Subgroup: Health

Case-study: Cornwall

(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."

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1. General Case Study Description

a) Location

(Please insert the coordinates of the geographical centre of your case study and additionally the area of the entire are under investigation. For a city, for example, use the city centre and the area of the municipality. Illustrate in the map the area in study)

Cornwall is a county located in the far South West of England, UK indicated in red below.

GPS: 50.3°N / 4.9°W
Area: 3,563 km²

(Source: http://commons.wikimedia.org/wiki/File:Cornwall_UK_mainland_district_map_%28blank%29.svg)

b) Case Study Summary

Cornwall is a county located in the far South West of the United Kingdom and has a population of 532,300. Cornwall is characterized by a mild, maritime climate, but has experienced several major extreme events in recent years, notably incidences of flash flooding in Boscastle in 2004 and major coastal flooding due to storm surge in early 2014.

The case study will develop a methodological framework to assess costs and benefits of cross-sectoral adaptation strategies to reduce the impacts of climate change in Cornwall, UK. It will focus on local plans for adaptation to climate change. We provide a pragmatic approach to identifying, estimating and comparing the costs of the main adverse climate change impacts on human health. This case study will explore potential tools for decision-making, drawing in particular on cost-benefit analysis and multi-criteria analysis of adaptation options.

Specifically this case study on adaptation to climate change related health risks in Cornwall, will adapt a "science-first" approach. This impact-based approach evaluates impacts and then uses this as a basis to identify adaptation options (Ranger et al 2010). Therefore the case study will focus on:

1. The likely linkages between climatic variation and health
2. The key climate induced health risks in Cornwall, UK.
3. The economic value of these risks
4. The potential adaptation strategies either in place or planned to manage these effects
5. Assessment of adaptation options using cost-benefit and multi-criteria analysis

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*

Climate change may have significant adverse impacts on human health (IPCC 2007). Consequently, increasing attention is now being given to the issue of adaptation (IPCC 2007; Stern 2007; Costello et al. 2011). The effects of anthropogenic climate change have been discernible for a number of years (WHO 2009a). Most people will have noticed changes to the weather (Kerr 2011) and in the timing of seasonal events such as earlier flowering (Fitter and Fitter 2002). Weather anomalies and extreme events are becoming more frequent globally (e.g. heatwaves and flooding). Over the coming decades, societies will need to adapt to the changing climate (Stern 2007) based on local requirements. Climate change adaptation in terms of minimising or avoiding human health impacts is now taking centre stage (Kurane 2009; Bell 2011). Improvements in the resilience of healthcare systems to meet future climate change will save money long-term and will also assist in coping with natural catastrophes. The World Health Organization (WHO) and the European Commission are both funding research aimed at

facilitating health adaptation to climate change (WHO 2009b; European Commission 2012). Because, different geographical regions will be impacted differently by climate change, each country will need to prepare for and adapt to their changing local climatic conditions to protect health.

Direct adverse impacts are related to heatwaves, flooding and other extreme weather events (Pall et al. 2011), and these have received the most attention to date (García-Herrera et al. 2010). However, many impacts of climate change on human health will be indirect, i.e. not linked directly to weather events (Kurane 2009). In the UK the main climate related health threats include: summer heatwaves and droughts; flooding and its associated mental health issues (Paranjothy et al. 2011); interactions between air pollutants, pollen and higher temperatures (Cecchi et al. 2010; Laaidi et al. 2011); deterioration in food and water quality (Lobell et al. 2011); increase in vector borne diseases (Jones et al. 2008) and increased exposure to elevated UV irradiance. Different UK regions will experience these impacts to different extents will be required to adapt locally to the new conditions.

Increases in UV flux due to changing climate and prolonged exposure will likely increase the risks of both melanoma and non-melanoma skin cancers. Predicted reductions in cloud cover, the uncertainty around ozone depletion levels and behaviour change (> exposure), may all interact to result in a greater skin cancer incidence. Understanding the how exposure in early years may result in increased risks is also the focus of much research. Additional risks of adapting to this increased UV flux (e.g. via avoiding strongest UV, applying sun protection) may have secondary impacts if it inhibits the production of vitamin D (i.e. the benefits of UV exposure). Despite predicted climate change effects on UV radiation, the critical factors affecting human exposure are lifestyle and behaviour (O'Hagen et al 2011). Predicted higher temperatures under climate change scenarios accompanied with interactions with predicted decreases in cloud cover and uncertainty around the ozone depletion in the future, may lead to increasing incidence of skin cancer in human populations. This is of particular importance in Cornwall, UK, given its popularity as a holiday destination. The south west also has a higher incidence of skin cancers anywhere in the UK where the UV intensity is higher, compared to the north of the country (by ~25%) (SWPHO 2014).

Cost-benefit analysis of health adaptation measures is rare and this case study will help improve understanding of the issues in implementing such an approach in the health context.

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 county of Cornwall (SW England, UK) has a maritime climate and will experience significant changes in weather patterns over the coming decades and it is predicted that by 2050-2080 the local climate will be 2 to 3 °C warmer than now, both in winter and summer (IPCC 2007). Cornwall will also experience longer periods of warm/hot and dry weather in spring and summer (CCRA 2012). Overall levels of precipitation will be similar to now, but more concentrated in the winter months (CCRA 2012). In addition it is predicted that extreme

weather events will become more frequent, including heatwaves, storms, heavy rainfall, and cold spells (IPCC 2012). These changes will occur over the medium term, and are within the time frame of planning and development.

TEMPERATURE

Until recently it has been assumed that climate change will decrease winter mortality in temperate countries as winters warm (CCRA 2012). This assumption has been shown to be naïve and two recently published articles have conclusively shown that winter warming will not decrease winter mortality, one in the UK (Staddon et al. 2014) and one in the USA (Ebi and Mills 2013). Furthermore the increase in winter temperature volatility and the possibility of increased cold spells (CCRA 2012), increased severity of temperature drops, occurrence of earlier cold spells, could all lead to increase in winter deaths despite generally warmer winters. This makes the prediction of how climate change will impact winter deaths very uncertain. Currently, Cornwall has over 300 excess winter deaths per year, which is similar to the national average (NHS 2012). This is because despite a higher proportion of elderly residents, an older housing stock, and a relatively high level of fuel poverty, Cornwall has a generally milder winter climate, and escapes a proportion of cold spells suffered by the rest of the country. A decrease in excess winter deaths will be more dependent on progressive welfare and equality policies than on climate change.

Heatwaves, along with flooding, are topics which have received the most attention from an adaptation point of view in Europe (García-Herrera et al. 2010). This is partly because both of these impacts are already occurring with greater frequency and severity, and when they do occur can result in many deaths and / or massive destruction of property and related stress. Point events like these receive saturate media coverage and thus easily enter the public consciousness leading to various responses from politicians. The 2003 European heatwave is a classic example. Cornwall was less affected than other areas of the UK, such as the South East, but nonetheless exhibited a significant number of excess deaths, especially amongst the elderly. Thanks to its location as a peninsula jutting into the Atlantic Ocean, Cornwall will suffer less from this aspect of climate change than other regions, but the health costs may nevertheless be substantial.

Currently most wildfires in Cornwall are extremely small with only between 5 and 14 a year consuming more than 1 hectare (Cornwall Council 2012), which again is very small in comparison to wildfires on the continent consuming 100s of square kilometers. Wildfires in Cornwall are generally on heathland and gorse covered land. Most fires are arson related indicating that education and more facilities for young people could play a vital role in limiting the problem. Due to their small size and location costs are currently very minor and injuries are extremely rare (none reported in past 5 years). Even with an increase in occurrence as a result of hotter and drier springs and summers with climate change, it is unlikely that wildfires will be a significant problem in the future and certainly will not be seen on the level of that observed in Southern France or Portugal in recent years.

RAINFALL AND STORMS

The increased frequency of droughts in Cornwall (CCRA 2012) will affect agriculture, especially in terms of what crops are planted and the risk of crop losses. This impact on local food production is however unlikely to have any meaningful impact on local food supplies assuming the UK remains in a position to import its food needs. The security of the water supply could be temporarily affected by drought and the risk of flash flooding will increase as a result of dry compacted surface soils. The main health issue resulting from drought relates to mental health issues, especially in the farming sector. Farmers and employees in the farming sector already suffer from a disproportionately high rate of psychological illness and exhibit high suicide rates (Booth et al. 2000). The increased uncertainties arising from climate change and the very likely increased risk of substantial losses in any one year can only further fuel these mental health issues amongst workers in the agricultural sector.

Cornwall currently experiences two main types of flooding: coastal flooding and flash flooding of which the latter is by far the most significant (Cornwall Council 2011). This is likely to continue to be the case in the future despite the impact of sea level rise and increased risk of storm surges on coastal communities. Many of the villages susceptible to flash flooding are often also at risk of coastal flooding. There are numerous estimates and assessments of the impact of climate change on flood risk in England and the South West of England, e.g. Climate Change Risk Assessment (CCRA 2012), South West Regional Flood Risk Appraisal (SWRFRA 2007), Association of British Insurers (ABI 2009). This case study will assume the view of CCRA, a central view based on the best evidence available. The Boscastle floods in 2004 (Environment Agency 2008) in Cornwall are a key example of flash flooding and the information on these floods were augmented with other relevant data from England to obtain more robust information of current expected impact.

Storms are intimately linked to flooding, however we will concentrate purely on wind damage and related health risks. Storms will probably be more frequent in the future (CCRA 2012). It is therefore likely that the health impact of severe wind episodes will increase with climate change, but as the current impact on health and wellbeing is relatively low, the future health impact of storms is unlikely to increase to alarming levels. As with flooding, mental health issues arising from experiencing storms and possible financial losses will form a significant component of the impact of storms on health and wellbeing. The UK rarely exhibits large scale storms, hurricanes or tornadoes when viewed from a global perspective - deaths are rare and certainly never run into the 1000s or 10s of thousand as in less developed countries.

WATER AND FOOD

Water quality encompasses many aspects including, chemical composition, and occurrence of pesticides, pharmaceuticals, heavy metals, other hazardous chemicals, natural toxins, and pathogens. Climate change will impact water quality via several key mechanisms: first, droughts followed by flooding have the potential to greatly increase the amount of farm runoff (Boxall et al. 2009); second, flooding often results in raw sewage from combined sewage overflows (CSO) entering water courses (Wilby et al. 2006); third, reservoirs may experience excessive phytoplankton and cyanobacteria blooms in hot periods (especially if combined with drought) (Thorne and Fenner 2011); fourth, agricultural inputs will probably increase under a warmer climate (Chen and McCarl 2001; Gale et al. 2009). Agriculture is the main source of

contaminants in Cornish water. Agriculture plays a vital role in the Cornish economy and the land area occupied by farming is substantial (University of Exeter, 2011). The externalised health costs associated with agriculture are high (Pretty et al. 2000; Kusiima and Powers 2010). Climate change will induce large changes in agricultural inputs, including water, pesticide, fertiliser, and pharmaceutical use, which could have serious repercussions for the 'natural' environment, including terrestrial, freshwater, and coastal marine, and by extension for human health and wellbeing (Miraglia et al. 2009; Johnson et al. 2009). In particular, there is the health risk associated with increased pharmaceuticals in the environment (Lee et al. 2007) and the potential for food and especially water contamination. Water standards and regulations are generally good in the UK and will remain so. The UK Drinking Water Inspectorate (DWI) reported no serious events involving water contamination due to environmental factors in the past 3 years in Cornwall (DWI 2012). Climate change will result in some additional cost (< 10%) to treating the water supply (Thorne and Fenner 2011), but this will not be in proportion to additional contaminants. Currently, two key water quality risks are identified impacting health: gastroenteritis (Semenza et al. 2012) and colon cancer associated with nitrate levels (van Grinsven et al. 2010).

For the UK, food security is unlikely to be a serious issue. Purchase of food from our European partners and globally will continue to make up the shortfall in domestic food production. Globally, future food security is a very serious issue that will primarily hit the poorest people in the developing world (Godfray et al. 2010), those in fact least responsible for anthropogenic climate change. Food quality will be impacted by climate change via various mechanisms and the following contaminants could be expected to rise: mycotoxins, pesticides, pharmaceuticals, polycyclic aromatic hydrocarbons, and marine biotoxins (Tirado et al. 2010). In addition, food borne pathogens are likely to increase with climate change (Lake et al. 2009). Similar to water quality, food quality is subject to strict control in the UK greatly limiting health risks. In Cornwall the greatest risk in terms on food quality is probably from seafood contaminated with marine biotoxins, especially from HABs (Fleming et al. 2006). The health impacts can be quite substantial and costs the US economy over a US$ 100 million per year (Hoagland et al. 2002). The frequency of harmful algal blooms (HABs), caused by microalgae, is increasing globally. Climate change and nitrogen inputs from human activities are implicated, but the precise mechanism underlying these HAB events are unclear (O'Neill et al. 2012). Food borne diseases, principally causing gastroenteritis, are expected to increase by a small degree as a result of warmer conditions. In all but a few cases, treatment is inexpensive, but occasionally death can occur. Much of the increased cost of food borne disease is linked to the forecast local population increase.

VECTOR BORNE DISEASE

There are several tick borne diseases that are likely to respond to climate change as a result of a longer tick season. These include *Lyme borreliosis, rickettsiosis, ehrlichiosis, babesiosis*, and tick-borne encephalitis (Halos et al. 2010). Lyme borreliosis, or Lyme disease, is by far the most common in Cornwall and it can assumed climate change impacts will be similar for all of these tick borne diseases as the same vector is responsible for their transmission. Lyme disease may result in severe neurological disorders many months after initial infection (Henningsson et al. 2009). In the UK, the main carrier is the sheep or deer tick (*Ixodes ricinus*). Lyme disease is

present throughout the UK, particular in moor type habitats with significant deer populations (Stanek et al. 2012). Many small mammals and birds are also a reservoir for the disease (Pietzsch et al. 2005) making eradication unlikely. Tick density and tick infectivity has increased over the past decades (Smith et al. 2011), and climate change could further accentuate this. Also, there is evidence that the timing of the tick lifecycle and the proportion of ticks at different stages may alter with climate warming making infection more likely (Jaenson and Lindgren 2011). In conjunction with the response of ticks to warmer temperatures, there is also the impact of warmer weather on human leisure activity. Together this will result in greater contact between humans and active ticks and a greater number of infections.

Malaria could extend into southern Europe, but it is unlikely to become established in the UK (Lindsay et al. 2010). West Nile virus, transmitted by temperate Culex species, has the potential to establish permanently in the UK, as has happened in the US (Medlock et al. 2005). Whether this would be strictly as a result of climate change is of secondary concern to addressing the health risk. Cornwall has suitable mosquito habitats, but mosquito borne diseases are currently not endemic.

OTHER PLANT AND ANIMAL RELATED HEALTH CONDITIONS

Pollen causes hayfever (pollinosis) and is intricately linked with asthma symptoms (d'Amato et al. 2007). Weather related variables play a crucial role in determining pollen production. The longer growing seasons and warmer and drier summers predicted for Cornwall as a result of climate change are very likely to exacerbate pollen related allergies (Cecchi et al. 2010; Ziska and Beggs 2012). Also, some species produce far more allergenic pollens than others and it has been demonstrated that the specific allergenicity of pollen from a given species may be affected by weather variables (Reid and Gamble 2009). Understanding the future spread of highly allergenic pollen producing plants, such as birch (Betula), ragweed (Ambrosia) and oil seed rape (B*rassica napus*), is a key area to focus on.

Macroalgal blooms, also termed marées vertes or green tides, currently cause significant health and economic concerns in some coastal regions, such as Brittany, France (Charlier et al. 2008; Ménesguen et al. 2010). A moderate further increase in temperature as a result of climate change could result in all the necessary conditions being met for a similar phenomenon to occur in Cornwall. Currently, the Cornish climate limits the growing season for Ulva to the extent that the number of growing degree days is below that required for the formation of green tides (Merceron et al. 2007). Nutrient runoff from agricultural lands is known to be a key contributor to the Breton marées vertes (Charlier et al. 2008), and Cornwall also a highly agricultural region. The human health impacts include both the direct health risks associated with the production of hydrogen sulphide in the decomposing algae (Ménesguen et al. 2010), and the indirect mental health risks, associated with financial loss (collapse of tourism industry and property prices) (Morand and Merceron 2005).

The EU Bathing Water Directive sets the minimal standards of water cleanliness considered safe for bathing (Georgiou and Bateman 2005). This primarily relates to pollutants and concentration of microorganisms, such as enteroviruses, originating from sewage waste. Nonetheless, gastroenteritis as a result of bathing in contaminated waters is relatively common and may affect 15000 people in Cornwall annually (Georgiou and Langford 2002). In addition to this

health risk there are numerous other marine health risks, which will be impacted by climate change. These risks include the production of toxins by HABs or cyanobacteria blooms (Fleming et al. 2006) and the increased occurrence of dangerous exotic animals, such as sharks and jellyfish, in Cornish waters. These risks are currently relatively small compared to the risk of catching gastroenteritis whilst bathing, and this is likely to remain so even with climate change.

AIR POLLUTANTS

Particulates, especially coarse (PM10) and fine (PM2.5) particulate matter, are a key aggravating factor in most respiratory diseases (Laumbach and Kipen 2011). In addition to asthma, already discussed in the context of pollen, particulates affect other respiratory diseases including pneumonia, bronchitis and other chronic obstructive pulmonary disease (COPD) (Laumbach and Kipen 2011). Other air pollutants and pollen may interact with particulates in their impact on respiratory disease. Hotter and drier weather in the warmer months are likely to exacerbate the impact of particulates on respiratory health. In Cornwall, in addition to the ubiquitous impact of traffic pollution on air quality, there are other sources of concern locally, especially dust from past mining activity and clay works (Parsons et al. 2003).

SKIN CANCER

Climate change could affect incidence of skin cancer due to higher temperatures changing people's behaviour so they stay outside for longer as well as increasing the carcinogenic effectiveness of solar UV (Diffey, 2004). Predicting the impact of solar radiation is complex and dependent on socio-economic factors and behaviour and lifestyle as well as other climatic variation such as cloud cover. However the south west is likely to experience the greatest levels of increased UV radiation (Vardoulakis & Heaviside 2012) and is already experiencing an alarming increase in both malignant and non-malignant melanoma of 9,000 and 80,000 new cases reported each year (Vallejo-Torres et al 2013). The south west also has a higher incidence of skin cancers anywhere in the UK where the UV intensity is higher, compared to the north of the country (by ~25%) (SWPHO 2014).

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*

This case study focuses on the impacts of climate change in Cornwall, with specific interest in the impact of increased solar radiation and on incidence of non-melanoma and melanoma skin cancers. More broadly, Cornwall has generic adaptation policies for promoting and maintaining green infrastructure and flood risk adaptation and are s follows:

- Green Infrastructure Strategy for Cornwall 2012 (http://www.cornwall.gov.uk/media/3623031/Designed-Green-Infrastructure-Strat.pdf)

    - Not explicitly a climate change adaptation strategy but incorporates resource use and effective green and blue infrastructure management for health and wellbeing, in which health and wellbeing strongly features.
    - It has both a Climate Change (adaptation and mitigation) Theme and a health and wellbing theme as part of its strategic framework
- Green Cornwall (http://www.cornwall.gov.uk/media/3624737/Green-Cornwall-Strategy-2011-2020.pdf)
    - This is Cornwall Councils overarching programme to coordinate efforts to reduce carbon emissions and strengthen our wider leadership role within Cornwall. Given the current local, national and international drive to reduce impacts on the environment, the role of Green Cornwall in bringing together our combined resources to achieve this goal is crucial. Green infrastructure is an integral element of the Green Cornwall programme and will provide evidence and information about the potential benefits that green infrastructure can play in particular in helping Cornwall adapt to the projected impacts of climate change.
- Climate South West 'Warming to the Idea: Building resilience to extreme weather and climate change in the South West' 2010 (http://climatesouthwest.org/library/Resources/warming-to-the-idea-2010sml.pdf)
    - Region wide – rather than a specific Cornwall focus
    - No specific goals, plans or measures regarding adaptation strategies.
- The Cornwall Local Flood Risk Management Strategy: Part 1 Strategic Vision 2014
    - Not specifically a climate change adaptation strategy but incorporates the impacts of climate change directly and indirectly on human health and wellbeing.
- Strategic Flood Risk Assessment (SFRA) 2009 (http://www.cornwall.gov.uk/media/3639947/Cornwall-SFRA-Level-1-FINAL-version-Dec-09.pdf)
    - a study carried out by the local planning authority to assess the risk to an area from flooding from all sources, now and in the future, taking account of the impacts of climate change, and to assess the impact that land use changes and development in the area will have on flood risk.

In terms of specific adaptation options/strategies for increased exposure of the population to UV and the potential for increase incidence of skin cancers), there is no explicit strategy for Cornwall but rather a broad set of public health campaigns for the UK. These include:

- Met Office 'UV Index' prediction – is designed to warn of increased risks to health from UV radiation and encourage individuals to take actions to minimise the risks whilst still enjoying the sunshine (http://www.metoffice.gov.uk/health/public/uvindex). By combining information relating to the position of the sun in the sky, forecast cloud cover and amounts of ozone in the stratosphere, an index can be calculated (0-8 for the UK) to give an indication of the level of exposure for that day.
- Cancer Research 'Sunsmart' (http://www.sunsmart.org.uk/) - Sunsmart is the UKs cancer prevention campaign which conducts research and promotes public awareness of

enjoying the sun safely by using shade, clothing and a minimum SPF15 sunscreen to protect yourself.

- Chartered Institute of Environmental Health 'Saving our skins toolkit' (www.cieh.org) – Raise awareness of the risks of skin cancer for health care professionals to utilise

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)

'Drought Risk and You' NERC-funded project with Tim Taylors involvement.

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, Cornwall Health	[x] Objective 1 [x] Objective 2 [ ] Objective 3 [x] Objective 4 [ ] Objective 5 [ ] Objective 6 [x] Objective 7	Example: [D] Companies	[x] Rural [x] Urban [x] Coastal [ ] River Basin	[x] Local [ ] Regional [ ] National [ ] Transnational [ ] European /Global	[x] Bottom-Up [x] Top-Down	[x] Retrospective [x] Prospective	ongoing

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
[1] Extreme Temperatures [ ] Water Scarcity [1] Flooding [ ] Sea level Rise [2] Droughts [ ] Storms [ ] Ice and Snow	[1] Extreme temperatures [ ] Water scarcity [1] Flooding [ ] Coastal Erosion [2] Droughts [ ] Soil Erosion [2] Vector Borne Diseases [ ] Damages from extreme weather related events (storms, ice and snow)	[ ] Agriculture and forest [ ] Biodiversity [ ] Coastal Areas [ ] Disaster risk reduction [ ] Financial [ ] Health [ ] Infrastructure [ ] Marine and Fisheries [ ] Water Management [ ] Urban	[ ] Agriculture [ ] Biodiversity & Ecosystems [ ] Coastal and Marine systems [ ] Energy [x] Health and Social Policies [ ] Transport [ ] Production Systems and Physical Infrastructures [ ] Water resources [ ] Tourism	[ ] Yes [x] Ongoing [ ] No	[1] Assessment [ ] 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

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

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

[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.

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

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.*

This case study aims to develop a methodological framework to assess the costs and benefits of cross-sectoral adaptation strategies to reduce the impacts of climate change in Cornwall, UK. It will focus on local plans for adaptation to climate change and will provide a pragmatic approach to identifying, estimating and comparing the costs of the main adverse climate impacts on human health. This case study will be used as a means to explore potential tools for decision-making, drawing on in particular, the tools used for cost-benefit analysis and multi-criteria analysis.

This case study contributes to the BASE project by investigating the application of cost benefit analysis to decision making in the health context.

Principal research questions for this cases study are:

1. What are the likely linkages between climatic variation and health?
2. What are the key climate induced health risks in terms of skin cancer in Cornwall, UK?
3. What is the economic value of these risks?
4. What are the potential adaptation strategies either in place or planned to manage these effects?
5. Assessment of adaptation options using cost-benefit analysis

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.*

Building on a number of existing relationships with partner organisations in Cornwall, we will work with key stakeholders to identify climate change adaptation strategies in order to conduct economic valuation.

Key stakeholders to be engaged in this case study are:

Cornwall Council, a unitary authority for Cornwall, England, UK. It has responsibilities for public health, environment, planning, schools, social services, rubbish collection and highways. In particular, services to be engaged include:

- Environment division – with responsibility for climate change adaptation planning
- Public health – responsibility for public health interventions. Public health has recently been moved into the council from the National Health Service (NHS).
- Planning – responsibility for spatial planning and the local plans
- **Cornwall Health and Wellbeing Board** works to improve health and wellbeing, help identify and meet needs across Cornwall and work together to tackle health inequalities.

Public Health England, primarily the Air Pollution and Climate Change Group, Centre for Radiation, Chemical & Environmental Hazards

Royal Cornwall Hospitals Trust (RCHT) is a major provider of health care in Cornwall. The RCHT is part of the NHS.

University of Exeter Medical School has as major teaching and research hub located in Cornwall.

To a lesser extent we will engage with General Practitioners and patient groups in the region and the Environment Agency.

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.*

This case study adopts a "science-first" approach (table 1; fig. 1). First, we attempt to identify the likely linkages between climatic variation and health, before identifying possible adaptation options. Climate change impacts of temperature (heat/cold waves), extreme weather, flooding, drought, UV and vector-borne diseases are considered. The steps taken are:

1. Review of literature to identify health risks posed by climate change;
2. Analysis of the effects of climatic variability on incidence of skin cancer (MSC and NMSC)
3. Valuation of impacts – drawing on existing literature on costing mental health impacts;
4. Identification of adaptation options, based on the literature and discussion with key stakeholders;
5. Assessment of adaptation options using cost-benefit analysis.

We have conducted a review of the literature on the potential health impacts of climate change, drawing on relevant bibliographic databases and existing studies by the UK government, IPCC, World Health Organisation and others. In order to capture emerging threats that are identified in the literature, but which not yet be mainstream additional Web of Science searches will be made using terms such as “melanoma*” AND “ultra*violet” AND “health”. From this we will identify key health impacts on health with particular focus and importance in Cornwall, UK and will develop economic estimates of physical impacts on health based on this literature, drawing on adjustments for the climatic and socioeconomic nature of the region and future climate scenarios. For baseline health values we will utilise data available for melanoma and non-melanoma skin cancer incidence (NHSIC (https://indicators.ic.nhs.uk/webview/)) and calculate projected population rise in Cornwall up to 2050 by extrapolating % population growth for the UK (IIASA SSP1) which is associated with rcp4.5 climate scenario, and applying to Cornwall population data from 2011 census. Then

Using data obtained from key literature sources (i.e. van der Leun et al. 2008), we calculated the incidence and estimated crude rate for non-melanoma and melanoma skin cancers at a predicted 3% and 6% increase per 1oC rise in mean temperature to give a total excess of NMSC and MSC cases in 2050 due to impact of UV radiation associated with climate change.

These figures were then applied used to calculate the cost of NMSC and MSC cases in Cornwall.

Estimates of future health impacts were similarly taken from available sources. Where no real estimates are available, a value will be assigned based on expert judgement of the link between climate variables and the health impact in question. The intention of this work is not to provide precise figures, but rather to provide a pragmatic approach to estimating these figures and to allow meaningful comparison between them in terms of costs of various health impacts. Cost valuations of the adverse impact of climate change on each of the main health and wellbeing measures will be carried out for three variables: cost of treatment, disutility, mortality and cost of associated economic losses. It is expected that in most cases, valuations will be obtained from the literature.

An attempt to place monetary values on health endpoints, where possible, will be made, drawing on existing studies that use cost-of-illness methods or stated or revealed preferences. Presenting both the quantities and the monetary values is appropriate to allow for comparison across impacts. In the literature addressing willingness to pay to avoid health risks the emerging debate on the differential values attributable to voluntary health risks taken by individuals, compared to involuntary risks shows that mortality risks are valued differently depending on the nature of the risk. Hence lives lost

estimates are usefully supplemented by valuation data that reflects the different types of risk. We will estimate most of the costs for mortality based on the value of a prevented fatality.

The next step is to identify adaptation options and to evaluate them by conducting cost benefit analysis and/or multi criteria analysis.

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	YES
Cost-Benefit Analysis (CBA)	Yes
Cost-Effectiveness Analysis (CEA)	No
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	No
Process-based Modelling	Yes
Welfare variation analysis under restrictions	Yes
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	Yes
D) Participatory Methods	
Scenario Workshop	No
Participatory Cost Benefit Analysis (PCBA)	No
Participatory add-ons to CBA	No
Participatory add-ons to Multi Criteria Decision Analysis	No

[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

Participatory add-ons to Adaptation Pathways	No
Other (add extra lines if necessary):	

(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 approach to the research, identifying stakeholders and partner organisations

May – September Literature searches and method development

October – December Drafting of case study

November – February 15 Adaptation identification Data and analysis

March -June Economic valuation of adaptation options

July – August Drafting CSLD

e) Collaboration with other Partners and Case studies

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

Case: ______________________________; Person: ______________________

Case: ______________________________; Person: ______________________

Case: ______________________________; Person: ______________________

Case: ______________________________; Person: ______________________

Case: ______________________________; Person: ______________________

Case: ______________________________; Person: ______________________

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

Name: _Aline Chiabai__; Partner: __BC3_

Name: ________________________________; Partner: ______________________

Name: ________________________________; Partner: ______________________

Name: ________________________________; Partner: ______________________

Name: ________________________________; Partner: ______________________

Name: ________________________________; Partner: ______________________

Name: ________________________________; Partner: ______________________

f) Research Outputs

a. Scientific Publications

- Interim reports + final case study report for D5.5 (Month 30)

- Scientific papers:

(add more papers in case you need)

b. Other Publications

- Books/Books Chapters: # 1

Provisional Title: ____ ____; Month/Year: ___/_______

c. Other

- Scientific conferences: # ___

Provisional Title: ____ ________________________ Conference: ________________________________

Month/Year: ____/______

Provisional Title: ____ ________________________ Conference: ________________________________

Month/Year: ____/______

- Invited seminars, presentations at local events, etc…

3. Participation in Climate Change Adaptation

j) 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)

The adaptation options under consideration are public health campaigns associated with delivering information regarding reducing the risk of excessive UV exposure. This is linked to changes in behaviour and the interacting effects of decreased cloud cover, rising temperatures and uncertainty surrounding ozone layer depletion levels and potential increase levels of UV. Currently there are a number of UK-wide public health campaigns aimed at educating and informing the public on how to reduce their individual risk of excessive UV exposure. These initiatives are employed and/or are applicable at the local level (Cornwall) and include: Met Office UV index; Sunsmart; 'Saving our skins' toolkit; general behaviour change.

No formal participatory process was employed in the preparation of this case study, though we have engaged with Cornwall Council's public health team and Public Health England.

k) 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, <u>why/why not were they involved</u>.

Process phases:

1. Initiative/decision to act

Stakeholders - Cornwall Council and Public Health and Health and wellbeing boards

Citizens - No

Experts - Public Health, European Centre for Environment & Human Health, UoE
Politicians – Cornwall Council

Officials/legislators- None

2. Development of potential adaptation options

Stakeholders - Cancer Research - regionally in terms of sunsmart campaigns taken up locally (Sunsmart Cornwall)

Citizens - No citizens involved

Experts ECEHH, University of Exeter, Cancer Research, Southwest Public Health Observatory, Public Health England.

Politicians - No politicians directly involved Cornwall Council supports Sunsafe campaign on their website

Officials/legislators - None

3. Decision-making

Stakeholders - Met Office

Citizens- None

Experts - Cancer research, Public Health, NHS

Politicians – Cornwall Council

Officials/legislators - None

3. Implementation

Stakeholders

Citizens

Experts

Politicians

Officials/legislators

l) 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)

No formal participatory experience

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

m)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?

   There is no specific adaptation strategy in place for the impacts of climate change on mental health. Participation by individuals in Public Health and the council were informal interactions relating to developing an understanding of the mental health position in the broader climate change impacts on health in general. Engagement with these stakeholders helped the identification of priorities and to identify potential options.

b) How you think the participatory process in your case could be/have been improved?
   Formal participatory methods in a health context are difficult to implement – stakeholder time is valuable and stakeholders change frequently in this sector.

c) Any novel (use of) participatory methods observed in the case studies

n/a

4. Climate Change Adaptation Measures and Strategies

n) 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): Public Heath campaigns specifically Sunsmart Cornwall. Other options exist and include the following, but these are not under consideration in this case study.

1) UV index (Met Office)____
2) ____
3) Saving our Skins Toolkit____

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

1) Cancer Research 'Sunsmart' (http://www.sunsmart.org.uk/) - Sunsmart is the UKs cancer prevention campaign which conducts research and promotes public awareness of enjoying the sun safely by using shade, clothing and a minimum SPF15 sunscreen to protect yourself.
2) Met Office 'UV Index' prediction – is designed to warn of increased risks to health from UV radiation and encourage individuals to take actions to minimise the risks whilst still enjoying the sunshine (http://www.metoffice.gov.uk/health/public/uvindex). By combining information relating to the position of the sun in the sky, forecast cloud cover and amounts of ozone in the stratosphere, an index can be calculated (0-8 for the UK) to give an indication of the level of exposure for that day.
3) The aim of the Save Our Skins toolkit is to help professionals working in local authorities, primary care trusts (PCTs), local health boards (LHBs), cancer networks and their partner agencies to develop strategies and campaign programmes to tackle the increasing incidence of skin cancer. The toolkit provides an evidence base to support action, signposts where information and promotional materials can be obtained, provides information and advice on running successful campaigns and includes a comprehensive listing of local interventions across a range of community settings. Whilst the information contained in the tool kit is comprehensive, it is neither exhaustive nor exclusive, and local authorities could add and use any further information that they feel may be of assistance.

o) 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)

A key outcome from the literature is the increased and continued risk of skin cancer in south west. This is highlighted by a series of public health campaigns to deliver messages regarding individual risk of exposure to UV, particularly in the summer months. The complex interactions between cloud cover, ozone depletion and higher UV levels is difficult to project but some studies/reports tentatively suggested summer UV irradiance will increase in the southern parts of the UK to approximately 12 Wm-2 and/or a slight increase in current UV flux, up to 10% by the end of the

century (Hames & Vardoulakis 2012). Understanding how these climate induced effects on health maybe influenced by socioeconomic dimensions is also considered but adds further complexity to using predictive methods. For example, melanoma is currently increasing at a rate of 5% per annum in the UK (Hames & Vardoulakis 2012), but this is largely attributed to individual changes in behaviour such as increased foreign travel and use of sunbeds. The IPCC (2014) states that globally, *"carcinoma was 5.5% higher for every 1°C increment in average temperatures, and basal cell carcinoma was 2.9% more common with every 1% increase. These values correspond to an increase in effective UV dose of 2% for each 1°C (van der Leun 2008; IPCC 2014)".*

The UK Climate Projections database provides data relating to historic and projected (2100) surface downwelling shortwave radiation (W m-2). The South West Public Health Observatory (SWPHO) is a key cancer registry for skin cancer and has undertaken a number of initiatives to address the incidence of skin cancer and have data relating to malignant and non-malignant melanoma incidence in Cornwall from 2010 – 2012 as does the Health and Social Care Information Centre (http://www.hscic.gov.uk/) which also provides information on GP list size in Cornwall. Valuation of the costs of skin cancer in the UK have been conducted (e.g. Vallejo-Torres et al. 2013;) and provide a starting point for assessing more focussed, local-level assessments for Cornwall. Public Health campaigns that either focus specifically on Cornwall or can be scaled to Cornwall population provide a mechanism by which messages regarding the risks of exposure to UV can be delivered to the public.

The case study will also utilise extant data relating to incidence of melanoma and non-melanoma skin cancers in Cornwall and calculate estimates of population increase using SSP1 (which is related to rcp 4.5 climate scenario). Calculations for the association between climate change (namely temperature increase) and skin cancer incidence (i.e. van der Leun et al 2008) will be employed in our local-level calculations.

p) 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)?

No, interventions needed by public sector.

II. Does the measure initiate further activities for adaptation to climate change?
Yes

a. If Yes, please name which
Further actions would be required such as individual behaviour change and appropriate urban planning that considers the role of trees for example, in providing shade and the impact of albedo from pavements etc.

III. Does adaptation aim for flexibility and reflexivity (i.e. the ability to change as CC and other factors develop)? (Y)
Yes, but note that this measure is a no-regret option.

IV. Is the measure effective under different climate scenarios and different socio-economic scenarios? (Y)
Socioeconomic and climate scenario irrelevant for an effective benefit.

V. Is the adaptation measure iterative? (N)
Broadly yes. As our understanding of climate change and projected UV impacts improves, coupled with a better understanding of how these impacts may be different in different social groups, the design of SunSmart programmes will also improve.

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)
Yes

a. Please describe briefly how

Alleviates existing costs of skin cancer to NHS and society. This is a particular issue in Cornwall and the south west more widely, given the greater UV intensity and a desirable location for tourism.

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

VIII. Yes

<u>Outcome</u>

Relevance and effectiveness of adaptation measures

IX. 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 ?

Predicted higher temperatures under climate change scenarios accompanied with interactions with predicted decreases in cloud cover and uncertainty around the ozone depletion in the future, may lead to increasing incidence of skin cancer in human populations. This is of particular importance in Cornwall, UK, given its popularity as a holiday destination. The south west also has a higher incidence of skin cancers anywhere in the UK where the UV intensity is higher, compared to the north of the country (by ~25%) (SWPHO 2014). The cost of skin cancer treatment is considerable. The critical factors affecting human exposure are lifestyle and behaviour. Continued, lie-long exposure and occasional extreme exposure are both factors in risk of skin cancer.In Cornwall, climate change contributes to 7% - 13% of additional skin cancer cases by 2050.

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

Unknown – likely range 1% - 80%.

Efficiency

XI. 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)

Benefit to cost ratio varies from 9.4 to 108 depending on scenario used (table 1). Costs of the public health campaigns are justified by the benefits of reducing skin cancer cases,

XII. 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 ?

Total costs estimated at £5,000 per annum based on UK wide £5,000/annum

XIII. 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)

No

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

No, but may have impacts of productivity.

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

Effects are likely to be immediate to long-term, outcomes will depend on sun exposure over a given period.

XVI. What is the timeframe during which the measure will have an effect? Only estimate effect in one year

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

No

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

Has the potential to increase the levels of certain skin care and products in coastal environments, the impacts of which are unclear in terms of use and disposal of products.

Equity

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

Unknown, but likely that over-exposure to UV in childhood is a factor in developing skin cancer in later years.

impacts on particularly vulnerable groups? (distributional impact)

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

XXI.

Yes, improves quality of life in terms of prolonged enjoyment the sun and the outdoors safely. More broadly, improvements to health in the form of avoided skin cancer.

4. 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.

q) 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?

Climate change may have significant adverse impacts on human health (IPCC 2007). Consequently, increasing attention is now being given to the issue of adaptation (IPCC 2007; Stern 2007; Costello et al. 2011). The effects of anthropogenic climate change have been discernible for a number of years (WHO 2009a). Most people will have noticed changes to the weather (Kerr 2011) and in the timing of seasonal events such as earlier flowering (Fitter and Fitter 2002). Weather anomalies and extreme events are becoming more frequent globally (e.g. heatwaves and flooding). Over the coming decades, societies will need to adapt to the changing climate (Stern 2007) based on local requirements. Climate change adaptation in terms of minimising or avoiding human health impacts is now taking centre stage (Kurane 2009; Bell 2011). Improvements in the resilience of healthcare systems to meet future climate change will save money long-term and will also assist in coping with natural catastrophes. The World Health Organization (WHO) and the European Commission are both funding research aimed at facilitating health adaptation to climate change (WHO 2009b; European Commission 2012). Because, different geographical regions will be impacted differently by climate change, each country will need to prepare for and adapt to their changing local climatic conditions to protect health.

Direct adverse impacts are related to heatwaves, flooding and other extreme weather events (Pall et al. 2011), and these have received the most attention to date (García-Herrera et al. 2010). However, many impacts of climate change on human health will be indirect, i.e. not linked directly to weather events (Kurane 2009). In the UK the main climate related health threats include: summer heatwaves and droughts; flooding and its associated mental health issues (Paranjothy et al. 2011); interactions between air pollutants, pollen and higher temperatures (Cecchi et al. 2010; Laaidi et al. 2011); deterioration in food and water quality (Lobell et al. 2011); increase in vector borne diseases (Jones et al. 2008). Different UK regions will experience these impacts to different extents will be required to adapt locally to the new conditions.

The county of Cornwall (SW England, UK) has a maritime climate and will experience significant changes in weather patterns over the coming decades and it is predicted that by 2050-2080 the local climate will be 2 to 3 °C warmer than now, both in winter and summer (IPCC 2007). Cornwall will also experience longer periods of warm/hot and dry weather in spring and summer (CCRA 2012). Overall levels of precipitation will be similar to now, but more concentrated in the winter months (CCRA 2012). In addition it is predicted that extreme weather events will become more frequent, including heatwaves, storms, heavy rainfall, and cold spells (IPCC 2012). These changes will occur over the medium term, and are within the time frame of planning and development.

Due to the increase in temperatures, it is also likely that individual's exposure to UV radiation will also increase and therefore the risk of developing skin cancer. The south west of England currently experiences the highest incidence of both malignant and non-malignant melanoma in the UK (South West Observatory 2013). Although there are no specific figures for Cornwall, given its draw as a holiday destination, exposure its likely to be high. A key outcome from the literature is the increased and continued risk of skin cancer in south west. This is highlighted by a series of public health campaigns to deliver messages regarding individual risk of exposure to UV, particularly in the summer months. The complex interactions between cloud cover, ozone depletion and higher UV levels is difficult to project but some studies/reports tentatively suggested summer UV irradiance will increase in the southern parts of the UK to approximately 12 Wm-2 and/or a slight increase in current UV flux, up to 10% by the end of the century (Hames & Vardoulakis 2012). Understanding how these climate induced effects on health maybe influenced by socioeconomic dimensions is also considered but adds further complexity to using predictive methods. For example, melanoma is currently increasing at a rate of 5% per annum in the UK (Hames & Vardoulakis 2012), but this is largely attributed to individual changes in behaviour such as increased foreign travel and use of sunbeds. A study based on findings from mice and suggested that, *"carcinoma was 5.5% higher for every 1^{o}C increment in average temperatures, and basal cell carcinoma was 2.9% more common with every 1% increase. These values correspond to an increase in effective UV dose of 2% for each 1^{o}C (van der Leun 2008; IPCC 2014)".*

Table 1: Summary of calculations for estimates of 'Total absolute excess of NMSC and MSC cases in 2050 due to impact of UV associated with climate change (3% and 6% increase in skin cancer per 1oC temperature increase).

Non-melanoma skin cancer @ 3% increase per 1 deg C rise in mean temp		**Non-melanoma skin cancer @ 6% increase per 1 deg C rise in mean temp**		**Malignant melanoma @ 3% increase per 1 deg C rise in mean temp**		**Malignant melanoma @ 6% increase per 1 deg C rise in mean temp**	
2010 population	532300	2010 population	532300	2010 population	532300	2010 population	532300
2010 incident cases of NMSC	1922	2010 incident cases of NMSC	1922	2010 incident cases of NMSC	184	2010 incident cases of NMSC	184
Crude rate 2010 per 100k pop	361.0746	Crude rate 2010 per 100k pop	361.0746	Crude rate 2010 per 100k pop	34.56697	Crude rate 2010 per 100k pop	34.56697
Estimated crude rate in 2050 = 3% per deg = 7.5% increase in crude rate with a rise of 2.5 deg	388.1552	Estimated crude rate in 2050 = 6% per deg = 15% increase in crude rate with a rise of 2.5 deg	415.2358	Estimated crude rate in 2050 = 3% per deg = 7.5% increase in crude rate with a rise of 2.5 deg	37.1595	Estimated crude rate in 2050 = 6% per deg = 15% increase in crude rate with a rise of 2.5 deg	39.75202
Population 2050	665596.9	Population 2050	665596.9	Population 2050	665596.9	Population 2050	665596.9
Estimated total cases per year in 2050 with pop increase and effects of UV due to climate change	2583.549	Estimated total cases per year in 2050 with pop increase and effects of UV due to climate change	2763.796	Estimated total cases per year in 2050 with pop increase and effects of UV due to climate change	247.3325	Estimated total cases per year in 2050 with pop increase and effects of UV due to climate change	264.5882
Estimated crude rate of NMSC in 2050 with no climate change (=rate in 2010)	361.0746	Estimated crude rate of NMSC in 2050 with no climate change (=rate in 2010)	361.0746	Estimated crude rate of NMSC in 2050 with no climate change (=rate in 2010)	34.56697	Estimated crude rate of NMSC in 2050 with no climate change (=rate in 2010)	34.56697
Total cases per year in 2050 with pop increase only - if no effects of UV due to climate change	2403.301	Total cases per year in 2050 with pop increase only - if no effects of UV due to climate change	2403.301	Total cases per year in 2050 with pop increase only - if no effects of UV due to climate change	230.0767	Total cases per year in 2050 with pop increase only - if no effects of UV due to climate change	230.0767
Total absolute excess of NMSC cases in 2050 due to impact of UV associated with CC	180.2476	Total absolute excess of NMSC cases in 2050 due to impact of UV associated with CC	360.4952	Total absolute excess of MSC cases in 2050 due to impact of UV associated with CC	17.25575	Total absolute excess of MSC cases in 2050 due to impact of UV associated with CC	34.51151

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.

No adaptation tipping points can be identified in this case study as it is a 'no regrets' option.

r) 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?

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"?

Figure 1 and table 2 give an overview of the major factors involved in driving skin cancer rates and for some potential adaptation options. Significant among these are options including:

- Public health campaigns
- Urban planning and design in terms of shade availability and albedo of the ground
- Treatments; and
- Warning systems to raise awareness

In terms of the timing of adaptation for health impacts, it may be possible to adapt and apply the "adaptation pathways" model of Haasnoot (2012, 2013). This model identifies "tipping points" for adaptation, and in the health context major tipping points can be seen as being linked to the timing of damages:

- Primary interventions – before damage occurs to minimise exposure (e.g. a number of public health interventions)
- Secondary interventions – aim to prevent disease before it becomes manifest (e.g. screening tests)
- Tertiary interventions – applied once impacts occur (i.e. treatment regimes)

The development of new drugs or treatment regimes may also lead to the potential for a tipping point – e.g. the development of a new vaccine against a particular climate related condition. Factors that change the cost-effectiveness of given interventions may also be important – for instance through changes in the costs of raw materials or in the costs of production. Such factors may have a lagged impact – as they may take significant time to pass through government decision making (e.g. review by NICE, the National Institute for Clinical Excellence, in the UK).

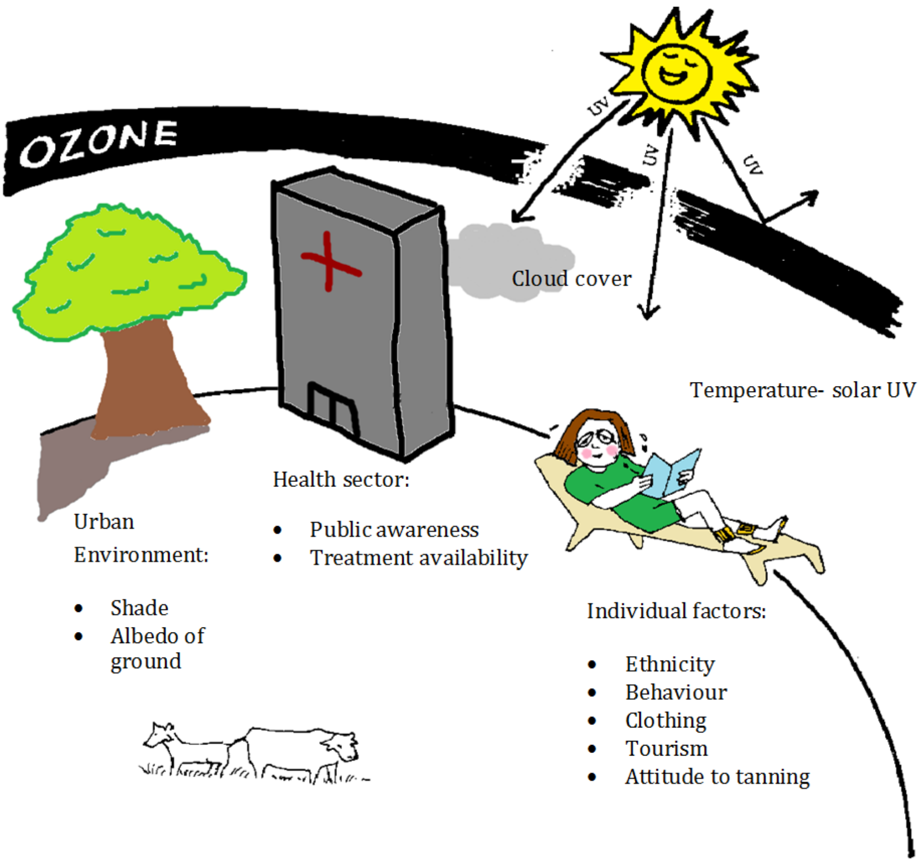

Figure 1 Factors determining skin cancer incidence and possible adaptations

Here, we consider the costs of the SunSmart programme. The SunSmart scheme cost £500k in England in 2010. Adjusting for population in Cornwall, this implies a cost of just under £5k for the Cornish case. The SunSmart programme involves a range of actions to increase awareness of the risks of skin cancer and sun exposure.

Table 2 Overview of these interventions for skin cancer.

Health impacts	Primary	Secondary	Tertiary

Skin Cancer	Educational campaigns; Urban design: shading, altering albedo of the ground	Disease surveillance and monitory	UV warning system. Skin cancer treatments

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

k) 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?

We estimate the costs and benefits of the SunSmart scheme, considering the impacts on numbers of cases of skin cancer. We do not have a clear idea of the effectiveness of the programme, so we present the results for two scenarios: a 1 in 100 reduction in the number of skin cancer cases and a 8 in 10 reduction. The latter case is taken as 4 in 5 cases of skin cancer are thought to be avoidable – so this gives an upper bound.

l) 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)

We use cost-benefit analysis, as it is possible to assess all cost and benefit criteria in monetary terms.

m)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)

Not applicable

n) 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?

Taking the estimates of 3 to 6% increase for skin cancer and socioeconomic scenarios for population change, we can estimate the future cases in Cornwall (table 1).

To value these impacts in monetary terms, the Climate Change Risk Assessment took a central value of £2,425 per case of skin cancer based on a review of the literature. Valuing the impacts of melanoma and non-melanoma skin cancer using the same monetary value implicitly assumes the impacts are the same. Vallejo-Torres et al(2013) present an estimate of the cost of skin cancer in England in 2008, finding an average treatment cost per case of malignant melanoma of £4239 and of NMSC of £888. Taking these estimates and adding to the estimates for the welfare losses of a case of skin cancer based on the estimate used in the CCRA of £700 gives costs as follows (adjusted for inflation):

- Malignant melanoma - £5826 per case
- Non-melanomia skin cancer - £1874 per case

Note that these are likely underestimating the true cost of skin cancer – as we are valuing the welfare impacts using values from a study that has valued skin cancer in a generic way. Using these values, we can estimate the costs of skin cancer in Cornwall at £4.7 million in 2010. Under RCP4.5 and SSP1, these costs will increase to between £6.4 to £6.7 million by 2050 (table 3).

Table 3: Costs of skin cancer in Cornwall in 2010 and 2050, under RCP 4.5, SSP1 (no discounting)

	2010	2050
Non Melanoma Skin Cancer 3% per 1C rise	£3,602,230	£4,842,111
Malignant melanoma 3% per 1C rise	£1,071,995	£1,541,507
Total	**£4,674,225**	**£6,383,618**
Non Melanoma Skin Cancer 6% per 1C rise	£3,602,230	£5,179,932
Malignant melanoma 6% per 1C rise	£1,071,995	£1,541,507
Total	**£4,674,225**	**£6,721,440**

What is the evaluation time frame?

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

Annual

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%)).)

The UK government recommends a declining discount rate for climate change relevant projects. Here because the campaign is likely an annually renewing scheme, we compare costs and benefits for different years, rather than aggregating to one NPV.

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?

Where possible we will identify uncertainties and use appropriate methodologies to assess the impact of these.

o) 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)?

We estimate the benefit/cost ratio in 2010 and 2050 (table 4) . The results are as shown in Table # below. It can be seen that the benefits far outweigh the costs, even if only 1 in 100 cases are avoided – and that with climate change and population growth the benefits will become even greater. It can also be seen that this is a “no regrets” option – i.e. it should be applied whether climate change occurs or not. Indeed, the climate impact is relatively small – of the total cases between 7 and 13% are attributable to climate change).

Table 4: Benefit Cost ratio for SunSmart in Cornwall

B/C ratio	**2010**	**2050**
1% reduction in cases		
3% per 1C	9.4	12.8
6% per 1C	9.4	13.5
Max benefit (4 in 5 preventable)		
3% per 1C	751.7	1026.6
6% per 1C	751.7	1080.9

5. 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)

To be determined through the completion of the case study

6. 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**

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