

## **The Impact of Climate Change on the work of Historic Scotland: Preliminary Assessment**

### 1. Purpose

The complex impact of climate change is currently projected to have a considerable, yet unquantifiable, influence on the built heritage. This paper sets out some relevant background material and a preliminary assessment on how these influences might impact on different parts of the Agency. It also offers an insight into some consequential and related aspects which could have a bearing on how these issues might be addressed.

### 2. Priority

Views are sought on how the suggested climate change issues might be reflected in drafting the next Agency Corporate Plan.

### 3. Discussion

The Patterns of Climate Change across Scotland study, published by the Scotland and Northern Ireland Forum for Environmental Research (SNIFFER) in March 2006, focused on the identification of trends in Scottish climate over the period 1914-2004. Whilst the report provided regional and spatial detail that national averages mask the study did not seek to explain or attribute cause for the identified trends. Neither did it assess the likely consequences on buildings, or the built heritage.

4. In February 2007 the Inter-Governmental Panel on Climate Change presented 'Climate Change 2007: The Physical Science Basis'. This report assessed current scientific knowledge of the natural and human drivers of climate change; observed changes in climate; the ability of science to attribute changes to different causes; and projections for future climate change. In summary it identified that:-

- It is very likely that human activities are causing global warming.
- Temperatures will probably rise between 1.8C and 4C by the end of the century.
- Possible temperature increases by the end of the century will be between 1.1C and 6.4C.
- Sea levels are likely to rise by 28-43 cms.
- Arctic summer sea ice will be likely to disappear in the second half of the century.
- It is very likely that parts of the world will see an increase in the number of heat waves.
- Climate change is likely to lead to increased intensity of tropical storms.

5. In consequence, over the next few decades, it is anticipated that the effects of climate change will become more apparent. In terms of disasters this will create a multi-layered effect. Increasing frequency of extreme weather events (such as flooding and storms) may promote disasters in vulnerable areas, causing a loss of cultural heritage in a matter of hours, or days. In addition, the natural performance of buildings may subtly change as the environment in which they sit is altered; their ability to withstand disaster may be compromised, as structures become weakened.

6. Key effects of climate change on the historic environment are likely to include:
- Increasing temperature and moisture fluctuations. This will result in accelerated decay of the materials that make up the building fabric.
  - An increased demand for building maintenance. The type and frequency of maintenance will affect the ability of the building to adapt to climate change.
  - An increasing number of flooding events leading to damage and coastal erosion. Geographical factors will increasingly affect the assessment, monitoring and diagnosis of building decay.
  - Increasing ground subsidence. Shifts in the water table, will significantly affect the stability of buildings.
  - Increased biological colonisation and insect attack will occur on the building fabric.
7. When operating in tandem these changes are likely to impact on the stability, rate of decay and performance of buildings. Key issues that will arise from this combined threat include:
- The lack of researched findings into how climate change will affect the building fabric: Some traditional buildings are likely to be particularly susceptible to the impact of climate change, particularly those that have previously suffered inappropriate cleaning or repair techniques.
  - The need to balance the handling of increased flood and precipitation events with the conservation of the historic environment.
  - The need to assess the increased demand to install ill-considered energy efficiency measures in traditional buildings (heating, ventilation, insulation, windows, etc.): Measures that are designed primarily for new-build construction are likely to have a negative impact on traditional structures.
8. Importantly, none of these factors have yet been assessed regarding the future physical well-being of the built heritage. By anticipating the effects of climate change, and the issues associated with it through detailed research and investigation, the likelihood of buildings suffering a serious failure could be greatly reduced. Disaster planning and risk management issues are likely to become major considerations when devising related analytical techniques and predictive decay processes.
9. Against this background a series of meetings have been held within the Agency to discuss the impacts of climate change on respective areas of interest. Topics under consideration were:
- Grants programme
  - Properties in Care
  - Listed buildings and Conservation Areas
  - Archaeology and landscapes
  - Specialist conservation activities
  - Influences on the construction industry.
10. Commissioned by English Heritage the May Cassar Report "*Climate Change and the Historic Environment*" offered 9 key impacts of climate change. To ensure a consistent approach, a matrix was devised whereby these 9 effects were listed and Agency areas of interest assessed against each. The results were summarised on "spider charts" (where the most significant aspects of concern emerge closer towards the external ring of each chart). Under the above headings the charted results of this preliminary work were interpreted and this is presented in Annex 1, along with the supporting charts. (Annexes 2-6).

## 11. Conclusions

In the intricate topic of climate change there is a clear need to devise relevant policies and strategies to assist in directing available resources to deal with the related technical complexities. This will involve attempting to identify the full range of threats and issues confronting the historic environment, and categorise these according to whether they represent 'direct' threats (consequences of actual changes in climate) or 'indirect' threats (consequences of societal and policy responses to actual or perceived climate change).

12. These two aspects might be further subdivided according to whether an issue represents an 'urgent' problem (one which demands an immediate response to a particular problem, e.g. policy statements on renewable energy, or by providing guidance of how to adapt traditionally constructed buildings to improve their energy efficiency) or, whether they are 'important' issues (climate change impacts which, based upon the best predictions, are likely to have significant consequences for the historic environment).

13. Associated technical research activities might include:

- Assessing the impact of climate change on the historic environment, specifically buildings and archaeology.
- Understanding the impacts of temperature and moisture fluctuations on the range of indigenous traditional building materials, and their performance under threat.
- Evaluating the accelerated rates of decay and the resulting increased cycle of maintenance requiring skills and materials.
- Identifying flood risks to the historic environment and mitigating measures.
- Understanding how energy efficiency measures relate to traditional buildings, and how traditional buildings can contribute to sustainable development.
- Evaluating the performance, environmental and social costs of importing materials to Scotland.
- Integrating the emerging results to start to offer appropriate technical guidance on how to ameliorate the consequences and risks.

14. Not one body, let alone the Agency, can cope with all of the factors that are liable to emerge and require answers, so partnership activities and involvement will be essential. To better understand some of these concerns, and provide a synthesis of what opportunities might exist for joint action, a TCRE Research Intern is currently carrying out a one year Scoping Study. This will identify the range of current activities on climate change in the built heritage sector. Once this unique study is to hand a more focused approach, related to identified Agency concerns as set out in Annex 1 and as guided by the Board discussion, will be possible.

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Director TCRE

20 August 2007

## **ANNEX 1: Impact Assessment of Climate Change on Agency Activities**

With reference to the “Spider Diagrams”, attached as Annexes 2-6, a diagrammatic overview of the assessment of climate change impacts on the work of Historic Scotland can be given in the following breakdown.

### Grants Programme

Whilst climate change is acknowledged as a risk in any assessment of the grants schemes it is at the moment assessed as low risk. Changes in design specifications of buildings to meet climate change models will have an effect on costs but this could be marginal. Not every grant -aided project will be similarly affected (given structure, location, etc) and accordingly we cannot predict the cost on the grant schemes with any certainty. As such, research on the effect of climate change for the grant schemes and the spend consequence would be invaluable. In the past year it has been observed that climatic conditions have allowed for a longer working year on-site, leading to a greater number of projects being completed to time, benefiting cash flow and achievement of spend within a financial year.

The Investment and Projects Team see a greater risk from climate change in the choices between new and traditional materials in ensuring that carbon emissions are reduced and also that traditional buildings are made fit to meet the expected changes. This is discussed further under “*Listed Buildings and Conservation Areas*”, below.

### Properties in Care

Within the PIC estate the range of properties, geographic locations and states of preservation mean that we hold properties which could be seen as a useful barometer of the effects of climate change on the historic environment as a whole. The main hazards of climate change include storms, heavy rainfall, flooding, coastal erosion, summer drought and raised temperatures. We are already dealing with the consequences of these, often over centuries of impact, and although we can surmise that climate change is likely to change the frequency and severity of these threats, we are not yet able to say by how much or when. If as has been forecast the summer seasons become longer, hotter and drier, there could be a potential extended summer season and an increase in visitor numbers.

High profile coastal sites such as Skara Brae and Fort George have suffered from removal and deposition of beach material over their lifetime. Localised sea defences at coastal PIC have been successful in the short term but cause other problems. Coastal defence projects installed to address the perceived risks from climate change would be controversial due to major visual impacts, and high cost. Studies are underway to map changes and investigate longer term solutions to both Skara Brae and Fort George, but this should be done through partnerships as the ownership of the coastline is in most cases separate from PIC’s holdings. In the meantime we have ensured our recording of our sites is comprehensive, where there is a threat.

Conservation work is about responding to change, both environmental and inherent in the fabric, and the need to address issues for “use” by staff and the public - climate change is one of several factors which have an impact on the PIC and the wider historic environment. We are likely to see changes to our working practices arising from climate change, but the impact on our overall programme cannot yet be forecast among the existing pressures. In the wider

historic environment it is likely to be the secondary impacts arising through the perceived need to improve carbon footprints, green energy production and energy conservation of specific buildings which will have the greater overall impact in relation to climate change.

### Listed Buildings and Conservation Areas: Annex 3

Paper SMT 41/06 listed issues that TCRE Group raised relating to the impact of climate change on built heritage. This applied to listed buildings and conservation areas. The key findings related to water damage through increased rainfall, flooding and increased relative humidity.

The present condition of much of Scotland's built heritage renders it vulnerable to damage by high winds and increased water levels. There could be an increase in falling masonry and damage to building fabric. However this condition derives principally from the value of the property: either too low to justify maintenance, or having a perceived high site value if only it could be removed. Climatic factors might be relatively minor. More significant are human responses to the climate change issue.

Some responses to climate change may damage the historic environment include:

- Air conditioning to fight high temperatures requires hermetic seals, as opposed to natural ventilation, and leads to more global warming. A traditionally-built, naturally-cooled, building can be shown to be part of the answer to the problem.
- Replacement windows are energy-efficient once installed but may harm the character of buildings and areas. If made from plastic, steel, aluminium and several layers of thick glass their very construction may be considered unsustainable. Research is needed to balance the environmental capital cost against their performance during their expected, more limited, lifetime. Otherwise energy certification will disadvantage older, and listed, properties.
- Insulation to reduce carbon emissions may trap moisture, shorten the lives of traditionally-constructed buildings and so waste the embodied energy that went into their construction and use to date.
- addition of micro-generators and photo-voltaic panels may be visually and physically intrusive (but are still very few in terms of caseload, and are usually approved).
- wind farms impact on the landscape, as would large new hydro schemes.
- Proposals to replace inefficient housing stock with new-build that will be more efficient, but the energy savings are unlikely to repay the already expended energy invested in existing buildings. This is an area in which we need a better evidence base.

But the historic environment can play a part against climate change:

- Historic mixed-use towns are more pedestrian-friendly and so more sustainable. They are favoured by planning policies to reduce car dependency and therefore repay investment through CARS and THI.
- When flood plains are built upon, they are in places our ancestors knew not to develop. So understanding the historic environment can be part of the solution if development can be further accommodated in already-developed locations. This means increased pressure to adapt or demolish buildings as well as to use existing sites more intensively.

- Older buildings can perform well due to thick walls, small windows, passive ventilation, and some traditional building materials like thatch. This needs to be quantified.
- Wooden elements are more easily repaired than modern replacements from unsustainable sources such as uPVC and aluminium. “Maintenance free” usually means incapable of repair.
- Small hydro schemes may re-use existing weirs and lades.
- Heat pumps in canals or in the ground (watch for archaeology) are unobtrusive.
- Re-use of buildings ensures that the energy previously expended in their creation is not wasted. Recycling means a lower carbon footprint than would occur if the same development were new-build. This should be quantified through research.
- Conservation work that uses recycled materials, where the equivalent newly-produced would be difficult to source, encourages a cautious attitude towards replacement, and often reduces transport costs.

HS is in a position to promote energy efficiency where opportunities arise, suggesting suitable opportunities for shared services, solar panels and the like, where they will not harm the character of the building or area. HS must not always be depicted as against these, and so somehow “anti-environment”.

#### Archaeology and Landscapes: Annex 4

The greatest present environmental threats to archaeology relate to coastal erosion, agricultural soil loss and wetland archaeology. Climate change is expected to exacerbate these existing problems.

In terms of coastal erosion, building coastal defences is prohibitively expensive and ultimately futile. The “managed retreat” approach of agencies such as Scottish Natural Heritage is not suited to historic environment assets as these tend to be in fixed locations without any possibility of relocation or natural regeneration. The most feasible option is to survey as much of Scotland’s coastline as possible; roughly 30% of this has been achieved already. Significant archaeological sites then need to be recorded at a variety of levels. At present, significant sites are being identified and washed away faster than they can be dealt with at current resource levels.

Soil loss caused by water movement is expected to accelerate under the emerging climate conditions. Soil loss exposes archaeological sites to damage from, for example, farmers ploughing fields. English Heritage has done a good deal of research in to this area. HS could promote a complementary scheme of exploring alternative land management schemes to slow or reverse soil loss; the SE Soils Strategy broadly supports measures to minimise soil movement and loss.

Climate change is seen as less of an immediate threat to wetland archaeology than it is to coastal erosion or soil loss. To some extent this is because natural heritage agencies protect wetland environments for their own interests. An existing research programme is underway with future avenues currently being explored.

One potentially positive implication of climate change is that with increased storminess, new archaeological sites may be uncovered in a manner similar to the Skara Brae exposure, but of course this is only positive if resources exist to capitalise upon it.

## Specialist Conservation Activities: Annex 5

In terms of conservation activities, the effects can be described as either effects on working practices, such as operating on-site or up scaffolds, or on the physical materials such as carved stone or painted surfaces.

The changing weather pattern will give wetter winters and drier summers, with an increase in storms, particularly across the West of Scotland. A more temperate climate may allow for a longer overall working year. However, an increasing frequency of high winds, will affect outdoors working. It is unclear given new environmental conditions how repairs, the frequency of condition surveys, and the ability to access sites at certain times of the year, will work in practice.

The physical materials being worked on may well change in character, with stone saturation, salt crystallisation, levels of biological growth, movement of timber and falling plaster becoming increasingly common.

## Construction Industry: Annex 6

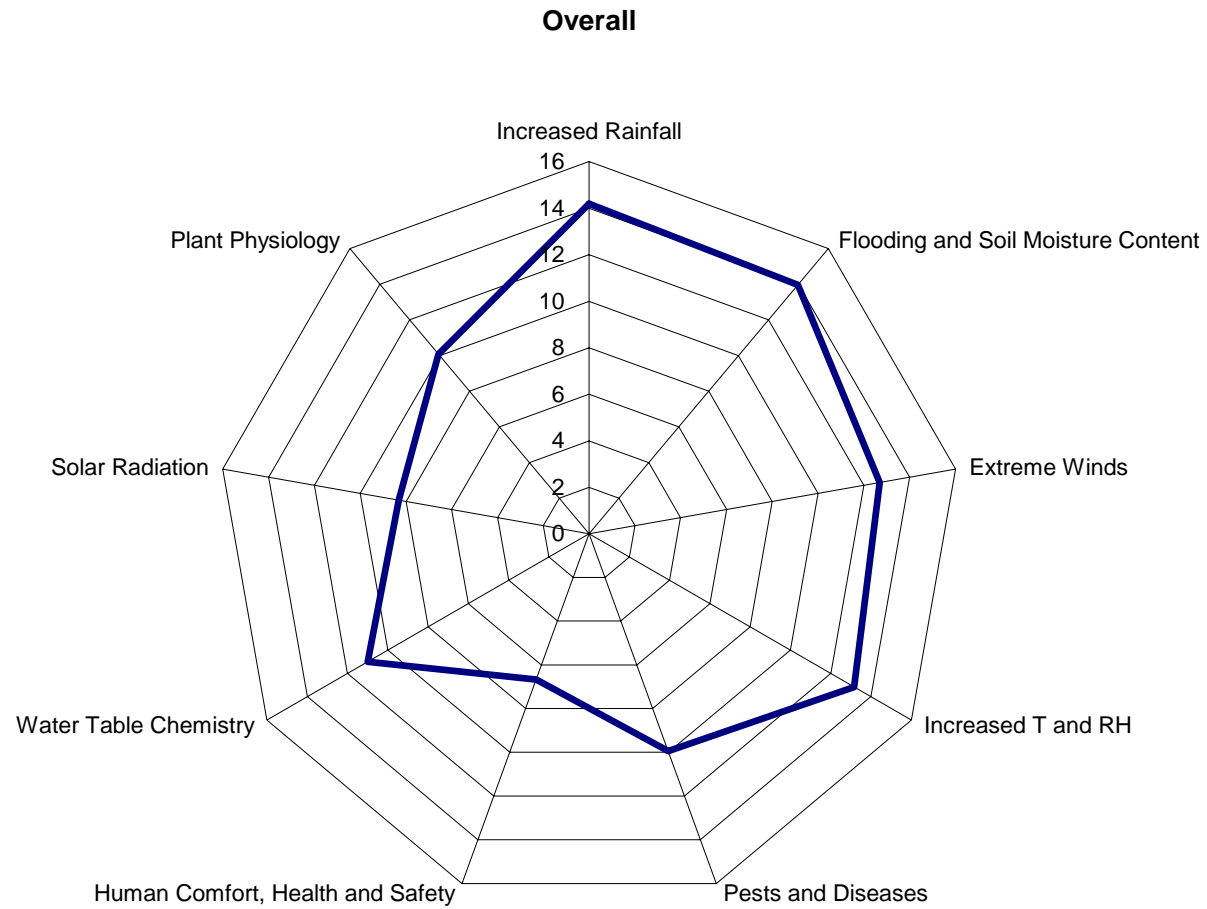
The construction industry is charged with repair and maintenance of traditionally constructed buildings and structures. As the properties of materials change under new environmental conditions, (for example through stone saturation and extreme drying, depending on time of year) skills, training and education will have to adapt to accommodate. Materials such as cement and lime mortars, for example, will behave differently at the height of summer and during winter than they currently do under predicted climate models.

The demands on the construction industry and the level of hazards increase may be expected to increase as issues such as falling masonry become more common. The present condition of many of Scotland's buildings is less than adequate in the face of increased wind and water effects and this will present the greatest needs for increased repairs, maintenance and preventive action.

Recent reports such as "*Safeguarding Glasgow's Stone-Built Heritage*" and the "*Scottish Small Towns Report*" have highlighted existing deficiencies in the skills sector and materials availability; climate change is likely to exacerbate this shortfall. In terms of disaster planning, in a worst case scenario, should a large number of buildings need urgent repairs due to a heavy storm, the current skills base in Scotland could not cope. Untrained or inadequately trained personnel using inappropriate materials would be likely to be put to work on some of Scotland's finest buildings in such circumstances.

Currently traditional building material supplies are inadequate. With increased water and drying, some types of stone will deteriorate faster due to enhanced salt crystallisation. The need for replacement stone in routine repairs, as well as the need for large quantities of available stone in the event of a disaster, is set to rise, against a base of insufficient quarries producing appropriate repair stone. With increased environmental pressures may come the need for more ethical procurement, with materials sourced close to or within Scotland, to reduce the carbon footprint of construction activities. A considerable degree of modelling and planning is required to obtain a clearer understanding of such issues.

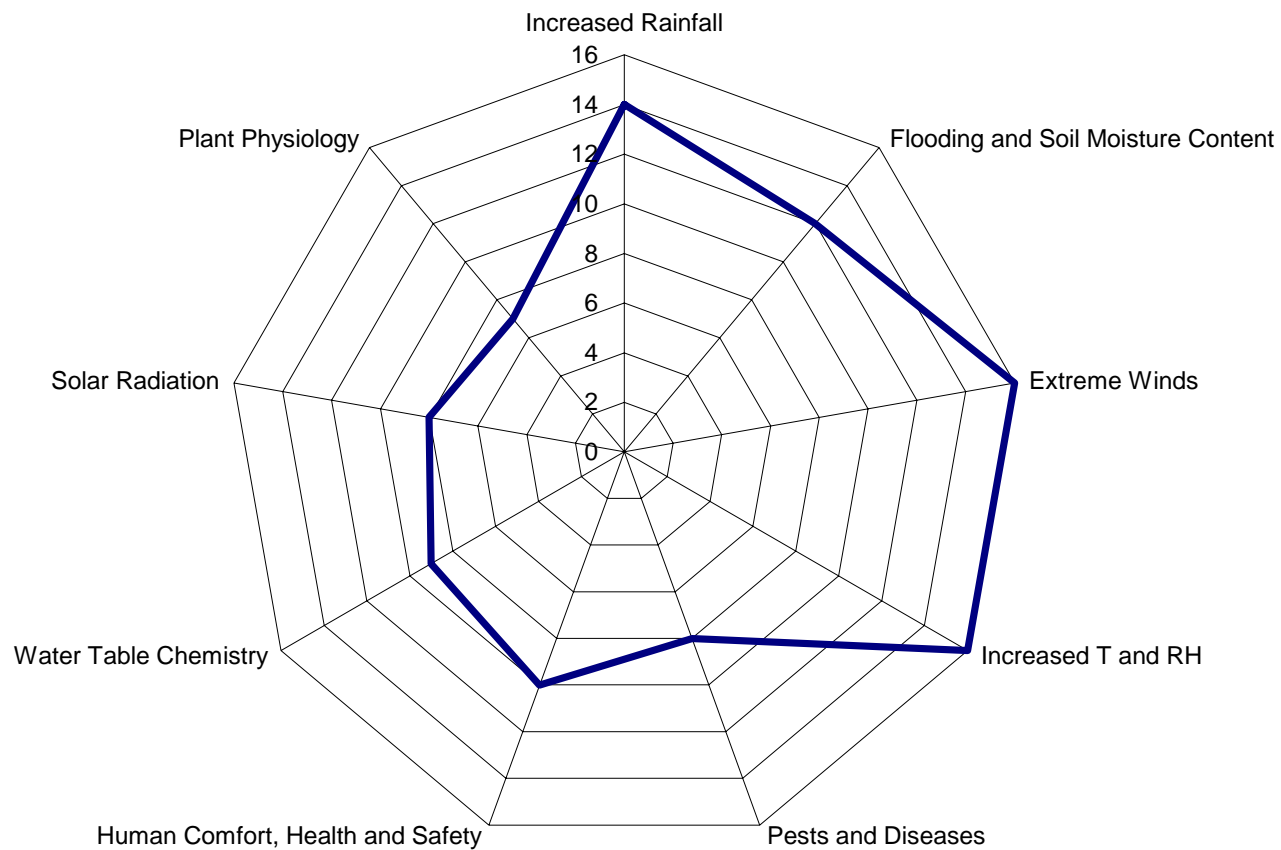
**ANNEX 2**



**The overall impact of nine key climate impacts on Historic Scotland activities, expressed in terms of percentages.**

### Listed Buildings & Conservation Areas (SMT 41/06)

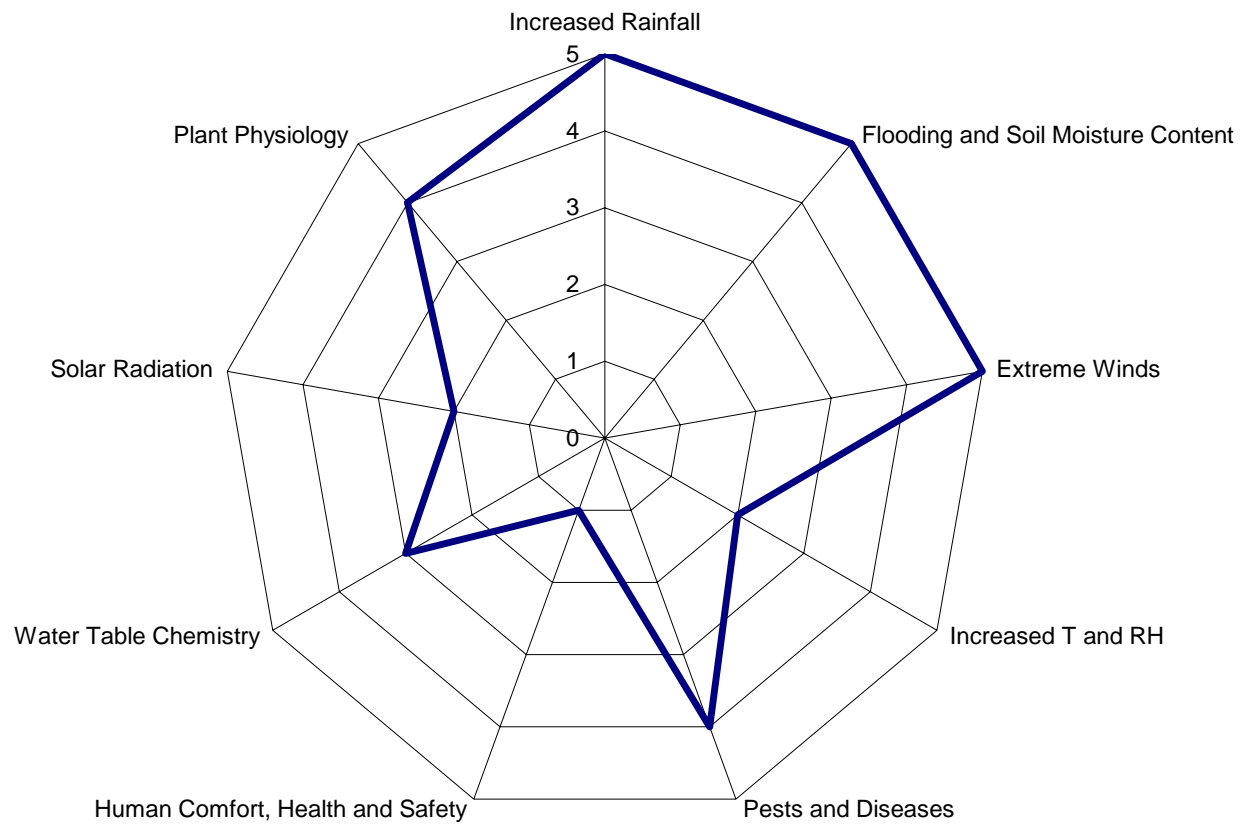
#### ANNEX 3



The main climate impacts on listed buildings and conservation areas (adapted from SMT 41/06)

**ANNEX 4**

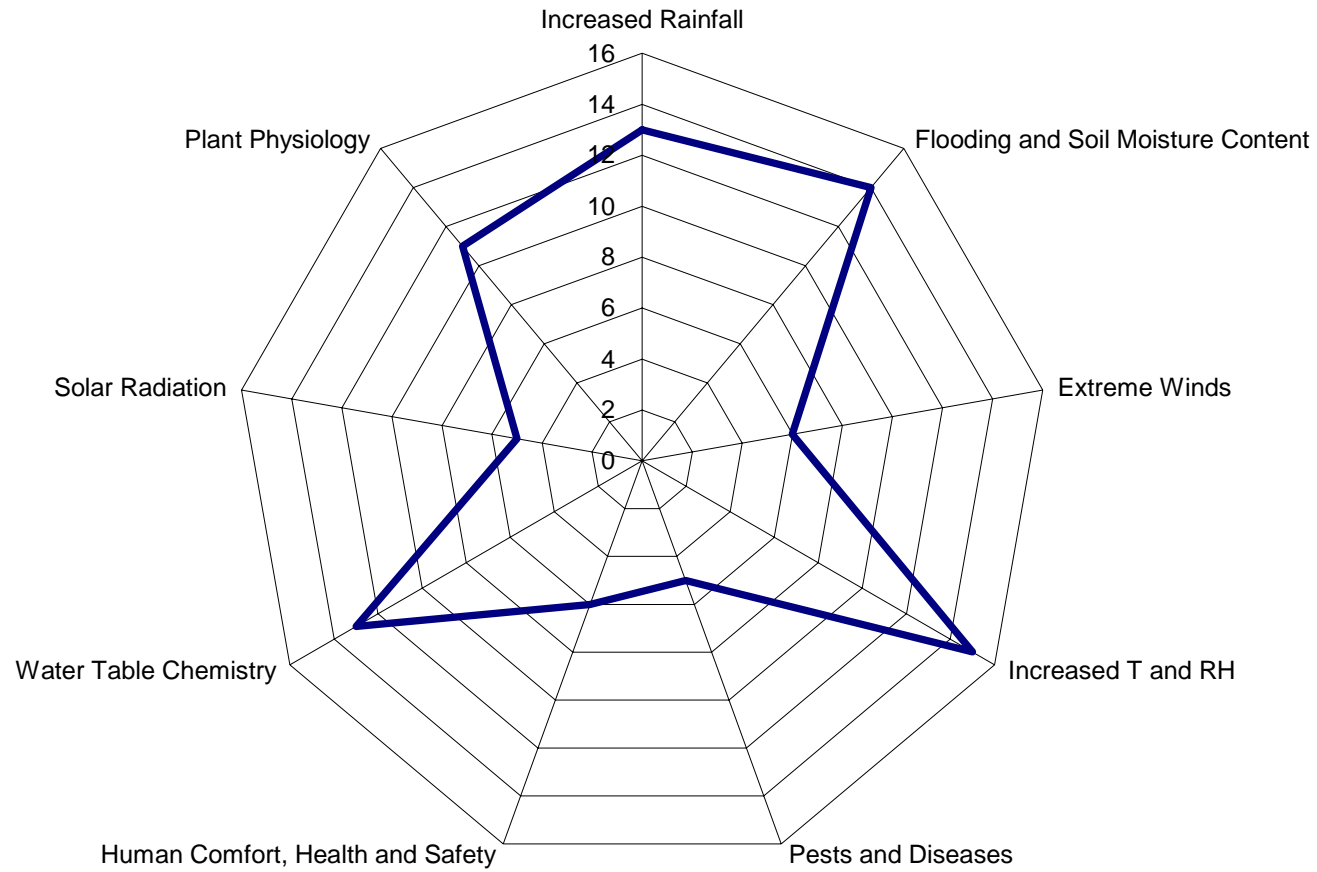
**Archaeology & Landscapes**



**The main climate change impacts on archaeology and landscapes.**

**ANNEX 5**

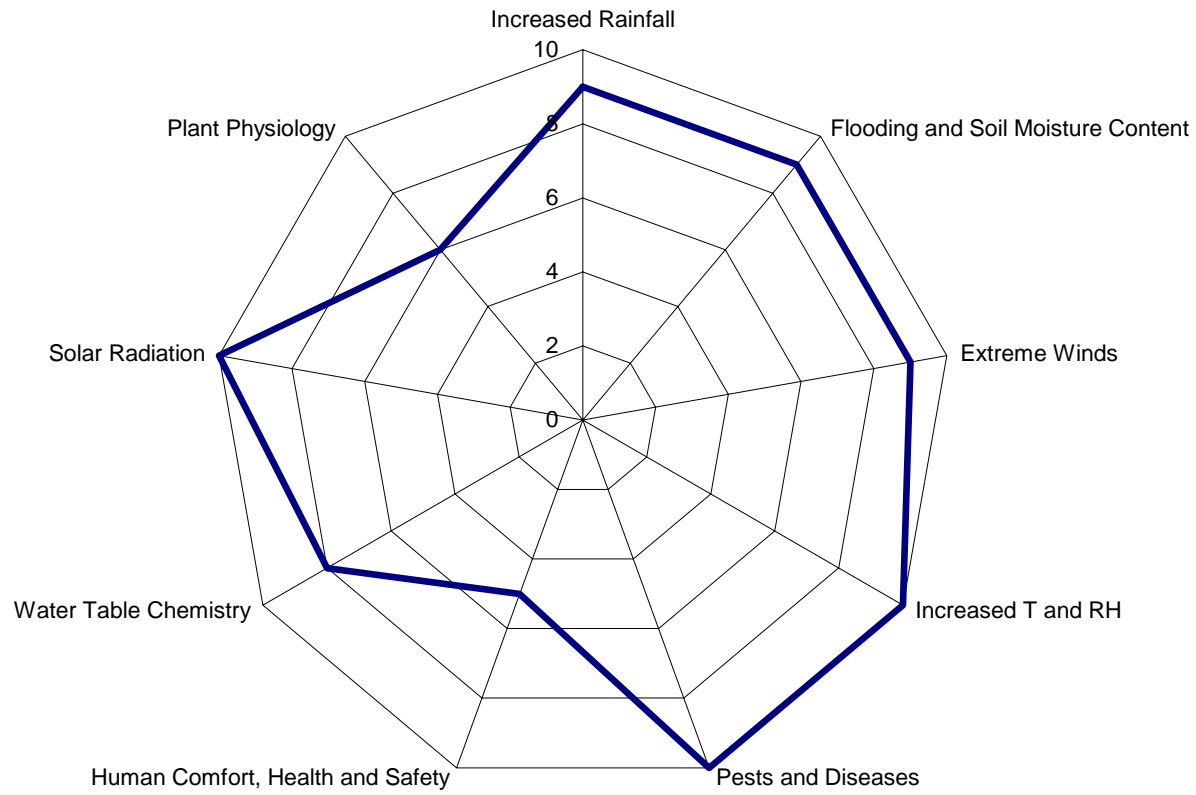
**Specialist Conservation Activities**



**The main climate change impacts on specialist conservation activities**

**ANNEX 6**

**Construction Industry**



**The main climate change impacts on the construction industry**