



TAYplan: Strategic Land Use Change 2035-2050

Phase 1 Report

Universities of Dundee, Abertay and St Andrews

January 2013

Authors

Illsley, B., Duffy, A., Rowan, J., Blackwood, D., Bebbington, J., Horner, M., Falconer, R., Gilmour, D., and Isaacs, J.



Project Funders

TAYplan Strategic Development Plan Authority
Architecture + Design Scotland
Forestry Commission Scotland
Scottish Natural Heritage
Scottish Environment Protection Agency
Tactran Tayside and Central Scotland Transport Partnership



Contents

	Page No
Executive Summary	4
Chapter 1: Introduction	6
Chapter 2: Methodology	8
Chapter 3: Review Findings	11
Chapter 4: Conclusion	29
Annex 1: References	32
e-Annex: Document Summaries	Separate file

Context and purpose

TAYplan, the first strategic development plan for the region covering Dundee, Perth and Kinross, Angus and North Fife, was approved by Scottish Government in June 2012. TAYplan Strategic Development Plan Authority and its partners commissioned this study to consider what key societal, economic and climatic changes may occur over the next twenty to forty years, how this could change the way people lead their lives and what are the strategic implications for land use in the TAYplan area in order to inform future thinking. This report presents the results of Phase 1 of the work.

Methodology

Phase 1 consists of a scoping exercise of existing research relating to twenty one drivers of change identified in the study brief. Material identified by the key stakeholders and the research team came from academic, governmental and private sector sources. Given the time and resource constraints of the study, the exercise sought to be comprehensive although not exhaustive and as a result a total of 122 relevant documents were reviewed in detail covering all of the specified drivers of change.

Review findings

The findings are organised around eight broad challenges which are likely to influence the form and function of the TAYplan region over the next twenty to forty years as identified from the research. These are:

- Managing resource use efficiently
- Moving to low carbon, efficient energy supplies
- Changing economy
- Increasing use of ICT and impact on delivery and use of public services
- Increasing significance of place
- Changing demographics and health
- Infrastructure and transport
- Responding to climate change.

For each challenge a number of issues arising from the analysis are identified and these are reported in detail in Chapter 3: Review Findings.

Conclusion

The exercise reveals that a significant quantity of relevant research relating to the future challenges facing TAYplan has been carried out to date. The main research gaps identified fall into four categories:

- Scaling gap: there is considerable wider research (national and international) but the implications or significance for the Tayplan region has not been studied;

- Integration gap: interesting and relevant research relating to the TAYplan area exists but the majority of these studies are subject or agency specific;
- Process gap: a number of the studies were concerned with new or evolving methods, approaches and processes (assessment tools, scenario planning, transition etc) which could be applied to TAYplan;
- Timescale gap: much of the work deals with the short or medium term with relatively few longer term studies considering the implications of change for land use.

This report provides the foundation for Phase 2 of the study which aims to prioritise and develop a number of specific research questions for future study in collaboration with the project funders and other TAYplan stakeholders.

Purpose of the study

This study was commissioned by TAYplan Strategic Development Authority and partners in order to help inform policy formulation for the next Strategic Development Plan for the TAYplan area. Its main aim is to examine existing research, identify gaps and recommend future research areas related to long-term societal, environmental and economic change drivers i.e. how people will lead their lives and the strategic implications for land use in the TAYplan area. As well as contributing to the strategic development planning process, the results may also help inform wider public policy through Tayplan's partnership with other public sector organisations.

The study is organised in two parts with specific objectives for each phase as follows:

Phase 1

- a. To identify and review current, research relevant to the TAYplan area being undertaken by TAYplan's four Authorities and thirteen Key Stakeholders and identify gaps in the knowledge of issues facing the region;
- b. To identify and review wider academic research which could inform the project.
- c. To prepare a Phase 1 report

Phase 2

- d. Drawing on the results of Phase 1, to identify specific areas for new research to inform policy makers in the preparation of future strategic development plans, including the role of scenario planning.
- e. To promote discussion about the proposed research agenda amongst partners and stakeholders in order to agree priorities;
- f. To identify potential funding sources for the future research.

This report documents the outcomes from Phase 1 of the work.

Context – Strategic Development Planning

TAYplan, one of Scotland's four strategic development planning authorities, is charged with the task of preparing a strategic development plan for the region covering Dundee, Perth and Kinross, Angus and North Fife. This relatively new form of strategic planning was established under the Planning etc Scotland Act, 2006. The first plan was approved by Scottish Ministers in June 2012 and sets out a vision and development framework for the period 2012 to 2032 with policies designed to promote sustainable economic growth, create better quality places, reduce resource consumption, support local communities and ensure climate change readiness. The plan's vision is:

“By 2032 the TAYplan region will be sustainable, more attractive, competitive and vibrant without creating an unacceptable burden on our planet. The quality of life

will make it a place of first choice where most people choose to live, work, study and visit, and where businesses choose to invest and create jobs”.

According to the Scottish Government, strategic development plans should be visionary, succinct, place-based, proportionate and focussed on the big ideas for change. The primary focus of such plans should be on land and infrastructure but to be successful in moving towards their visions and shaping quality places of the future, more contextual and layered approaches are needed which go beyond physical matters and combine strategies for the built and natural environment with wider social, economic and environmental considerations.

An important part of the new approach to plan making is its integrative nature. Strategic development planning involves a range of public and private stakeholders including designated key agencies with a responsibility to co-operate under planning legislation. These agencies are particularly important in helping to improve co-ordination both vertically and strategically. Taking a strategic approach to planning means being selective and focussing on priority issues. Plan-making must be based on a thorough understanding of the needs, opportunities and constraints of the locality and as a result it is important to study external trends and forces and gather relevant evidence of change. In looking to the future, there can be a tendency to extrapolate existing trends forward but experience shows that this approach can be problematic. It is vital to consider the assumptions underpinning today's activities and try to manage long term uncertainties in order to meet future goals. This is needed to help understanding and build new insights that will inform policy and strategy formulation.

It is against this backdrop that TAYplan Strategic Development Authority has commissioned this study to build a picture of current research which is relevant to the future form and functioning of the region.

Structure of the report

The report is structured in four main parts. The purpose of the study and context is described in Chapter 1. Chapter 2 sets out the methodology used to select and analyse the literature. Chapter 3 analyses the material from the review with respect to eight broad challenges facing the region and Chapter 4 draws conclusions regarding the research gaps identified.

Methodology

The study was conducted by a team of academics from three of the universities located within the TAYplan area; the University of Dundee, University of Abertay, Dundee and the University of St Andrews. Adopting a collaborative approach across institutions has allowed the study to draw on a wide range of expertise from a variety of disciplines.

Phase 1 of the study involved a review of existing research relating to twenty one drivers of change identified in the brief. These drivers were:

- availability and use of **natural resources**
- **land use** change resulting from climatic conditions
- **agriculture** including land availability for crop growth and future crop types
- **forestry** and woodland including the amount and change over time
- **biodiversity** including change over time
- **water resources**
- **energy use** including supply and demand
- **carbon pricing**
- patterns of **economic growth** including green growth and low carbon economy
- state of the **regional economy**
- types of **employment** and service provision
- nature of **technological change** including electronic communications
- **place** quality
- **green space** including how use of this space may change and the quantity
- **population** and demographic changes
- **health** including its relationship with the environment
- **education** including how delivery of education may change
- **infrastructure** and the climate resilience of this
- travel patterns and modes of **transport**
- risk of coastal and river **flooding**
- **lifestyles** including reducing environmental footprint

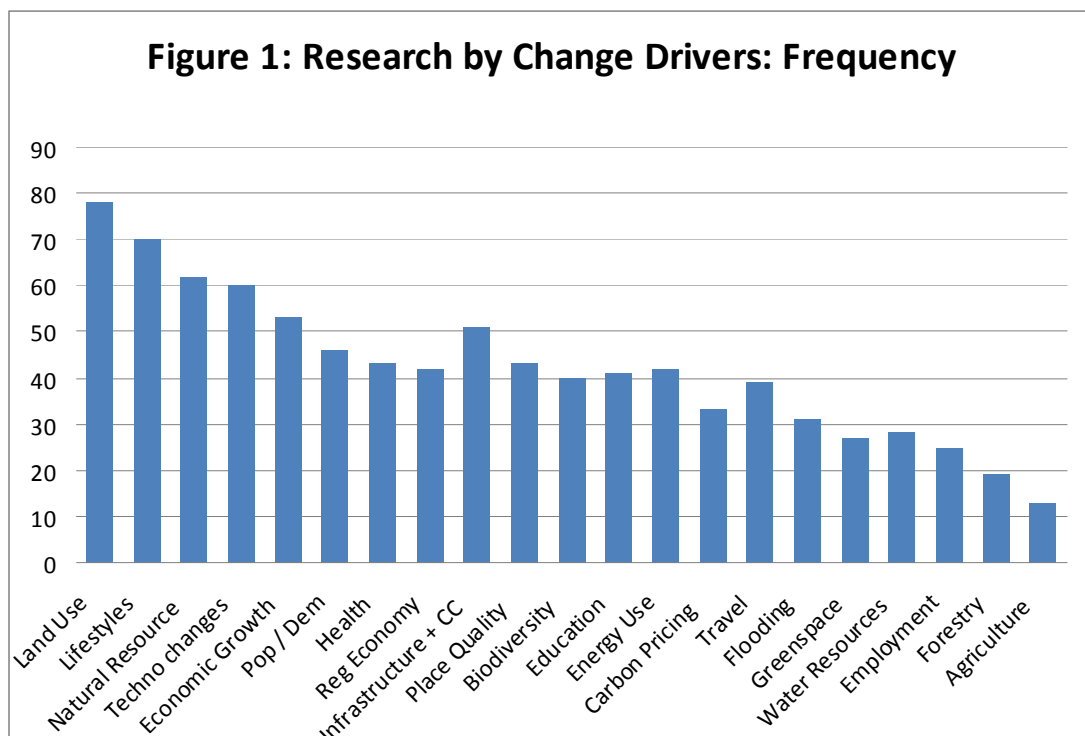
A structured approach to identifying existing research relevant to the drivers of change was agreed with the TAYplan client team. Firstly, the four TAYplan local authorities and thirteen partner agencies were contacted and asked to identify relevant research produced within their organisations as well as other related research in their fields. Follow up interviews were used to clarify and amplify the information provided. Details of more than 70 documents were identified through this process.

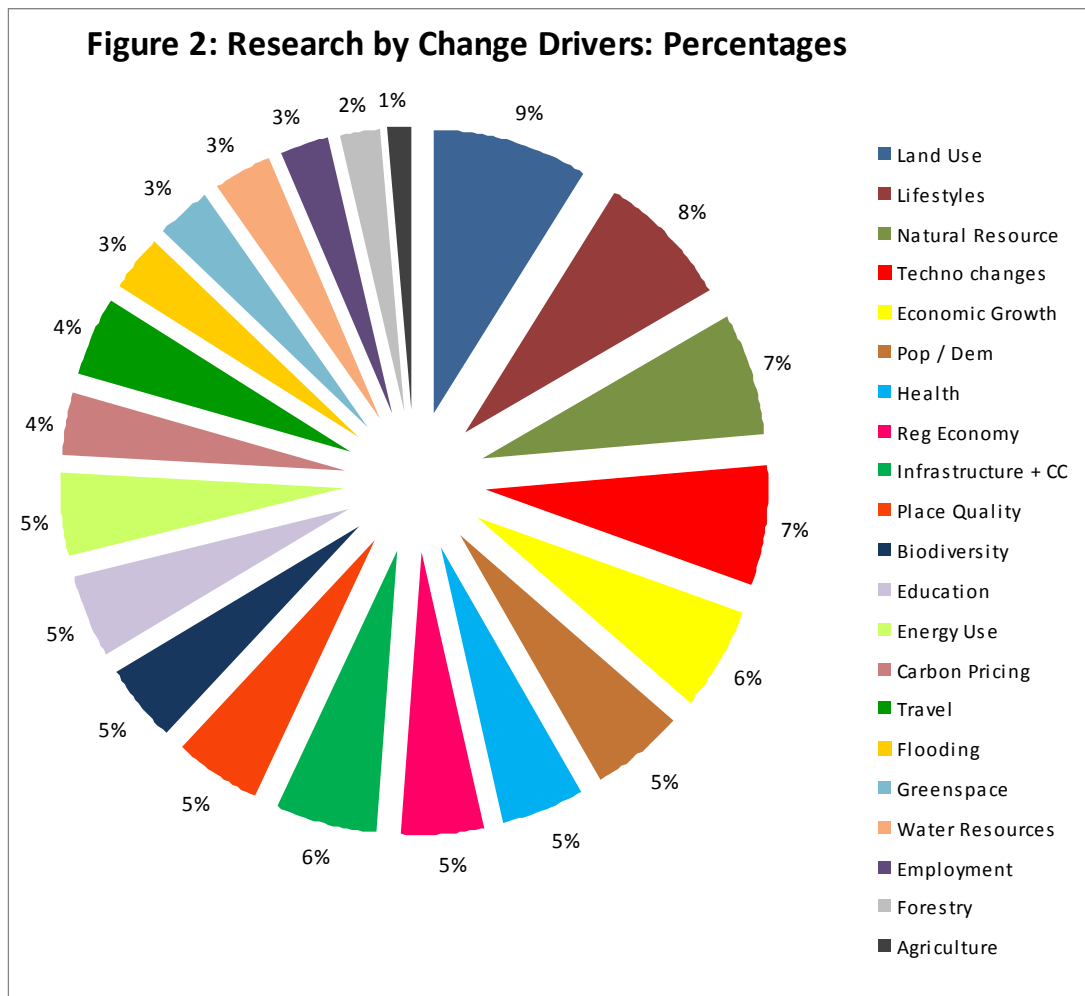
Secondly, wider research (international, government, private sector, and academic) was identified in two main ways; additional research sources were highlighted by 25 academics who attended workshops hosted at each of the participating universities; and this process was complemented by searches of research databases. Together these methods produced a list of over 90 documents.

A two stage sieving process was undertaken to ensure the relevance of the material to the study. Initial information about the documents was reviewed and those documents that were obviously non-strategic in nature, entirely policy based or over five years old were removed from consideration. The remaining documents were read and analysed in detail with summaries prepared using a standard template (summary of research undertaken, key conclusions, areas for further research, potential cross linkages to other research, and relevance). This more detailed review meant that some additional documents could be removed from the subsequent analysis. Where policy and strategy documents were based on recent, relevant research they were retained in the sample.

This process produced a final total of 122 reports. The coverage, which includes key research in respect of the 21 the drivers of change, was agreed with the client as proportionate to the study. While acknowledging that there may be additional research of relevance that has not been considered, a wider review was not possible within the time constraints of the project.

Quantitative analysis was carried out of the content of the selected documents against the 21 drivers for change (Figures 1 and 2) showing coverage by frequency and in percentage terms. The detailed reviews are available in the electronic folder (e-Annex), provided separately on CD for further reference.





The analysis by drivers of change was helpful in ensuring adequate coverage of the issues of concern to TAYplan but the detailed summaries demonstrate that many of the reports are cross-cutting in nature with relevance to multiple drivers as well as the interactions between them. In order to reflect the main thrust of the research more accurately, a new framework was devised for presenting the outcomes of the review focusing on a smaller number of key challenges facing the TAYplan region. These challenges are:

- Managing resource use efficiently
- Moving to low carbon, efficient energy supplies
- Changing economy
- Increasing use of ICT and impact on delivery and use of public services
- Increasing significance of place
- Changing demographics and health
- Infrastructure and transport
- Responding to climate change.

Introduction

The chapter summarises the findings from the review of current research about key societal, economic and climatic trends and their implications for future land use planning. The findings are organised around the eight broad challenges, likely to influence the form and function of the TAYplan region over the next twenty to forty years, which were identified from the research. These eight challenges are inter-connected which means some research could be considered under more than one heading. In these situations, a decision on where to include the work was taken on the basis of its main focus (see e-Annex). Cross-reference is made to the 21 drivers of change by highlighting key terms in bold and in italics.

Managing resource use efficiently

Managing scarce resources efficiently is central to future strategic planning. The approved strategic development plan highlights the need to protect and manage the region's ***natural resources*** including its prime agricultural land, woodland and forestry resources, environmentally sensitive sites (including carbon-rich soils), internationally renowned landscapes, mineral deposits and extensive coastline. Rural businesses contribute to the regional economy, through the generation of employment and income, prime agricultural land can make a contribution to ensuring future food security, and the area's landscapes and natural heritage contribute to a sense of place, identity and wellbeing, as well as providing opportunities for leisure and recreation. (NB. Energy-related resource use and management will be considered as a separate heading).

It is anticipated that pressure on ***land use*** across the UK will continue over the next fifty years as a result of three factors, the rise of the low carbon agenda in response to climate change, a growing and ageing population with more people living alone, and rising expectations associated with growing incomes, such as the demand for more space for living and better ***transport***⁽⁴⁵⁾. The Land Use Futures Report used scenarios to allow an assessment of associated uncertainty and risks and highlighted the importance of adopting a multifunctional approach to land use in order to deliver multiple benefits.

Agriculture and ***forestry*** are the dominant land uses within the TAYplan area and the implications of changing climatic conditions on these activities have been the subject of much recent work. In relation to agriculture, a recent national study examined the influence of seasonal weather and crop variability on crop yields and found that length of sunshine and precipitation are key controls on yields, while temperature was less significant⁽⁶²⁾. It was thus concluded that "a long term trend to drier summers may therefore be good for national crop productivity in Scotland (with the caveat that this may require additional irrigation water)". A second study, suggests that drought risk may pose a threat to land use and agriculture in Scotland, potentially limiting the range of crops that can be grown and reducing land capability in some places⁽⁶³⁾.

Forestry Commission studies have addressed the issue of climate change on forests and the dual role they can play in both mitigating and adaptation. Risks have been categorised as primary, which are those linked to future climate and extreme weather events, and secondary which include biological interaction and ecological responses. While recognising that knowledge gaps still exist, Stokes and Kerr concluded that a number of the risks can be mitigated through the use of Continuous Cover Forestry, an approach to forest management that results in diverse forests⁽¹⁴⁾. Drought is one climate change risk that is expected to impact on the future health of Scotland's forests, as is the number and frequency of disease⁽¹⁵⁾. The role of forests in responding to climate change was explored in a national study in 2009⁽⁹⁾. Using a scenario analysis of woodland creation and management, the authors found that an enhanced woodland creation programme would help promote continued uptake of CO₂ while also delivering a range of co-benefits. Other studies have examined the implications of changes to forestry cover⁽¹²⁾, the limitations of existing analytical frameworks to analyse the relationship between land use and state of the natural environment⁽¹¹⁾ and the potential of forest policy scenarios to inform policy including maximising biomass carbon, giving priority to biodiversity, promoting wood energy and fostering innovation⁽¹⁸⁾.

Despite perceptions of abundant **water resources** in Scotland, there is an uneven distribution when supply and demand are considered. Future climate and land use changes are expected to change these patterns. Brown *et al.* considered the implications for water resources of climate change projections using different land use scenarios with a particular focus on agriculture⁽¹¹⁰⁾. In the absence of infrastructure to enable inter-basin transfers of water, the authors suggest consideration may need to be given to the introduction of new crop varieties which are more drought resistant, adoption of co-ordinated approaches to using and sharing water, and the use of stricter regulation and enforcement of water abstraction. The impacts of climate change may be compounded by other drivers of land use change and the need for further research into the inter-linkages between water demand and land use is identified.

Considerable work has already been undertaken to assess the impacts of such future **land use** change on the natural environment but more sophisticated approaches may be needed to explore the inter-relationships between activities including economic and social mechanisms that move beyond cause and effect models⁽¹¹⁾. The ecosystem services approach is growing in popularity and is supported by Scottish Government in the Land Use Strategy. The UK National Ecosystem Assessment demonstrates the role of natural capital (e.g. **biodiversity**, soil formation) to provide goods and services (e.g. flood regulation, improved water quality) and provides an analysis of the benefits of the natural environment to society and the economy⁽²²⁾. A number of reports focus on differing aspects of biodiversity, such as its importance to nature tourism⁽²⁴⁾, the link to green space networks⁽³⁵⁾ and river basin management planning⁽³⁶⁾. The habitats of the TAYplan region offer a diverse collection of ecosystem services.

Scenario-based approaches are widely used in climate change assessments. Land Use Consultants⁽²³⁾ concluded that although there are measurable effects nationally, the impacts are likely to be most significant in coastal and lowland parts of the country where the majority of the population live. Change is expected to be more gradual in upland areas. McManus reported on trends within the Tentsmuir area concluding that further studies are needed on wind-induced change and its impact on beaches and protected sites⁽²⁰⁾. Similarly, future coastal **flooding** is a related aspect of landscape change and Werritty and Duck stress that the focus of future action needs to be shifted from hard-engineering solutions towards

measures which aim to reduce flood risk and increase individual resilience⁽⁹⁵⁾. While the benefits of adopting Integrated Coastal Zone Management are well recognised nationally and internationally, an EU transnational study is currently underway which aims to support and enable this process⁽¹¹²⁾.

Adopting an ecosystem services approach, Myall *et al.* considered the contribution of geodiversity, defined as “the natural range (diversity) of geological (rocks, minerals, fossils), geomorphological (landform and processes), and soil features. It includes their assemblages, relationships, properties, interpretations and systems”, to ecosystem services and found that it delivered substantial benefits to the Scottish economy, environment and society, although it was not possible to quantify this in monetary terms⁽²¹⁾.

In summary, two key points emerge. Firstly, while many of the studies relating to the management of resources are not specific to the TAYplan area, they provide important insights into possible changes to land use, including agriculture, forestry and landscapes, primarily as a result of changes in climatic conditions. Secondly, the ecosystem services approach is increasingly being used in research as a way of integrating the consideration of social, economic and environmental objectives and the potential to use it at the regional scale needs to be considered. Both climate change and ecosystem-based approaches are strongly associated with scenario-based methodologies.

Topics identified for further investigation:

- Interpretation of national studies into the impact of climate change on rural land use at the TAYplan scale;
- The impact of demographic change and changing lifestyle expectations on land use change;
- The inter-linkages between water demand and land use change;
- The application of an ecosystem services analysis to the TAYplan area.

Moving to low carbon, efficient energy supplies

There is widespread acceptance regarding the major challenge facing societies across the globe linked to energy, namely how to maintain reliable and affordable supplies whilst shifting towards low-carbon, efficient and environmentally friendly sources. Existing trends in energy supply and use are seen as unsustainable. The planning system can play a role in responding to changes in energy supply and use, by establishing frameworks for production, distribution and consumption.

Governments at EU, UK and Scottish levels have set demanding carbon reduction targets for 2020 and beyond and there are a range of studies which look at current and future **energy** needs, different options for delivery and comparative costs of power generation across a range of technologies^(69, 70). Factors such as behaviour and changing **lifestyles, technological change**, fuel choices, **carbon pricing** and possible structural change in the economy were taken into account. Common themes to emerge from the different pathways included the importance of reducing the demand for energy especially where there are barriers to low carbon energy provision, the need for further electrification in relation to **transport**, industry and heating, distributional challenges associated with increasing energy from renewable sources and the continuing potential of fossil fuels. This work was carried out at a UK level although drawing on inputs from across the country including Scotland. It is valuable in

highlighting a range of possible scenarios that could deliver the Government's objectives although it does not present these as policy choices.

A complementary study, commissioned by Scottish Enterprise, considered future trends in affecting the energy industry in Scotland: North Sea oil and gas, including decommissioning which it is anticipated will be serviced from Aberdeen; nuclear energy which is politically unclear but is thought to be unlikely that it will go beyond the replacement of existing power stations, coal including the possibilities of carbon capture, and renewables⁽⁹²⁾. The report concludes that opportunities still exist in Scotland across all fuel sources: the on-going exploration and development of North Sea oil and gas; decommissioning of nuclear power stations; the development of carbon capture and storage; and offshore wind. Opportunities for small scale hydro schemes in Tayside are specifically mentioned. It notes that while the shift to low carbon technologies is part of a global trend, the political dimension is a major factor in shaping future developments.

The commitment to expanding energy from renewable sources, evident at Westminster and Holyrood, has led to research in relation to offshore wind generation, deep geothermal energy, and marine biomass. Offshore wind energy is an important component of the renewable energy mix being pursued in the UK and, according to the Centre for Economics and Business Research Ltd, it offers a range of positive benefits in the medium to long term⁽⁹⁸⁾. The researchers found that, "by harnessing less than a third of that resource, the UK could, by 2050, generate the electricity equivalent of 1bn barrels of oil a year, reduce its CO₂ emissions by 1bn tonnes, and create over 145,000 new jobs". This research appears to reinforce the commitment already made in the TAYplan SDP to support the growth of this form of renewables in Dundee and Montrose. The sensitivity and capacity of seascapes to accommodate offshore wind farms should also be of concern to decision-makers, however. Findings of research by Scott *et al.* suggest that the capacity is generally higher on the east mainland coasts than elsewhere around Scotland with both the East Fife and Tay Estuary coasts assessed as being of medium sensitivity⁽³³⁾. Recommendations included ensuring that visibility issues are covered in future policies, that consideration be given to discrepancies of scale between onshore and offshore windfarms, and that the economic needs of remote communities are balanced with natural heritage protection.

Deep geothermal energy, defined as "natural heat encountered at depths in excess of 300 metres" (p19) can be used either directly or as a source of electricity⁽⁸⁰⁾. While recognised for many decades, exploiting heat primarily from sites of volcanic activity, the fact that geothermal sources can provide constant and low carbon energy has made its exploitation more attractive and has led governments to incentivise its development. The researchers, Younger *et al.* conclude that recent advances in technology, affecting drilling, reservoir simulation and power generation mean that deep geothermal energy is now "a realistic target for full-scale development in the UK". There are believed to be areas of deep geothermal potential in the Grampians, on the edge of the Tayplan area. Development of this form of energy could make a positive contribution to Scotland's renewable sector and Scottish Government has commissioned further research into the policy and planning implications of its development.

Marine biomass, such as seaweed, is regarded as a potentially important source of feedstock for the production of bioenergy through anaerobic digestion⁽¹¹³⁾. However, seaweed salinity has been reported as an impediment to effective digestion. Research being undertaken at the University of Abertay, Dundee, has investigated the factors affecting anaerobic digestion of a seaweed species, highlighting the importance of feedstock salinity. Much more

research is required on the viability of gas production and hence energy production from seaweed.

As well as considering the opportunities for expanding renewable energy, research has also been carried out into the implications of Scottish energy targets from an engineering point of view⁽⁷²⁾. Practical barriers identified include technological issues, such as development needs in the marine sector, the requirements for substantial investment in the National Grid, a potential lack of skilled engineers, the need for investment in new manufacturing against competition from other parts of the globe, and current difficulties in accessing investment funding.

Overall, the energy-related research was primarily concerned with energy supply and the need to move to a more diverse range of low carbon sources. There are opportunities to develop both existing and new fuel sources, some of which may have future land use implications. Although the need to reduce energy demand is identified, notably in the Energy 2050 Pathway analysis, the role of planning in achieving this is not explored at any length. Decisions regarding the spatial organisation of land uses, set out in development plans, can have a major impact on the demand for energy both within the built fabric of developments and in relation to patterns of movement.

Topics identified for further investigation:

- The requirements and impacts of existing and emerging energy technologies for TAYplan;
- The spatial implications of delivering a low-carbon energy future both generally and specifically within the TAYplan area.

Changing Economy

The pursuit of sustainable economic growth lies at the centre of the Scottish Government's agenda and is a key plank of the TAYplan development strategy. Understanding the characteristics of the local economy and the ways in which it may change in the future are essential to the process of promoting new development opportunities in sustainable locations.

The changing nature of economies is an important theme in the wider literature. In a global context, there is evidence of the increasing concentration of the world's population and economic development in major cities, with associated advantages of clustering, innovation and knowledge exchange⁽⁷⁷⁾. The Futures Report, for example, states that new kinds of employment are being generated as a result of urban growth, associated with **technological change**, globalisation and climate change⁽⁸¹⁾. It also suggests that service sector employment in the UK is likely to continue to expand over the medium term and that the workforce will be increasingly diverse.

A study carried out for the Welsh Government considered these issues and the implications for achieving future **economic growth** in medium sized cities as found in Wales⁽⁴⁶⁾. The Core Cities Partnership Report, identified three key factors: addressing skills gaps, investment in infrastructure and innovation. City regions were then considered as a policy response. The authors concluded that adopting a city regional approach in Wales could deliver larger and more efficient labour markets, larger markets for goods and services and greater knowledge exchange and innovation. Examples from elsewhere demonstrate the

importance of funding, investment and partnership. In the absence of change, weak economic performance will continue. City regional planning is in place via Tayplan although this report highlights the importance of funding and investment at the regional scale.

Trends in economic performance have been the subject of European research, linked to the EU's agenda of achieving smart, sustainable inclusive growth⁽¹¹²⁾. The research, part of the ESPON 2013 Programme, provides information on the comparative status of European regions in relation to the 2020 agenda based on indicators, including **employment**, innovation and research, economic reform, social cohesion, and the environment. The territorial patterns found include: strengthening regions in the West and North of Europe, best educated labour forces in northern EU, existing disadvantaged regions have lost ground in terms of competitiveness, capital cities have grown in influence. The economic downturn has had uneven impacts across regions. In general northern regions are out performing those in the south.

New indicators are being introduced in relation to the development of greener economic development such as tertiary **education** levels and renewable energy consumption and potential showing the importance of these activities to future economic performance. A number of cities and regions are pursuing green growth strategies, including Leeds City Region, Manchester and Wellington in New Zealand^(44, 1, 77). In Leeds, the low carbon sector is seen as one of two sectors where jobs growth is possible, the other being healthcare. Globally, the low carbon and environmental goods and service sector is worth £3.2 trillion per annum and will continue to grow. It is argued that future demand in this sector will come from China and other countries with growing populations as they seek to reduce their energy costs and carbon footprints as well as from investing in energy efficiency within the region itself. Leeds City Region commissioned the Centre for Low Carbon Futures to undertake research into the economics of low carbon cities, recognising that a significant proportion of GDP is lost to the region every year through high energy bills.

The Leeds City Region example highlights the desire to reduce energy use in a way that is cost neutral (inclusive of political, social and financial considerations)⁽⁴⁴⁾. Substantial levels of investment would be needed together with new investment mechanisms and delivery vehicles. Research focuses mainly on the economics of a low carbon region and it is acknowledged that further work is needed to explore the extent to which actions would be acceptable both politically and socially as well as work on future proofing in relation to carbon reduction targets beyond 2022. The work on which this article draws, looks at the options for a low carbon future for a major UK city region. While larger in scale than the TAYplan area with a population of 3 million people, the methodology and many of the conclusions are relevant.

There are links between this work and a new research programme, the Low Carbon Land Use Innovation Network (LoCal-Net), which aims to coordinate research and development opportunities for the small and medium enterprise business sector, to innovate low carbon activities, products and services⁽⁹⁷⁾. There is an emphasis on the **agriculture**, food and rural industries sectors which present opportunities in low carbon innovation. This is a cross-sectoral initiative involving local authorities within the TAYplan area, the Forestry Commission in Scotland, Scottish Enterprise, Scottish Renewables, Scottish and Southern Energy and others. As LoCal-Net is a new programme, there may be scope to identify existing projects to demonstrate the processes involved in transferring to a low carbon economy through products and services. Once established there may be an opportunity to and include larger business and industry.

Research has been carried out into two important economic sectors of particular importance to the TAYplan **regional economy** notably the Arts and Creative Industries (A&CI) and tourism⁽³⁷⁾. Creative Scotland and Scottish Enterprise commissioned a study into the contribution of the A&CI to the Scottish economy. The study looked at sixteen sectors and considered both direct impacts in terms of employment and indirect impacts. Adjusting the figures for population, the major Scottish cities have higher than average A&CI employment. Scotland has relatively few A&CI businesses but they are typically larger than elsewhere. The role and contribution of A&CI to tourism is recognised including both direct and indirect influence with the strongest being in the field of Heritage and the Performing Arts. The study shows that the A&CI are important in the TAYplan area with Dundee in particular having employment above the Scottish average when adjusted for population size. The economic impact, both directly and indirectly via tourism and links to HE, are important. This report is helpful in understanding the current contribution of A&CI but it does not consider future trends. There may be scope to develop this further including consideration of the longer term impact of the new V & A museum in Dundee.

Tourism is of major importance to many parts of the region and has been the subject of several studies and strategies. Evidence shows that in recent years there has been an increase in the levels of domestic visitors to Scotland, with a rise of the “staycation” and a decline in the numbers from overseas, although there are opportunities to target visitors from emerging markets such as China, India and Brazil^(6,7). Tourism is a very competitive business with evidence of destinations elsewhere increasingly tailoring experiences to meet specific targets. Golf is recognised as a tourism asset of importance to the region that has development potential. A study of Scottish tourism destinations commissioned by Scottish Enterprise included St Andrews and Highland Perthshire and the report highlights the importance of quality products in ensuring success as well as effective tourism management⁽⁸⁾. Environmental quality is also a key feature in the growth of nature-based tourism, which has been shown to make a major contribution to Scottish tourism economy, in terms of both the value of economic activity and jobs⁽²⁴⁾. The activities considered included wildlife watching, field sports, walking/mountaineering, snow sports, cycling, water sports, horse riding, adventure activities, conservation work, other specialist interests, and scenery. This study did not consider the economic impact of nature-based tourism on particular localities and this is identified as an area for further investigation.

The theme of environmental quality and a sense of **place** is also part of the economic development literature and associated with the theory of smart growth⁽⁴⁹⁾. Canadian research considers the possible connections between the theory of smart growth and the locations requirements of high tech firms, by comparing experiences in contrasting locations. Positive connections were found between economic development and sustainable forms of urban development, based around aspects of amenity, centrality and proximity. It was also recommended that further research is needed to demonstrate which types of firms have a legitimate need to be separated from other areas of cities and on how to accommodate such firms while helping the city to maintain sustainable land-use patterns.

A special issue of the Journal of Urban Technology features ideas on the inter-relationship between business, government and higher **education** and its potential to support innovation and economic development⁽⁵⁰⁾. This relationship, the triple helix model, can be used to study the knowledge base of an urban economy in terms of civil society’s support for innovation. The contributing authors identify three dynamics of the relationship; the intellectual capacity of universities, the wealth creation of industries, and the democratic government of civil society and suggest that the interaction across these spheres creates

dynamic spaces where knowledge can be exploited for the benefit of regional innovation. These ideas have resonance in the TAYplan region given the number of higher education institutions and the nature of the partnership arrangements in place as part of the Community Planning and strategic planning processes.

Overall, in terms of the economy, research is available in relation to some of the region's key sectors such as A&CI, tourism, land-based business and renewables but there appears to be less covering other important sectors such as retailing and bio-medical research.

Topics for further investigation:

- Economic studies of key TAYplan employment sectors such as retailing, bio-medical research;
- The potential of the low carbon sector in the TAYplan area including political and social acceptability;
- Long-term economic potential and requirements of tourism including nature-based tourism and the impact of the V&A;
- Opportunities for collaboration between government, business and higher education within the region in order to maximise the benefits of environmental quality, innovation and economic growth.

Increasing use of ICT and impact on delivery and use of public services

Technological change, particularly involving information and communication technology (ICT), is altering the way in which individuals live their lives, impacting on the delivery of services by government and businesses and ultimately will have implications for the way society is organised and planned from the architecture of individual buildings, to **transport** and the design of cities.

The significance of technological developments in ICT is widely discussed in the literature and identified as a key driver of change in the Global 2050 Report, the Futures Report and Wellington Towards 2040^(40, 81, 77). These reports highlight the importance of increased global connectivity, the impact on service delivery in both the public and private sectors and the potential for new technologies to empower people in their daily lives.

A range of studies are underway concerned with changing the way government and business engage with service users. Some of this work is focuses at the level of the individual, such as research into human-computer interfaces and the use of 'virtual agents', graphic representations of someone from the organisation, to assist users in undertaking on-line tasks⁽⁷⁵⁾. Advances in graphics associated with the computer games development, now allows high resolution motion virtual agents. The development of usable and accessible technologies for specific groups as users, such as the novice elderly, can help facilitate lifestyle changes and provide support for vulnerable and socially exclusive sections of society⁽¹⁰⁸⁾.

Other work is concerned with the potential use and impact of ICT at a city and regional level. New technologies are being used to enhance opportunities for collaborative engagement of stakeholders and the public in decisions about the urban environment^(82, 99). Environment map-based and 3-D visualisation tools have been developed and tested, for example as part of the Dundee Waterfront project, opening up the planning process beyond the expert. The use of ICT in combating social exclusion, improving employment opportunities, quality of life

and community participation is also being explored through I-Age⁽⁷⁴⁾, which is an EU project involving partners from the ten North Sea Regions. A project is also underway to improve the quality and availability of environmental information to the public⁽¹⁰⁷⁾. It is hoped that by providing accurate environmental data and reports on a single website that it will ultimately have an impact on people's behaviour.

Digital technologies also have a contribution to make in the transition to a low carbon economy⁽³⁹⁾. Digital technologies are expected to play a role by replacing goods and services with virtual equivalents, allowing more efficient use of **energy** and offering virtual technologies for shopping, teleworking and on-line services. Such changes will have an impact on how future generations live their lives and the way people work, shop, learn and access other services. There are currently barriers to digital participation, defined as "people's ability to gain access to digital technology, and understand how to use it creatively"⁽¹¹⁹⁾. Factors affecting digital use have been explored and include age, income, educational qualifications, working status, and disability. Little difference was found in participation levels between urban and rural areas.

Extensive work has been carried out into the concept of the 'smart city' and its development in practice across the globe^(47,48,51,91). While the smart city involves the use of ICT, it is widely argued that the concept is a much broader one. Caragliu *et al.* identify six characteristics of the smart city⁽⁴⁷⁾: the utilization of networked infrastructure to improve economic and political efficiency and social and cultural urban development; emphasis on business-led urban development; focus on social inclusion of residents; stress on the role of creative industries; role of social and relational capital and the context of learning; social and environmental sustainability and state:

"We believe a city to be smart when investment in human and social capital and traditional and modern communications infrastructure fuel sustainable economic growth and a high quality of life with a wise management of natural resources with participative governance".

Southampton is described as the first smart city in the UK as a result of the development of a portal to support the use of smart card applications for transport, recreation and leisure activities⁽⁴⁸⁾. Others, such as ARUP, stress the potential link between the use of ICT and related technologies and the development of sustainable solutions to urban problems, such as the introduction of smart grids, which optimise the energy network⁽⁵¹⁾. The authors review the experience of international projects in Melbourne, Sitra, Helsinki and Musheireb and Qatar and argue that the full potential of ICT has yet to be realised.

A final important strand of thinking is the relationship between ICT and **place**, understood as "space enriched by the assignment of meaning". Walters starts from the view that developments in ICT are likely to continue to change both the way in which people use space for work, home and leisure, and their perceptions of it although the manner in which this occurs remains unclear⁽⁹¹⁾. He suggests that ICT developments could potentially result in "themed environments devoid of place-specific design" (p199) and argues that there is a key role for those managing cities to combine physical, place based planning and design with the positive aspects of virtual or 'smart' advances to enhance the distinctiveness of individual localities. It is suggested that public forums are needed to discuss place-specific futures.

The development of new technologies is an area of rapid change which is likely to impact on people's lives in somewhat unpredictable ways. In relation to TAYplan, the most important

consequences are those which impact on the way space is used and organised. The smart cities research is of particular relevance and raises several issues. One issue is the importance of continuing to focus on 'place' as development in ICT make populations more mobile in terms of the places they want to live and work, while a second is process related highlighting the opportunities that ICT and e-governance provide local populations to shape the future of their area.

Topics for further investigation:

- The impact of e-governance and the 'smart city' agenda on shaping land use change particularly in relation to Dundee and Perth;
- The changing nature of 'place' and the resulting consequences on the way people live and travel in light of technological advances.

Increasing significance of place

The nature and characteristics of places can be important drivers of change in their own right although, as already discussed, 'place' issues are also interrelated to the use of new technologies and economic development. The creation of high quality places has been identified as a priority by Scottish Government and it is central to the vision and strategy set out in the approved TAYplan SDP. The concept of 'place' is extremely complex, with multiple socially-constructed meanings. It encompasses the built and natural environments and the ways in which people interact with them, the spatial distribution of activities and the ways in which they are interlinked, as well as aspects of history, culture, distinctiveness and resilience.

'Place' and 'placemaking' are recurring themes in the material and it is anticipated that as a result of globalisation and enhanced travel individuals will have higher expectations of places in the future⁽⁷⁷⁾. A great deal of work has been undertaken exploring the meaning of sustainable design at the level of buildings and neighbourhoods including considerations of energy efficiency and health^(25,30,31). While this work is important it is not of direct relevance to forward planning at a strategic level.

Of wider significance is a body of research concerned with developing new sustainability assessment tools linked to concerns about future resource use and the well-being of future generations^(66, 84, 85, 86). An array of such tools have been produced offering approaches which combine the environmental, social and economics considerations of sustainability in ways that can be taken into account in the decision making process. Examples include the sustainability framework created for the Dundee Waterfront Project⁽⁸⁴⁾ and the Sustainable Built Environment Tool (SuBET) used in example projects in Milan and Saudi Arabia^(85,86). Though these tools have mainly been applied at a local level, they may be adaptable to regional and national applications.

While a great deal of research has been carried out into improving the environmental performance and design of new housing development in recent times and in understanding the impacts of design on social behaviour and people's sense of place, there remain questions about what constitutes a strong community and what can be done to build them. Research led by Dixon adopted the concept of 'social sustainability' as a framework to help develop such understanding and as the basis for measuring factors that influence quality of life and strength of community, encompassing physical and non-physical factors⁽⁴¹⁾. This

approach was tested in new housing developments in SE England and the authors conclude that it provides a valuable tool to benchmark and compare developments.

There have been recent debates in Australia about the best approach to create liveable settlements which can accommodate population growth in a sustainable manner. The city of Adelaide provides a good example of a strategic approach to this issue where new development is planned based on walkable neighbourhoods, centred on public transit links, and using predominantly brownfield land. At the heart of the process is a commitment to engage with the community in an integrated decision-making process⁽⁴²⁾.

Energy efficiency and zero carbon buildings are part of the sustainable place agenda. A significant proportion of the buildings present within the TAYplan area today will still be standing in 30 years so work on energy efficiency retrofitting of existing buildings has a contribution to make. Research into energy efficiency retro-fit in London, as part of a regeneration scheme, demonstrated major benefits in terms of improving homes and saving energy arising from this type of project although achieving wider benefits depended on establishing good relationships with residents⁽³⁸⁾. Although a study of a specific estate, this work has wider significance and links to sustainable building case studies produced by Architecture and Design Scotland.

The role of **green space** as part of the place agenda has been the subject of a great deal of recent research. Studies have looked at the multi-functional role of green infrastructure, the relationships between peoples' use and perceptions of green space and their health and wellbeing and links between green space urban water management^(22, 59, 60, 67, 35).

The principal aim of the 'Green Networks and People' project for SNH was to examine how new data sets and analytical tools can be applied to support the planning and management of multi-functional green networks⁽²²⁾. The research highlighted the lack of spatially referenced social data on how people use green networks. Priorities for research included how people move through the landscape and how they use green networks; motivations for using (or not using) green networks; how to balance competing needs, interests and priorities for different user groups; and monitoring and evaluation of the effectiveness of green network improvements.

A number of these questions may be answered when the outcomes of the Green Health Project are published⁽⁵⁹⁾. This project, which was commissioned by Scottish Government, aims to quantify the relationship between the quantity and quality of green and blue space, its proximity and use, and associated health outcomes as well as seeking better understanding of the mechanism involved. Environment factors, both actual and in terms of people's perceptions, which are related to health and wellbeing are being tested and the results will inform public policy assessments in relation to the role and benefits of green space.

Other studies include research into the impact of quality **green space** on **health** and wellbeing in six socially deprived neighbourhoods in London, the West Midlands and Greater Manchester, with particular focus on understanding the ways in which green space, ethnicity, deprivation and health are interlinked⁽⁶⁰⁾; an exploration of the way in which different physical and non-physical characteristics of greenspace such as lighting, season, time of day, and weather, impact on user perceptions including safety and quality⁽⁶⁷⁾; a study of how best to deliver the benefits of green networks for both people and wildlife⁽³⁵⁾; and a review of policy and practice relating to environmental interventions and child health in

Scotland and in particular in four Scottish cities (Glasgow, Edinburgh, Aberdeen and Inverness).

Overall, place is a topic of both relevance to TAYplan and of substantial research interest particularly in relation to the quality and sustainability of the built environment and the contribution of green infrastructure. An aspect where there has been less focus is on the particular aspects of place, urban and rural, that are valued within the TAYplan region, an issue that has links to the economy, identity, landscape, health and well-being.

Topics for further investigation:

- Aspects of 'place' that are valued by communities in the TAYplan region;
- The inter-relationship between green infrastructure and urban form and its significance for the region.

Demographics and health

Understanding the changing nature of the population of a locality is an essential prerequisite for future planning. The number and characteristics of an area's population are important in relation to the provision of jobs, housing, schools and other facilities as well as having wider implications in relation to social inclusion, health and well-being.

A number of studies and reports summarise global and area specific **population** trends and in broad terms the global population is expected to grow significantly over the next 40 years with 70% of the world's population living in cities by 2050 with predictions of populations being both older and healthier^(40,77,81,101). The Global Europe 2050 Report, for example, which explores global trends affecting the EU through a series of scenarios, highlights population growth, changing family structures and **lifestyles** as one of the six key challenges that will face Europe by the middle of the century⁽⁴⁰⁾. Some of the trends identified in such reports may be of relevance to the UK but it is important to look more closely at the Scottish and TAYplan context.

Some more targeted pieces of research on aspects of demographic change were identified and reviewed relating to migration, life expectancy and **health**. Two studies consider aspects of migration. The first used the 2001 Census to try and understand in-migration to Scotland including return migration and found that returners were more likely to be upwardly mobile than other groups can have a positive impact on population and economic growth⁽⁹³⁾. It is suggested that this kind of analysis could be repeated for the 2011 census, particularly to consider if the recent recession has made a difference to returners. The second study considered potential levels of migration to the UK in the next 50 years as a response to the challenges associated with climate change⁽⁵⁸⁾. Survey topics included estimated gross immigration by 2030 and 2060, current and future levels of immigration related to environmental change, demographic and economic drivers of immigration to the UK and return migration to the UK due to adverse environmental change. Those engaged in the survey believed that migration to the UK associated with environmental change was likely to rise over the next 50 years set against a predicted slight decline in overall immigration. There remained great uncertainty, however, about the actual levels. This type of work can contribute to understanding of forecasts of future population within the Tayplan area but it is unclear the extent to which the factors identified in this research operate at a regional as opposed to national level.

The life expectancy of Scotland's population is lower than elsewhere in the UK and Europe despite year on year improvements. One explanation put forward for this difference in the past has been Scotland's relatively high levels of poverty and unemployment compared with elsewhere⁽⁹³⁾. This appeared to have declined in significance in relation to the 1991 and 2001 censuses leaving an element of unexplained excess deaths named the 'Scottish effect'. Research explored this phenomenon and found some evidence to support the theory that the Scottish effect reflects the impact of poverty over a lifetime, leading the authors to conclude that decreasing deprivation in Scotland could mean improving health of the population. Some recent policies particularly, in community regeneration, assume health and well-being benefits can be gained from living in socio-economically mixed communities. The Census was also used to explore this relationship and consider neighbourhood effects on the life chances of residents, building on suggestions of a causal link on employment prospects.

Other studies related to **health** focused on a wider context. Grady and Goldblatt explore the social determinants of health⁽⁴³⁾. Drawing on work undertaken as part of the WHO Health Cities Network, they stress the significance of social, economic, environmental as well as personal factors on health and the need for a political commitment to improving citizen health by implementing strategies at a local level. The built and natural environments are identified as important determinants of health, especially for disadvantaged and excluded groups with fewer choices open to them. Numerous studies are identified which record the coincidence of spatial disadvantage and poor environmental quality, often described as environmental injustice. Of particular significance to TAYplan is the view that:

“Strategic decisions determining urban form affect the proximity of facilities, access to employment and income, access to high-quality green spaces and viable modes of transport and hence determine where people live and work and their mental well-being and physical health”.

The need to give greater consideration to health as an element of spatial planning is also highlighted in a mapping exercise undertaken as part of the local development planning process for Inverness⁽²⁷⁾. This study looked at the changing strategies for healthcare and the infrastructure needed to support it and considered the linkages to different future development scenarios for the city.

Understanding demographic change in the Tayplan area is central to the strategic planning process and the limited number of studies reviewed under this heading complements the data provided by GROS population and household projections. The census-based studies demonstrate that opportunities exist for more tailored research in the future using the 2011 Census.

Topics for further investigation:

- The delivery of services in an ageing society
- Health as an element of spatial planning

Transport and infrastructure

The reform of the planning system in Scotland introduced in 2006 sought to improve the co-ordination of development and infrastructure provision with an increased focus on delivery. This change in emphasis reflected past experience when often there were delays in investing

in the infrastructure needed to support development. Changes in wider society are impacting on **infrastructure** needs with shifts to more sustainable modes of travel, an increased emphasis is waste reuse and recycling and the adoption of sustainable urban water management practices. Addressing issues of territorial and mobility dynamics is recognised as a major challenge of the future⁽⁴⁰⁾. This involves thinking not just about the patterns of development but also **transport** and communications networks and associated issues of connectivity and accessibility⁽⁴⁶⁾. The desire to decarbonise transport is one of the main drivers of change in this field.

Research was undertaken by the Stockholm Environment Institute to assess the contributions that different CO₂ emission reduction measures could make in helping the UK to move towards a zero carbon transport sector by 2050⁽¹⁰⁴⁾. Using a scenario approach, different potential interventions were assessed. These included changes to the design and density of urban areas in order to reduce car travel, fiscal measures involving adjustments to spending on different modes of transport, action to encourage behaviour change, and the impact of new technology for example in relation to the development of electric vehicles and electrified lines. Action is needed across all areas if the move to zero carbon transport is to be achieved and it is noted that technological solutions alone will not deliver the required reductions.

While this study related to the UK as a whole, complementary research has been carried for the Scottish context which considered ways of reducing emissions from transport to meet Scottish Government emission reduction targets⁽¹¹⁵⁾. Car Demand Management Smart Measures such as work place travel plans were found to have a significant potential to reduce emissions. The effects of different measures were estimated to vary over time with gains from efficient driving being more important in the short term and the impact of **land use** measures increasing in the medium term. A follow up study has been commissioned by Tactran, the Tayside and Central Regional Transport Partnership to produce and analyse estimates of future surface transport CO₂ emissions relating to both the Tactran and TAYplan areas⁽¹²²⁾. Two scenarios are used as the basis for developing forecasts of transport emission levels to 2030, a “do-minimum scenario” which assumes that existing measures to reduce CO₂ levels will continue to 2020 but not beyond and a “Committee on Climate Change (CCC) Carbon Budget Recommendations scenario”, which assumes there will be on-going improvements. While the former scenario results in continuing upwards emissions, off-set in the short term by enhanced efficiencies in vehicles, the latter suggests declining emissions, small in scale initially but increasing towards 2032. This is primarily a result of a greater uptake of electric vehicles and improvements to the efficiency of commercial road vehicles. While it is recognised in the report that land use and planning related measures have a part to play in reducing future transport emissions, such measures are only one of a number of responses to this challenge. The scale of the contribution that might be made by reducing the need travel via land use change is not explored in this report.

Bonsall and Harrison consider the factors affecting the future demand for electric vehicles including subsidies, price, operating costs, speed, fuel availability, emissions ratings and range⁽⁵⁴⁾. These factors are used to develop a model of the growth of electric vehicles which is tested in relation to different market scenarios. The authors emphasise the sensitivity of projected uptake depending on a range of market conditions including subsidies and conclude that there is a question about whether the market in electric vehicles is sustainable without the continuation of subsidies.

Changes in travel behaviour will also be needed to reduce CO₂ emissions linked to transport. A study explored public attitudes to climate change and how this would effect travel decisions as well as the barriers and motivations behind travel behaviour⁽¹⁰⁵⁾. The results showed that most people were more willing to reduce domestic CO₂ emissions than those linked to transport use and that they will adjust trip patterns and driving behaviours rather than modes of travel. The main barriers to behaviour change include attitudes, lack of information, lifestyle, and practical issues. This study has relevance to TAYplan where a significant percentage of the population commute to work.

In recent years there has been a growing acceptance of the need for more sustainable systems of urban water management, covering the supply of water, sewerage and drainage services⁽⁹⁰⁾. In a Scottish context, this has led to legislation requiring sustainable drainage systems to be provided for all new development with local development plans playing a coordination role. A comparison of sustainable drainage systems and traditional ones reveals that sustainable systems are more cost effective both to construct and to maintain with the added advantage that they comply with environmental regulations⁽¹⁰⁹⁾. It is recognised that further research may be needed to consider the impact of sustainable drainage on the viability of new developments given the on-going change in climatic conditions. The incorporation of trees as part of sustainable drainage schemes could deliver arrange of benefits such as regulating microclimates, filtering of rainwater, attenuating noise, improving air quality, carbon sequestration, and enhancing biodiversity and a new approach is currently being tested⁽⁷⁶⁾.

Looking to the future, there is an on-going need to ensure that sustainability becomes firmly embedded in water management decision-making and that more integrated and coherent approaches to urban water management are developed⁽¹¹¹⁾. Recent EU funded research, SWITCH (Sustainable Water Improves Tomorrow's Cities Health) considered ways of encouraging such a shift in thinking and practice over the next 30 to 50 years^(89,90). The project adopted an approach based on transition theory⁽⁸⁸⁾.

“A transition is a structural change in the way in which society operates. In simple terms it is a process whereby culture, markets, networks, institutions policies, individual behaviours and trends evolve together from one relatively stable system state to another” (p1).

SWITCH was concerned with deepening understanding of integrated and sustainable urban water management and, based on the assumption that transition is needed, it considered how this shift could best be effected. The SWITCH approach assumes that stakeholders and policy makers wish to improve the management of urban water and create a Learning Alliance to identify the appropriate local objectives. At present there is a lack of political commitment in relation to the transition to integrated and sustainable urban water management in many parts of the world as well as a lack of the necessary strategic planning mechanisms in place to take advantage of new technologies. The research highlighted a requirement to build the capacity of managers and operators and to raise wider awareness of the benefits of transition through the media.

This review has highlighted research into two important aspects of infrastructure: transport and water management and in addition reference is made elsewhere to aspects of energy infrastructure and health. The implications for the TAYplan area of the wider move to decarbonise transport is of particular importance given its close links with the strategic planning process. A topic not captured in the material is that of waste management. Given

the Scottish Government's zero waste ambitions, as set out in the Zero Waste Plan, there may be a need to consider the long term consequences of this commitment for waste management infrastructure in the TAYplan area.

Topics for further investigation:

- The implications of the move to decarbonise transport
- The move to zero waste and its implications for waste infrastructure

Responding to climate change

Tackling climate change is the major, cross-cutting challenge facing society today. Delivering GHG emissions targets by 2050 will impact on all sectors of activity. Climate change as a driver of change has already been woven into much of the material discussed in the previous sections but here the main focus is on research concerned with responses to climate change which address issues of vulnerability and resilience, behaviour and *lifestyle* change and adaptation strategies.

Understanding issues of vulnerability and resilience are central to many climate change studies and these concepts are explored as part of the URBAN-NEXUS Project, funded by the EU, which aims to stimulate dialogue and develop partnership approaches to sustainable urban development⁽⁷¹⁾. A report published in 2012 reviews current research on the uncertainties associated with climate change, governance approaches, the ability of individuals to respond and impacts on place. The authors draw a number of conclusions including that although there is substantial body of research on the subject, few studies take an integrated approach, most focus on mitigation, and cross-disciplinary work is needed on adaptation and promoting greater resilience, which should be seen as an evolving process.

The themes raised in the URBAN NEXUS report are picked up in other work such as considerations of how to increase the resilience of vulnerable members of society to natural hazards⁽⁶⁸⁾. Drawing on the academic literature, researchers question the use of broad generalisations such as vulnerable communities highlighting the importance of setting the risk in its specific cultural and context. Vulnerability is not just linked to personal capacity but also the support or lack of it available. It is important to conceptualise vulnerability as a pathway or process, shaped by spatial and temporal contexts rather than as something associated with particular groups. The concept of resilience is often associated with the ability to 'bounce back' from challenging situations but it is felt it could also be seen as a chance to 'bounce forward', a process of on-going learning, so that questions of resilience are considered routinely in planning for the future. Complementary research has looked at ways in which the results of research into vulnerability and risk, including vulnerability mapping, can be used in the preparation of future strategies in health and social care⁽¹¹⁸⁾. Not only are there practical problems associated with this task but the different sectors appear to take different approaches with the health sector focusing on reducing CO₂ emissions by its organisations while social care has focused more on adaptation. The importance of cross-sector working was stressed.

The concepts vulnerability and resilience are also central to research into the impact of climate change on the risks of pluvial *flooding* in the UK⁽⁵⁶⁾. A recent study identifies current urban populations at risk and considers future exposure, concluding that although the population at risk of pluvial flooding will increase by 1.2 million across the UK by 2050, this will be associated with population growth as well as climate change. The role of planning

and flood risk management responses to flood risk is highlighted and partnership approaches are advocated. Research into changing the availability of flood insurance to reflect the risks of flooding more accurately considered the potential impact generally and on socially deprived households⁽⁵⁷⁾. This study raises some important issues which may affect the future patterns of housing demand, if, as is predicted, premiums for house insurance rise significantly in high risk areas.

There is considerable recent research which explores issues of behaviour change in relation to climate change⁽¹¹⁴⁾. Central to understanding behaviour change is the recognition of the importance of different contexts influencing behaviour; the individual context relating to influences on individual attitudes and choices, the social context relating to wider shared norms and practices, and the material context covering technologies and infrastructure which shape behaviour. International case studies show that the majority of initiatives are targeted at the individual context, such as information campaigns although infrastructural changes did have an impact on behaviour. The importance of addressing multiple contexts was highlighted in encouraging behaviour change, suggesting the need for greater collaboration across sectors.

Related studies have also been undertaken looking at the factors influencing the behaviour of farmers in response to the challenge of changing climate⁽¹¹⁷⁾, which suggested a balance between mandatory and voluntary approaches was needed, and exploring behaviour change in the workplace⁽¹¹⁸⁾. The latter study found that employers are more likely to introduce energy saving and waste recycling schemes than travel ones and recommended that to achieve long-term success there was a need for both enhanced **education** and a change in values.

At a UK level greenhouse gas emissions from **agriculture, land use, and forestry** (ALULUCF) amount to 8% of the total and, given UK climate change targets, the issues of **carbon pricing** in different sectors is under scrutiny. It is accepted by the Committee on Climate Change that reductions in emissions must be achieved in an economically efficient way. Modelling futures by sector suggests that there is potential for abatement in relation to crops, soils and livestock management measures but limited opportunities in relation to land use change⁽⁶⁵⁾. The estimated total abatement for ALULUCF is particularly sensitive to action taken in relation to forestry, such as the use of timber products in place of carbon intensive construction materials. Analysis of emissions trading within agriculture in Scotland show a positive relationship between increases in carbon price and increases in emission reduction targets⁽⁶⁴⁾. Organic soils can both absorb and release CO₂ depending on land management practices. In Scotland, it is believed that the soils absorb more CO₂ than they release but there are some uncertainties surrounding this assumption. Research has considered a methodology for calculating the carbon emission savings that can be achieved from the development of wind farms on peatlands, which are seen as potentially attractive sites for windfarms because they are less likely to be in productive agricultural use than other soils, and are frequently found on exposed locations⁽⁸³⁾. The findings suggest that localised factors can have a significant impact on the potential overall carbon savings of new windfarms (up to three quarters of the gross carbon savings) and while most wind farms are likely to result in savings, with poor site location the new benefits could be quite small.

The need for integrated, holistic responses to the challenge of climate change is recognised and efforts are being made to develop adaptation policies and strategies. However, are authorities prepared for this challenge? This was the remit of a study commissioned by the

Eco Cities Project which aimed to examine the awareness and understanding amongst the relevant authorities in Greater Manchester^(1,2,3). The research explored evolving **land use** patterns in the city using two scenarios, 'the long descent' and 'the upward spiral' to help consider the implications for climate change adaptation. It highlighted the interconnected nature of land use and climate change factors in adaptation responses. There are similarities between this research and a recently established initiative, Climate Ready Clyde⁽⁵²⁾. This project, involving agencies and other stakeholders and supported by consultants, has been set up to create a vision for the region and develop an adaptation strategy.

In New Zealand, similar work had been undertaken in Wellington, Auckland and Christchurch as the basis for developing future strategies^(77,78,79). The Wellington 2040 Project, for example, is concerned with the future development of the city over the next three decades. One of the main strands of the work was research into the main trends which could have an impact on the city's development. The subsequent vision to emerge is based around four goals: a people centred city; a connected city; an eco-city; and a dynamic central city. These goals were then developed in the form of a future strategy for Wellington with a number of supporting projects.

This section has highlighted research into three important aspects of climate change response; the need for on-going learning for future planning to address resilience, the need to understand the influences of behaviour change in a range of contexts and the need to address the balance between mandatory and voluntary behaviour change drivers. In relation to resilience, it supports the conclusions of other studies regarding the benefits to be gained from adopting appropriate transitioning frameworks involving wide stakeholder engagement and the importance of assessing both the political and social acceptability aspects of the challenges. In terms of behaviour change, there may be an opportunity to look at community responses to climate change to complement understanding at the individual and agency or organisational levels.

Topics for further investigation:

- Climate change mitigation and adaptation needs;
- The application of a transition framework to facilitate a holistic approach to climate change;
- Understanding of ways in which communities in the region (as opposed to individuals and organisations) respond to climate change, including travel choices;
- Building resilient places.

Overview

The main aim of Phase 1 of this study was to review existing research related to long-term societal, environmental and economic change drivers in order to assist the TAYplan Strategic Development Plan Authority and its partner agencies by providing insights into way in which future generations may lead their lives and the strategic implications for land use.

Within the parameters set for the study, this review demonstrates the diversity and breadth of research that is being carried out at international, national and national scales which can help inform the strategic planning process, including considerable work being undertaken by the higher institutions located within the TAYplan region. The material has been synthesised around 8 main challenges facing the TAYplan area going forward which capture the major drivers of changes such as the move to low carbon renewable energy, the increasing significance of digital technology, a focus on place, shifting demographics, the growth of collaborative approaches to service and infrastructure delivery and the need to adapt to climate change.

Research opportunities

The review has revealed a number of research opportunities as follows:

Managing resource use efficiently

- Interpretation of national studies into the impact of climate change on rural land use at the TAYplan scale;
- The impact of demographic change and changing lifestyle expectations on land use change;
- The inter-linkages between water demand and land use change;
- The application of an ecosystem services analysis to the TAYplan area.

Moving to low carbon, efficient energy supplies

- The requirements and impacts of existing and emerging energy technologies for TAYplan;
- The spatial implications of delivering a low-carbon energy future both generally and specifically within the TAYplan area.

Changing economy

- Economic studies of key TAYplan employment sectors such as retailing, bio-medical research;
- The potential of the low carbon sector in the TAYplan area including political and social acceptability;
- Long-term economic potential and requirements of tourism including nature-based tourism and the impact of the V&A;

- Opportunities for collaboration between government, business and higher education within the region in order to maximise the benefits of environmental quality, innovation and economic growth.

Increasing use of ICT and impact on delivery and use of public services

- The impact of e-governance and the 'smart city' agenda on shaping land use change particularly in relation to Dundee and Perth;
- The changing nature of 'place' and the resulting consequences on the way people live and travel in light of technological advances.

Increasing significance of place

- Aspects of 'place' that are valued by communities in the TAYplan region
- The inter-relationship between green infrastructure and urban form

Changing demographics and health

- The delivery of services in an ageing society
- Health as an element of spatial planning

Infrastructure and transport

- The implications of the move to decarbonise transport
- The move to zero waste and its implications for waste infrastructure

Responding to climate change.

- Climate change mitigation and adaptation needs
- Understanding of ways in which communities in the region (as opposed to individuals and organisations) respond to climate change, including travel choices
- Building resilient places

In broad terms the research gaps fall into four categories.

Scaling gap: There is evidence of relevant research across all of the original drivers of change with many of the studies being undertaken at international, national and Scottish scales. A relatively small percentage of the work, however, has focused specifically on change within the TAYplan region and the implications for strategic land use. Recognising the importance of context, there is scope for more targeted research which considers the implications and significance of higher level change for the TAYplan region.

Integration gap: A significant proportion of the research across all scales is subject or agency specific, some of it commissioned by the TAYplan partner agencies, looking at particular aspects of future change. There are opportunities to take more integrated and multi-sector approaches to the challenges facing TAYplan in order to enhance understanding and arrive at more effective solutions drawing on the experience of similar work elsewhere. The TAYplan partnership is in a good position to act as the hub for improved research knowledge management across public agencies in the region. Cross-cutting themes that emerged from the review include place, smart cities, climate change resilience and ecosystem services.

Process gap: A number of the studies involve the development of new methods, approaches and processes which could be adapted and used in a TAYplan context. These include sustainability assessment frameworks and tools, approaches for visioning future change and stakeholder engagement techniques such as 3D visualisation and design-based

placemaking. Adopting a transition framework as the basis for developing a more integrated approach to strategic planning could be useful means of moving the agenda forward.

Timescale gap: The majority of the research took a short or medium term view, seeking to understand current trends or explore alternative possible strategies. A relatively small number looked to the long term as required by this study. Those that did take a longer term view frequently used scenarios as a way of helping to manage future uncertainty.

Next Steps

This report covers Phase 1 of the research brief, analysing existing research dealing with long term social, environmental and economic change of relevance to the TAYplan area and highlighting potential research gaps. It will provide the foundation for Phase 2 of the study which aims to prioritise and develop a number of specific research questions for future study in collaboration with the project funders and other TAYplan stakeholders.

Annex 1

References

Ref No.	Title	Author	Date	URL or Publication
1	Adapting to climate change: a Greater Manchester policy perspective. Ecocities project.	Carter J and Connelly A	2012	http://www.adaptingmanchester.co.uk/documents/one-city-multiple-futures-two-scenarios-exploring-future-greater-manchester
2	Land use change scenarios for Greater Manchester: analysis and implications for climate change adaptation	Carter J	2012	http://www.adaptingmanchester.co.uk/documents/land-use-change-scenarios-greater-manchester-analysis-and-implications-climate-change
3	Adapting to Climate Change – a Greater Manchester Policy Perspective	Carter J and Connelly A	2012	http://www.adaptingmanchester.co.uk/documents/adapting-climate-change-greater-manchester-policy-perspective
4	Strategic Flood Risk Assessment	TAYplan / SEPA	2011	http://www.tayplan-sdpa.gov.uk/SFRA%20-%20TAYplan%20-%20May%202011.pdf/view?searchterm=Strategic Flood
5	Strategic Environmental Assessment	Perth and Kinross Council	2010	http://www.tayplan-sdpa.gov.uk/Environmental%20Report%202010.pdf
6	Scotland National Visitor Survey	Insights Dept	2012	http://www.visitscotland.org/research_and_statistics/visitor_research/all_markets.aspx
7	National Tourism Plan	Scottish Tourism Alliance	2012	http://scottishtourismalliance.co.uk/national-strategy-2/
8	St Andrews Tourism Destination Plan 2012-2016	Scottish Enterprise	2012	http://www.scottish-enterprise.com/your-sector/tourism/how-we-can-help/tourism-destination-development/tourism-destinations-st-andrews.aspx
9	Combating climate change – a role for UK forests	Read D J et al	2009	www.forestry.gov.uk/climatechange

10	The state of the natural environment, land use and the future of forestry	Moffat AJ, Quine C P, and McKay H	2009	http://www.bis.gov.uk/assets/for esight/docs/land-use/jlup/er32 the state of the natural environment land use and forestry.pdf
11	Land use and the state of the natural environment	Potschin M	2009	http://www.bis.gov.uk/assets/for esight/docs/land-use/jlup/20 land use and the s tate of the natural environmen t.pdf
12	Possible Opportunities for Future Forest Development in Scotland: A scoping study	Towers W, Schwarz G, Burton R, Ray D, Sing L, Birnie R V.	2006	www.forestry.gov.uk/website/forestry.nsf/byunique/infd-6mgfky
13	Impacts of climate change on forests in Scotland – a preliminary synopsis of spatial modelling research	Ray D	2008	http://www.forestry.gov.uk/pdf/fcrn101.pdf/\$FILE/fcrn101.pdf
14	The evidence supporting the use of continuous cover forestry in adapting Scotland's forests to the risks of climate change	Stokes V and Kerr G	2009	www.forestry.gov.uk/pdf/CCF_and_Climate_Change_Report.pdf/\$FILE/CCF_and_Climate_Change_Report.pdf
15	Potential impact of drought and disease on forestry in Scotland	Green S and Ray D	2010	www.forestry.gov.uk/pdf/fcrn004.pdf/\$FILE/fcrn004.pdf
16	Woodland Expansion GIS project	Towers et al	2011	http://www.forestry.gov.uk/website/forestry.nsf/byunique/infd-8meebv (paper WEAG6)
17	Scottish Enterprise Six Destinations Study	Scottish Enterprise	2011	http://www.evaluationsonline.org.uk/evaluations/Search.do?ui=basic&action=show&id=459
18	European Forest Sector Outlook Study II 2010-2030	UNECE/FAO	2011	http://www.unece.org/efsos2.html
19	UK National Ecosystem Assessment	Watson R and Albon S (lead authors)	2011	uknea.unep-wcmc.org
20	Trends of change in coastal landforms and processes	McManus J.	2012	http://www.dpea.scotland.gov.uk/Documents/qj13769/J211150.pdf

21	Report 420: Strategic assessment of the value and state of Scotland's geodiversity: an assessment of potential approaches to the economic and social evaluation of geodiversity	Mydall D, Birch J and Knapman D	2012	<u>SNH Commissioned Report 420: Strategic assessment of the value and state of Scotland's geodiversity: an assessment of potential approaches to the economic and social evaluation of geodiversity</u>
22	Report 490: Green networks and people: A review of research and practice in the analysis and planning of multi-functional green networks	SNH	2011	<u>SNH Commissioned Report 490: Green networks and people: A review of research and practice in the analysis and planning of multi-functional green networks</u>
23	Report 488: An assessment of the impacts of climate change on Scottish landscapes and their contribution to quality of life	Land Use Consultants	2011	<u>SNH Commissioned Report 488: An assessment of the impacts of climate change on Scottish landscapes and their contribution to quality of life: Final report</u>
24	Report 398: Assessing the value of nature based tourism in Scotland	Bryden D, Westbrook S et al	2010	<u>135. SNH Commissioned Report 398: Assessing the value of nature based tourism in Scotland (2010)</u>
25	Sustainable building guidance	Sust	various	<u>http://www.ads.org.uk/sust/guidance/sust-guidance</u>
26	Climate change burdens	Sust	2012	<u>http://www.ads.org.uk/sust/guidance/guidance-on-the-application-of-successful-climate-change-burdens</u>
27	Local development and health assets	A+DS Health	no date	<u>http://www.ads.org.uk/healthierplaces/features/local-development-public-assets</u>
28	Education, buildings, places	A+DS schools	various	<u>http://www.ads.org.uk/smarterplaces/features</u>
29	Learning towns: an assets approach to learning in place	A+DS schools	various	<u>www.learningtowns.org</u>
30	Masterplans: lessons learned from design review	A+DS Design Forum	2009	<u>http://www.ads.org.uk/designforum/features/lessons-learned-from-design-review-masterplans</u>

31	Working together to deliver better masterplans	A+DS Design Forum	2011/12	http://www.ads.org.uk/designforum/features/working-together-to-achieve-better-masterplans
32	Urban placemaking/leadership	A+DS Urbanism	2012	http://www.ads.org.uk/urbanism/features
33	An assessment of the sensitivity and capacity of the Scottish seascape in relation to offshore windfarms	Scott, K.E., Anderson, C., Dunsford, H., Benson, J.F. and MacFarlane, R.		http://www.snh.org.uk/pdfs/publications/commissioned_reports/F03AA06.pdf
34	Processing Planning Applications for National and Major Developments	Tribal Consulting. Shiel L, Hudson N and Richards F	2012	http://www.scotland.gov.uk/Resource/Doc/260282/0077466.pdf
35	Urban Networks For People and Biodiversity – Form and Function	SNIFFER	2008	http://www.sniffer.org.uk/files/3413/4183/8008/UEUB01_Final_report_e-version_May_2008.pdf
36	Ecological networks and River Basin Management Planning: Clyde Pilot Study	SNIFFER	2010	http://www.sepa.org.uk/science_and_research/publications.aspx
37	Economic Contribution Study: An Approach to the Economic assessment of Arts and Creative Industries in Scotland	DC Research	2012	http://www.creativescotland.com/sites/default/files/editor/ECS_-_Final_Report_June_2012.pdf
38	High Rise Hope: The social impact of energy efficient retrofit in large multi-storey tower-blocks	LSE and Rockwool	2012	http://www.rockwool.co.uk/solutions/facade+systems/high+rise+hope
39	Scotland's Digital Future	Scottish Government	2011	http://www.scotland.gov.uk/Resource/0040/00404183.pdf
40	Global Europe 2050	EU DG Research and Innovation	2011	http://ec.europa.eu/research/social-sciences/pdf/global-europe-2050-report_en.pdf
41	Creating strong communities: how to measure the social sustainability of new housing	Social Life and Dixon T	2012	http://www.berkeleygroup.co.uk/media/pdf/k/o/9441_002_BG_Social_Sus_essay_LR.pdf
42	If you want a city of the future, ditch yesterday's rules	Horton T	2012	New Start, Sep, p10-13

43	Addressing the social determinants of health: the urban dimension and the role of local government	Grady M and Goldblatt P	2012	http://www.euro.who.int/en/wh-at-we-publish/abstracts/addressing-the-social-determinants-of-health-the-urban-dimension-and-the-role-of-local-government
44	Low carbon cities can kickstart the economy	Burton M	2012	Local Government News 34-7 pp10-11
45	Foresight Project: land use futures, one year review Feb 2010 - May 2011	Foresight, Gov office for Science	2012	http://www.bis.gov.uk/assets/foresight/docs/land-use/12-1128-land-use-futures-one-year-review
46	City Regions: Final Report	Hayward et al	2012	http://wales.gov.uk/docs/det/publications/120710cityregionsfinalrpten.pdf
47	Smart cities in Europe	Caragliu A et al	2011	Journal of Urban Technology, 18,2, pp65-82
48	Creating smarter cities An overview	Allwinkle S and Cruikshank P	2011	Journal of Urban Technology, 18,2, pp1-16
49	Smart growth and economic development: connecting economic development and land use planning using the example of high tech firms	Wlodarczak D	2012	Environment and Planning A , 44,5, pp1255-1269
50	The triple helix model of smart cities	Deakin M et al	2011	Journal of Urban Technology 18,2, pp53-63
51	The future of sustainable cities	Cosgrave E	2012	Sustain, March/April, pp30-32
52	Climate Ready Clyde Project	Adaptation Scotland	2012	http://www.adaptationscotland.org.uk/4/110/0/Area-based-project--Climate-Ready-Clyde.aspx
53	Adapting to climate change in health and social care	BIOPICCC	2012	http://www.dur.ac.uk/resources/geography/BIOPICCC/Adaptingtoclimatechangeinhealthandsocialcare.pdf
54	Factors affecting future demand for electric vehicles	Shepard S, Bonsal PI, Harrison G	2012	Transport Policy 20, pp62-74
55	Imagining city futures: the use of prospective through scenarios in urban planning	Radcliffe J and Krawczyk E	2011	Futures 43 pp642-653
56	Pluvial (rain-related) flooding in urban areas: the invisible hazard	Houston D, Geddes A et al	2011	http://www.irf.org.uk/sites/files/irf/urban-flood-risk-full.pdf

57	Flood Insurance Provision and Affordability: Beyond the Statement of Principles: Implications for Scotland	Ball, T, Werrity, A, Geddes A, Black A, Easton	2012	http://www.scotland.gov.uk/Resource/0039/00397678.pdf
58	A delphi survey of immigration to the UK to 2060 with particular reference to environmental mobility	Findlay A, et al	2012	A delphi survey of immigration to the UK to 2060 with particular reference to environmental mobility
59	Green Health Project	Ward Thompson C, Roe J, Aspinell P, Zuin A, Bell S	2012	http://www.openspace.eca.ac.uk/researchprojects_openspacecontributionpublichealth.php
60	Community green: using local spaces to tackle inequality and improve health	Ward Thompson C, Roe J, Aspinell P, Zuin A, Travlou P, Bell S	2010	http://www.openspace.eca.ac.uk/researchprojects_Not_so_green_and_pleasant.php
61	Climate change and health and social care: Defining future hazard, vulnerability and risk for infrastructure systems supporting older people's health care in England	Oven KJ, Curtis SE, et al	2012	Applied geography, Vol 33, pp16-24 http://www.sciencedirect.com/science/article/pii/S0143622811000956
62	Influence of seasonal weather and climate variability on crop yields in Scotland	Bell I	2012	http://link.springer.com/article/10.1007/s00484-012-0588-9
63	Climate change, drought risk and land capability for agriculture: implications for land use in Scotland	Brown et al	2011	Regional Environmental Change 11,2, pp 503-518
64	Estimating carbon price in a low emissions trading system in the agricultural sector	Bakam et al	2011	Journal of Land Use Science, 7, 2
65	Developing carbon budgets for UK agriculture, land use land use change and forestry to 2022	Moran et al	2011	Climatic Change, 105, pp529 - 553
66	Building sustainability assessment methods	AlWaer, H and Kirk R	2011	http://www.icevirtuallibrary.com/content/article/10.1680/ensu.10.00058
67	The application of visual environmental economics in the study of public preference and urban greenspace.	Laing, R.; Davies, A.M.; Miller, D.R.; Conniff, A.; Scott, S.; Morrice, J.G	2009	Environment and Planning B, 36, 355-375

68	Increasing the Resilience of Vulnerable Citizens to Natural Hazards and Disasters	Hall E, Kroll T and Dawson S	2012	File saved
69	Energy 2050 Pathways Analysis	Department of Energy and Climate Change	2010	http://www.decc.gov.uk/en/content/cms/tackling/2050/calculator_exc/calculator_exc.aspx#
70	Energy 2020: A strategy for competitive, sustainable and secure energy	DG Energy	2010	http://ec.europa.eu/energy/strategies/2010/2020_en.htm
71	Urban Climate Resilience	Urban Nexus	2012	http://www.sniffer.org.uk/news-diary/synthesis-report-urban-climate-resilience/
72	Scottish Energy 2020	IME	2011	http://www.imeche.org/Libraries/2011_Press_Releases/IMechE_Scottish_Energy_Report.sflb.ashx
73	Mapping Study for GOOD PLACES, BETTER HEALTH. Practice, what works?	Rawlence S	2011	http://www.sniffer.org.uk/files/7713/4183/7427/GPBH_Practice_Mapping_study_final.pdf
74	e-inclusion in ageing Europe	iAge: Gilmour D	2012	http://www.iageproject.eu/
75	Animated Virtual Agents to Cue User Attention	Martinez, S., Sloan, R., Szymkowiak, A. & Scott-Brown, K.	2011	http://www.thinkmind.org/index.php?view=article&articleid=intsys_v4_n34_2011_19
76	SUDS and Green Infrastructure	Duffy A	Forthcoming	http://sudsnet.abertay.ac.uk/presentations/National%20Conf%202012/SUDSnet_2012_ConferenceBook_web.pdf
73	Wellington Towards 2040	Wellington City Council	2011	http://www.wellington2040.co.nz/unfolding-future/megatrends
78	Auckland Sustainability Framework	Auckland Regional Growth Forum	2007	http://www.aucklandoneplan.org.nz/subsites/fms/OnePlan/Supporting%20Documents/ASF/Auckland%20Sustainability%20Framework.pdf
79	Magnetic South: Exploring a future for Christchurch together	Landcare Research	2011	http://magneticsouth.net.nz/

80	Development of deep geothermal energy resources in the UK	Younger, P.L., J.G. Gluyas, and W.E. Stephens	2011	Energy, 164, pp1-14
81	The Futures Report	Global Futures and Foresight	2011	http://www.thegff.com/Groups/175830/Global_Futures_and/Reports/The_Future_report/The_Future_report.aspx
82	Enhancing urban sustainability using 3D visualisation.	Isaacs, J., Falconer, R., Blackwood, D. & Gilmour, D.	2011	http://www.icevirtuallibrary.com/content/article/10.1680/udap.900034
83	Calculating carbon budgets of wind farms on Scottish peatlands	Nayak, D.R.; Miller, D.R.; Nolan, A.J.; Smith, P.; Smith, J.U.	2010	Mires and Peat, 4, Special Volume: Wind Farms on Peatland, 2008-2010, Article 9, 1-23
84	Sustainable development indicators for major infrastructure projects.	Gilmour D., Blackwood, D., Banks, I. and Wilson, F.	2011	http://www.icevirtuallibrary.com/content/article/10.1680/muen.800020
85	Building Sustainability Awards 2010 - Sustainable Innovation of the Year	AlWaer H and Croome D	2011	http://www.urbansustainabilityexchange.org.uk/media/ISSUEsevents/IDCOP%20SUBET%20Revised.pdf
86	Key performance indicators (KPIs) and priority setting in using the multi-attribute approach for assessing sustainable intelligent buildings	AlWaer H and Croome D	2009	Building and Environment 45 (2010) 799–807
87	Smart green cities: from modernisation to resilience?	Antrobus	2011	Urban Research and Practice 4,2, pp 207-214
88	Holding the future together: towards a theory of the spaces and times of transitionisation	Brown G et al	2012	Planning and Environment A 44-7, pp1607-1623
89	SWITCH Policy Briefing Note 4. Managing the Transition of Urban Water Systems.	Duffy A., Jefferies C., Fisher J.	2010	http://www.switchurbanwater.eu/outputs/pdfs/WP1-3_GEN_PBN_Managing_the_transition_of_urban_water_systems.pdf
90	The SWITCH Transition Manual.	Jefferies C., Duffy A.	2011	
91	Smart cities, smart places, smart democracy: Form-based codes, electronic governance and the role of place in making smart cities	Walters D	2011	http://www.mires-and-peat.net/map04/map_04_09.pdf

92	Energy ready reckoner	Cogentsi: Higgins J and Gibson H	2011	http://www.evaluationsonline.org.uk/evaluations/Browse.do?ui=browse&action=show&id=446&taxonomy=LMS
93	Scotland's census as a research resource. In Scotland's Population 2010	Graham, E, Findlay A, McCollum D, Popham F and VanDam M	2010	http://www.gro-scotland.gov.uk/files2/stats/annual-review-2010/rgar2010.pdf
94	The role of map-based environmental information in supporting integration between river basin planning and spatial planning	Smith, H.M.; Wall, G.; Blackstock, K.L	2012	Environmental Science and Policy. Published online
95	Legislation relevant to coastal flooding. Chapter 2 In: Coastal Flooding in Scotland – A Guidance Document for Coastal Practitioners	Werritty, A. and Duck, R.W	2012	Centre of Expertise for Waters (CREW), The James Hutton Institute and The Scottish Government.
96	A decade of delivering sustainable coastal zone management: The Tay Estuary Foru	Booth L and Duck RW	2012	http://www.crew.ac.uk/sites/www.crew.ac.uk/files/publications/Peat_PES_Briefing%20Note_final.pdf
97	Low Carbon Land Use Innovation Network	(LoCal -Net): Gilmour D	Forthcoming	http://localnet.abertay.ac.uk/
98	The macroeconomic benefits of investment in offshore wind	CEBR	2012	http://www.mainstreamrp.com/content/reports/benefits-of-offshore-wind.pdf
99	Immersive and Non immersive 3D virtual city: Decision support tool for urban sustainability	Isaacs J P, Gilmour D, Blackwood D, Falconer R	2011	http://www.itcon.org/cgi-bin/works/Show?2011_10
100	A Water Vision for Johnstone 2007	Duffy A, Jefferies C	2008	http://web.sbe.hw.ac.uk/staffprofiles/bdgsa/11th_International_Conference_on_Urban_Drainage_CD/ICUD08/pdfs/611.pdf
101	Demographic Change Towards a new spatial agenda for the north sea region	UWE	2005	http://www.northsearegion.eu/files/user/File/Norvision/Demographic%20Change.pdf
102	The Greenhouse Gas Regional Inventory Protocol: Tayplan Strategic Development Planning Authority	Carbon Captured Ltd	2011	http://www.tayplan-sdpa.gov.uk/publications
103	Planning our electric future: a white paper for secure, affordable and low carbon electricity	UK Government	2011	http://www.decc.gov.uk/assets/decc/11/policy-legislation/emr/2176-emr-white-paper.pdf

104	Towards a Zero Carbon Vision for UK transport	Stockholm Environment Institute	2010	http://www.sei-international.org/mediamanager/documents/Publications/SEI-ProjectReport-Whitelegg-TowardsAZeroCarbonVisionForUKTransport-2010.pdf
105	Exploring public attitudes to climate change and travel choices	Department for Transport	2009	http://webarchive.nationalarchives.gov.uk/20100413203302/http://www.dft.gov.uk/pgr/scienceresearch/social/climatechange/
106	Selling Sustainability in SKINT (SSIS)	SKINT Berwick N	2012	http://www.skintwater.eu/skint/nl/skint-water-series-ii
107	Scotlands Environmental web partnerships	SEWeb: Isaacs J	Forthcoming	http://www.environment.scotland.gov.uk/
108	AGILE Interface for 'No-Learning nor Experience required' Interaction	Martinez, S. Carrillo, A.L., Scott-Brown, K. and Falgueras, J.	2013 in press	
109	A cost comparison of traditional drainage and SUDS in Scotland	Duffy, A., Jefferies, C. Blackwood, D., Waddell, G., Shanks, G. and Watkins, A.	2008	http://www.iwaponline.com/wst/05709/09/default.htm
110	Implications of land use and climate change for water balance in Scotland	Brown I et al	2012	IWA World Congress
111	Making Asset Investment Decisions for Wastewater Systems that include Sustainability.	Ashley R, Blackwood D, Butler D, Jowitt P, Davies J, Smith H, Gilmour D, and Oltean-Dumbrava C.	2008	http://ascelibrary.org/doi/abs/10.1061/%28ASCE%290733-9372%282008%29134%3A3%28200%29?journalCode=ioeedu
112	Sustainable coastal Management in Practice.	Gilmour D	Forthcoming	http://www.northsearegion.eu/ivb/projects/details/&tid=118
113	Investigating Factors Affecting Anaerobic Digestion of Ascophyllum Nodosum Species of Seaweed	Akunna J C and Kwiatkowska B	2012	Proceedings Venice 2012, Fourth International Symposium on Energy from Biomass and Waste
114	International Review of Behaviour Change Initiatives	Southerton, D, McMeekin A and Evans D	2011	http://www.scotland.gov.uk/Publications/2011/02/01104638/0
115	Mitigating Transport's Climate Change Impacts in Scotland	Atkins	2009	http://www.scotland.gov.uk/Publications/2009/08/26141950/0
116	Low Carbon Scotland : Meeting the Emissions Reduction Targets 2010 – 2022	Scottish Government	2011	http://www.scotland.gov.uk/Topics/Environment/climatechange/scotlands-action/lowcarbon/rpp

117	Agriculture and Climate Change	Hallam A, Bowden A and Kasprzyk K	2012	http://www.scotland.gov.uk/Publications/2012/10/9121
118	Impact of Workbased Initiatives on Low Carbon behaviours	Cox A, Higgins T, Gloser R, Foley B and Darton A	2012	http://www.scotland.gov.uk/Resource/0039/00390309.pdf
119	Digital Participation in Scotland	Myant K	2012	http://www.scotland.gov.uk/Publications/2011/12/22155754
120	2002-2012 A decade of territorial evidence Trends in Economic Performance of European Regions 2000-2006	ESPON	2010	http://www.espon.eu/main/Menu_Publications/Menu_Territorial_Observations/trendseconomicperformance.html
121	Development of a methodology for predicting the impact of demographic change and urban development on biodiversity	SNIFFER	2008	http://www.sniffer.org.uk/files/7313/4183/7999/UEUB02_final_report_web.pdf
122	Tactran Transport Carbon Assessment	Atkins	2012	http://www.tactran.gov.uk/documents/121211Item6ClimateChangeDutiesAppendixA.pdf