CHAPTER 7

SOCIETY AND INFRASTRUCTURE DOMAINS

LIKELY IMPACTS & POSSIBLE ADAPTATION RESPONSES

Introduction

This section considers those domains in the South West which fit broadly under the heading of 'society and infrastructure'. Such headings are necessarily arbitrary but have proved useful in progressing and reporting on the study. So, the section explores the following impact domains:

1. Built Environment
2. Health
3. Heritage
4. Housing
5. Transport
6. Utilities

(For details of the methodology adopted for researching and reporting on these domains please see Annex 2.)

This introductory section precedes the detailed consideration of each domain and considers some of the general issues that relate to climate change and its impact on 'society and infrastructure'. A brief discussion of these general issues is followed by a summary table of recommendations.

Physical Infrastructure

The physical infrastructure of buildings, bridges, power transmission lines, transport (road, rail, air) and heritage (both natural and built) is vulnerable to most aspects of climate change. The necessary lead-time and investment periods justify serious risk assessment based on UKCIP02 scenarios. Whilst changes in average conditions (e.g. increased rainfall in winter) will have some effect on infrastructure, it is mainly changes in extreme conditions that will have the greatest impact. For example, although the UKCIP02 scenarios do not suggest any significant overall changes in windiness and storms, the likelihood of extreme one-off wind and storm events will increase, and it is these that will cause physical damage. The main impacts are therefore likely to include flooding (riverine, coastal and urban) and wind damage.

Climate change will affect energy demand, with reduced heating requirements in the winter, probably offset by increased demand for summer cooling. Of particular importance to the region is the potential opportunity for renewable energy: biomass, vegetable oils, solar, hydroelectric, wind and wave power are all areas upon which climate change will impact. More work is required to understand better the subtle impacts of the different climate variables.

Lifestyle

Lifestyle will influence climate change (through patterns of energy usage, transport etc) and be influenced by it (through choices in holiday patterns and destinations, increased *al fresco* eating etc). Such changes are elusive and there is little literature on the subject. Nevertheless we can look to examples of societies and cultures that operate in the type of climates that we anticipate, as an indication of the way that society in the region may develop.

We have identified some possible lifestyle impacts in the South West. These include the increased use of bicycles and walking as modes of transport; increased use of external spaces in urban areas (with a consequent impact on the street scene); increased outdoor recreation (with potential improvements in general health); but exposure to radiation and associated cancer risks. More research is required to track possible lifestyle changes and their wider implications.

The Management of Change

The management of physical infrastructure will be dealt with in very different ways. Existing structures may need modification to accommodate new weather conditions, but in most cases it has been judged that the cost of modifying existing structures to cope with increased vulnerability is too great to justify this type of investment. Obvious exceptions include improvements to certain flood defences. On the other hand, new buildings and structures can be designed with these future scenarios in mind. Technical standards, codes and regulations need to change to reflect the anticipated climate.

Adaptation responses must be managed in a way that does not exacerbate the global warming phenomenon by increasing greenhouse gas emissions. In the built environment there is the potential need for increased cooling in summer: conventional responses would install fans, air-conditioning or similar cooling devices, all of which will increase energy consumption, and therefore increase global warming. This is a vicious circle that must be avoided.

There are philosophical and political implications, as well as economic ones, in considering how best to manage some of this change. Generally decisions will be more easily made in the public sector, particularly at the large scale, if climate change attains sufficient priority. Some aspects of the private sector can be controlled by legislation, regulation, fiscal policy etc. Perhaps the biggest challenge will be influencing individuals and householders to adapt to the changing climate in ways that do not make the global climate even more challenging.

Recommendations for Society and Infrastructure Domains

- Review regional infrastructure for transport and utilities in order to identify further areas of vulnerability to climate change over a long time scale.

- Review opportunities for increased production of renewable energy as a result of potential climate change: e.g. wind, water turbine; solar; biomass; wave; tide; biofuels.

- Undertake further research into lifestyle changes associated with climate change, including the implications for the socially excluded.

- Change relevant codes and standards to reflect anticipated climate conditions, particularly with regard to increased summertime temperatures, grey water systems, and increased exposure to driving rain and wind damage from extreme events.

- Invest in research into offshore **renewable energy** sources - wind, wave energy, and reassess the environmental and economic effects of the Severn Barrage.

- Design **new buildings** to anticipate reduced heating load in winter and passive cooling in summer.

- Investigate passive or low energy techniques for increasing ventilation rates and cooling for **existing buildings** in higher summertime temperatures.

- Increase awareness amongst those with responsibility for developing and managing **housing** stock: (including housing developers, Registered Social Landlords, local authorities, Housing Corporation, designers, and owner-occupiers).

- Include adaptation to climate change within regional strategies for **sustainable construction.**

- Review potential impacts of extreme events (storms, floods, high temperatures, etc.) on **transport infrastructure** (road, rail, air, shipping) and undertake appropriate risk assessment.

- Review enhanced specifications of maintenance regimes for **transport infrastructure** (road, rail, air, shipping).

- Encourage pedestrian and cycling modes of **transport** where improved climate conditions permit.

- Undertake feasibility studies for alternative and diversionary routes for those strategic **rail and road routes** that are threatened by climate change impacts and extreme events, and lobby at national level as appropriate.

BUILT ENVIRONMENT DOMAIN

Scope

The design, construction, maintenance and use of all building types; other engineering structures and systems (except transport and utilities infrastructure). Aspects specific to the location, design and construction of housing are dealt with in the section on Housing Domain.

See Also

Housing, Utilities, Heritage, Water Resources, Environmental Technologies.

Background

Data on the existing regional building stock is elusive. Available data is split broadly between housing and other building types. There were approximately two million dwellings in the region at the 1991 census. The amount of non-domestic floorspace in the region is indicated in the 1994 figures below.

Use Category	Floor area (,000 $m^{2)}$
Offices	5,000
Retail	9,000
Warehouse	7,000
Factory	18,000
Others	17,000
Total	**56,000**

Around 50% of the retail provision and 40% of the office provision pre-dates 1900.

Industrial development reflects the national pattern of 19th century factories and warehousing being replaced by new post-war industrial estates, many of which are in new, out-of-town locations. Overall the trends towards national and international approaches to building construction mean that most of the recent (post 1950) buildings will have national rather than regional characteristics.

It's really good that you are doing this study in this way. Its not until we take a look at climate change in this sort of detail that we realise how important it could be.

Architect in SW Region

There is a growing expertise in, and examples of, 'Sustainable Construction' in the region. Architects such as Fielden Clegg Bradley, Gale and Snowden and The Somerset Trust for Sustainable Development provide regional expertise and examples of good practice. (See also Future Foundations.)

Key Issues

Adaptation issues in the built environment must be addressed within the wider context of the construction industry to have any meaningful effect. This is reflected in many of the points raised below:

- The design and construction of buildings continues to keep pace with general economic growth, and will continue to make up a large proportion of the national and regional economy.
- The expected lifespan of new and existing buildings (say 20 to 100 years) allows issues related to the built environment can be considered over a similar time period to that of current climate change predictions.
- Building Stock is replaced at about 1% per annum. So, as well as considering design strategies for new-build, it will be important to consider the refurbishment and maintenance of existing buildings to accommodate climate changes.
- Restructuring of the industry will lead to larger UK based companies and the general European-isation of the industry. This will apply to contractors and those companies providing building materials, products and components.
- Changes in design and construction in response to the sustainability agenda will increase, driven by central and local government policy and European legislation.
- The location of new developments must take account of the increased potential for coastal, riverine and urban flooding.
- Different strategies are required to deal with both the design of new buildings and structures and the management and maintenance of existing building stock.
- There will be increasing emphasis on the need for the cooling as well as the heating of buildings, especially in the southern part of the region.
- Practical technologies are required for the passive cooling of buildings (both existing

and new) in order to avoid further releases of greenhouse gases in energy-consuming cooling, ventilation and air-conditioning plant and equipment.

- Increased solar radiation should improve the performance of solar panels, photovoltaic cells etc. throughout the region and especially in the south. More information is required on the incidence of cloud cover and other climate features to understand the full impact.
- The reduction in demand for heating will reduce heating costs although the capital costs of heating installations will probably remain the same, in order to cope with continuing cold spell conditions.
- The impacts on site construction processes are not considered to be great. Generally site conditions will be improved (e.g. less days lost through frost) though there may be increased vulnerability during the construction process from winds, rainfall and storms, especially in exposed locations.

Traditional buildings in, for example France, may provide exemplars for design and construction details to cope with new climate. e.g. small windows, high-ceilings, external shutters, internal reflecting blinds.

- Increased use of existing technologies is required to reduce the consumption of mains potable water in buildings (both existing and new), especially in summer.
- Both existing and new buildings may be exposed to higher intensities of driving rain in winter, making certain types of construction vulnerable (e.g. cavity filled walls).
- There is considerable scope for linking adaptation strategies for the built environment in response to climate change to the growing understanding of sustainable building construction.
- A combination of sustainable construction and responses to climate change, particularly increased temperatures, could lead to a regional (or sub-regional) 21st century vernacular construction.
- There are potential lifestyle changes, particularly to do with the greater use of the external environment associated with buildings, both public and private.
- The construction industry is ill-informed about, and ill-prepared for, climate change impacts. Wide ranging education and training is required across the whole sector.
- There is considerable need to increase awareness of potential climate change and implications for the whole of the construction industry, particularly building design.

Building Stock is only replaced at about 1% per annum. So, as well as considering design strategies for new-build, it will be important to consider the refurbishment of existing buildings to accommodate climate changes.

Lowe 2001

- Finer grain data on some climate variables is necessary to determine appropriate responses. e.g. extremes of temperature, solar radiation, diurnal temperature changes.
- Standards and design criteria within existing industry practice guidelines will need modification. It will also be essential to shift sector use of meteorological data from historical to future based data.

There is already expertise in the design of sustainable buildings in the South West Region. This can be exploited to design new, regional buildings that are both sustainable and anticipate changes in climate.

STSD Conference 2002

- Commercial opportunities exist for developing regional expertise in passive solar heating, cooling, shading and other such environmental technologies.

Issues of particular regional concern

Some of the potential changes in climate need to be examined further in order to understand the differential impacts across the region.

- Specific locations within the region are potentially vulnerable to coastal and riverine flooding. *(See Coastal and Flooding Impact Domains.)*
- Specific locations within the region are vulnerable to extremes events of winds and storms.
- The geographical differences in temperatures across the region, leading to increased demand for cooling of buildings to achieve thermal comfort, especially in the more southerly locations.
- Reduced heating demand due to warmer winter temperatures. In the southern part of the region this will mean a reduced requirement for conventional space heating.

Adaptation is still not broadly understood in the construction industry. Building owners are unaware of possible impacts, particularly to structures built before stringent workmanship controls were in place.

Buro Happold 2002

- Increased solar radiation providing opportunity for solar gain to provide both heating in winter and cooling in summer. Again this will apply to the whole region but with greater opportunity in the south.
- Opportunities for exploiting external and semi-external environments.

The Way Forward

The expected lifespan of new and existing buildings means that the timescale for climate change scenarios is of direct relevance to the design, construction, maintenance and use of buildings.

Action needs to be applied immediately as buildings constructed now will be required to operate in conditions at least of the 2020's scenarios, and probably of the 2080's scenarios.

Design options are available to minimise climate impacts on new buildings. Design can minimise subsidence in clay soils, dampness from rain penetration, and weather damage to materials. These may incur additional capital costs at the outset, but are likely to be offset by consideration of lifetime costs.

Calculations suggest that in most cases there are unlikely to be cost-benefits in radical improvements to existing buildings. Regular maintenance to a good standard is the general guidance.

Good design can also help to reduce the need for increased air conditioning through the provision of good ventilation. Otherwise the increase in air-conditioning is expected to absorb the 12% - 19% energy-use savings that could be expected from the warmer winters. This will in turn add to global warming.

Changes to Building Regulations and other standards are required to address these issues.

The integration of information on Climate Change into design tools that support standards is a step that could be taken more quickly and easily than the amendment of the standards themselves. (E.g. BREVe, a software tool for calculating design windspeeds and loadings.)

Lowe 2001

There is an urgent need to develop passive designs and low-energy technologies for cooling, as well as more efficient air-conditioning equipment. (e.g. BRE/DEFRA market transformation initiative on air-conditioning).

Planning can help to avoid problems from flooding and coastal erosion.

In addition, the finance industry may take a stronger view about future-proofing building designs as pressures build on insurance companies to increase premiums or withdraw totally from insuring buildings in certain vulnerable locations.

Landowners, developers and sponsors of new buildings, particularly local authorities, can nominate standards of performance for new build that recognise potential changes in climate.

Sustainability

There is some evidence of regional enthusiasm for, and expertise in, the idea of sustainable building construction. (STSC Conference: Taunton June 2002). It is clear that adaptation of the built environment to climate change is unlikely to be pursued in its own right. However, there is considerable scope for linking adaptation responses to the wider sustainable construction agenda. (e.g. South West Future Foundations, SWRDA)

It would be useful to develop more distinct regional approaches to design and construction of buildings in the future. This is inconsistent however with the observed tendency to minimize or eliminate regional variation. The trend towards larger construction companies, encapsulated by 'Re-thinking Construction', tends to work against regionalisation of construction. The development of systems and approaches that allow and promote appropriate regionalisation despite these trends must be a matter of priority. (Lowe 2001).

As the built environment accounts for roughly 50% of greenhouse gas emissions in the UK it is important to seek further reductions in the use of energy generated from non-renewable sources. The continued implementation of energy saving measures and the use of renewable energy will both assist in this matter.

Knowledge levels

There is little evidence that the sector has made any use within the region of the latest scenarios published by UKCIP, although there now some studies underway nationally. Climate scientists, natural scientists and natural resource managers within the region have a grasp on the data and the issues. For others the phenomenon does not appear to justify research. The built environment domain is one where the climate scenarios can at least be used for modelling, for example thermal performance as part of a decision making and design process, as in the BRE tools for determining insulation, glazing etc.

Some professionals in the South West acknowledge the potential impacts of climate change on the built environment, but for most practitioners climate change means mitigation – reduction in energy usage and greenhouse gas emissions, not adaptation. A regional firm of architects with a high reputation for the design of sustainable buildings admitted that they had no formal policy on adaptation to climate change. Another firm of environmental engineers with an international reputation reported a tacit rather than explicit approach to adaptation issues.

Adaptation is still not broadly understood in the construction industry. Building owners are unaware of possible impacts, particularly to structures built before stringent workmanship controls were in place. (Buro Happold 2002.)

The potential hazards of flooding are acknowledged, and the statutory and advisory roles of the Environment Agency and Local Planning Authorities seem appropriate to deal with these issues.

Wessex Water Operations Centre building is interesting due to the number of strategies that the client was not prepared to commit to at construction stage, but allowed space for retro-fitting at a later stage. e.g. photovoltaics, cooling system.

Wessex Water

Building designers and consultants identified potential litigation as major concerns. It was unlikely that previously completed projects would be revisited, but new buildings must be designed to industry standards. We were advised therefore, that changes in standards that reflected potential changes in climate would be a highly effective mechanism for improving performance.

Initiating change

The following recommendations for arose from discussions within the sector:

- Change Building Regulations to reflect anticipated climate conditions, particularly with regard to increased summertime temperatures, grey water systems, and increased exposure to driving rain and wind damage from extreme events.
- Change professional and trade Codes and Standards to reflect anticipated climate conditions through appropriate lobbying of professional bodies, trade associations etc.
- Introduce future-based climate scenarios, rather than historic meteorological data as the basis for technical decision-making.
- Educate the construction industry including architects, surveyors, engineering and environmental consultants as well as contractors. Initially this may concentrate upon regional interpretation of the UKCIP02 scenarios, and then proceed to wider implications for the industry.
- Develop new forms of building contracting and procurement that requires developers to take responsibility for their products over a longer period of time.
- Develop strategies for future-proofing existing building stock, including the development of robust repair and refurbishment standards.
- The focus should be on the shift in emphasis from heating to cooling, particularly in urban locations, and in the south of the region.

- Encourage continuing dialogue between developers, designers, contractors, occupiers, financiers and insurers on all aspects of climate change, probably through the SWRDA, GOSW, professional bodies and trade associations.

Potential barriers

The need to adapt to potential climate change is not widely acknowledged in any part of the construction industry, whether this be clients, designers, or contractors.

It is suggested that there are two main reasons for this reluctance to engage with adaptation issues. These are to do with both the type of data available and the degree of uncertainty attached to the data.

While uncertainty is bound to reduce the level of practical response, straightforward ignorance is still a principal barrier. This ignorance probably results from the way in which climate data and scenarios are presented. It appears that, even in a sector that makes some use of quantitative predictive techniques, a more practical representation of climate is needed if the industry is to grasp the likely changes and their implications.

Despite this, some more sophisticated data is required within the industry if environmental engineers are to quantify the opportunities for passive collection and the challenges of sustainable cooling strategies.

A further potential barrier to change is the trend towards pre-fabrication, particularly of housing. This invites a national (or even international) approach to building design, rather than a regional, climate responsive approach.

Challenges and Opportunities of Key Climate Impacts in Built Environment Domain

Climate Impacts		Challenges + Opportunities
Increased Summer Temperature	C	Overheating within existing and new buildings.
	C	Building fabric exposed to thermal stress.
	O	Increased requirement for specialist expertise in technical aspects such as cooling, ventilation, passive solar design.
	O	Increased solar gain for passive water heating, photovoltaics etc.
	O	Prospect of new internal finishes (e.g. ceramic floor tiles in place of fitted carpets).
	O	Increased opportunities for outdoor activities relating to the built environment.
	O	Generally improved construction site conditions.
Reduced Summer Rainfall	C	Drying of substrata, especially in clay areas such as Bristol, Dorset, Gloucestershire leading to increased subsidence & associated insurance claims.
	C	Water supply problems both during construction and during building's use.
Increased Winter Temperature	O	Less requirement for space heating (fewer degree days).
		Possible increase in demand for canopy type structures externally.
Increased Winter Rainfall	C	Litigation risks for consultants and contractors, associated with both new designs and existing buildings.
	C	Some worsening of construction site conditions e.g. concrete, mortar etc.
	C	More robust designs required for rainwater disposal systems above and below ground.
	O	More water available, but will need capturing and storing, and require incentives from water companies to reduce consumption from mains supply.
Increased Sea Level and Tides	C	Restrictions on location of proposed developments.
	C	Requirement for flood defences to protect existing buildings.
Longer Growing Seasons and Reduced Frosts	C	Lawns and other amenity planting likely to require more maintenance.
	O	Less days lost through frost on construction sites.
Flooding Increased	C	Litigation risks for consultants and contractors, associated with both new designs and existing buildings.
	C	Higher specifications required for new drainage systems (especially urban)
	C	Improvements required to existing drainage systems (especially urban).
	C	Opportunity for introducing Sustainable Urban Drainage Systems (SUDS) in new developments.
Potentially Increased Winds and Storms	C	Walls and windows, especially cavity-filled walls vulnerable to driving rain penetration, especially in exposed locations.
	C	Structures and roofs vulnerable to damage in exposed locations.
	C	Buildings and infrastructure under construction vulnerable to extreme events, especially in exposed locations.

HERITAGE DOMAIN

Scope

The management, conservation and protection of the historical and natural heritage of the South West Region, including the designed landscape, parks, gardens, buildings, environmental & human archaeology and the natural landscape.

See Also

Rivers and Flooding, Water Resources, Coastal, Natural Environment, Built Environment, Tourism

Background

The South West region forms one of the UK's richest areas of natural and human heritage, containing for example 46% of England's Grade I listed buildings.

Percentage (%) of England's classified heritage found in the south west

	I	II*	II	Total
Historic Parks and Gardens	24	20	17	19
Listed Buildings	46			24
Scheduled Ancient Monuments				32
Conservation Areas				18
Protected Wrecks				41

The Heritage as discussed here (c.f. Natural Environment, specifically) is largely controlled, managed, and conserved though the aegis of the National Trust, English Heritage and Country Archaeological groups. National Parks, with their designated governing bodies and Areas of Outstanding National Beauty (AONBs) form important designations in the conservation and management of the landscape. Individual landowners (e.g. Duchy of Cornwall) and property owners also play an important part in this process.

Heritage in the region is particularly important in the context of tourism, and forms an important facet in the marketing of the region both site-specifically and as a whole.

Key Issues

- Deterioration of unearthed archaeology driven by drying out of uplands with enhanced heather growth and greater rooting densities
- Loss of archaeological remains and degradation of their palaeo-environmental context driven by accelerated oxidation arising from greater variability of water table in lowland wetlands (e.g. Somerset levels, Exe valley) as a result of shifts in rainfall and evaporation patterns
- Deterioration of unearthed archaeology arising from the potential ground-disturbance effects of agricultural changes (e.g. willow expansion, as bio-energy crop; exploitation of wetlands for crops requiring higher moisture, when free-draining valley sides become drier);
- Exposure and damage of buried archaeological remains (track-ways etc) in the inter-tidal zone caused by increased storminess and potential sea-level rise;
- Damage to protected wrecks as a result of increased storminess;
- Increased costs associated with maintenance of coastal structures (e.g. National Trust owned harbours) arsing from accelerated damage brought about by increasing storminess and sea-level rise.
- Increased management tensions and conflicts between conservation agencies and local communities brought about by implementation of 'managed retreat' or 'managed re-alignment' of coastal and riparian margins.
- Increased visitor pressures and increased revenue for historic buildings brought about by expansion of tourist season and increase in the number of short-break holidays predicted within a warmer climate;
- Potential increased insurance costs for listed buildings and National Trust properties arising from climatic damage
- Maintenance of historical planting schemes in gardens created in colder climate – e.g. increased grass cutting will raise maintenance costs.
- Potential increase in storm damage, light-degradation, rain damage, fungal and beetle damage to the exterior and interior of historic buildings;
- Changes to natural landscape contexts for heritage sites, National trust land, AONBs etc. as a result of climate driven vegetational shifts.

Issues associated with heritage and climate change can be broadly split into those pertaining to the 'natural' and those relating to the 'designed' landscape. In the context of designed landscape, a further sub-division can be made into archaeology (buried and above ground), historic

buildings and structures, and designed landscapes (parks, gardens etc). Each of these 'territories' is examined discretely.

Effects upon historical environment

Key issues concern the management of coastline and decisions on protection, managed re-alignment or retreat. Regional examples include Porlock Shingle Ridge (half National Trust owned)– breached in 1996 – where decisions were made to allow natural change. Freshwater marsh inland has now become brackish despite some pressure to re establish the shingle ridge.

There is often local pressure to preserve landscape, as this is what local people are familiar with. In other areas (e.g. Birling Gap E Sussex) the National Trust has allowed cottages to 'fall into sea' rather than attempting to protect them.

Designed landscapes

Significant park and garden acreage occurs in the South West. A large number of these landscapes have been created or laid out in the seventeenth and eighteenth centuries – a time period when Europe was at the height of the so called Little Ice Age. The potential impacts of climate change on these designed landscapes are various.

The historical shape and/or planting schemes that were designed for tolerance to colder climate may become unviable in the future. One of the most notable examples of a garden potentially at threat is the Late Seventeenth Century garden at Westbury Court, Gloucestershire on the banks of the Lower River Severn. Here repeated flooding over the last decade has created management problems particularly associated with the increased incidence of the water-borne pathogen *Phytophera* (related to potato blight) that has begun to attack the important and extensive Yew Hedge plant-scape. Westbury Court Garden is a site whose long-term viability has been directly questioned, with the threat being attributed particularly to climate change.

Other impacts have been on historical fruits such as the medlar. This was a popular Elizabethan fruit that was eaten after exposure to the first frosts in autumn. The lack of autumnal frosts in recent years has meant that these fruits are only edible after been deep frozen for six hours after picking. Both increased flooding and frost reduction are predicted in the UKCIP02 scenarios.

Climate change is also thought, already, to have influenced the management of some garden sites owned by the National Trust: Properties once closed for the entire winter are now closed for only 6 weeks. The South West, in particular, has witnessed such changes. These can be partially attributed to changing character in tourism-demand (e.g. the move to short-break holidays, and off-season breaks).

Nevertheless, the National Trust regards climate change as being one of the significant drivers in the longer opening season of garden properties. Many of the region's National Trust Gardens have a predominantly spring focus and warmer, drier springs have brought forward the first flowering (e.g. of camellias, flowering bulbs and rhododendron). Notable gardens with extended opening include the Cornish Trelissick and Glendergan gardens, both of which have started flowering earlier, potentially as a result of climate change.

Whilst this has greater cost implications for management it also increases income and is considered valuable for local employment by reducing its seasonality. The increasing short-break, off-peak trend in the region has also benefited the National Trust which is a considerable owner of holiday cottages. The occupancy of these has increased, again reducing the seasonality.

Water resources in heritage gardens may also become an issue, either through increased demands on irrigation to maintain historic planting, or through low-flows (or flood flows) diminishing or damaging water supply associated with formal water-gardens and pond systems. Water harvesting assessments may be needed to optimise such water gardens, e.g. as the Painswick Rococo gardens in Gloucestershire (McEwen and Hunt, 2002).

Additional threats associated with water features relate to ponds and lakes whose catchments are susceptible to overland flow and sediments erosion. Shifting agricultural practice and climate change may combine to accelerate sediment infilling of such features, leading to a dredging requirement. Dredging in such situations can lead to the loss of valuable palaeo-environmental data and should only be undertaken after sediments have been recovered for analysis. These sediments may hold valuable evidence that can be used to reconstruct environmental change (e.g. flooding histories) in specific garden catchments, which in turn can be used to investigate and monitor the impacts of climate change itself (valuable evidence was lost, for example when 300 years of sediment accumulation were dredged from the ponds at Westbury Court in the early 1970s, removing evidence of the flooding history of the River Severn).

Historic buildings, as with significant proportions of the building stock, are at risk from specific aspects of climate change related phenomena. Maintenance of historic buildings can range from the relatively recent structures (such as Castle Drogo, built between 1910 and 1930) through to decaying mining structures such as the Cornish tin mines and ruined buildings such as the 13th Centrury Hailes Abbey in Gloucestershire and Tintagel Castle in Cornwall.

Ruined sites pose particular problems as they are not readily protected from the weather. Shelter buildings are generally not deemed as allowable as they would have too great an impact on the settings of the protected structures (John Fidler, pers comm. 2002). In extant as well as with ruined buildings, the strong conservationist approach required ensures that climate change will remain a difficult issue. Replacement materials are required to be in sympathy with original materials, and internal changes in a building's air-movements can potentially lead to the ingress of fungal or faunal agents of decay. The chief agents of degradation are moisture ingress associated with timber decay, and the dissolution of calcareous materials and transport of salts in porous building stones (John Fidler, pers comm. 2002). Increasing temperatures are also known to increase the impacts of acid rainfall and other pollutants on building materials and artistic / sculptural works in building stones and stained glass. Storminess and increased winter rainfall predicted by the UKCIP2002 scenarios all pose threats to the maintenance of the historical buildings in the south west.

Additional temperature-related effects relate to biological decay. Whilst the immediate termite threat to British buildings has arisen through the accidental introduction of the subterranean termite *Reticulitermes lucifugus*, the northward movement of *R. santonensis* is occurring unaided and would adapt to warmer conditions in southern Britain quite readily. The northern penetration of the oak-beam-eating deathwatch beetle (*Xestofobium rufovillosum*) into Scotland may occur directly as a result of warmer conditions. However, in the south west the warmer temperatures may facilitate destruction of they egg-laying female beetles – heat triggers flight making the females more susceptible to integrated pest management based on light traps (John Fidler, pers comm. 2002).

The surface or exposed archaeological landscape

Increased storminess may lead to an accelerated rate of erosion. Other environmental factors include the marked increase in flood alleviation work undertaken by the Environment Agency due to increased risk of flooding. Some of these works are particularly damaging to the HE.

There are also increased problems to historic bridges caused by higher river levels and faster river flow. This is causing scouring of material around abutments and the loss of mortar.

The principal areas of extensive buried archaeology (i.e. that archaeology which is yet to be 'un-earthed' or examined for its palaeo-environmental and cultural / pre-historic evidence) lie in the extensive wetlands of the region. These include the upland peatlands on Dartmoor, Exmoor & Bodmin Moor, the lowland peatlands in the Somerset Levels & elsewhere, alluviated lowlands in Somerset, Avon & Devon, and coastal marshes in Devon, Gloucestershire & Somerset. Two threats are paramount in these sites: (i) the potential for changing water tables in the terrestrial peatlands leading to accelerated decomposition of organic remains (wood, leather, and fabric artefacts and structures; human and animal remains); and (ii) the erosion of coastal and near coastal deposits as a result of increasing sea-levels and storm-driven tidal surges.

The most effective preservation of archaeological and palaeo-environmental remains occurs when host (burying) sediments are continuously saturated below the local water table. Cyclical drying and wetting that is predicted to occur following the enhanced seasonality highlighted in the UKCIP2002 models is extremely likely to affect the preservation of buried evidence. The greater the oscillation of the water table, the greater will be the zone of oxygenation and leaching in the peats and soils. Thus wetter winters *and* drier summers re-enforce the problem. In drier (un-saturated) deposits archaeological preservation is generally poorer and more research is needed to confirm anecdotal evidence that environmental stratigraphy may be disrupted as a consequence of increased seasonal waterlogging.

The buried and surficial archaeology of upland peatlands is also vulnerable to root-disturbance, particularly by the invasive penetration of woody roots of heather species. Evidence of damage to archaeology is not uncommon in Dartmoor and Exmoor (Conservation Bulletin, 2002; Robert Van de Noort, pers. comm. 2002), particularly as a result of the spread of bracken, Bracken rhizomes favour well-drained ground often associated with buried upland archaeology and are able to exert both physical and chemical damage to the colonised area (Conservation Bulletin, 2002). Drying of upland peatlands are a result of the general shift to reduced annual precipitation (UKCIP2002 scenarios) is thought to favour heater and bracken growth therefore placing the archaeology under threat.

The Way Forward

Many of the national organisations, especially English Heritage and The National Trust have begun to consider climate change as a major issue and there is an increasing occurrence of climate change related policy statements arising from these organisations that testify to this. Staff in both organisations are involved in policy and research activities at national and international levels. Much of the research into the physical behaviour of building materials and historical structures has been undertaken by, or been done in association with, these organisations. As the South West region contains a significant proportion of the Nation's 'heritage' as defined in this Domain, this national process will have particular benefit to the South West.

The fabric of our heritage is prone to many pressures, of which climate change is but one, whilst climate change may indeed pose some

threat, for example, to Stonehenge it is the visitor pressures and transport facilities in the area that have been criticised as impacting most severely on the appreciation of heritage, both landscape and builtscape

To an extent it can be argued that the fabric of the buildings has the potential to withstand the assaults of predicted climate change (albeit with potential impact on 'purist' conservation principles) more so than the planted and 'wild' landscapes, woodlands, parks and gardens. In both cases however, it is clear that further investigations are required to evaluate the magnitude of challenges and their potential solutions. The principle organisations involved are, as highlighted above, already active in this process.

4 Recommendations

The public attitude to conservation of 'heritage' has the potential to be improved. This can be done hand in hand with the enhancement of the public understanding of science schemes, possibly through association with schemes such as COPUS (Commission on the Public Understanding of Science). Particular areas where public understanding has the potential to be improved relate to an appreciation of the 'innevitability' of change and the consequences of attempting to prevent it. The notion of 'managed retreat' in riparian and coastal areas of heritage interest is particularly appropriate to this approach.

There is some sense, that despite national initiatives in many organisations, there is an over-reliance on 'casual' consideration of climate change at a site-specific level. This is not to sugest that there are sites in which 'bad' or 'indifferent' practise is occurring. Rather it is to recommend that the national bodies may give stronger steers to regional- and site-based staff to ensure that climate change issues become a 'standard' component of site management and regional planning.

Challenges and Opportunities of Key Climate Impacts on Heritage Domain

Climate Impact		Challenges + Opportunities
Summer Temperature Increased	C	Increased potential for termite infestation
	C	Increased risk of reduced water supply to historic gardens and landscapes
	C	Increased risk of upland desiccation and consequent deterioration of buried archaeology
	C	Expansion of agriculture into the potentially drier areas that are now wetland, with damage to unearthed archaeology
	C	Potential for increased light – driven and temperature driven damage if historic fabrics and building's contents
	C/O	Change in visitor patterns to 'special interest' (e.g. Spring flowering) gardens
	C/O	Expansion of the visitor season due to warmer conditions and 'extension' of the summer
	O	Increased visitor numbers and improved income streams to specific sites
Winter Temperature Increased	C	Potential for greater survival of pests that have potential to damage structures and plants
	C	Potential for change to natural planting schemes and management practices
	C	Expansion of agriculture into the potentially drier areas that are now wetland, with damage to unearthed archaeology
	C	Potential for increased light–driven and temperature-driven damage to historic fabrics and building contents
	C/O	Change in visitor patterns to 'special interest' (e.g. Spring flowering) gardens
	C/O	Expansion of the visitor season due to warmer conditions and 'extension' of the summer
	O	Increased visitor numbers and improved income streams to specific sites
Summer Rainfall Reduced	C	Increased pressure on lowland (archeologically rich) wetlands for agriculture
	C	Potential for certain historic garden planting strategies becoming unsustainable
	C	Increased risk of desiccation of archeologically rich peatlands
Winter Rainfall Increased	C	Increased moisture penetration into historic buildings
	C	Potential impacts on historic planting schemes

HOUSING DOMAIN

Scope

The domestic environment in terms of lifestyle (indoors and outdoors), building maintenance and refurbishment, and the location, design, and construction of new dwellings. Technical aspects of housing construction are addressed in the section on the Built Environment Domain.

See also

Built Environment, Utilities, Heritage, Water Resources, Environmental Technologies.

Background

There were nearly 2 million dwellings in the region at the 1991 census. There is some variation of housing tenure when compared with averages for England. Owner Occupation is as high as 75% by comparison with 70% for the whole of England. Only 7% of public housing stock now remains with local authorities (English equivalent is 13%). Much has been transferred over recent years (the 1991 figure was 14%) to Registered Social Landlords (RSLs) who now own and manage 7% of stock within the region (2% in 1991). The private rented sector is relatively steady at 11% of the total stock, consolidated by recent 'buy to rent' investments and increasing employment mobility.

There is a wide variety of vernacular building traditions ranging from limestone in the north of the region, cob and thatch in the southeast, brickwork and clay in Devon and rough worked stone in Cornwall. Typical urban developments of 19th Century include (mainly brick) housing in settlements such as Swindon, Bristol, Cheltenham, Gloucester, as well as the coastal settlements of Poole, Bournemouth, Weymouth and Plymouth where property is more typically rendered.

Dwelling types are shown in the table below:

Dwelling Type	Percentage of region total (%)
Detached	30
Semi-Detached	27
Terraced	27
Purpose Built Flat	11
Converted Flat	5

Detached properties range from 43% of the local total in Dorset to 17% in the Bristol area. Flats in converted properties range from 8% in the Bristol area to 2% in Wiltshire.

Key Issues

The consideration of adaptation issues across the built environment must include the wider agendas facing the housing sector, some of which are included in the list of issues given:

- Projections for household numbers are 2.32 million in 2011 increasing to 2.52 million in 2021.
- The availability of land for housing development is a key issue for parts of the region. New legislation, funding and new planning regulation will all influence future developments.

The Housing Corporation relies on the Building Regulations to boost the standard of new dwellings and tends to concentrate more on creating sustainable communities through good design and high interior comfort plus community facilities (e.g. open space).

Housing Corporation

- The SWRDA is committed to providing 50% of new housing by 2010 on previously developed land and through the conversion of existing buildings.
- The demand for new housing continues to keep pace with general economic growth and increased household formation.
- Social housing will be a major focus particularly in the most deprived local authority areas and as part of a comprehensive regeneration strategy.
- Changes in lifestyle are anticipated as a result of climate change though it is not yet clear what form this might take.
- Pre-fabricated dwellings are being proposed as a way of speeding production and increasing quality.
- Different strategies are required to deal with a) the design of new housing and b) the management and maintenance of the existing housing stock.
- The impacts of some aspects of climate change (e.g. technical issues) will be common to all types of tenure. However, the responses will be managed very differently, particularly between owner-occupied properties and managed properties in both public and private sectors.

- There will be an increasing emphasis on the need for the cooling rather than the heating of residential buildings in the southern part of the region.
- The location of new housing developments must take account of increased potential for coastal, riverine and urban flooding.
- Those parts of the region where housing is founded on clay (including parts of Gloucestershire, Wiltshire, areas around Bristol and Bath, parts of Dorset and South Devon) are vulnerable to subsidence and ground movement from the drying out and shrinkage of clays in drought periods.

There will be increasing pressure on Registered Social Landlords to merge into larger units to spread the costs of all sorts of climate change impacts.

Those Registered Social Landlords (RSLs) with properties at sea level, near the coast, may potentially lose it. Insurance will cover the cost; if not we will seek mergers between RSLs to 'spread' the load financially or have to write off stock and the grants given to produce it.

Housing Corporation

- External space in the form of balconies, parks and gardens will be at a premium, especially in high-density schemes in urban areas.
- Practical, affordable technologies are required for the passive cooling of all housing in order to avoid further releases of greenhouse gases in energy-consuming cooling and ventilation equipment.
- The reduction in demand for heating may reduce heating costs and therefore current aspects of fuel poverty, but the need for cooling in summer may increase costs and create a new type of fuel poverty.
- Households are likely to increase their use of water for drinking and garden irrigation, pools etc. So, there will be a need to reduce consumption of mains potable water especially in summer, probably through the increasing use of water butts and grey water systems.
- Housing may be exposed to higher intensities of driving rain, particularly in exposed areas of Cornwall, North and South Devon and Dorset. Certain types of construction (e.g. cavity filled walls) are particularly vulnerable.
- There are potential lifestyle changes, particularly to do with the greater use of the external environment associated with all housing types.
- The housing sector is generally ill-informed about, and ill-prepared for, climate change impacts. Wide ranging education and training is required across the sector, for owner-occupiers, managers and developers of housing stock.
- The short-term nature of most housing investment, and the NHBC cover limited to a 10-year period, discourages long-term considerations in housing investment.

The Way Forward

There is little published material on the impact of climate change on housing except that concerning the technical issues of the building fabric. Clearly aspects such as flooding, exposure to winds, driving rain, heat stress etc. are important and are dealt with both in this section of the report, and in the section on the Built Environment.

Much greater understanding is required of the 'softer' aspects of housing, particularly lifestyle changes associated with changes in the weather.

Planning and design options are available to minimise climate impacts. These include:

- Ensuring that new developments avoid locations that are potentially vulnerable to coastal, riverine and urban flooding.
- Improving the technical specification of new housing to deal with extreme events of winds, storms and driving rain.
- Designing to improve cooling and ventilation in summer conditions and to reduce the need for increased air conditioning. The geographical differences across the region, will lead to increased demand for cooling in the more southerly locations (Dorset, Devon and Cornwall), and also in the urban centres (such as Swindon, Bristol, Plymouth) where the effect of urban heat-islands can uplift temperatures by a further 3^{o}C.

Heating/Cooling – enjoy 12% to 19% reduction in heating energy use……..use some of the gain to improve comfort and reduce damp.
Graves and Phillipson, 2000

- Exploiting external and semi-external environments to the full. This will be particularly important in urban environments generally and particularly in high-density housing where private open space is often at a premium.
- Creating adaptable dwellings that can respond more sensitively to changing climate conditions, requiring less costly alterations/additions for example.

Ventilation – raise temperature to dispel damp. Provide good natural ventilation where air pollution and security allow, especially in the southern part of the country. Consider mechanical ventilation only as a last resort.

Graves and Phillipson, 2000

Such initiatives may well incur additional capital costs but these are likely to be offset by consideration of lifetime costs. Planning can help to avoid problems from flooding and coastal erosion. Design can minimise subsidence in clay soils, dampness from rain penetration, and weather damage to materials.

Those responsible for RSLs have indicated that increased funds will be required from central government to improve the standards of both existing and new stock. A further response to resource problems will be to combine smaller RSLs into larger administrative units able to absorb the costs of particular schemes and achieve economies of scale.

The response of the insurance industry will be critical in both private and public sectors. There is some indication that insurers could withdraw from certain locations at high risk, as well as increasing premiums in vulnerable locations. The concept of 'future-proofing' building designs may be applied as a way of setting premiums.

Changes to Building Regulations and other standards may be an appropriate way of addressing some of these issues.

Knowledge levels

"Is this a wind-up? I don't do science."

Local Authority Housing Officer on receipt of Climate Change Impacts questionnaire.

Some housing professionals in the South West acknowledge the potential impacts of climate change on the built environment, but for most housing practitioners climate change is not on the agenda. Within this study it was difficult to elicit any response from many regional housing organisations, in both the public and private sectors. Many organisations could not identify appropriate personnel to deal with the topic.

Within the Housing Corporation the Senior Technical Officer for the region indicated that the HC had no explicit policies that addressed climate change issues (either adaptation or mitigation). The same was true for the Regional Operations Director of a major Housing Association who also reported being unaware of the concept of 'adaptation' before receiving the questionnaire.

No specific enquiries were made of owner-occupiers within this study, but other work suggests that many interested householders are aware of some of the potential impacts but unclear on how best to respond.

Recommendations

The following are recommendations for areas within which change can be initiated.

- Introduce future rather than historic meteorological data as the basis for technical decisions when revising codes and regulations relating to housing design and construction.
- Design new buildings using the following indicative strategies (BRE, 2000):
  - Design roofs in anticipation of 5-10% increase in wind loads.
  - Increase foundation depths by around 0.5m in susceptible clay soils.
  - Design for driving rain assuming higher levels of climatic exposure.
  - Avoid floodplains. Raise floor levels, and avoid underfloor wiring in vulnerable locations.
  - Plan for good ventilation.
  - Anticipate reduced heating load in winter, and design for passive cooling in summer.
- Educate the housing sector including housing developers, RSLs, local authorities, Housing Corporation, and designers. Initially this may concentrate upon regional interpretation of the UKCIP02 scenarios, and then proceed to implications for the sector.
- Educate owner-occupiers. Initially this may concentrate upon regional interpretation of

the UKCIP02 scenarios, and then proceed to adaptation responses.

- Develop new forms of housing development, procurement and financing which extends the investment period.
- Develop strategies for future-proofing existing building stock including the development of robust repair and refurbishment standards. The focus should be on the shift in emphasis from heating to cooling, particularly in urban locations, and in the south of the region.
- Undertake further research into lifestyle changes associated with climate change, and the implications for the socially excluded.
- There is a recognised need to understand more subtle characteristics of climate change e.g. sunshine hours, relative humidity, cloud cover, and pattern/magnitude of extreme events.
- It would be beneficial to modify standards and design criteria within existing industry practice guidelines, and to shift sector use of meteorological data from historical to future based data.

Potential barriers

One respondent identified a potential conflict between a sustainable construction and the creation of maintenance-free building fabric, presumably because a material which did not degenerate under any environmental conditions likely to be experienced in a changing climate would not be themselves organic in origin or remotely biodegradable.

The barriers to change with regard to existing properties vary according to the type of tenure.

Most properties in the South West are owner-occupied. It will be very difficult to achieve appropriate adaptation responses in this sector, as responses will be dependent on individual actions by individual households. Public awareness campaigns, particularly with regard to the avoidance of further energy consumption, will be important here.

Properties managed by local authorities, Registered Social landlords (RSLs) and large private landlords will benefit from strategic management and maintenance strategies. Adaptation responses will nonetheless not be forthcoming without appropriate funding from central government.

With regard to new-build there are five main barriers to change:

- Building Regulations and Codes do not sufficiently take account of climate change predictions in setting new performance standards.
- Professional and lay people have difficulty in responding to the degree of uncertainty associated with future climate scenarios.
- House buyers are reluctant to invest in anything other than the most conventional house designs.
- The move to centralised pre-fabrication of residential buildings may prevent the production of houses designed for local climate conditions.
- The general unavailability of building land forces housing development to what are perceived as difficult sites. In turn this makes development more complex, requiring more consultation which slows the process, and makes the resultant housing more expensive. All this makes it less likely that adaptation responses are given serious consideration.

Challenges and Opportunities of Key Climate Impacts in Housing Domain

Climate Impacts		Challenges and Opportunities
Increased Summer Temperature	C	Overheating of the interior environment of existing and new housing stock.
	C	Increase in certain types of household pests such as insects etc.
	C	Increased problems of keeping food free from bacterial infection.
	C	Heating costs down as less requirement for space heating.
	O	More outdoor socialising, barbecues etc.
	O	New types of food and possible changes in diet.
	O	New internal finishes (e.g. ceramic floor tiles).
	O	Increased opportunities for outdoor activities.
	O	Improved viability of solar water heating.
Reduced Summer Rainfall	C	Increased use of and demand for water: e.g. for irrigation of gardens, swimming pools, drinks etc.
	C	Less availability of potable water.
	C	Increased potential for subsidence & insurance claims due to drying out of substrata, esp. clays in areas such as Bristol, Dorset and Gloucestershire
	O	Greater and more consistent use of outdoor space.
Increased Winter	C	None identified.
Temperature	O	Heating costs reduced as less requirement for space heating.
Increased Winter Rainfall	C	Increased grant requirement for RSLs to deal with upgrading and maintenance.
	C	Improvements in rainwater disposal systems above & below ground will be needed.
	C	More foreign holidays to escape British winter.
	O	More water available but needs capturing and storing.
Increased Sea Level and Tides	C	Restrictions on location of proposed developments.
	C	Requirement for flood defences to protect existing buildings.
	C/ O	Relocation of housing stock associated with managed retreat.
Longer Growing Seasons and	C	Lawns & other amenity planting require more maintenance through increased growth and use.
Reduced Frosts	O	Less maintenance and associated costs arising from frost damage, thaws, etc.
Flooding Increased	C	Need to improve flood defences.
	C	Need to relocate vulnerable housing stock.
	C	Ensure no new housing development in vulnerable locations.
	C	Consider possibility of changed use for ground floors to less vulnerable activities (e.g. no electrical equipment).
	O	Opportunity for introducing SUDS in new developments.
Potentially Increased Winds and Storms	C	Walls and windows, especially cavity-filled walls vulnerable to driving rain penetration, especially in exposed locations.
	C	Structures & roofs vulnerable to damage in exposed locations.

PUBLIC HEALTH DOMAIN

Scope

Issues of health and well-being, including diseases, pests, vulnerable groups and positive opportunities.

See Also

Water Resources; Tourism and Leisure, Housing.

Background

The population of the South West is one of the lowest in the UK, although this level is expected to increase by nearly 11% from 1996 values by 2016. Households are likely to increase by almost 25% over the same period.

A large proportion of this population is elderly due to the attractions of retiring to the region, and large numbers of both the retired and working age community live in rural areas. Allowing for this age structure, the South West currently has the lowest mortality rate in the UK.

The region is greatly influenced by tourism – some parts of the region have a temporary summer population more than twice that of the rest of the year – which has its own influence on public health concerns.

Key Issues

- Potential for increase in radiation levels and skin cancer.

Incidences of skin cancer have increased in the last ten years even with increasing awareness.

Climate change is likely to continue this trend, particularly in the South West of the country.

Medical professional, Bath

The South West is particularly vulnerable to health impacts of climate change due to its high proportion of elderly people and pressure on local services dependent on tourism.

This makes the region open to perceptions of risk that might follow from climate-related health scares.

Public health officer, Exeter

- Maintenance of water quality and supply, essential for health and well-being, may be compromised if water companies etc. “fail to get it right”. Supply will be especially stretched if tourism does increase as a result of climate change.
- Psychological impact of flood events has been reported to be as damaging as the physical effects of flooding, particularly where domestic properties are concerned.
- Atmospheric conditions could favour an increase in urban pollution, while summer changes could alter the pattern and distribution of pollen and spores.

Water quality and reliability of supply is likely to be a significant factor where Public Health is concerned.

Public health officer, Exeter

- Mould growth, already a common concern in houses in the far south west of the region, is likely to become more widespread. Moulds are well recognised triggers for allergy sufferers and asthmatics.
- Very little regional research has been done in the area of climate change impacts on public health.

Issues of particular regional relevance

Climate change may affect the demography of the region via its influence on migration. The region is a popular choice for retirement and so has a large elderly population. Changes towards what is perceived to be better climate could increase the attractiveness of the region to migrants. However, since similar changes in climate are also anticipated in some of the major source areas of migrants (e.g. south east England) changes in relative attractiveness may be limited. It is also possible that increases in extreme weather associated with climate change could reduce the attractiveness of the region to potential migrants.

The water companies must be prepared for climate change to ensure that water quality does not decrease due to changes in climate, with potential consequent health impacts. There are many private water supplies in the region that also need to address climate change, but these may be difficult to regulate.

Strategies to reduce the potential health impacts should be addressed now, e.g. building design for optimal space cooling, and the planting of trees within urban areas to reduce the "urban heat-island" effects. It would be false economy to delay such activities until the health effects are being experienced on a regular basis.

The South West is likely to be the first region affected by increases in radiation, leading to a potential for skin cancer increase. This is enhanced by the region's having a generally good air quality, which allows greater radiation penetration. The likelihood of more summer visitors to the region also means that visitors to the region will transport this increase back to their home regions.

Notable risks

While it is easily understood that extreme weather events can lead to injuries and even deaths, it is also considered that they may lead to considerable long-term psychological impact. Such events and their aftermath could additionally burden the healthcare system. Following floods in Bristol in 1968 for example, 3,000 homes were flooded and there was one fatality, but there was also an increase of 53% in visits to the doctor during the year following the event.

The incidence of food poisoning in the United Kingdom has been rising in recent years for a variety of non-climatically related reasons. Superimposed on this general increase there is also a marked annual seasonal pattern of higher risk associated with periods of hot summer weather (e.g. salmonella peaks in the summer each year). Warmer summers are therefore likely to increase the incidence of food borne disease, all other things being equal.

Lyme disease is the only important vector-borne disease in the UK and is already prevalent in the South West region. It is not clear what effects, if any, climate change might have on the ticks and parasites that cause the disease. However, it does seem likely that a warmer climate would encourage changes in human behaviour (more outdoor leisure activities in tick-infested areas, lighter-weight clothing) that could increase risk.

Changes in rainfall patterns under climate change may affect surface water quality and the risk of microbiological contamination of public water supplies. Surface water is more likely to be contaminated than ground water.

The water-borne disease cryptosporidiosis has been associated with flooding following periods of dry weather. The South West already has a high incidence of cryptosporidiosis, which could be exacerbated by the predicted change to drier summers followed by milder, wetter winters.

An increased frequency of flooding associated with climate change could in theory also increase the contamination of estuarine and coastal waters with heavy metals. These metals are currently locked away in sediments, or even old mining spoil-heaps, but could be re-exposed by heavy rain or flood events. Warmer summers with higher near-shore water temperatures are likely to encourage more sea bathing and similar activities, which could increase population exposure to microbiological and other contaminants, including heavy metals.

The lack of large river systems in several areas of the region will increase pressure on existing water supply systems due to both high and low rainfall, with a corresponding risk of water quality deterioration. It should be noted however that water quality standards in the south west are high, and if regulation increases, increasing temperature should not cause any quality problems.

The region experiences high ozone episodes associated with stable anticyclonic conditions with high temperatures and strong sunlight, and these may be increased under climate change, although this is currently highly uncertain. Population exposure to ground level ozone and the associated respiratory health effects may therefore increase.

Heatwaves are associated with short-term increases in mortality and morbidity, primarily in the elderly, and those with chronic lung or heart disease. Climate change will increase the frequency of heatwaves in the region, although acclimatization will reduce some of the impacts

of increases in temperature. The direct effects of temperature on mortality occur at temperatures that are not necessarily extreme; for example, heat related mortality can be observed above 17^{o}C in London.

Skin cancer and other health impacts due to exposure to ultraviolet radiation are likely to be of increasing concern in the region. Warmer, sunnier summer weather is likely to encourage patterns of behaviour (e.g. more outdoor leisure and lighter clothing) that increase exposure to the sun.

Water quality and reliability of supply is likely to be a significant factor where Public Health is concerned.

Source unknown

Notable opportunities

The costs of adapting to climate change, i.e. reducing or preventing health impacts will be cost-effective because they are likely to have near-term health benefits as well, for example, improving disease monitoring and public health infrastructure.

Milder winters should reduce winter mortality rates.

Warmer summers should encourage the eating of healthier (salad type) foodstuffs and also increase participation in outdoor (physical) activities.

Health aspects of climate change may be sufficiently interesting to the general public that they are hooked into considering impacts where they might otherwise not have been. Every person, regardless of age or occupation, can understand the relevance of health matters, where they might perhaps feel that certain business or environmental impacts are "nothing to do with them".

The Way Forward

The drive towards more sustainable energy +

provision and use, including energy efficiency measures, will in many cases have a beneficial effect on public health.

The general aim of increasing awareness about sustainability issues may also encourage people's thoughts towards public health issues as they affect them in their personal lives.

Many of the believed anthropogenic causes of climate change are also related to the main causes of poor health in developed countries. A healthier and more sustainable lifestyle – for example less driving of fuel-powered cars and correspondingly more use of bicycles or walking will be encouraged by better weather, contribute to better health and reduce negative impacts on the environment.

Example of Good Practice

Isles of Scilly Health Centre have installed a ground sourced heat exchange unit for provision of both heating and cooling without an increase in greenhouse gas emissions.

Potential barriers

The difficulties to be overcome in the region are likely to be inertia due to a lack of funds and a tendency to believe that the South West, as part of an affluent Western society, is immune to situations and diseases more commonly associated with poorer developing parts of the world.

Knowledge and awareness

Public health workers are very well tuned to developments in their own field, but are less likely to attribute them to external influences. Those in positions to influence wide scale changes on a regional level may need further information before they are willing to act when the region is seen to have a generally good record for public health.

The Department of Health commissioned a UK national health impact assessment of climate change, which was produced in 2002, but as yet there has been no regional work carried out in the Health Sector. An integrated approach to monitoring impacts (health outcomes) and exposures (e.g. air pollution, water quality) is required to accurately gauge the true impact of climate change on health issues and this has not yet been achieved.

More research is also needed on heat related deaths and illness, and the role of temperature in food and water-borne disease transmission. Such research will require inter-sectoral collaboration; for example, between the water, health, academic sectors. Uncertainties exist on such matters as:

- How fast will people acclimatise to the warmer climate?
- How great is the risk of introduction of "new" diseases? (Currently not considered to be very great).
- How will adaptation measures in other sectors affect health, for example, increased use of insecticides in agriculture or home gardening? (Considered to have little regional relevance at this time).

Recommendations

Many health risks relating to climate change will be avoidable if appropriate changes in behaviour are encouraged. The biggest challenge and easiest way to protect and improve the health of those living in the region is to increase knowledge and understanding of what climate change will mean in terms of health impacts.

This process needs to start with the health sector itself, which requires increased access to and training in, the information available. Specific examples include recognition of weather-dependant diseases, such as those caused by *Giardia* cysts and *Cryptosporidium* oocysts, which may increase in streams following heavy rain events.

In addition to changes in diseases contracted locally, awareness of tropical diseases which could change distribution globally will be required by health workers in the region who treat people on their return from travel abroad.

Once local health scientists are better informed, they will be in a position to inform the general public – providing information and recommendations regarding specific risks for local environments (e.g. diseases in marshland areas) or “at risk” groups (e.g. heat stroke in the elderly).

They will need to establish and then advise on preventative measures available and response systems in place locally. There will be scope for involvement with LA21 initiatives across the region in many of these areas.

Challenges and Opportunities of Key Climate Impacts in Public Health Domain

Climate Impact		Challenges and Opportunities
Increased Summer Temperature	C	Risk of increased exposure to radiation; increased incidence of skin cancer.
	C	Increased risk of heat exhaustion and dehydration.
	C	Risk of heat stress in participants of summer sports.
	C	Risk of heat stroke especially among the elderly and children.
	C	Increased risk of food poisoning, including shellfish poisoning.
	C/ O	Need for more environmental health officers and laboratories to monitor abattoirs, food supplies etc. for potential food risks.
	O	Tendency towards eating healthier foods in warmer weather.
Reduced Summer	C	Risk of deterioration of water quality and supply.
Rainfall	O	More opportunities for outdoor activities, with associated health benefits.
Increased Winter Temperature	C	Increased pests and vermin surviving the winters – rats have increased 50% in recent times which may be partly climate related (C-CLIF 2001).
	C	Reduced winter die-off of bacteria and viruses.
	O	Less ill health due to living in what are currently cold, damp conditions.
	O	Less carbon monoxide poisoning due to a reduction in space heating requirements.
	O	Fewer deaths due to hypothermia.
Increased Winter Rainfall	C	Increased incidences of mould growth and associated health risks (asthma, allergies etc.), particularly in poorly heated/ventilated housing..
	O	None identified.
Increased Sea Level and Tides	C	Danger of being swept to sea by unexpected high tides and sea swells.
	O	None identified.
Longer Growing	C	None identified.
Seasons and	O	Less risk of accidental injury caused by slipping on ice etc.
Reduced Frosts	O	Fresh healthy and locally produced food available for a longer period.
Flooding Increased	C	Health risks associated with sewage system overloads.
	C	Risk to life and health through property flooding.
	C	Risk of long term psychological impacts on victims of flood events.
	O	None identified.
Potentially Increased Winds and Storms	C	Risk of personal injury due to falling or wind-propelled objects, or damage to infrastructure, electric cables etc.
	C	Limited risk of direct injury due to weather conditions.
	O	None identified.

TRANSPORT DOMAIN

Scope

Provision, management, maintenance and use of transport in, to and from the SW (road [incl. bus], rail, air, waterways); Includes supply, demand, investment and infrastructure strategies, sustainable transport strategies and promotion.

See also

Business; Tourism; Built Environment

Background

The south west region has a high-density network of A-, B- and unclassified roads, and two principal motorways: M4 and M5 (plus M32). The major trunk road and rail networks provide spinal routes to the Southwest peninsula from London and from the Midlands. The major North-South artery is the M5, which is paralleled by the A38. There are two major trunk road routes from East Devon towards Cornwall (A30; A38) but only one rail route. The regional airport with greatest passenger flow is Bristol, with lesser flows at Plymouth, Exeter, Bournemouth and also at Newquay, which recently has experienced a significant expansion of low-cost services to and from London.

The Scillies are connected by air mainly to Land's End (St Just) and to Penzance (heliport). The region has a very long coastline and has major freight ports at Portbury and Avonmouth, naval facilities at Devonport and Portland, major natural harbours at Falmouth (claimed to be the third largest in the world) and Poole, plus tourist and pleasure craft at many coastal resorts. Inland waterways operate principally for leisure/pleasure craft.

In terms of journeys made other than on foot, the private car overwhelmingly dominates. Cycling is a minority pursuit; rail use in the region is proportionately relatively low, except for inter-city travel between principal urban areas and to London. Local commuting by road greatly exceeds that by rail, even in the major conurbations; indeed within Britain, Bristol has one of the lowest rail-based commuting proportions (claimed by David Redgwell, Transport 2000, to be under 1%) for a city of its size. (This proportion might increase when the LRT scheme for Bristol is built.) Nevertheless, despite well-publicised difficulties over punctuality, rail passenger journeys are increasing, especially in Somerset/Avon/Gloucester — up 12.89% from 2000/1 to 2001/2 — and in Cornwall — an annual growth of 6.34% for the same period. The Exeter–Waterloo line has shown an overall growth in passenger journeys of 49% from 1994/5 to 2001/2.

The environmental effects of transport are explored in the Commission of the European Commission's White Paper *European Transport Policy for 2010: Time to decide*. This major policy consultation document is intended to provide the basis for a sustainable transport system and it counsels a significant shift in the balance of transport from road and internal European air flights towards rail, shipping and intermodal transport. A key driver therefore for the direction of future national transport policy may be this recent White Paper on transport policy, and this may then cascade into the regional transport strategy.

The context for the South West region is Regional Planning Guidance for the South West (RPG 10), which sets out the Regional Transport Strategy (RTS) for which the Southwest Regional Assembly has statutory responsibility. The RTS has 5 key objectives and provides ten transport policy guidelines, including reducing the need for travel (TRAN 1), and the maintenance of strategic Inter-urban and Inter-regional transport networks (TRAN 2).

The RTS derives largely from PPG 13 (Transport) and is soon to be revised. Its updates will be influenced by possible revisions to the Government's 10-year Transport Plan, which has been criticised recently by the House of Commons Transport Select Committee; future revisions to the Strategic Rail Authority's (SRA) 10-Year Plan, which presently offers very little for the south west region; the reports from various multi-modal studies; and the development of a South West regional public transport strategy.

Within the region the recommendations of the SWARMMS (London to South Wales and South West Area Multi-Modal Study) study of May 2002 — and indeed the TVMMS (Thames Valley Multi-Modal Study; continuing), which may suggest ways of unlocking capacity improvements for the west and south west — may be particularly influential, provided the South West Regional Assembly can then take the recommendations forward and lobby Central Government for public transport improvements. A possible forum for helping to identify priorities for the region may be the South West Public Transport Users' Forum (SWPTUF), which was established recently by the South West Regional Assembly.

Key Issues

Awareness

- Much of the transport sector in the South West has not yet significantly responded to the issue of climate change.

- In transport within the region, other issues have recently dominated the agenda, particularly how to develop the policy response to the various multi-modal studies being conducted (e.g., SWARMMS, which reported in May 2002).
- Climate change has nevertheless been invoked by the Strategic Rail Authority as one among several reasons for *not* extending electrification of the rail network to the West Country (see quote from SRA Chair).
- There is little evidence of awareness amongst transport operatives of the Commission for the European Union's White Paper on transport policy (except in so far as it directly impacts on their business).
- There is recognition in the European White Paper of relationships between transport use, emissions and climate change, and the need for mitigation, but there seems to be limited awareness in the industry of possible adaptation responses.
- Hence, climate change is not explicitly taken into account in the transport sector in terms of adaptation (other than perhaps in terms of dealing with the effects of flooding). There is some attempt to address mitigation through the reduction of carbon emissions.

Vulnerability

- Parts of the transport infrastructure of the south west are particularly vulnerable to flooding.
- Several towns and major cities within the region are susceptible to periodic flooding, the frequency of which could increase if winter precipitation levels and intensities increase, which would cause major disruption, especially to road-based transport within these towns and cities.
- During Autumn 2000, the South West peninsula was effectively cut off from the national rail network for several weeks by flooding at Cowley Bridge (River Exe), near Exeter, which washed away track embankment, and at Honiton tunnel. Recurrent severe flooding may sever the link in the future.
- For several winter months, the Tarka line (Exeter to Barnstaple) has been out of use, owing to flooding and consequent flood damage. The main (and only) rail line to west Devon and Cornwall is vulnerable to storm surges, high tides and to cliff instability near Dawlish. Main rail lines to and from the Midlands and the London-South Wales line (and diversionary route) have been disrupted by flooding especially in tunnels at Chipping Sodbury, Wickwar and Sapperton.

> **I am not convinced about the business case for electrification [of the Great Western main rail line] … [and] the environmental case is not as persuasive as it used to be, especially when you take into account power station emissions and then there's the climate change issue and the fact that electrification is susceptible to poor weather.**
>
> **I think the case for electrification has significantly weakened over the last few years.**
>
> Chairman, Strategic Rail Authority, quoted in RAIL, 438, June/July 2002.

Implications

- Climate scenarios indicate increased opportunities for travel to the south west (especially in summer), but the major transport mode currently is by road, primarily the private car. Motorway congestion in summer could be worse if tourism to the South West increases as a response to warmer summers.
- The rail network is underdeveloped and is vulnerable, especially to flooding, and there are no rail diversionary routes from the Midlands to the south west, or from Exeter to west Devon and Cornwall.
- The conflict between satisfying demand for travel and meeting carbon-reduction targets gives rise to considerable issues relating to traffic management, demand management, etc.

Adaptation responses

- Where transport planning does engage with the issue of climate change it seems to be concentrating more on mitigation (carbon reduction) topics, especially urban cycleways; and on safety issues such as traffic calming; rather than adaptation responses.
- Adaptation response to the threatened railway at Dawlish could be to build a new rail link inland, or to extend the Dartmoor railway from Meldon, via Okehampton and Tavistock, to Bere Alston and Plymouth, to provide an alternative and diversionary route.

Issues of particular regional relevance

Several towns in the region (e.g. Lynmouth; Bruton) have suffered from occasional flash

flooding, with road links temporarily severed. The A38 is particularly vulnerable to flooding at Tewkesbury and in the northern approaches to Gloucester. Climate change scenarios suggest road flooding could become more frequent in such areas.

The main (and only) railway to West Devon and Cornwall runs along the coast through Dawlish and is vulnerable to high tide spray, undercutting (recently combated by a major programme of concrete reinforcement commissioned by Railtrack), and cliff instability on the landward side, producing a recurrent risk of landslips occasioned by intense or prolonged rain. This rail link is increasingly vulnerable under climate scenarios of more intense precipitation, severe storms and higher sea levels. It is particularly vulnerable at times of high tides; indeed, in October 2002 new 'Voyager' services were suspended during 'exceptional' high tides, which in scenarios of higher sea level will tend towards the norm rather than the exception.

Climate warming might attract even more long-term residents to the South West. The region might also be perceived as an even more attractive area for retirement. These demographic changes will have impacts on transport needs.

Even amongst professionals, the notions of 'sustainability' and of 'climate-change mitigation' can be misrepresented. The recommendations of the SWARMMS study have been couched in terms of sustainability; its proposals reflect the major role that transport provision can play in this. However, the consequences of some of its recommendations may produce precisely the opposite effect from that intended.

For example, the South West Regional Assembly noted that SWARMMS, in recommending development of a second strategic road route to the south west, argued: "The A303 route through the Blackdown Hills is shorter [than the M5] and will minimise the use of fuel and production of greenhouse gases". The argument being that a shorter road route with free-flowing traffic, uses less fuel than a longer route that is congested at peak times.

However, this argument is of course spurious, as creation of an improved road link will result *overall* in increased traffic flows along both routes, which generate more greenhouse gas production! A 'do nothing' option would not relieve road congestion, and so would not improve fuel use. Significantly it would also deter any markedly increased road use, especially at peak periods (due to driver perception of congestion and increased journey times), and so would actually *save* on what would be increased greenhouse gas production (if the A303 be dualled) from increased volumes of road traffic.

"Despite increasing concerns on climate change, there's a lack of awareness on how the weather can affect business on a fundamental level… The transport sector is burying its head in the sand more than most — it's the least likely to agree that the British climate affects business revenues — and 96% think they spend enough accounting for the weather"

Stephen Lawrenson, Met Office Commercial Division Managing Director, quoted in Railway Strategies, Spring 2002.

As a transport authority, it is interesting to note that, in line with government policy, we are actively encouraging the use of sustainable modes of transport in order to meet, among other things, the target of reducing the production of greenhouse gases.
Some of the climate changes such as warmer, drier summers will aid this aim and encourage more use of sustainable modes, whilst other changes, e.g. increased rainfall and flooding, will discourage such action.

Transport Authority

Notable risks

- Specific locations along the transport infrastructure of the region are vulnerable to flooding; flooding is more disruptive to rail than road, owing to absence of adequate diversionary routes in the region.
- Weather extremes produce transport disruption (e.g., severe winds affect the two major road bridges over the Severn and closure to high-sided vehicles; trees brought down on rail lines).
- Repeated severance of only rail artery to the South West which could be caused by flooding (e.g. Cowley Bridge) or coastal erosion (Dawlish) or by conditions of higher tides; flooding of tunnels on main Midlands-Bristol rail route and London–South Wales lines.

Notable Opportunities

- Create strategic rail *diversionary* routes to combat flood/storm/other disruption, notably by dualling of Exeter–Salisbury route to the south west; dualling of Swindon–Kemble (to create a diversionary route via Gloucester to South Wales when tunnels flooded/closed on main Swindon to South Wales line); re-opening the Cheltenham–Honeybourne–Stratford line (as an alternative route from the South West to Birmingham).
- Potential to use climate change as a tool to help develop integrated transport and discourage people from needing to travel; this will help promote the sustainability agenda. Working from home could become a more feasible and accepted alternative to the travel-to-work lifestyle.
- Opportunity to encourage workplace Green travel plans, as way both of educating the public to curb increase in car use and to help achieve sustainability agenda of European White paper on transport.
- Gives greater reason to re-define the Cost-Benefit analysis of rail v. road to take greater account of (a) carbon emissions from transport; (b) the costs of not just the direct deaths (comparing road and rail accident rates) but also the indirect deaths (through respiratory ailments, caused largely by road traffic pollution); (c) the period over which capital costs can be recovered, as rail infrastructure is more expensive than road but has a longer life-span; (d) other environmental costs of transport.

The Way Forward

Within the transport sector, and perhaps more so than in any other sector other than energy supply, decisions made about developing mitigation responses to climate change also feature as adaptation responses (in terms of developing long-term sustainable transport systems).

It is not so easy therefore to separate mitigation responses from those concerned with adaptation. For example, modal shift might be built into planning as a direct result of the multi-modal studies. ARRB Transport Research has suggested this: "A very positive direction is to investigate the concept of a higher density development with better land-use mixes around railway nodes and along railway corridors" (Luk *et al*., 1998, p.1). This for example could be incorporated in the development of Clyst Hayes and development at nodes between Exeter and Salisbury, with investment in Salisbury–Exeter rail, rather than in upgrading the road capacity.

For modal shift to be encouraged on other transport corridors in the south west region, it would seem that multi-modal studies need to be given different frames of reference and working models (unlike, for example, the Bristol/Bath to South Coast Multi-Modal (*sic*) Study, which is largely road-based).

Local initiatives in rural areas, to improve Public Transport and to help encourage its use compared with the private car, may be funded through Rural Transport partnerships – a new scheme funded by the Countryside Agency.

The development of integrated transport is in its infancy in the South West, but some pilot schemes — such as the PlusBus scheme at Truro, the 'bus branchline' concept in Cornwall, integrated transport in the Fal Estuary, and bus-rail links in Gloucestershire — show the potential for these. Workplace Green Travel plans are becoming more widespread.

Currently, rail freight in the region is overwhelmingly dominated by transport of fossil fuels (with a large number of coal trains carrying imported coal from Portbury Docks). This raises the question as to whether this is a sustainable basis for the rail freight network in the longer term. Diversification, and expansion of other rail-freight activity, including wagon-loads, the use of freight multiple units, intermodal facilities and the provision of dedicated freight sidings and freight distribution yards may be more appropriate in the longer term.

One example is the site plan for development of a 25-hectare site near Swindon alongside the Honda car manufacturing plant, which includes provision for an intermodal terminal and rail-linked warehousing. Another is Cabot Park, a distribution park that has provision for rail-linked warehousing and an intermodal terminal, close to Bristol Port.

Sustainability issues

There seems to be a disjunction between the worthy 'sustainability' aspirations of the European White paper and of LTPs and the continuing national and regional increase in car ownership and car use. The abandonment of the Fuel Cost Escalator in the UK in response to fuel-price protests means that models of future motoring traffic growth (including road freight) may underestimate the growth in road use.

If environmental sustainability is to be achieved there is an even greater case (as argued by SUSTRANS and Transport 2000) for making cycling more possible and rail an affordable alternative to the private car in the south west. Education of the general public will be required, but this raises questions as to the ethics of social engineering on a large scale.

Knowledge levels

In a recent study conducted by the Meteorological Office, 20% of transport bosses said they do not take the weather into account, but feel that they should. The transport sector was the most likely of those questioned to fail to meet deadlines owing to weather-related problems.

Nevertheless, a recent (2000) appointment to Railtrack (Great Western Zone) has been made whose responsibility is (i) to analyse impacts of weather and climate on performance so causes are better understood and can either be mitigated or better predicted; (ii) brief the control centre on use of weather information and produce seasonal preparedness documents for winter, summer and autumn; (iii) attend a national weather group (with representatives from all zones) and feed back best practice on weather related issues to GW zone; (iv) provide advice on potential impacts of climate change for Railtrack staff at HQ in London and within GW zone.

Railtrack (successor: Network Rail) has recently set up a climate strategy group with an initial remit to look at the next 10 years. However, there is no group looking beyond this period (yet), none dealing with climate change in the train operating companies, nor in regional road-freight hauliers.

In this context it is not surprising that climate change issues do not yet figure highly amongst senior professionals in the transport industry. It does feature, however, as a driver for change in the European Union White paper, in LTPs etc., and in campaigning organizations such as SUSTRANS and Transport 2000.

The transport policy direction shown in the European White paper contrasts with continuing development of domestic air services to and from the region, which are (per passenger) very wasteful in terms of fuel, not a feature of 'green' transport and sit very uneasily with notions of 'sustainable development'.

Surface vehicles are a greater problem than aircraft in terms of pollution and thus climate change impact. [This ignores the *per capita* production of CO_2 from aircraft]

From a contributor in the air industry

The Highways Agency is aware of issues concerning increased frequency of intense rainfall events and of the need to develop the capability of the carriageway to cope with excess water. Within the South West region, the vulnerability of main rail lines to closure from flood or storm damage emphasises the need for adaptation responses; these should include the urgent development of alternative/diversionary rail routes, so as to ensure operational flexibility. This will facilitate modal shift from road to rail, as a main deterrent to rail travel and rail freight use is a perceived unreliability of services.

Within Great Western zone, some projects have taken climate change into account at the design stage so that schemes that will be around for decades in the future can be expected to withstand the changing weather patterns. One such example of this is Chipping Sodbury tunnel. This floods maybe once or twice during a typical winter. At present a scheme is being designed to pump the water to holding fields before being discharged to rivers when the levels have fallen. The rainfall amounts used in the design for the pumping capacity and other aspects took account of climate change.

Railtrack (Great Western Zone)

Awareness of climate change is subliminal in the transport sector. Few operators and fewer strategists have engaged with the issue. The transport sector is a major contributor to carbon dioxide emissions, and so is particularly relevant for mitigation measures. For example, highlighted in the SWARMMS study is the need to develop the rail infrastructure of the South West region (framed in the context of sustainable development), and there is also a need to eliminate rail bottlenecks to ensure that modal shift from road to rail is possible so that national rail passenger and freight growth

targets can be achieved (there are no agreed *regional* targets).

At present, the Strategic Rail Authority (SRA) seems unaware of potential adaptation responses to the climate change issue (except to see climate change as an excuse *not* to invest in electrification of the Great Western Main Line) and has not so far been able to capitalise on rail's 'greener' image in transport in the South West. Perhaps adaptation to climate change could form part of the 'business case' for developing the rail network in the South West, whereas the assumed axiomatic 'business case' for road investment should be counterbalanced by the environmental costs of increased carbon emissions that increased road capacity would produce.

There is clearly a need to consider predicted climate change when making long-term decisions about the provision and upgrading of transport infrastructure, vehicles and rolling stock. Ways to take this forward are suggested in a recent report by Wilson & Burtwell (2002).

The really serious changes for society rest with the NEED TO TRAVEL for work and recreation, BUT this moves quickly into the realms of social re-engineering and qualities of life arguments and exclusion for some sections of society. … research could extend to examine the impacts on climate to be derived from having a significant part of the population working from home.

Source unknown

Potential barriers

There is a dearth of finance available and at present a lack of political will to develop the rail network within the region significantly. Rail schemes have to pass stringent economic tests to show a return on investment, and the Strategic Rail Authority has in each instance to make out a strong "business case", which at present does not include taking account of climate change issues (except in a negative sense).

This contrasts with the effectiveness of the Highways Agency in finding access to finance for road schemes, the strength of the road user organisations, and in the assumed (almost axiomatic) business benefits that would flow from bypasses and other new road schemes. In the current Strategic Rail Authority 10-year plan, for example, there is no money to deliver the rail recommendations made in the SWARMMS study.

Significant numbers of the general public remain to be persuaded or are still unaware of the climate change issue and the role that transport can play in helping to mitigate or to adapt to anticipated changes.

As regards congestion charging and workplace levy charging in urban areas, there is little sign of many of these being introduced as yet. This is because the general feeling in local authorities is that the public remain hostile, and that public transport improvements need to come first, before the charges can be introduced; so any planning that assumes the money from charges will fund the *start* of public transport improvements is flawed.

There is an opportunity here to learn from the light rail (or combined light/heavy) schemes that have delivered passenger growth (e.g. Manchester and Tyne & Wear) and to analyse reasons for success, so that best practice can be introduced within the region (e.g. in Bristol).

Challenges and Opportunities of Key Climate Impacts in Transport Domain

Climate Impact		Challenges and Opportunities
Summer Temperature Increased	C	More visitors to the South West, so potentially increased road congestion and lack of rail capacity.
	C	Increased pollution from increased road traffic (leading to increased incidence of asthma and other respiratory problems, and so devaluing quality of life – one of the region's greatest assets).
	C	Rail expansion and danger of rail buckling, resulting in imposition of Temporary Speed Restrictions.
	O	Encourage use of sustainable transport – bus, rail, walking and cycling to alleviate congestion on roads and protect the environment.
	O	More opportunities to encourage tourism related to outdoor activities e.g. walking and cycling, public transport and circular walks, etc.
	O	Potential for publicity working with public transport operators, countryside access and tourism board.
	O	Opportunity to re-link Newquay to St Austell by rail, to provide direct regional rail link and so facilitate more tourism by rail within Cornwall, rather than by private car (Currently only 17% of rail traffic on Newquay line is local; information: Wessex Trains).
Winter Temperature Increased	C	Extension of tourist season in South West, especially to surfing resorts such as Newquay, increasing the period of congestion in the region.
	O	Less frost damage to roads from winter cold, so potentially less frequent need for road repairs.
	O	Fewer points failures on rail lines.
	O	Reduced frequency of use of rock salt for de-icing on roads, so savings from County budgets on salting works.
	O	Fewer ice/snow related road traffic accidents.
	O	Increased probability of meeting road accident reduction targets.
Flooding Increased	C	Flood risk to major roads in and between major cities, including Gloucester (A38); and in major towns including Tewkesbury.
	C	Flash-flood risk in Devon and Cornwall from high-intensity storms, disrupting travel.
	C	On roads, more surface water overload.
	C	Delays to public transport schedules and freight movements, owing to route flooding, bridge scour/damage.
	C	Perceived high risk of mainline rail connection to region being severed by flooding.
	C	Major issues of flooding at a number of vulnerable points on the rail network, including Cowley Bridge (R. Exe); the Tarka (Barnstaple) line; Sapperton and Chipping Sodbury tunnels; and just to the north of the south west region (disrupting the mainline between Cheltenham and Birmingham).
	O	For rail, opportunity to develop strategic alternative routes (e.g. dual the Salisbury-Exeter rail line; dual Swindon–Kemble; create new line Exeter to Plymouth, via Okehampton–Tavistock; reopen Honeybourne route Cheltenham–Birmingham) to provide robustness of communications when other lines are flooded and/or tunnels closed.
Summer Rainfall Reduced	C	Subsidence to roads (and rail), especially in clay areas.
	O	Risk of subsidence provides an opportunity to justify substantial embankment strengthening and capacity improvements, facilitating general benefit to rail services.

Climate Impact		Challenges and Opportunities
Winter Rainfall Increased	C	Fewer opportunities to encourage walking and cycling, thus encouraging more cars onto the roads
	C	Failure to meet targets for these sustainable modes of transport.
	C	Traffic moving to and between towns and cities vulnerable to floods.
	C	Major challenge to keep Tarka (Barnstaple) rail line open.
	O	Provide better bus shelters and rail-platform canopies.
	O	Lobby rail industry (Strategic Rail Authority; Train Operating Companies) and central government to ensure good rail links are maintained, and alternative rail routes are developed.
	O	Increase in air travel over rail travel to Devon and Cornwall, if improvements to airport capacity provided [Note: this in conflict with need to reduce greenhouse emissions, and against recommendations of European White paper]
Increased Sea Levels and Tides	C	Vulnerability of sole rail route to south-west peninsula at Dawlish at times of high tide; vulnerability exacerbated by rising sea-levels or storm surges; high tides exacerbate drainage problems further inland (e.g. north of Exeter)
	O	Construct alternative rail route Exeter-Plymouth, to ensure peninsula is not cut off from the rest of the national network, as happened in Autumn/Winter 2000-2001, and to encourage modal shift, road to rail.
	O	Flood risk reinforces the case to redouble whole of rail line Salisbury to Exeter, to provide alternative and diversionary route.
Longer Growing Season and Reduced Frosts	C	Encroachment of vegetation obscuring road signs, requiring more frequent maintenance and therefore increased costs.
	C	Increased weed growth on rail tracks requiring extra maintenance.
	C	Footpaths overgrown requiring increased maintenance or limiting use.
	O	Potential to increase the number of walking and cycling friendly routes.
	O	Walking and cycling become more attractive for commuters, every day activities, and tourism.
Potentially Increased Winds and Storms	C	More trees falling onto road and rail network, so higher budget and more operatives required to maintain and clear network.
	C	Increased risks to transport infrastructure.
	C	Less opportunity for helicopter and fixed wing planes to fly to the Isles of Scilly, so difficulty in keeping air link to Scillies open.
	C	Rail electrification may not be viable owing to increased risk of storm damage.
	C	Train operating companies required to run replacement bus services on already overcrowded roads if no alternative rail route is developed.
	O	Opportunity to encourage the construction of alternative and diversionary rail routes to and from South West.

UTILITIES DOMAIN

Scope

The provision and maintenance of utility supplies including considerations of supply and demand of energy (electricity, gas, oil, coal) and telecom services.

See Also

Water resources, Built environment, ICT.

Background

The south west, like the rest of the UK, is heavily dependant on fossil fuel for electricity, transport and heating needs. In 2001 the energy generation within the South West was estimated to be in the region of 3,950 MW, largely from nuclear power stations that are nearing the end of their lifespan. There is a new gas fired power station due to come on line by 2010.

There is a growing awareness in the region for a need to develop renewable energy resources, and in fact the region hosts the UK's first commercial wind farm, in North Cornwall. Cornwall in particular has been proactive in the field of renewables and produces over the national average for renewable energy, largely through wind power. The recent renewable energy audit for the south west suggests that the region can do much more in this area, and sets out ambitious targets for the next few decades.

Solid fuel and some gas supplies are transported through the region by road and rail. Large quantities are also imported through the region's ports. Considerations affecting these are dealt with under other sectors as being primarily concerns of transport and the marine sector.

The far south-western parts of the region rely heavily on electricity carried through an extensive cable network which bottlenecks at certain strategic points, such as Indian Queens in mid Cornwall.

Key Issues

- Space heating requirements will be reduced, but summer energy loads increased due to a greater demand for cooling (air conditioning).
- Increased use of renewable energy (RE) is possible, although changes in future wind, wave and solar conditions will influence planning considerations.
- Storm events may increasingly affect storm drainage and sewers, which are already highly susceptible to flooding, thus impacting on underground cables, pipes etc. for electricity, telecommunications and other utilities.
- Changing rainfall patterns may influence hydroelectric power output.
- Rising sea levels may increase the number of underground cable faults.
- Increased development of resource use efficiency measures is likely.
- Increased tourism and a growing population may increase pressure on supplies and require expansion of infrastructure.
- Existing infrastructure may be at increasing risk from storm events, sea level rise and coastal erosion.

Specific Climate Issues

The periferality of much of the extreme South West will make disruption to supply that much more time consuming to remedy. At the same time, many of the organisations involved with utilities provision are not based in those areas likely to be first affected by climate change, and are so not perhaps as "switched on" as might otherwise be the case.

Particular risks

- Damage to cabling both underground (flooding, subsidence) and above ground (flooding, extreme weather events).
- Reduction in heating demand may reduce markets in some instances.
- Large scale loss of power to the region through damage "upstream" of the region, caused by extreme events. In particular for the far south-western parts of the peninsular.

The Way Forward

There currently seems to be little real concern in these sectors, which will have to be addressed before progress can be made. That being accepted, there are a number of potential drivers that could bring the debate and eventually action, forward in the region.

- Energy – Government targets and financial incentives will encourage, or otherwise, the development of the renewables industry.
- Demand for affordable private air conditioning units will drive the market for this technology.

- Public pressure for continuity of supply both in energy and telecommunications will be a major factor in how these industries respond to the potential threats due to climate change.

Particular opportunities for the region

- Development of community renewable energy schemes connected to locally operated and connected grids would allow a sustainable use of power while protecting the region from disruption caused by situations occurring outside the region itself.
- Development of a market for air conditioning.
- Development of new equipment better able to withstand the predicted conditions.

Knowledge base

There appears to be very little involvement within the South West energy and telecommunications sectors as to the impacts and opportunities of climate change. This would suggest that there is a considerable need for an increase in information for this sector.

The CCIRG publication "*Review of the Potential Effects of Climate Change in the United Kingdom*" (1996) states that little research into physical impacts of climate change on the UK energy sector had been conducted at that time, and that furthermore there was little point in conducting such research until better, more regional projections of climate change became available. With the publication of the UKCIP02 scenarios, this might now become a more viable proposition. A study of the impacts of climate change on the electricity supply industry, funded by EPSRC (working with UKCIP) is due to begin in Spring 2003.

Challenges and Opportunities of Key Climate Impacts in Utilities Domain

Climate Impact		Challenges and Opportunities
Increased Summer Temperature	C	Capabilities of equipment used to transport electricity generally reduce with increased temperature. May need to invest in network improvements.
	C	Traditionally increased temperature relates to a reduction in electricity demand, which may be broken by increased use of air conditioning. This might require maintenance programmes to be rescheduled to cope with shifting demand/system capacity relationships.
	C	Cooling water in power stations less effective due to increased temperature.
	O	Potential for development of air conditioning business.
Reduced Summer Rainfall	C	Subsidence effects could damage underground cabling, pipe networks etc. (Not believed by TRANSCO to be a threat to gas infrastructure).
	C	Reduced water supply available for cooling water in power stations.
	O	Reduced rainfall may allow for easier and swifter summer maintenance work.
Increased Winter	C	Potential problem to power companies arising from increased demand for heating and therefore reduced sales..
Temperature	O	Reduced winter demand for electricity may reduce the need for investment in increased network capacity.
Increased Winter Rainfall	C	Access to land for fault repair may be impeded and maintenance programmes more difficult to carry out. There may be a need for increased 4-wheel drive/tracked vehicle capacity for access on soft ground.
Increased Sea Level and Tides	C	Coastal power stations and distribution network could be at risk from both sea level rise and increased tidal heights.
	C	Rising sea levels would increase the length of cabling under water and could increase the number of underground cable problems.
Longer Growing Seasons and	C	More tree trimming might be required to maintain clearance for overhead lines if tree growth starts earlier and continues for longer.
Reduced Frosts	O	Possible less risk of frost damage to underground infrastructure. (Limited due to frost precautions already taken.)
Flooding Increased	C	Electricity supply services have the capacity to be affected by river flooding, standing water and slope flooding and by drainage system overload.
	C	Substations may need isolating during extreme flood events. Extra attention is already applied to substation design if placed in a flooding prone area.
	C	Public may be at risk from overhead power lines if using boats on flooded land.
Potentially Increased Winds	C	Windborne debris can damage overhead equipment and cause power interruptions.
and Storms	C	Wind speeds over 100mph can cause direct damage to overhead equipment.
	C	Increased frequency of damage will require more frequent maintenance.
	C	Increased storm intensity may ultimately require a revision to equipment standards.