Business Case for Adaptation

Cost Benefit Analysis methodology

Feb 2014

1.1. Step 1: Determine the baseline

Determining the baseline will help to indicate the potential costs associated with climate change impacts in the absence of any adaptation measures being implemented. The different adaptation options you identify can then be compared against this baseline to assess their level of effectiveness and value for money.

The following actions will help you establish a baseline for your project.

1.1.1. Assessing the costs of current climate risks

The costs of the direct damages from climate change impacts will be unique to each project and will have to be determined by the project manager on a case-by-case basis. For example, the extent to which a building might be damaged by flooding would be determined by the duration and severity of the flooding, and the size and design of the building, its purpose, contents and a range of other factors.

Indirect costs should also be taken into account, such as loss of productivity from the disruption caused by an event. For example, if a factory is expected to be out of action for a period of time after a flood because of the necessary clean up and repair work, the value of the lost productivity should also be taken into account when estimating the cost of that future flooding event.

There are two approaches that can be used to estimate potential costs from different impacts:

- gathering internal cost data, if they are available, on how similar projects run by the company have been affected by these costs in the past
- gathering external data on how similar projects elsewhere in the UK have been affected by these impacts

There are a number of different sources of external data on climate impacts, such as the Environment Agency, or industry bodies, such as the Association of British Insurers. For example, the British Continuity Management Survey 2013 has information on recent climate costs experienced by businesses[1].

Practical example

A factory is being built near a river at a cost of £1,500,000. It is expected to have a life expectancy of 15 years. If it is flooded, it will suffer at least £75,000 in direct damage costs and will be out of action for three weeks.

[1] Weathering the storm - the 2013 Business Continuity Management Survey

In this situation, the lost productivity for the three weeks can be calculated by the number of days out of action (15) multiplied by the number of employees on site and their average daily value (100 employees x £250 = £25,000 per day). So, the total lost productivity is £375,000. Therefore the **total costs** of a flood event at the site will be at least **£450,000.**

According to the Environment Agency's flood risk maps, the site has a medium risk of flooding (1 in 75 chance in any given year). In a CBA approach, the expected value of the annual costs is the flood risk multiplied by the damage costs. In this case:

1/75 x £450,000 = **£6,000** (using the current flood risk level).

If the flood risks increase as a result of a changing climate, the expected value of the annual costs will also increase.

1.1.2. Discounting the costs

A discount factor is an interest rate used to determine the present value of future cash flows. It takes into account the time value of money (the idea that money available now is worth more than the same amount of money available in the future because it could be earning interest) and the risk or uncertainty of the anticipated future cash flows. The discount factor can be written as:

$$\frac{1}{(1+r)^t}$$

where r is the discount rate and t refers to the year of the project's lifetime being considered. For most companies, the discount rate is commonly based on the cost of capital.

As with other potential project costs, a discount rate should be applied to the costs of climate impacts depending on when these costs are expected to occur across the lifetime of a project. This will then ensure the costs properly reflect their present value.

It is important to note that the risks of a particular threat may increase or decrease over time and this should be reflected in discounted annual costs.

Practical example

A factory is being built near a river at a cost of £1,500,000. It is expected to have a life expectancy of 15 years. The expected value of the annual costs of a flood is £6,000.

Table 1 shows the current value changes over time if a relatively typical discount rate of 7.5% is applied over its lifetime – *Note: intervening years between year 4 and 15 have been omitted from the table*.

Description	**Year**						**Total**
	0	1	2	3	4…	15	
Potential losses	–	6,000	6,000	6,000	6,000	6,000	90,000
Net annual cost (discounted)	–	5,550	5,134	4,749	4,393	1,863	51,020

Table 1: How current value changes over time (7.5% discount rate applied)

If the net annual cost of this risk is added up for each year of the project, the total comes to **£51,020**, the 'cost of inaction'.

However, this assumes the risk of flooding stays the same in a future climate. However, if our changing climate changes flood risks, these risks will needs to be taken into account.

This is explored in more detail in the next section.

1.1.3. Considering future climate change – Applying a Sensitivity Analysis

Our climate has and will continue to change, both in terms of average conditions and the frequency and impact of extreme weather. In the UK we face rising temperatures, sea level rise and more severe weather events.

These changes need to be taken into account as they could affect the level of risk the project faces over its lifetime, increasing or decreasing the frequency and severity of certain events such as heatwaves and floods. If they are not taken into account, you could be underestimating the potential costs to your project, or be selecting adaptation options that will not be adequate.

It is possible to build a detailed assessment of how the climate risks may change over time through detailed risk assessments and scientific analysis, an approach that some companies (such as oil companies) do use with high-value projects located in areas/regions that are particularly vulnerable to climate impacts. However this can be quite a complex and expensive process and may require the use of external experts and research organisations to do properly.

An alternative approach would be to undertake a **sensitivity analysis** of both the climate impacts and the adaptation options. This would involve assessing how the project might be affected by different levels of climate impact risk and severity, allowing you to create 'best case' and 'worst case' scenarios. For example you could see what the potential costs would be if the frequency of river flooding or the severity of flood events increased or decreased.

The **UK Climate Projections (UKCP09)**[2] provide climate information designed to help those needing to plan how they will adapt to a changing climate. The data is focussed on the UK and is free of charge. UKCP09 reflects the scientific community's best understanding of how the climate system operates and how it might change in the future.

The information presented includes:

- observed climate data from the 20th and 21st centuries
- climate change projections for temperature, precipitation, air pressure, cloud and humidity
- marine and coastal projections for sea level rise, storm surge, sea surface, and sub-surface temperature, salinity, currents and waves

The UKCP09 projections can be used to inform estimates of how the likelihood and severity of different impacts may change over time. Depending upon your attitude to risk, you can test the sensitivity of your project to varying degrees of climate change.

For example, under a given projection, e.g. 50% under the medium emissions scenario the UKCP09 may suggest that for a particular region there may be increasing levels of rainfall during the winter period. Therefore this might result in an increase in the risk and severity of surface water, river flooding and

[2] https://www.gov.uk/government/policies/adapting-to-climate-change/supporting-pages/the-uk-climate-projections-2009

erosion at this time of the year. Similarly, where precipitation is expected to be lower during the summer there might be an increased risk of water shortages.

If you wished to apply a sensitivity analysis you could do so by also considering how your project and the different adaptation options may perform under a range of possible future climates - to give an indication of how robust they may be and to help inform your final decision.

However, it must be remembered that how overall changes in the climate affect weather at the local level will depend upon a wide variety of factors, ranging from local geographical factors such as the local geology and topography to urban planning and building designs.

Practical example

In the previous example, it was estimated that a factory suffers a moderate risk of flooding (1 in 75 chance in any given year). In a cost-benefit analysis approach, the expected value of the annual costs is the flood risk x damage costs:

1/75 x £450,000 = £6,000 (using the current flood risk level)

Table 1

Description	Year						**Total**
	0	1	2	3	4…	15	
Potential losses	–	6,000	6,000	6,000	6,**000**	6,000	90,000
Net annual cost (discount rate 7.5%)	–	5,550	5,134	4,749	**4,**393	1,863	51,020

By applying a sensitivity analysis you can test the effects of changes to your assumptions when calculating these costs. For example, perhaps your original estimates of the costs of an individual flood event were too optimistic and underestimated the real costs, which would more likely be around £750,000, for example.

1/75 x £750,000 = £10,000

If these changes are included in the calculations, the results change accordingly, as shown in Table 2.

Table 2

Description	**Year**				**Total**
	0	1	2	15	
Potential losses	–	• 10000	• 10000	• 10000	• 150000
Net annual cost (discount rate 7.5%)	–	• 9250	• 8556	• 3913	• 91690

In this example, the total costs (discounted) increase by £40,670, which may be enough to justify further investment in adaptation measures at the factory.

Alternatively you could see what the costs of the impacts would be if the frequency of the flood event decreased or increased over time and help identify which adaptation options work best under different scenarios.

1.2. Step 2: Defining adaptation options

An adaptation option is something that will help reduce the probability or severity (or both) of a particular risk and/or increase the adaptive capacity of the project to respond if it occurs.

For example, when considering flood risks to a property, one option may be to build a curtain wall around it to reduce the likelihood it will be flooded. Alternatively, the building could be designed so that, if it is flooded, the amount of damage caused by the water would be reduced.

It is likely that there will be a number of different options available to address specific threats. It is important these are properly assessed to ensure that they add sufficient value to justify their cost.

In a cost benefit analysis approach, the benefits of different adaptation options need to be quantified and measured in terms of a **reduction in the annual cost of the risk to the project.**

When considering how to respond to climate impacts, businesses can respond in a number of ways.

Do nothing and tolerate losses where it is not possible or cost-effective to avoid them.

Seek to better understand and monitor risks. While the business may feel that action is not yet necessary, it may decide that developing knowledge (information on hazard and risk, education, research on risk assessment and management), raising awareness and preparedness and implementing early warning systems (monitoring, forecasting, alarms) are useful first steps.

Prevent effects or reduce exposure to risks. This can include a range of actions to build the organisation's resilience, such as:

- diversifying the supply chain
- diversifying energy supply
- investing in new facilities
- relocating parts of the business
- altering products and services and using materials that are less exposed to climate risks

Transfer risks. This is usually done through insurance, which can be used to manage those risks that cannot be prevented or are too expensive to prevent. It should be noted that risks of this sort cannot be fully transferred out of an organisation since losses of some kind will still occur.

Exploit opportunities. Climate adaptation also offers market opportunities across a range of sectors for businesses to develop new products and offer new services.

[3] Four categories of adaptation options: are widely recognised (UKCIP, 2009)

1) No regrets
2) Low regrets
3) Win-win
4) Flexible/adaptive management

No regrets adaptation options refer to those measures that are worth doing regardless of the extent of climate change. For example, they may help address current risks and be further justified if these risks increase with climate change. These measures are good to start with for most projects as they are most likely to be approved and implemented.

Example: Ensuring that water efficient piping and systems are installed at the start will minimise waste and, in the event of water shortages, help to ensure a facility can continue to operate.

Low regrets refer to those measures where the associated costs are relatively low and for which the benefits may be relatively large.

Example: Slight adjustments to the design of a property to ensure that, if there is a flood, the electrical systems will not be as badly damaged. For example, ensure wiring is run along the top of rooms rather than the bottom and plug sockets are positioned higher up a wall.

Win-win options are those that will have the desired results in terms of minimising climate risks, but will also provide other benefits to the business. These may require some investments but will be justified by the benefits.

Example: Installing green roofs on a property may help insulate the building from high and low temperatures, but will also reduce energy costs and help the company achieve its sustainability targets.

Flexible or adaptive management options are good approaches to take where adaptation measures may be necessary, but are too large for a company to undertake in a single go, such as through a series of incremental modifications that can be put in place over time to achieve long term goals.

The advantage of this approach is that is helps spreads the costs over a longer time period, and may be easier to implement than larger measures. It also recognises that risks change over time and measures can be put in place when it is felt that the risks have sufficiently increased to justify the measures.

Example: A company can plan for what seems to be sensible for the present, but ensures the designs of a building leave enough room for further measures to be installed later if they are felt to be necessary, for example, internal air-conditioning units or external flood defences, such as curtain walls.

1.2.1. Assessing the costs and benefits of adaptation options

Once a detailed understanding of the possible adaptation options has been obtained, all of the costs and benefits must be plotted in time (over the expected lifetime of the project) with a discount factor applied depending on in which year the expenditure is made (or benefit received). Specifically, you will need to:

[3] For more information, see UKCIP Adaptation Wizard Step 4: Adaptation Options: http://www.ukcip.org.uk/wizard/adaptation-options/

- **calculate the present value of costs and benefits** of different adaptation options using the discount factor and then the difference of these (NPV)
- **compare the NPV to the baseline scenario** (the potential costs of the climate impacts if you implemented no adaptation options)
- **repeat the exercise using different adaptation options** to assess their costs/benefits
- **repeat the exercise using slightly different number**s, such as discount rates (a 'sensitivity analysis')

1.2.2. Calculating benefits

To calculate the benefits of the adaptation options, it is important to consider what objective they are seeking to achieve. This could range from reducing the vulnerability of the project to a specific climate impact through to meeting wider strategic objectives for the organisation, such as corporate values or sustainability targets. As such there may be an element of subjectivity in calculating the benefits of different options, though for the CBA approach to work the benefits do need to be measured and quantified.

The **Adaptation Wizard (Environment Agency, 2013)** provides useful information on how to consider the benefits of different adaptation options – See Section 4: Further Resources for more information.

For simplicity, this guidance will focus on assessing the effectiveness in reducing vulnerability to specific impacts. One approach would be to consider the probability of the option working in any given event (reducing exposure) and how effective it will be reducing the damage caused (reducing sensitivity). A rating of 'effectiveness' can then be calculated in percentage terms to each option, and this can be used (along with the cost of the option itself) to calculate the residual annual cost to the project.

For example, to address the problem of flooding damaging machinery in a building, for a cost of £25,000 slightly raised doorways could be installed at a height that would prevent water from entering in the case of light flooding, which could represent half of all flooding events in that area. In the case of severe flooding, however, it is insufficient as the water may rise higher than the doorways and flood the building.

As such it might be 100% effective in reducing damage but only in, say, 50% of scenarios. It may be 0% effective in the remaining 50% of scenarios. Therefore it has an overall effectiveness rating of 50%.

If this approach won't completely prevent machinery from being damaged (perhaps some of it is outside the main building) then its effectiveness could drop further. If, say, it was only 50% effective in reducing damage to machinery in only 50% of scenarios, its overall effectiveness would then drop to only 25%.

An alternative approach may be to build for £50,000 a flood wall around the property which will protect it completely from all but the most extreme of flood events, which may represent 5% of all occurrences. This would therefore give you an effectiveness rating of 95%.

Practical example

Table 3 shows a number of possible options for a factory to adapt to the impacts of flooding. Options 1 and 2 involve physical changes to reduce the risk of the property being flooded.

Option	Description	Cost (£)	Effectiveness	
			Probability of option working in any given event	Effectiveness factor (if the option does work, how effective is it?)
1	Flood wall	50,000	95%	100%
2	Raised doors with all machinery inside the building	25,000	50%	100%
3	Raised doors with leakages or machinery outside building	25,000	50%	50%

Table 3: Possible options for adapting to flooding

If the annual cost to a factory of a flood is £6,000, then by introducing the first adaptation option that has an effectiveness level of 95%, the residual annual cost would be £300 a year.

However, if the second adaptation option was selected, which has only a 50% probability of working, then the residual annual cost would be reduced to only £3,000.

These two options are fairly simplistic in that they assume that if they work, they will ensure all potential damages are avoided. If the probability of the option working is 50% and the effectiveness of the measure is also 50%, then the total effectiveness would be 25%.

1.2.3. Calculating the costs of adaptation options

As with the costs of the climate risks, the costs of the adaptation options also need to be plotted over time with a discount factor applied to calculate the net annual cost.

To do this, you need to consider the costs of the adaptation option, such as the initial investment or ongoing operational costs of the option, and the residual annual cost.

Practical example

Considering Option 1 in Table 3, which has an initial upfront investment of £50,000, no ongoing operating costs and a residual annual cost of £300, the net annual costs for years 0 and 1 are shown in Table 4.

Year	**0**	**1**
Investment	£50,000	–
Residual cost of risk	–	£300
Net annual cost at present day cost	**£50,000**	**£300**

Table 4: Net annual costs for years 0 and 1

1.2.4. Calculating the NPV of adaptation options

The **NPV** helps to determine which adaptation option will make the most financial sense. It takes into account the costs and benefits of different options over the lifetime of a project and takes into account the discount rate to reflect the current value of money.

The NPV is calculated by assessing the present value of costs and benefits of different adaptation options using the discount factor and then the difference of these (NPV).

Practical example

Table 5 illustrates the costs of the different options over the lifespan of the project, with a 7.5% discount rate applied to get the NPV.

Option	Description	Year						Total
		0	1	2	3	4	15	
1	• Investment	£50,000	–	–	–	–	–	£50,000
	• Residual cost of risk	–	£300	£300	£300	£300	£300	£4,500
	• Net present value	£50,000	£278	£257	£237	£220	£93	£52,553
2	• Investment	£25,000	–	–	–	–	–	£25,000
	• Residual cost of risk	• –	• £3,000	• £3,000	• £3,000	• £3,000	• £3,000	• £45,000
	• Net present value	£25,000	£2,775	£2,567	£2,374	£2,196	£932	£50,510
No action	• Residual cost of risk	–	£6,000	£6,000	£6,000	£6,000	£6,000	£90,000
	• Net present value	–	£5,550	£5,134	£4,749	£4,393	£1,863	£51,020

Table 5: Costs of different options over the lifespan of the project

When the tables are summed up (including the omitted years 5-14), Option 1 costs more than the cost of inaction. Option 2 costs less and is, therefore, a better choice. This is shown in Table 6.

Option	• NPV	• Comment	
1	£52,550.98	3%	more expensive than 'do nothing' option
2	£50,509.80	-1%	less expensive than 'do nothing' option
Baseline	£51,019.59		('do nothing' option)

Table 6: Comparing NPV for different adaptation options

The climate is changing. Are you?
A support service led by the Environment Agency
www.environment-agency.gov.uk/climateready

1.3. Step 3: Compare the options

Determine the baseline → Define the adaptation options → **Compare the options** → Report in the project appraisal

The penultimate step is to compare the different options. As previously mentioned, the **NPV** helps to determine which adaptation option will make the most financial sense – those options that cost less (once the residual costs are taken into account) than the cost of inaction would be worth doing, whereas those that cost more would not be.

Additionally, another similar method is to use a **benefit cost ratio (BCR)**, which is described below, to assess the suitability of different options.

However, it is important to remember there may be other, non-financial factors to take into account that may have an impact on an option's desirability. For example, one option may make less financial sense than another, but deliver greater non-financial benefits, such as reputational enhancements or be more in line with a company's values. This is discussed below.

1.3.1. Calculating a BCR

A **BCR** takes into account the amount of monetary gain realised by performing a project versus the amount it costs to execute the project. The higher the BCR, the better the investment. A good general rule of thumb is that if the benefit is higher than the cost, then the project is a good investment.

Practical example

The same data can be summed into a BCR comparison. In this example, the 'benefit' in any given year is the difference between the 'do nothing' scenario and the scenario in which the option is implemented. The table below illustrates how the BCR for different options can be calculated. In this example, the results indicate that Option 2 is the best option as it provides the highest BCR of all the options.

Option	Benefit (discounted)	Cost (discounted)	BCR	Comment
1	£48,469	£50,000	0.97	Costs outweigh benefits compared to the 'do nothing' option
2	£25,510	£25,000	1.02	Benefits outweigh costs compared to the 'do nothing' option
Baseline	0	0	1.00	'Do nothing' option

Table 7: Benefit-Cost Ratio analysis of different adaptation options

1.3.2. Applying discount rates/sensitivity analysis

In reality, all these calculations will be dependent upon a wide range of estimations and assumptions, particularly the discount rate and the projected costs of different impacts, their probability, and so forth. In practice it may not be possible to identify and assess all these different factors, particularly how climate change may change the frequency and severity of specific risks.

As such, when considering the risks and adaptation options, it is wise to perform a sensitivity analysis to test their robustness under different scenarios and whether they still make the best economic sense. This can be achieved by varying the frequency and severity of particular risks, changing the discount rate and other factors to reflect other external factors such as changes in interest rates or the activities of other organisations, and assessing the results of the modelling. Climate projections such as UKCP09 can be used to provide some indication of how climate risks may change over time.

By undertaking a sensitivity analysis you can assess how effective your preferred adaptation options perform under different scenarios and conditions, and you may get surprising results. For example, an adaptation option that perfectly achieves your goals and objectives and is economically the most desirable may no longer make sense if the risks increase or decrease. You may also find that some adaptation options work very well and make good economic sense in most scenarios.

Depending upon the level of risk you are willing to accept you can then select those options that best achieve your objectives and make the most economic sense.

1.3.3. Other costs and benefits

It is likely that there will be secondary costs and benefits with any risk and adaptation option, some of which may be difficult to identify initially. For example, certain risks may have some benefits for the project if properly exploited, whereas some adaptation options may also have additional costs, such as those created by disruption to the project as they are implemented; or benefits, such as efficiency savings. They may also increase the organisation's reputation for reliability.

It may not be possible or practicable to capture and quantify in monetary terms all these secondary costs and benefits, but they may have an impact upon the final decision. For example, an adaptation option may have a lower BCR in terms of addressing a specific risk, but it may provide additional benefits beyond reducing risk, which can ultimately make it more appealing than other options.

Ultimately, you will need to consider how best to take these into account depending upon the project itself and your organisation's approach to non-financial issues during the project appraisal process.

Step 4: Reporting

Determine the baseline → Define the adaptation options → Compare the options → **Report in the project appraisal**

At this point, you should be able to answer the questions below.

Steps	Questions
Determine your baseline	What are the major climate impact risks facing your project over its lifetime? What are the potential costs of these impacts? How might these risks and costs change over time?
Define the adaptation options	What are the adaptation options available to you? What the costs and benefits of each are?
Compare the options	What is the NPV of each adaptation option? What is the BCR of each option? How do these results change when a sensitivity analysis is applied? What are the secondary costs/benefits to each option?

The answers to these questions can now be reported in the final project appraisal for consideration alongside other issues that will need to take into account for the project. By using a CBA approach, a clear and strong business case can be made for, or against, taking action to address potential risks from a changing climate in monetary terms.

If it has not been possible to calculate all the costs and benefits in monetary terms, or to take into account secondary or non-financial issues.