a top down approach, implementation can be an approved legislation or regulation. When the case study is about practical adaptation measures like a sand dune, for example, implementation should be considered finished when the dune is built in situ.

2. Case study research Methodology

a) Research Goals

(Máx 500 words) *Please insert which are the General Goals for the case study as well as how will the case study contribute for BASE projects and BASE key research questions.*

Our study aims to characterise and understand current climate change adaption discussions and possible plan making activities, by identifying:

- positions and plans of several actors groups involved in relation to climate change adaption (including identifying who are in charge of what of which management of the South Devon Coast);
- current physical, social, economic and political barriers and enablers to adaptation;
- possible risks and vulnerabilities under scheduled and/or possible adaptation actions;
- and further possible adaptation pathways that could assist groups involved at the South Devon Coast in adapting to climate change (including identifying who would decide about these possible interventions and their implementation)?

Core research questions include:

1. Who are the key stakeholders involved in climate change adaptation at the South Devon Coast? These may include actors from various governmental bodies (local, county, national, …), and from various sectors (railway transport, tourism, nature and heritage conservation, citizen groups, …).
2. How can the institutional setting and decision making structure for making decisions on climate change adaptation be characterised in this case?
3. What are the key social (including cultural and historical), economic, political, and bio-physical enablers and barriers to shaping the understanding of climate impacts; and to subsequent adaptation planning activities within the studied area?
4. What are the current and/or coming climate change adaptation plans/pathways, and to which extent do these plans sufficiently address the risks, vulnerabilities and issues under pressure?
5. What possible adaptation pathways can (additionally) address the issues under pressure at the South Devon Coast, which have not been addressed yet by current or coming plans, or that may address these issues in a more effective/efficient/legitimate/equitable/… way.

b) Stakeholders involved

(Máx 2000 words) *Please insert any information about the stakeholders involved in the adaptation process with which you will relate to, namely their nature, involvement in the process, etc. If possible highlight the decision-making process as well as the leadership process for Climate Adaptation Strategies. Do Mention if there exists any kind of public engagement and participation within the Adaptation process.*

Actively involved:

- Environment Agency, governmental agency involved in developing and implementing a flood risk plan for South Devon (http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/gesw1109bouo-e-e.pdf).
- Climate SouthWest, identify themselves as independent partnership, affiliated at the Environment Agency, funded by Bristol Water, Wessex Water, South West Water, Environment Agency, Forestry Commission

England, The National Trust. Concerned with developing and implementing a climate change adaptation strategy.
- Devon County Council, regional government concerned with preparing the area for climate change.
- Met Office, national governmental office which collects and stores climate data, and makes predictions of climate change impacts.
- Teignbridge District Council, the local government who is in charge of the area from Teignmouth until Dawlish Warren.
- Devon Wildlife Trust, concerned together with the Teignbridge District Council, with preserving the nature conservation area Dawlish Warren.
- Dawlish City Council.
- First Great Western, the train company that provides the main service between the south west of England and the rest of the country, which runs along the Dawlish coast.
- Network Rail, who is in charge of the physical infrastructure of the railway tracks.

Affected, to be studied how they are involved (or not):
- Cultural heritage organisations? (Heritage Museum Teignmouth?)
- Organisations from the tourism industry?
- Citizen groups? (from the municipalities of Dawlish and Teignmouth?)
- ….

c) Methodology

(Máx 2000 words) *Please insert what will be your research approach regarding this case study, how did you define it (did it include participatory sessions or not) and how you will implement it during the BASE Project period.*

The study will be based on a stakeholder analysis and a policy making analysis to achieve an understanding of the planning process for climate change adaptation process. Also some economic analysis will be conducted to determine key costs and benefits associated with adaptation actions.

Data will be gathered through review of project documentation, and through semi-structured and structured interviews with key stakeholders. Additionally, focus groups will be held to further identify issues under pressure and possible adaptation actions.

The next research steps will include:
- Establishing a ‘quick scan’ impression of the issues, plans, processes, stakeholders and institutional setting, based on online documentation and on consulting experts with experience in this field (Michael Winter, Rob Fish, and Robert van de Noort).
- Further deepening the assessment by firstly gathering and reviewing project documentation, then by interviewing key actors.
- Further identifying possible issues under pressure, and developing and evaluating possible adaptation actions (and/or pathways) by means of running a (or several if needed) focus group(s).
- The evaluation of possible adaptation actions will also include a cost-benefit analysis, for which the next steps will be: identifying the main adaptation options for Dartmoor and Dawlish; then, identifying possible

impacts of those adaptation options; and then finding monetary costs and benefits for those impacts (most of this will probably be based on secondary data).
- Further identifying possible issues under pressure, and developing and evaluating possible adaptation pathways by means of running a (or several if needed) focus group(s).

Interview questions may focus on:
- Current concerns and expected impacts relating to climate change, concerning the interviewed actor;
- Expected possible risks, damages and costs (under different adaptation options), for/to the interviewed actor;
- Expected possible benefits or opportunities (under different adaptation options), for the interviewed actor;
- Current strategies and/or options to adapt to climate change, undertaken by/for the interviewed actor;
- Ideas/perceptions on what/which actions should be taken by collective/public bodies, and which are private responsibilities;
- What factors help or restrict their ability to adapt.

Project documentation to be consulted:

- Climate South West (2010). Warming to the idea: building resilience to extreme weather and climate change in the South West. www.oursouthwest.com/climate
- Devon County Council (2005). A Warm Response, Our Climate Change Challenge, A Devon County Council Strategy for 2005 ... and the foreseeable future. Strategy document. Devon County Council, Exeter. Available at: http://www.devon.gov.uk/index/environmentplanning/climatechange/climate-strategy.htm
- Environment Agency (2009). Managing Flood Risk, South Devon Catchment Flood Management Plan. Summary report. Environment Agency, Exeter. Available at: http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/gesw1109bouo-e-e.pdf
- SDADCAG (2010). Shoreline Management Plan Review (SMP2), Durlston Head to Ream Head. Summary of Draft Final SMP. Prepared by, commissioned by the South Devon and Dorset Coastal Advisory Group. Available at: http://www.dorsetforyou.com/media.jsp?mediaid=156974&filetype=pdf
- Environment Agency (2013). Managing flood and coastal erosion risk for the Exe Estuary. Draft Strategy. Environment Agency, Exeter. Available at: http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/LIT_8599_8565ab.pdf
- The Met Office keeps records of climate characteristics such as rainfall, sunshine and temperature. Information can be found here: http://www.metoffice.gov.uk/climate/uk/regional-climates/sw
And here: http://www.metoffice.gov.uk/media/pdf/n/9/Fact_sheet_No._14.pdf
- The regional government (Devon County Council) is expecting climate change impacts for this area. Recent trends of temperature rise – resulting into milder, wetter winters, and hotter, dryer summers are expected to continue for this region (http://www.devon.gov.uk/index/environmentplanning/climatechange/climate-strategy.htm).
- The Environment Agency provides some information about climate change adaption in the Southwest of England here: http://climatesouthwest.org/about
- Media coverage about the Dawlish storm impacts in February 2014, on websites from the BBC, the Guardian, Express and Echo, ...

Academic literature to be consulted:

- Charlton, M.B., Arnell, N.W., 2011. Adapting to climate change impacts on water resources in England-An assessment of draft Water Resources Management Plans. *Global Environmental Change* 21 (1), pp. 238-248.
- Coles, T., Zschiegner, A.-K., 2011, Climate change mitigation among accommodation providers in the South West of England: Comparisons between members and non-members of networks. *Tourism and Hospitality Research* 11 (2), pp. 117-132.
- Coles, T., Zschiegner, A.-K., Dinan, C., 2013. A cluster analysis of climate change mitigation behaviours among SMTEs. *Tourism Geographies*, Article in Press.
- Coles, T., Zschiegner, A.-K., Dinan, C., 2013. Climate change mitigation policy and the tourism sector: Perspectives from the South West of England. *Journal of Policy Research in Tourism, Leisure and Events* 5 (1), pp. 1-27.
- Dawson, D., (2012). The Impact of Sea Level Rise on the London-Penzance Railway Line. PhD dissertation from the University of Plymouth.

- Note: Partners/Case Studies using PRIMATE tool will be using CBA (to prioritize) and/or MCA (with stochastic PROMETHE II) and the Monte Carlo Uncertainty Analysis, so please check these boxes.

METHODS to be used in Case Studies[3]	YES // NO
A) Methods for prioritizing adaptation options	
Cost-Benefit Analysis (CBA)	Yes
Cost-Effectiveness Analysis (CEA)	Maybe
Multi-criteria Analysis (MCA)	No
Analytic Hierarchy Process (AHP)	No
B) Quantification of impacts and relationships between factors affecting adaptation	
Causal Diagrams	No
Influence Diagrams	Maybe
Process-based Modelling	No
Welfare variation analysis under restrictions	No
C) Uncertainty and sensitivity analysis	
Probabilistic multi model Ensemble	No
Monte Carlo simulations (PRIMATE uses this method)	No
Real option analysis	No
Climate risk management process	No
D) Participatory Methods	
Scenario Workshop	Maybe
Participatory Cost Benefit Analysis (PCBA)	Maybe
Participatory add-ons to CBA	No
Participatory add-ons to Multi Criteria Decision Analysis	No
Participatory add-ons to Adaptation Pathways	No
Other (add extra lines if necessary): Focus group to identify how actors perceive and assess current and future climate change impacts and risks, and which actions could be considered to address these issues	Likely
Interviews with actors to gather data	Certain

(Máx 500 words) *Please highlight if you have any special need or focus regarding any of these methods and their use on your case study.*

d) Case study Timeline

(Please insert and image/graph of the Timeline of your Research Approach, highlighting important milestones and deliverables.)

January – April 2014 Developing research approach, elaborating on the background setting and the current situation, desktop search on adaptation plans, developing questionnaire, identifying and contacting key stakeholders, scheduling interviews.

[3] For descriptions and references of the Methods please refer to Milestone 8. For data requests from specific Work Packages please refer to Deliverable 4.1

May -September 2014	Conducting interviews + document review.
August-October 2014	Data analysis (of documentation and interviews).
November-December 2014	Drafting first raw version of case study report.

e) Collaboration with other Partners and Case studies

Collaboration with BASE case studies (see list in EMDESK):

Case: Other Coastal Cases (Kalundborg, Denmark; Timmendorfer Strand, Germany; Vargaira, Portugal; Cascais, Portugal); Person: Coastal Cases group

Collaboration within BASE partners/researchers (EX: for a specific competence):

Name: Tim Taylor; University of Exeter (for expertise on economic evaluation)

f) Research Outputs

a. Scientific Publications

- Interim reports + final case study report for D5.5 (Month 30)
- Scientific papers: contributing to papers from Work Package 5 where needed and possible

Plus:

- Den Uyl, R.M., Russel, D., (+ Tim Taylor? People from Leeds?) Do EU and UK climate change adaptation policies support knowledge use and needs in local climate adaptation planning?. To be submitted to *Environmental Science and Policy* or *Regional Environmental Change* in 2015.
- Den Uyl, R.M., Russel, D., (+ Tim Taylor? People from Leeds?) Understanding synergies and tensions between national and local responses to climate change. To be submitted to *Climate Policy* or *Environment and Policy C: Government and Policy* in 2015.

(add more papers in case you need)

b. Other Publications

- Books/Books Chapters: # 1

Provisional Title: _____

_____; Month/Year: ___/_____

c. Other

- Scientific conferences: # ___

Title: Understanding synergies and tensions between national and local responses to climate change Conference: Royal Geographical Society Annual International Conference 2014, London

Month/Year: 26-29 August / 2014

- Invited seminars, presentations at local events, etc…

3. Participation in Climate Change Adaptation

a) Process overview

(Please describe the use of Participatory Methodologies within your case study, namely its integration in the overall Research Methodology explained earlier in the CSLD, the rational behind it and key expected outcomes – Máx 1000 words)

Interviews with key stakeholders to explore governance issues.

At this moment (October 2014), a participatory process for policymaking for the South Devon Coast around Dawlish has not yet started. Network Rail, – which is the body responsible for the UK railway infrastructure, responsible for flood risk management in this area as they own the sea wall, and who is the leading actor in this process – has expressed the intention to start a collaborative and participatory process to which should contribute to the decision making process. When consulted in October 2014, they were not able to elaborate on (disclose) the plans for the participatory process. The questions below are answered based on the policymaking process so far, and based on what the various consulted actors have told us.

We shall have to reconsider running the workshop with stakeholders. For which we could invite representatives from several sectors affected (such as tourism, housing/residential and fisheries) to evaluate the proposal from Network Rail on the options for the South Devon Coast around Dawlish. The proposal from Network Rail, which was scheduled for this autumn, should have included a review of securing the current coastal line and a review of the feasibility of alternative routes. In this workshop we could assess the proposal from Network Rail to evaluation of the options proposed by Network Rail set against possible climate scenarios, adaptation pathways and/or a set of risks and vulnerabilities. Such a focus group session could also include response to the financial assessment of the costs and benefits of the options proposed by Network Rail. However, Network rail has done an assessment of alternatives to the railway line (file:///C:/Users/rmd212/Downloads/West%20of%20Exeter%20Route%20Resilience%20Study%20-%20presentation.pdf), but has not yet proposed a plan for the current railway line (http://www.networkrail.co.uk/custom/pages/GeneralError.aspx?aspxerrorpath=/publications/weather-and-climate-change-resilience/).

In response to the February Storms, a collaborative process has started in May 2014 between Network Rail, Teignbridge District Council and the Environment Agency, to discuss the future of this area.

Next to a policymaking process, specifically tailored for the Dawlish railway and seawall, a general Shoreline Management Plan is in place, which includes a participatory process, which also covers this part of the coast. The Shoreline Management Plan is not to be seen as an end-product, but as a continuous process, and the plan is updated when needed.

Network Rail also has their own internal policy for maintaining the seawall. This internal policy has so far not been participatory or public.

b) Participation in the Process Phases

(Please uncover the role of all participants in the process of implementing adaptation measures. The adaptation implementation has been divided into four phases for purposes of ease: 1) Initiative/decision to act, 2) Development of potential adaptation options, 3) Decision-making, and 4) Implementation. The process phases are to be filled out with information corresponding to each participant. I.e. if experts were not consulted in the 'decision-making' phase, then describe why they were not included. It is also important that a wide array of participants is described, including those that were excluded from parts of the process.)

Make a bullet point for each of the five participant categories below (and distinguish between for example different stakeholder or expert groups) and be as descriptive as possible how, why/why not were they involved.

Process phases:

There is yet no adaptation policy for the area. We are still in the process of mapping and consulting stakeholders to find out why.

1. *Possible stakeholders to take initiative/decision to act*

Stakeholders: Network Rail (key actor); tourism industry; commuters from Plymouth, Cornwall, or anywhere west of Teignmouth; contractors interested in building/renovating railway.

Citizens: residents from Dawlish and Teignmouth could play a role in initiating, but don't seem to be very active at the moment.

Experts: not likely, but experts on transport and infrastructure; on erosion; on tidal, wave and current dynamics; and on cost-benefit could play a role. Experts under the heading of climate change (adaptation) are less likely to be taken into consideration about taking initiative and/or decision to act

Politicians: Councillors from Teignbridge District Council; and Secretaries/Ministers from the Departments of Transport and DEFRA.

Officials/legislators: Teignbridge District Council; Department of Transport; DEFRA; Environment Agency.

2. *Possible stakeholders to develop potential adaptation options*

Stakeholders: Network Rail (key actor); tourism industry; commuters from Plymouth, Cornwall, or anywhere west of Teignmouth; contractors interested in building/renovating railway.

Citizens: residents from Dawlish and Teignmouth.

Experts: experts on transport and infrastructure; on erosion; on tidal, wave and current dynamics; on cost-benefit experts; and on climate change (adaptation).

Politicians: Councillors from Teignbridge District Council; and Secretaries/Ministers from the Departments of Transport and DEFRA.

Officials/legislators: Teignbridge District Council; Department of Transport; DEFRA; Environment Agency.

3. *Possible stakeholders to be key in the decision-making*

Stakeholders: Network Rail (key actor); tourism industry; commuters from Plymouth, Cornwall, or anywhere west of Teignmouth.

Citizens: residents from Dawlish and Teignmouth.

Experts: experts on transport and infrastructure; on erosion; on tidal, wave and current dynamics; on cost-benefit experts; and on climate change (adaptation).

Politicians: Councillors from Teignbridge District Council; and Secretaries/Ministers from the Departments of Transport and DEFRA.

Officials/legislators: Teignbridge District Council; Department of Transport; DEFRA; Environment Agency.

4. *Possible stakeholders to be key in implementation*

Stakeholders: Network Rail (key actor); tourism industry; commuters from Plymouth, Cornwall, or anywhere west of Teignmouth; contractors interested in building/renovating railway.

Citizens: residents from Dawlish and Teignmouth.

Experts: experts on transport and infrastructure; on erosion; on tidal, wave and current dynamics; on cost-benefit experts; and on climate change (adaptation).

Politicians: Councillors from Teignbridge District Council; and Secretaries/Ministers from the Departments of Transport and DEFRA.

Officials/legislators: Teignbridge District Council; Department of Transport; DEFRA; Environment Agency.

c) Participation Experience

(Please report with regards to your case study and the implementation of Participatory Methodologies using a traditional SWOT analysis – Strengths; Weaknesses; Opportunities and Threats)

Strenghts	**Weaknesses**
The Shoreline Management Plan holds sessions, where actors can raise issues and where plans are discussed, and it is experienced as fairly participatory. [About the new policymaking process for Dawlish, it's too early too tell.]	The Shoreline Management Plan is not geared to deal with the heavy challenges for the seawall and railway line. Network Rail is invited to the session of the Shoreline Management Plan, but tends not to show up. Network Rail's own internal policy has so far not been participatory, which could mean it has missed out on certain issues and risks.
Opportunities	**Threats**
The new policymaking process for Dawlish could be inclusive and tailored to deliver a good quality output. The new policymaking process for Dawlish could be well aligned, combined or merged with the process for the Shoreline Management Plan. Network Rail's own internal policy could be revised, and be transformed in a more consultative type of process (though not likely to happen in the nearby future).	The new policymaking process for Dawlish may become highly conflictual (too conflictual to make a decision) and may still be selective in its participatory process (could be unintentionally). The new policymaking process for Dawlish could not be in line or even conflicting with the Shoreline Management Plan. Network Rail's own internal policy has so far not been participatory, which could mean it will miss out on certain issues and risks.

d) Learning through Participation

In order to capture how participation could improve the climate change adaptation process, please report with regards to your case study:

a) Your view whether and how participation influenced the strategies and measures decided in your case?

So far, the policymaking process (so that's mostly the Shoreline Management Plan and the internal policy from Network Rail) has turned out to deliver insufficient capacity to deal with heavy storms such as this winter. Apparently, Network Rail did not feel incentive enough to participate in the Shoreline Management Plan process, and did not feel incentive enough to open up their internal policy. However, it is not that a lack of collaboration and lack opening up of the internal policy on behalf of Network Rail can be straightforwardly pinned down as the cause of the failure of the seawall. Rather, there is a mixture of reasons behind this (extreme weather event, national government policy on

climate change adaptation not very pro-active, national policy making context on public spenditures on infrastructure).

b) How you think the participatory process in your case could be/have been improved?

Network Rail has stated that their intention is to be inclusive and open to a collaborative process on the local level as well as the regional level (the Dawlish railway area also affects cities and areas further west, such as Plymouth and Cornwall). If they can really do that, it would be a great change with regards to the current and previous policymaking context. Let's see whether they can make that true.

Network Rail could also participate more in the Shoreline Management Plan.

c) Any novel (use of) participatory methods observed in the case studies
Not yet. Let's see how Network Rail is going to implement their intention of a collaborative and participatory process.

4. Climate Change Adaptation Measures and Strategies

e) a) Adaptation Measures under analysis in your case study

(Please identify your Adaptation Measures considered in this case-study and provide a short description of each)

Adaptation Measure(s):

1) _____
2) _____
3) _____
4) _____

Short description for each Adaptation Measure (Máx 50 words):

f)

g) b) Adaptation Measures selection and data availability prior to BASE

(Please describe how and why where these specific measures selected for further research and analysis under BASE and what is the baseline data already available for each specific adaptation measure. Máx 500 words)

h) c) Full description of Adaptation Measures

(Please provide a full description on each of the Adaptation Measures regarding this 21 leading questions under. If more than one Adaptation Measure please copy paste the structure provided.)

Process

I. Would, or at which part would, institutions and private stakeholders implement the measure autonomously to adapt to climate change (Adaptive capacity)?

(fill with your answer)

II. Does the measure initiate further activities for adaptation to climate change? (Y/N)
    a. If Yes, please name which

III. Does adaptation aim for flexibility and reflexivity (i.e. the ability to change as CC and other factors develop)? (Y/N)

IV. Is the measure effective under different climate scenarios and different socio-economic scenarios? (Y/N)

V. Is the adaptation measure iterative? (Y/N)

VI. Does the measure contribute to overall sustainable development, alleviate already existing problems and bring benefits for other social, environmental or economic objectives than adaptation (no regret measures)? (Y/N)

    a. Please describe briefly how

(fill with your answer)

VII. Can adjustments be made later if conditions change again or if changes are different from those expected today? (Y/N)

Outcome

Relevance and effectiveness of adaptation measures

VIII. How important is the climate change threat addressed by the measure? What economic values, ecosystem functions and socio-cultural values are at stake, and to what extent are they affected by climate change impacts? Is there an indication of overriding public interest, e.g. critical infrastructures, public health ?

(fill with your answer)

IX. What portion of the targeted potential damages can be avoided by implementing the measure? (0-100%)

Efficiency

X. How high are the benefits of the measure relative to the costs? Are the costs justified by the benefits
(Please refer to results of economic evaluation in chapter 5)

(fill with your answer)

XI. What are the costs of the administrative implementation of the measure? Are there potential funding under the umbrella of other European policies(eg. CAP/Cohesion policy ?

(fill with your answer)

XII. Does the measure give an incentive for innovation to different actors (e.g. SMEs) / can it deliver a competitive advantage for the local economy? (Y/N)

XIII. Does the measure have effects on employment? (Y/N)

XIV. How long is the time-lag between implementation of the adaptation measure and the effect of the measure? _____

XV. What is the timeframe during which the measure will have an effect? _____

XVI. Does the measure create synergies with mitigation (i.e. reduce GHG emissions or enhance GHG sequestration)? (Y/N)

XVII. Does the measure alleviate or exacerbate other environmental pressures? (Explain briefly)

(fill with your answer)

Equity

XVIII. What are the impacts on different social or economic groups, are there expected impacts on

(fill with your answer)

particularly vulnerable groups? (distributional impact)

XIX. Does the measure enhance well-being and quality of life (e.g. in the urban environment)? (Y/N)

5. Impacts, Costs and Benefits of Adaptation measures

(This section of the CSLD follows the Economic Assessment Steps put forward by UFZ and thoroughly described in D4.1, chapter 4. Please check D4.1 for any doubts or questions. In case of duplication of information with previous sections of the CSLD feel free to copy paste.) For more detailed guidance (incl. two examples) please see the above mentioned chapter 4 of D4.1. Please do not hesitate to contact volker.meyer@ufz.de, oliver.gebhardt@ufz or Filipe Alves if you have questions about how to fill out this section.

Some type of CBA will be conducted on the costs of different coastal protection options

i) Step 1 – Preliminary Risk Assessment and identification of adaptation tipping points (max 1500 words)

(some of these questions might be already answered in section 1 – if so, just copy&paste)

What is the climate change related problem/risk you would like to reduce by adaptation?

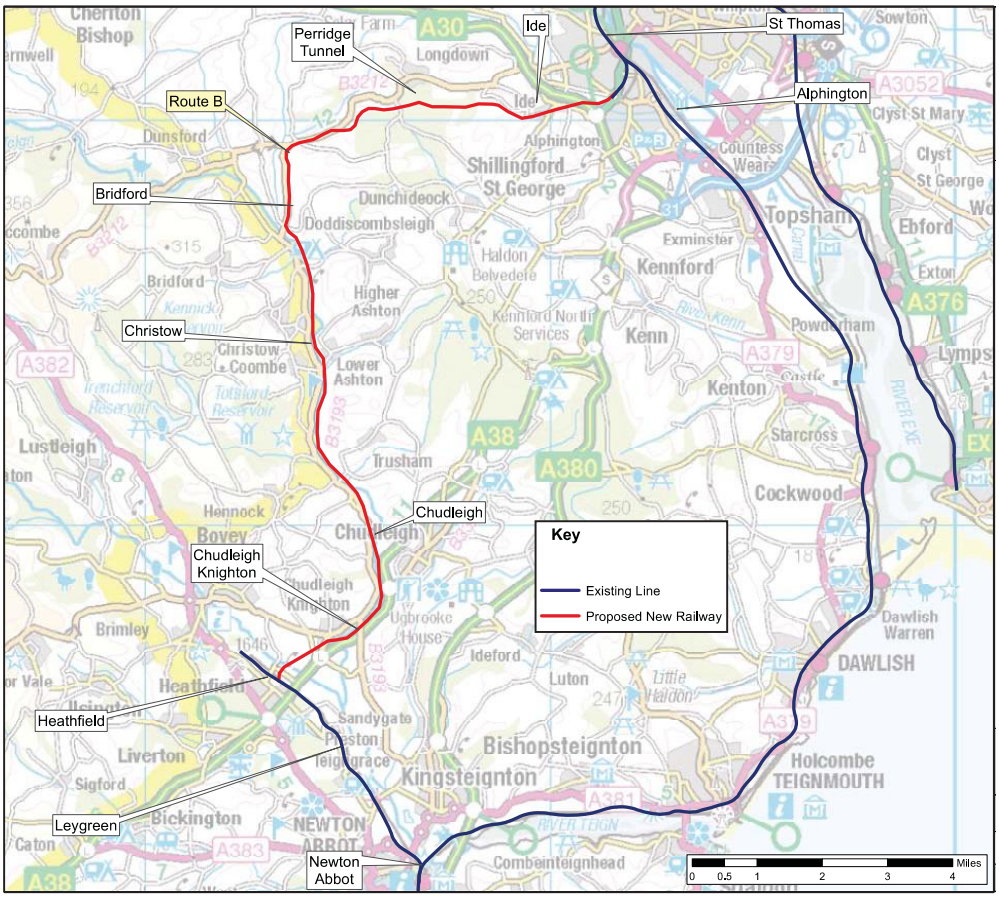
- Which problems already exist, what is/are the current risk/s?
- Which assets and sectors are at risk under current climate variability?
- Which adaptation or protection measures are already in place? (refer to typology of measures in D6.1, table 2)
- How do these risks presumably change due to climate and socio-economic change?
- What are the main drivers, impacts and affected sectors (refer to BASE impact and sector categories, see also Table 1 of D6.1)
- Which climate and socio-economic scenarios are used?

The South Devon Coast, located in the South West of England, is an important area for tourism; it includes two small towns, and it includes some sites with heritage and nature conservation. In addition, it includes some

important infrastructure connecting the South West of England to larger cities such as London. This study focuses at the coastal area stretching from the town of Teignmouth (at the relative southwest), including the town of Dawlish, through Dawlish Warren (at the relative northwest); covering a length of about 10km. Provision of housing/residential areas, infrastructure and tourism, and heritage and nature conservation are already under pressure from coastal erosion and sea and river flooding, a situation which will be exacerbated by climate change.

Storm surge risk to the Railway line

Figure 5.1 Existing railway and cheapest proposed alternative route



Source: Network Rail 2014

The recent extreme events at the coast at Dawlish (February 2014), which severely damaged the sea wall and the railway, increased the risk of flooding for the houses behind the sea wall, and disconnected the railway connection of the southwest of England to the rest of the country, demonstrate these pressures. The railway is on a wave cut platform sandwiched between sandstone cliff and the sea. Moreover, due to the geomorphological setting of rocky/cliff shores at the South Devon coast, options for managed flood plains, or for example dikes, or managed realignment of the coast are limited which presents further challenges when considering and developing climate change adaptation pathways. The railway infrastructure and associated sea wall are particularly vulnerable to sea

storm events and slumping of the cliffs due to undermining by waves and excess rainfall which soaks into the cliffs undermining the structural integrity of the rock. Climate change adaptation at the Dawlish coast has been topic of discussion. As adaptation it is a very complex issue at this location, several groups have formally and informally attempted to outline the main issues and several options. But a formal adaptation strategy has so far been absent. In general, after the recent extreme events at the Dawlish coast, we can diagnose that – as far as there have adaptation actions – these have been clearly insufficient to prevent severe disruptions such as severe flood risks and infrastructure disconnections. Projected increases in sea level rise from UKCIP (2009) even under low emissions scenarios suggest that minimum sea level rise could be 40cm under a low emissions scenario and up to 58.9cm under a high emissions scenario by 2080 (see table 5.1), significantly increasing the risk of waves topping and damaging the railway line flood defences during storm events in the future. Dawson (2012, p176) calculates that was for every historical 0.05m rise in sea level, line restrictions (reduced service or line closure) increased by on average 7%. As it is difficult to provide good estimate of future storm surge activities this data is used to understand the risks faced by the railway line, but does not include full risks as the soft sandstone cliff is also at risk of slumping when it has been exposed to a lot of rainfall. Data on the future risks of this are not possible to obtain.

	Sea-level rise low emissions (cm)	Sea-level rise medium emissions (cm)	Sea-level rise high emissions (cm)
2020	4.7	5.7	6.8
2040	15.1	18.3	22.00
2060	26.8	32.6	39.3
2080	40	48.6	58.9

Table 5.1. – Predicted sea level rise from 1990 levels or the Dawlish coast based on UK CIP data (Source Dawson 2012)

Fluvial flooding risk to property

!

Figure 5.2 – Map of Dawlish Water

Figure 5.3 Picture of Dawlish Water

Dawlish water is a small river that runs through the centre of Dawlish. It has a small catchment (2400ha) from the hill behind which is mainly covered by farm and woodland. It is flanked by a thin strip of parkland, which is in turn surrounded by commercial and residential property. Our field works suggests there are about 50 properties at risk from 1 in 30 year flood events. Data from UKCIP (2009) suggests that this risk is likely to increase to 1 in 24 by 2020, 1 in 18 by 2060 (see table 5.2). In the most recent flooding in this area in 2012, 5 properties suffered flood damage on their ground floors.

Time Period	**Flood risk**
Now-2020	1/30
2020-2040	1/24
2040-2060	1/24
2060 -2080	1/18

Table 5.2 – increases in the risk of extreme flooding events at Dawlish water for a low and medium emissions scenario (UKCIP)

Which adaptation tipping points can be identified?

- Can adaptation tipping points, critical levels for adaptation, be defined for this current strategy? (=when objectives are not met anymore due to changes)
  Refer to otherwise expand on Table 3 of D6.1
- When (roughly) will these critical levels be reached due to climate change or socio-economic change
- Give appropriate period (2015-2030, 2030-2050, after 2050) for each considered combination of climate and socio-economic scenario.

Key tipping points are related to increases in sea level and storm events in relation to the Dawlish Railway and increase in extreme run off events in relation to Dawlish Water. However our analysis which runs from the present until 2080, does not suggest a tipping point will be reached. Data on climate impacts are associated with 20 year time periods in line with UK CIP (2009) projections, namely the present-2020, 2020-2040, 2040-2060, and 2060-2080. After 2080, analysis from Dawson (2006) suggests that the viability of the Dawlish coastal section of the railway, may well depend on the vulnerability of its estuarine routes prior at either end of the exposed coastal section (the Exe and Teign Estuaries respectively), which would be vulnerable to minimum predicted sea-level rises of 54.5 cm by 2100 and maximum rises of up 80.6cm under a high emissions scenario (Dawson 2012).

j) Step 2 – Identification of Adaptation Measure and Adaptation Pathways (max 1500 words)

(some of these questions might be already answered in section 4 – if so, just copy&paste)

What are the alternative adaptation measures?

- What are the primary and secondary objectives of adaptation?
- What are potential measures to meet these objectives?
- (refer to typology of measures in D6.1, table 2)
- What is your baseline option (the "business-as-usual"-option)?
    - What is the ambition level of this baseline strategy?: Maintaining current risk levels or current protection levels (implying with CC risks may increase)?
    - Is current backlog of investments for adaptation measures included or excluded?
    - Does it include only planned adaptation or also autonomous, non-planned adaptation?
- Are there complementary measures? Is it appropriate to bundle these measures?

Dawlish Railway line

Objective – to make the South West of England's railway infrastructure and related economic benefits less vulnerable to storm events at the Dawlish coast.

There were three main options compared:

1) Business-as-usual. This option entails maintaining the existing sea defences at Dawlish and conducting repairs to damage to the rail infra-structure, cliffs and sea wall from storm events as and when they occur.

2) Strengthen the existing sea defences. This would involve strengthening and heightening the sea wall, stabilising the cliffs through wire netting and bolting, and measures to mitigate the erosion of beech material (e.g. improved groynes).

3) Reroute the railway inland away from the Dawlish coast. There are several proposed options for doing this, the cheapest of which is using the old Teign Valley line (Network Rail 2014) (see figure 5.1).

Dawlish Water

Objective: to reduce the risk of flooding to properties bordering Dawlish Water

So the three options for this analysis are:

1) business as usual

This entails no intervention to protect the 50 at risk properties. Flooding happens periodically and affected properties are cleaned up.

2) The installation of domestic flood gates at 50 at risk properties

Figure 5.3 – Example of a domestic flood gate

Individual domestic flood gates to be fitted to all 50 properties (figure 5.3).

3) The installation of sluice gates up stream to hold back flood water, thus protecting property in the two centre. In extreme events tis may not be enough to hold back all of the flood water and thus protect all properties.

In the analysis it is assumed that both options reduced risks by 100%. Sensitivity analysis is conducted around different risk scenarios for the two options.

What are alternative adaptation pathways?

- What is the “sell-by”-date of the measures or bundles of measures? I.e. when will they – under conditions of climate change – not any longer be able to meet the defined objectives?
- What would be alternative measures or bundles of measures at these “tipping points”?

k) Step 3 - Evaluation Criteria and Method (max 2000 words)

l) Step 3a Selection of evaluation criteria

Which evaluation criteria should be used?

- What are the relevant positive and negative properties of the measures (costs and benefits) to be considered in the evaluation process (economic, ecological and social effects)?
- (see D4.1, chapter 4 for examples)
- What is the appropriate unit to measure each of these criteria? Is the performance of the adaptation options measured in qualitative, monetary or other quantitative terms?

Dawlish Railway line

Direct costs: maintenance and repair costs of the sea wall and the railway infrastructure, statutory compensation to train operators and passengers for interrupted services, the building of new infrastructure in the form of a new inland railway, the upgrading of existing infrastructure (heightened sea defences etc);

Direct benefits: Avoided damages to the sea wall and rail infrastructure, avoided maintenance to the sea wall and rail infrastructure, avoided statutory compensation to train operators and passengers for travel interruptions.

Indirect benefits: Avoided wider economic disruption to the region, avoided costs of interruptions to freight transport, and avoided costs of interruption to business, commuter and leisure passengers.

Dawlish Water

Direct costs: capital costs of flood prevention measures (Sluice gate and domestic property floodgates), costs of clearing up flood damage to properties.

Direct Benefits: Avoided costs associated with flood damage to properties.

All costs and benefits can be expressed in monetary values, in this case £ Sterling.

m) Step 3b Selection of evaluation method(s)

What is the appropriate evaluation method?

- Is it possible to express all relevant cost and benefit criteria in monetary terms?
  (→ cost-benefit analysis)
- Is it possible to express the positive effect (objective) by a single non-monetary indicator?
  (→ cost-effectiveness analysis)
- Are there several relevant criteria which cannot or cannot easily be expressed in monetary terms?
  (→ multi-criteria analysis, PCBA)

Yes, past studies and a recent report by network rail and other government agencies have allowed us to collect data on monetary costs and costs and benefits. Most of the benefits valuations come in the form of avoided

damages. So a cost-benefit analysis is conducted. For Dawlish water, it would also have been suitable to have conducted a cost-effectiveness analysis. However, this would not have included details on avoided flood costs which provide a compelling case on the need for action. Thus a CBA was conducted.

n) Step 3c Weighting of evaluation criteria (applicable only to multi-criteria analysis)

What are the preferences of stakeholders regarding the different evaluation criteria?

- Are there different stakeholder groups with varying preferences regarding the evaluation criteria?
- Which weight do stakeholders and/or decision makers attach to a substantial change in the performance of the adaptation options regarding each evaluation criterion?
  (see D4.1, chapter 4.10.2 for guidance for the Swing-Weight method)

N/A

o) Step 4 - Data collection (max 2000 words)

What are the costs and what are the benefits of the alternative adaptation options?

- What potential data sources are available, including damage & impact assessment methods or existing CBA studies on adaptation measures?
- If no relevant data sources are available and modelling cannot be undertaken: Which experts can estimate proxies for assessing the performance of measures regarding the respective criterion?
- How do the adaptation options perform with regard to each of the cost and benefit criteria selected in step 3a?

Data has been collected form a variety of sources including a PhD thesis (Dawson 2012), reports from Network Rail, reports form the UK Environment Agency, the UK Climate Impacts Programme (UKCIP, 2009)

Dawlish Rail

Research by Dawson (2012) was used to gather many of the base line monetary data surround the likely impact and costs of climate change on the Dawlish railway line. Through modelling historical line closes in relation to line closes Dawson (2012, p176) was able show that for every historical 0.05m rise in sea level, average line restrictions (reduced service or line closure) increased by on average 7%. He then used this data to model future line disruptions and closure based on different UKCIP (2009) sea-level rise scenarios, namely low, medium and high. For the purpose of this analysis we use the mid-range estimates, with the impacts of the lower and higher ranges on costs being incorporated into the Monet Carlo simulation.

Direct costs

The UK National Audit office suggests that the standard delay minute costs for each train lies at around £73.47 per minute. These charges are used to compensate train operators and passengers.

Dawson's modelling (2012, p.198) of the Dawlish railway also found that frequency of delays are proportional to the frequency of maintenance and repair. Therefore an approximate cost of maintenance and damage repair was calculated by multiplying the average annual maintenance costs buy the annual % change in delay minutes. According to Network Rail (2014), current maintenance costs are approximately £0.8 million per year, above that of maintenance costs of a normal railway line, with a further £5 million spent on average every five years to repair a severe damage after a major event. As a point of reference the damage form the 2014 storm cost over £20 million in repairs. This means that annual expenditure is approximately £1.8 million a year.

Table 5.3 Projected sea level rise at Dawlish and associated increases in line delays and closures

Year	Sea-level rise based on UK CIP (2009) and Dawson (2012)	Average minutes with line restrictions and closures/yr (Based on Dawson 2012)
Low emission scenarios		
2015-20	3	3900
2020-40	4.7	6510
2040-60	15.1	12326
2060-80	26.8	18836
Medium Emission scenarios		
2015-20	3	3900
2020-40	5.7	7049
2040-60	18.3	14098
2060-80	32.6	22110
High Emission Scenarios		
2015-20	3	3900

2020-40	6.8	16178
2040-60	22	25847
2060-80	39.3	36825

Indirect costs

Drawing on information from The Department of Transport (2007), Dawson (2012) estimates (adjusted for inflation using the UK Treasury's GDP deflator) that value of working time per rail passenger is £45.91 per hour, non-working value time for a commuter is £6.18 per hour and for all other passengers is £5.47 per hour. Using data obtained from the train operating company, First Great Western, Dawson also calculates the annual number of business journeys on the line to be approximately 296,788, commuter journeys to be around 2,065642 and other journeys in the region of 1,594,739. With this data it is possible to estimate an average daily cost in terms of lost passenger time from line restrictions or closure. In terms of freight costs, there are approximately 12 trains a day. Based on research by Clarke et al (2010), delay costs of fright trains costs about £46 per train for a 30-60 minute delay and £1674 for a 12-14 hour delay.

In a recent report on the viability of the Dawlish line, the rail operator estimated that upgrading the existing line, to make it less vulnerable to storm events through cliff stablisation and raising the height and strengthening of the defences could cost between £398-659 million (including a 60% contingency). It should be noted that this estimate also covers work on the estuarine routes the line takes entering and leaving the coastal section of the railway. The costs of this work would be spread over a 20 year period meaning that the full effects of the work would not be realized for 20 years. As network rail did indicate the effectiveness of these measures in terms of risk reduction, calculations were based on a 50% reduction in damage scenario and a unlikely 100% damage reduction scenario. As the work would be completed over a 20 year period, the 50% risk reduction damage was phased in cumulatively over that period.

The Network Rail report (2014) also outlined different alternative railway routes and the costs. We calculated the costs and benefits of the cheapest of these options (see figure 5.1), the Teign Valley route at a capital building cost of £470 including a (60%) contingency. The work would be completed by 2027. Up until this time the existing Dawlish route would be used with associated maintenance and storm damage costs. Following this, these costs would be turned into benefits in terms of costs avoided. It is noted that that there are costs to the Dawlish line closure that we have not been able to include in these calculations, such as continued sea wall maintenance to protect the Town of Dawlish. These costs would be significantly lower than current costs as a major piece of infrastructure (the railway) will not need to be protected. It has not been possible to ascertain figures for these costs. There may also be costs in terms of reduced tourism as the line is a major attraction to the area and it also delivers tourists to nearby resorts. However, a line may be able to be maintained that stops at the nearby resort of Dawlish warren before the railway runs parallel to the sea.

Dawlish Water

It is estimated by the UK environment agency that ground floor flooding of property costs on average £20,000-£30,000 to clear up. Flood protection gates for individual property can cost (including installation) anywhere between £500-£1000 depending on the size of the property. For this analysis 50 gates are assumed fitted at the mean average of £750 per gate, the uncertainty in the price was handled through a Monte Carlo simulation. In addition, a sluice gate can be added to Dawlish water to hold back floodwaters before they hit the urban area. The Local Authority has just commissioned the building of a gate at the cost of £10,000. As it cannot be certain ultimately how affective these measures will be for protecting the property the cost benefit was conducted under different scenarios in terms of number properties protected by the measure and number of properties directly in the path of the flood. The projected annual costs of flooding per was estimated by multiplying the number of houses at direct risk of flood damage (50) by the mean average cost of property flood clear up (25000), divided by the risk factor derived from UKCIP (2009).

Table 5.4 Projected climate related increase in flood damage costs

Time Period	**Flood risk**	**Annual cost of flood damage**
Now-2020	1/30	£20,833
2020-2040	1/24	£26, 042
2040-2060	1/24	£26, 042
2060 -2080	1/18	£34, 722

What is the evaluation time frame?

- What is the lifespan of the measure with the longest lifetime?

All of the measures are potentially viable and therefore explored over a similar life span from 2015-2080.

Which discount rate should be applied?

- Which discount rate is recommended by national guidelines for climate change adaptation measures (or public investments)?
- Is it a linear discount rate or any other type (i.e. declining, hyperbolic, etc.)
- (In addition, for testing the sensitivity of the results with regard to the discount rate(s) used, also apply a low and high discount rate (1% and 5%)).)

We will follow discounting guidelines outlined in the UK Treasury's Green Book on appraisal (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf). Thus a discount rate of 3.5% will be used. Sensitivity analysis will be conducted using a 1% and 10 % discount rate where appropriate.

How to deal with data uncertainty?

- Can uncertainties related to the performance of the measures regarding certain evaluation criteria be described by a range (min-max), a triangular distribution (min, most likely, max) or any other kind of probability distribution?

Uncertainty is dealt with through a Monte Carlo analysis of the different options explored.

p) Step 5 – Evaluation and Priorization (max 1500 words)

What is the ranking order of alternative adaptation options (measures, bundles of measures or pathways)?

- For cost-benefit analysis:
  What is the net-present value (discounted benefits – discounted costs) of the alternative options?
  What is the benefit-cost ratio?
- For cost effectiveness analysis:
  Which alternative achieves a defined objective at lowest costs?
  What is the cost-effectiveness ratio?
- For multi-criteria analysis:
  Which adaptation option performs best?
  (e.g. for PROMETHEE approach: which option has the highest net flow?)
- What are the uncertainties associated with the performance of the different options?
- Is there and, if so, to what extent uncertainty in the ranking of options?
- Is it possible to determine which option most likely performs best or is it necessary to gather further information to reduce uncertainty (go back to step 4)?

Where we had data ranges for monetary costs and benefits we based the analysis on average figures and then under took a Monte Carlo analysis to account for data uncertainty associated with lower and higher end range boundaries.

Dawlish railway - Cost Benefit of the Options @ 3.5 discount rate, 2015-2080

Option 1 Business as usual

Costs of maintenance and repairs = £70,491,340

Fines and compensation for delays = £21,564,888

Indirect economy wide effects (passenger time and goods) = £48,661,451

PV total costs only = £140,717,679

The rail connection from the region to London and the North of England, provides a vital and quick transportation route for the region (compared to other transportation options), which in terms of other transport links is a fairly geographically isolated part of the UK. The recent closure of the Dawlish line was claimed to have cost the regional economy £20 million a day. This is a very rough estimate from the regional chamber of commerce. If this figure were to be true and assuming these costs were not offset but road transport (which is unlikely as the region has little capacity for vastly improving road routes), this would mean economic benefits of maintaining a rail link would be in the region of £5,175,007,808 (discounted at 3.5%) for the time period of this analyses (2015-2080).

Option 2 – Strengthen the existing line (50% damage reduction)

Capital of strengthening the works (50% damage reduction) = £381,824,989

Total maintenance costs =£54,352,226

Fines and compensation for delays = £13,070,810

Indirect delay costs (passenger time and goods transport) = £29,865,648

Total costs = £478,113,673

NPV (Benefits – costs)

Benefits (costs avoid from option 1) = £140, 717, 679

Benefits – costs = NPV £-337,395,994

At this level of NPV, even if the works provided 100% protection from line disruption, with total capital costs remaining at £381,824,989 and maintenance cost at £20,680,312 (this figure takes account of maintenance at 0.8 per year as in 2015), total costs are £402,505,301. Thus the NPV of benefits – costs is = £-261,787,622

Option 3-Cheapest new inland rail route.

Cost of works= £322,680,145

Maintenance of existing coastal track until 2027 = £20,407,947

Delay fines on existing coastal track until 2027 = £4,750,398

Indirect costs of delays (passenger time and goods) = £5,838,697

Total costs = £353,677,182

NPV (Benefits – costs)

Benefits (costs avoid from option 1) = £140,717,679

Benefits – costs = NPV £-212,959,503

Sensitivity analysis

Adjusted figures to reflect a 1% discount rate mean that

PV option 1 (costs only) = £324,592,996

NPV option 2 (benefits – costs): £ -346,711,065

NPV option 3 (benefits –costs) = £ -107,374,326

Adjusted figures for a 10% discount rate:

PV option 1 (costs only): £36,910,628

NPV option 2 (benefits – costs): £ -198,792,344

NPV option 3 (benefits-costs): £ - 145,289,448

Baseline of no climate impacts

As there is a commitment to maintain the railway line (option one) and negative NPVs for options 2 and 3, it was not necessary to conduct the analysis in light of no climate related impacts.

Data uncertainty: Monet Carlo analysis

To account for uncertainty in the data (outlined above), a Monte Carlo Simulation was conducted for each of the options:

Option 1: Standard deviation = 7930480; mean = 182945623; standard error = 1,733508 or 0.94%

Option 2: Standard deviation = 77,999,124; mean = 585,893,442; standard error = 8,201,604 or 1.4%

Option 3: Standard deviation = 130,094,182; mean =429,951,213; Standard error = 5785933 or 1.35%

Summary – Dawlish Rail

Option	**NPV @ 3.5%**	**Standard error**
1. Business as usual	PV £140,717,679 (costs only)	0.94%
2. Strengthen existing defences	NPV £-337,395,994 (benefits-costs)	1.4%
3. New inland rail route	NPV £-212,959,503 (benefits –costs)	1.35%

Table 5.5 summary of Dawlish Rail analysis

Given the importance of the rail link to the region, which could - if the regional chamber of commerce estimates that the recent railway closure cost the region £20 million a day are accurate - provide benefits (discounted at 3.5%) over the period of this analysis of £5,175,007,808. If this the case then here is a strong case for keeping the line open either in situ or through a new inland route. The cheapest of options for doing this, based on this analysis, is option one, business as usual. However, the line is also vulnerable to sea level rise in the along the estuaries it runs parallel to before and after leaving the coastal section (the Exe and Teign estuaries respectively) (see figure 5.1). Dawson (2012) estimates that these estuarine sections of the railway may be non-viable by 2100 because of sea level rise, meaning that a new inland route will eventually have to be built regardless of what happens on the coastal section. If this new route (based upon option 3 prices) were built over a six-year period from 2090, the costs (@3.5 discount) would be £27,615,751 compared to £322,680,145 to build the new route for completion by 2027. Thus even under this scenario, option one seems the base approach for the studied time period (2015-2080).

Dawlish Water

Measures to minimize the risk of flood damage – sluice gate and domestic flood gates - are relatively easy to complete with minimal maintenance costs. These can theoretically be installed in 2015.

Table 5.6 - Costs of anti-flood measures

Domestic flood gates (option 2)	£37,500 (installed in 50 properties at £750 per installation)
Sluice gate (option 3)	£10,000

Table 5.5 Costs and Benefits of measures and actions

	Total cost 2015-2080	NPV at 3.5% discount
Flood damage cost (50) at risk properties	£1,947, 917	£689, 707
Domestic flood gates (50 properties)	£37,500	£37,500 (installed in year 1)
Sluice gate upstream of the town	£10,000	£10,000 (installed in year 1)

Cost benefit of the options @ 3.5% discount, 2015- 2080

Option1 – Business as usual

No benefits identified.

Projected total flood damage cost: PV = £689,707

Option 2- Fitting of domestic flood gates to 50 properties

Costs of measure = £37,500

Benefits (flood costs avoided) = £689,707

Benefits – costs NPV = £652,207

Option 3 – Fitting a sluice gate upstream of Dawlish

Costs of measure= £10,000

Benefits (flood costs avoided/e) = £689,707

Benefits - costs NPV = £679,707

The Sluice gate and the domestic flood gates would require some maintenance. We have not been able to ascertain costs for these, but estimate them not be to be high. They would need to be extremely high to significantly lower the benefit cost ratio.

Sensitivity analysis

1% discount

The analysis was repeated with a 1% discount rate.

Option 1 – business as usual. PV (flood costs) = £1,375,647

Option 2 – installing 50 domestic flood gates, NPV (benefits – costs) = £1,340,647

Option 3 – installing a sluice gate, NPV (benefits-costs) = £1,365,647

10% discount

The analysis was repeated with a 10% discount rate.

Option 1 – business as usual. NPV (flood costs) = £475,273

Option 2 – installing 50 domestic flood gates, NPV (benefits – costs) = £ 437,773

Option 3 – installing a sluice gate, NPV (benefits-costs) = £465,273

Effectiveness of measures

If only 50% are properly protected by the measure the cost benefit ratio becomes negative. An only 50% protection of at risk properties is more likely to happen in a community wide measure like the sluice gate which are not targeted at individual properties, rather than a domestic measure like the individual property floodgates.

No change flood risk from 2015 baseline of 1/30 @ 3.5% discount

Option 1- Business as usual PV (costs only) = £416,269

Option 2 – Domestic flood gates NPV (benefits – costs) = £381,269

Option 3 - sluice gate NPV (benefits-costs) = £406,269

Data uncertainty: Monet Carlo analysis

Option 1: Option 3: Standard Deviation = 14594; mean = 139894; standard error = 4378 or 3.13%

Option 2: Standard Deviation = 17493.56; mean = 174772; standard error = 1883 or 1.08%

Option 3: Standard Deviation = 14594; mean = 139894; standard error = 4378 or 3.13%

Summary – Dawlish Water

Option	**(N)PV @3.5% discount**	**Standard Error**
1. Business as usual	£ 689707 (costs only)	3.13%
2. 50 domestic flood gates	£654,707	1.08%
3. Sluice gate	£679707	3.13%

Table 5.8 – summary of Dawlish Water analysis

Based on this analysis, it would seem that the sluice gate (option 3) provides the best-cost benefit outcome. Individual flood gates also provide a positive NPV and probably give property owners greater assurance that their houses are protected as opposed to a community wide protections measures such as the sluice gate which may not protect all properties in light of more extreme events.

What are the main lessons learnt from your case study?

e.g.:

- transferable results?

I am not sure how transferable the results are especially for the Dawlish railway analysis which is highly context specific because of the unique situation of the railway line. The analysis of domestic flood protection measures (domestic flood gates) vs community flood protection measures (sluice gate on the river), may have wider transferability to flooding in other contexts as it is less unique.

- lessons learnt with regard to the process of economic evaluation?

I learnt a lot especially as it has been a long time since I have conducted a CBA. Three, things stand out: first the number of assumptions that are made which although based on sound reasoning may never materialise; how the boundaries of the analysis in terms of what measures and costs and benefits to include and not include may impact upon the final results; and three, how through looking a localised case you may miss out important information from the bigger picture – in this case that the Dawlish coast is not the only part of the rail line that is vulnerable and that these other vulnerabilities may provide the tipping point for rerouting.

- feasibility of methods?

The CBA seemed to be feasible but some information wasn't available and I didn't have the resources to collect primary data to fill these gaps. See also my points in the above answer on assumptions etc.

- important data sources?

The work of other academics, the UKCIP, Government Agencies and business provided the bulk of the data that was needed.

6. Implementation Analysis – Understanding, Leadership and Governance of the implementation of adaptation measures

(Please describe the process of implementation of adaptation measures in real world contexts, namely key barriers and opportunities, governance dynamics and the concrete use of scientific knowledge and economic analysis in political decision-making. Please address Policy Questions from WP2&7 on the CSLD_Support doc)

The aim of this section is to establish whether adaptation measures can be implemented in the real world context of case studies, and what the key obstacles and opportunities are in doing so. To ensure the answers provided in this section are comprehensive and in line with WP2 and WP7, a checklist is provided below with the main factors that all case holders need to consider in their answers If relevant to the implementation of your case study.

Checklist

When answering the main questions below ensure you consider each factor listed in the checklist below that might have had a role in the implementation of your case study work. Write in the table how important each factor has been to the

implementation of your BASE work and adaptation in general at your case study; where 1 = unimportant, 2 = slightly important, 3 = Important, 4 = Very important, and 5 = Critical). The checklist might not be all-inclusive, so feel free to discuss other factors that are not listed.

Key factors:	Rank from 1 – 5
i. **Knowledge and information about climate adaptation**	2
ii. **Actors** (e.g. leadership, perceptions, understanding of climate adaptation, participation, decision making, stakes, conflicts/synergies)	5
iii. **Framing of climate adaptation** (e.g. as sustainability concern, (urban) planning or environmental issue, disaster risk mitigation topic)	4
iv. **Local and regional context** (e.g. culture, history, geography, environment, economy)	2
v. **European, national, regional and local regulatory framework** (e.g. be specific about laws, strategies, policies)	2
vi. **Institutional context** (e.g. integration of adaptation into existing structures/activities/strategies, decision making, conflicts/synergies, governance arrangements, incentives for engagement)	5
vii. **Resources** (e.g. financial, human)	5
viii. **Nature of adaptation measures** (e.g. no regret, flexibility, important co-benefits, side-effects)	3
ix. **Other** (specify _____)	

Summary Information (based on your answers to the questions below)

a) Specify sectors covered (e.g. coast, city, agriculture): coast and infrastructure

b) Specify adaptation measures covered (e.g. altering cultivation practices, building defences; explain why they were chosen): Reinforcement of sea wall (heightening and broadening), rerouting railway

c) Specify climate change impacts covered (e.g. flooding, heat stress, sea level rise): flooding, sea level rise, storm impacts (pushing wave strength and erosion from the cliffs)

d) Specify main results of activities (e.g. changes, outputs): at the moment (Summer 2015), no adaptation measures have been taken or are planned. Discussion about adaptation of the railway line has been put on hold.

Questions

Answer these six questions giving specific evidence and examples where possible. In principle all implementation activities should be included, i.e. adaptation activities supported by BASE partners as well as those by other actors. If it is possible to

inform about the implementation of those adaptation measures assessed for task 5.2, it is very important to do so in order to comply with the DoW. The measures covered can be extensive and/or particular to a case study. They can include for example, the development of plans and strategies, vulnerability/risk assessments, economic assessments such as CBA, MCA, the development of participatory processes/public dialogue, through to the implementation of actual measures including physical measures such as engineering developments and land use change, incentives/subsidies for behavioural change, etc. This list is not all-inclusive and is merely a guide. Your own case study may have very different measures. However, **you must be clear what measures you are refereeing to when answering these questions.**

1. How have climate change adaptation measures and strategies been advanced in the case study? Describe the process! *Note:* Retrospective case studies will not answer this question, but have to update their answer to question 1 E of this document on the history of adaptation at their case study. (Approximately 500 words)

   The discussion about how to adapt this coastal area to current and expected challenges, after the extreme events in Feb 2014, seemed to have focused on adaptation of the railway connection only, and did not link it to climate change more in general and flood risk and erosion management. Several options to adapt the railway in terms of rerouting were considered after the storms in February 2014.

   In brief, the seawall and railway tracks are owned and managed by a government-owned company, the train services are run by a private company, the local authorities do not have **the resources** and capacity to make major decisions around this part of the coast, and the national authorities claim adaptation in in this area is a matter of the local authorities.

   There were several adaptation measures considered (e.g. raising the sea wall, rerouting the railway more inlands), after extreme weather events severely damaged the seawall and railway in the winter of 2014.

   At **local level**, a dialogue was said to have been started in Spring 2014, among the **actors** Network Rail, Environment Agency and Teignbridge District Council about the future of this part of the coast and the railway. Network Rail has started a 18-months study to identify the “real costs” of maintaining the current line, a 6-months study to identify the “real costs” of rerouting. Network Rail had stated that in intended to include the Environment Agency and Teignbridge District Council in these studies. Although Network rail did not yet want to indicate how that would be done.

   The option of raising the sea wall was abandoned, mainly after protests of **local** residents concerning privacy (i.e. that train passengers would be able to look into their houses), and loss of scenic amenity (i.e. they would lose their view on the sea, which would also lower the value of their property). These concerns were apparently more important for the local residents than protection against storm surges from the sea.

   The cooperative process said to have been started at local level said in 2014 does not yet seem to be reflect at the **national level**. At the **national level**, there seems to be no dialogue between national departments involved. It is especially striking that there seems to be no dialogue between the Department for Transport and DEFRA. The Department of Transport is responsible for the railway line, DEFRA for coastal erosion and flooding.

   However, adaptation to future impacts of storm surges and erosion seems to be losing priority again, and it appears everything regarding adaptation has been put on hold. Because of the national elections in the UK in Spring 2015, all politically sensitive policy actions and discussions continued to be put on hold. It’s not clear whether the discussion on the railway line at the South Devon Coast has perhaps been picked up again informally (i.e. ‘behind the scenes’).

2. What and who drives (or enables) the adoption and implementation of adaptation measures and strategies/policies? Please explicitly refer to the factors mentioned in the checklist, highlighting the factor in bold, and be specific about any relevant policies! (Approximately 500 – 1000 words)

   We observe a fragmented **institutional setting**, with several bodies only partially involved at several levels. In this setting, there is no clear **actor** or **policy framework** driving adaptation. The UK's adaptation strategy (from 2013) does not appear to assist or drive climate change adaptation in this case.

   The case study shows an array of multiple actors, of which some seem to be relatively more key than other actors. The **local and regional public** (Environment Agency and Teignbridge District Council) and **semi-public** (Network Rail) **responsibilities**, which partly address aspects of adaptation, are fragmented. In particularly Network Rail appears to emerge as a relatively key actor. It is a privatised body, with no direct public accountability. Network Rail's task is to maintain the railway line. Followed by the local authority, which is stated by DEFRA to be in charge of coastal erosion management, but which seems limited in its resources and authority to lead climate change adaptation around this case (and it does not own the railway and seawall). So Teignbridge District Council's task is said to concern 'coastal management', although it is not actually clear whether that entails climate change adaptation, in particular when that concerns adaptation of issues beyond the local scale. The Environment Agency is also referred to a relative key actor, but it is also does not have a direct public accountability and is not owner of the seawall and railway. The Environment Agency's task is to address erosion management and flooding from the sea.

   Together this creates a setting with fragmented tasks. And there is no established deliberative structure to discuss and consider climate change adaptation (let alone decide upon).

   A regional **actors** group, including a consortium of businesses from in the Southwest, has been actively advocating climate change adaptation in this case, and made an appeal to the national government in the 2nd half 2014, proposing a rerouting of the railway line.

3. What obstacles were encountered during the adoption or implementation of adaptation measures and strategies/policies? Please explicitly refer to the factors mentioned in the checklist, highlighting the factor in bold, and be specific about any relevant policies! (Approximately 500 – 1000 words)

   Several obstacles were encountered during the process after the storms in February 2014. With regards to **actors**, there is no problem-owner or leader of climate change adaptation in this case, which may be related to the mechanism of blame-avoidance (when the risk of political or public blame is higher than the benefit of getting political or public credits).

   With regards to the **institutional context**, the fragmented decision making setting, no activating or programming adaptation policy, and no existing and active deliberative process at or between local and national level, all contribute to a setting not oriented towards climate change adaptation.

   With regards to **resources**, it is not clear who should bear the costs of implementing adaptation measures: local or national parties, Network Rail and Department for Transport, and/or DEFRA and the Environment Agency, or all these parties, and in with which contributions. In addition, in the wider context, it is not clear how much national public money is available and could or should be spend on a case like this: a local setting, with a privatised railways line, which serves a larger region and a regional economy.

4. If any obstacles were overcome, how was this achieved? (Approximately 500 words)

   The obstacles to develop (let alone implement) an adaptation strategy have not yet been overcome.

5. What are the future prospects of the climate change adaptation activities in the case study? (Approximately 200 – 500 words)

   The current national government in the UK is a Conservative government. It is generally not expected that this government will actively start considering, developing and /or supporting climate change adaptation strategies and policies.

   The local authorities do not have the funding to enhance the resilience of the existing line, or develop a new line.

   Network Rail has stated clearly and multiple times that their task is only to maintain the current line, not to go beyond that and address climate change.

   Together, that does not lead to much prospects to address climate change adaptation in this case.

6. What is the key message from this case study (and which could work in other cases as well)? Don't forget to consider any specific policy recommendations that arise in your case study! (Approximately 200 – 500 words)

   Adaptive capacity may hugely depend on the institutional context. In a setting with privatised, decentralised and fragmented responsibilities and tasks, decision making and funding of adaptation may be very difficult (to nearly impossible). Climate change adaptation requires a long term collective perspective and a willingness to anticipate uncertainties.

7. Development of new tools for adaptation planning and implementation

(Please describe the development and use of new tools for climate change adaptation planning and implementation which you have used under BASE research project and report on their SWOT analysis and overall feedback. Máx 2000 words)

New tool(s) developed and used during BASE:

1) _____
2) _____
3) _____
4) _____

Description for each New tool (Máx 50 words/each):

Swot Analysis:

Strenghts	**Weaknesses**
Opportunities	**Threats**

10. References

11. See list of project documentation and academic literature to be consulted.