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Sustainable Development Council

**Adapting to Climate Change:
The Challenge Ahead for Local Government**

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EXECUTIVE SUMMARY

Climate change is already being experienced globally, and its impacts are expected to become more prominent. Ireland is now on average 0.7°C warmer than a century ago and six of the ten warmest years have occurred since 1995. Overall, Ireland can expect more seasonal rainfall, with wetter winters and drier summers on average (Sweeney et al. 2007). Adaptation actions are taken to cope with a changing climate in the present or, importantly, to anticipate such changes in the future and plan accordingly. However, even if emissions of greenhouse gases stop today, these changes would continue for many decades. For this reason, actions to adapt to climate change in Ireland must be combined with greenhouse gas mitigation measures.

In local communities, the impact of climate change will be clearly felt and many of the consequences of climate change will be addressed by local authorities. The aim of this paper is to examine the implementation of adaptation policies in Ireland at both national and local level. This will not only feed into the development of the National Adaptation Strategy, but will also focus on the integration of climate change adaptation in local authority planning and actions.

METHODOLOGY

The purpose of this paper is to examine best practice, current practices and identify gaps to be considered in the development of future local adaptation plans. A desktop research approach has been utilised to collate information from published reports and documents from various sources including governments, research institutes and non-governmental organisations. Adaptation is an emerging research area and there is a growing body of literature available. Most of the literature was obtained from international sources. In Ireland, there is limited research addressing the future impact of climate change on the economy and society and assessing national adaptation options. Six¹ recent Local Development Plans have been examined in this

¹ The six development plans examined were Clare Development Plan, Galway City Development Plan, Kilkenny Development Plan, Monaghan Development Plan, Sligo Development Plan, Wexford Development Plan.

research for their treatment of climate change and the inclusion of adaptation policies.

The authors found that the concept of sustainable development is generally included in development plans. Climate change was also addressed in some of the development plans reviewed, but less comprehensively. In terms of climate change policy, the focus tends to be on mitigation, especially energy issues, such as reducing energy usage and increasing renewables, as opposed to adaptation. Dublin City Council has led the way in terms of climate change policy and developed a climate change strategy which deals with waste, transport, planning, energy and biodiversity. Adaptation to climate change was mentioned explicitly in one of the development plans reviewed. Some adaptation measures are implicitly included in the other development plans, especially in relation to water issues, although they are not linked to climate change as an issue.

Adaptation is a relatively new policy area which has come to the fore in Europe in 2007 with the publication of a Green Paper. In Ireland, the Department of Environment, Heritage and Local Government is currently drafting a national plan on adaptation. In this context, it is not surprising that adaptation is not yet a key concern in local authority development plans. There are many aspects to the issue of adaptation to climate change in Ireland and the following summarises the main recommendations of this paper by sectoral actions, which should be integrated into a holistic adaptation policy.

A RISK MANAGEMENT APPROACH TO FLOODING

Due to rising sea levels and more intense rainfall Ireland will face more flooding. Planning authorities have a key role in flood prevention and protection. Plans dealing with the assessment and management of floods should focus on prevention, protection and preparedness. The preparation of general plans for managing flood risks and devising an inventory of risk sites which suffer the most from floods is essential. Local authorities should abide by a no-regret strategy, which ensures flooding and other adaptation issues are fully considered before development. A shift away from structural or constructed flood defence measures to non-structural measures, emphasising a risk management approach is recommended.

MAINTAINING WATER SUPPLY

While Ireland has one of the highest rates of water availability in Europe, increased temperatures will reduce water supplies, which are essential for domestic consumption, industry, agriculture and maintaining biodiversity. Economic instruments and the user pays principle should be applied across all sectors, providing strong incentives to reduce water consumption and increase efficiency of use.

Leakage detection work is critical when it comes to protecting water supply. The Department of Environment, Heritage and Local Government's National Water Study (2000) found that up to 47% of all water produced by treatment plants surveyed is unaccounted for. There is strong evidence that preventing water leakage is a practical, realistic and economic way of meeting much of the extra demand for water.

COASTAL AREAS

To protect citizens living in coastal areas, it is crucial to integrate risks associated with coastal erosion into planning and development and the National Spatial Strategy. A reliable, controlled tide-gauge network with a data processing and archiving system needs to be established in Ireland in order to monitor sea level changes and provide real time feedback to a coastal flood warning system.

FOOD PRODUCTION

The changes in temperature and rainfall and increase in extreme weather events will have a significant effect on agriculture, putting global food supply at increasing risk. Integrated farming systems and integrated cropping systems can vastly increase our adaptive capacity through protecting soil, water and other resources. These issues need to be addressed in the policy processes at national level, in consultation with relevant parties at national and local level. Allotments, community gardens and urban vegetable growing are practical ways of strengthening urban resilience.

FISHERIES

Climate change can affect the distribution patterns, migration patterns and abundance of species, which may result in major changes in ecosystem functions

and geographical ranges in aquatic stock. Over-exploitation is one of the most threatening factors to sustainable fish stocks in Europe. Fishery systems should be built on monitoring and feedback management strategies in which fishing effort and catches are regularly modified based on the level and strength of the stock. Local authorities are not generally responsible for fishing concerns but actions in their sphere of activity can impact on fish stocks. Maintaining high water quality through monitoring the affect of development and drainage, especially in areas with strong fish stocks is important. Local authorities must work the relevant national fishery bodies to maintain and improve aquatic life in Ireland.

FORESTRY

Forests can help human societies adapt to climate impacts through absorbing water and increasing biodiversity. Local Authorities have been drafting County Indicative Forestry Strategies to inform decisions and highlight potential locations for future forestry planting in the county. There should be a focus on ensuring a proportion of all new forestry development consists of native hardwood species, which improves biodiversity. Forestry can be advanced in rural areas through farm forestry schemes incorporating woodland into the countryside. In urban areas, existing and new trees should be integrated into development.

BIODIVERSITY

The diversity of life on earth has substantially and, in many cases, irreversibly decreased. Healthy ecosystems are more resilient to climate change and more able to maintain the supply of natural resources on which our prosperity and wellbeing depend. They lie at the centre of any adaptation policy. Local biodiversity plans where they have not already been published should be developed as quickly as possible. These should implement conservation management plans and encourage private land conservation.

Protected areas are vital to biodiversity conservation. Ireland needs to ensure the integrity, coherence and connectivity of the Natura 2000 network. These should also account for distributional change among species.

Biodiversity needs to be a primary concern for all citizens. Biodiversity should be linked to agricultural, marine, fishery and infrastructure development practices in a more coherent manner.

INFRASTRUCTURE

Today's investments must take full account of the conditions projected for the end of the century. In Ireland, more rainfall will increase the risk of flooding of roads, houses and infrastructure located in flood plains or in coastal areas. To cope with this, there is a need to increase monitoring and maintenance activities and to make provision for adaptation measures in all future infrastructure on this island. In addition, it is necessary to study the vulnerability of municipal technology to the impacts of climate change, such as energy and water supply.

Spatial planning should provide an integrated framework to link up vulnerability and risk assessment with adaptive capacities and adaptation responses, thus facilitating the identification of policy options and cost-efficient strategies.

FINAL MESSAGES

In the absence of tight or strong national, regional, local and municipal authority co-ordination, it is doubtful that adaptation actions and flood management will ever be more than reactive. The forthcoming national adaptation strategy should address this. At the moment agencies and authorities are competing on a case by case basis with each other for scarce central government funding. In addition, there is no overarching advisory body dealing with adaptation measures. The effects of climate change impact on different sectors simultaneously and the response of one sector can have an effect on another. For this reason, it is necessary to designate responsibility to one well-resourced co-ordinating body. This high-level strategic adaptation body should collaborate fully with counterparts in the North.

A full impact assessment which examines the effects of climate change on economic and socio-economic factors needs to be conducted. This assessment should bring together research on all of the effects of climate change to provide a comprehensive

overview of the key issues we face going into the future. Some additional potential issues, beyond what has been mentioned above, include the effects of climate change on health, tourism, insurance, enterprise, individual well-being and people in poverty.

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Chapter One – Introduction

The aim of this paper is to carry out research on the implementation of adaptation policies in Ireland at both national and local level. This will not only feed into the development of the National Adaptation Strategy, but will also focus on the integration of climate change adaptation in local authority planning and actions. The purpose of this paper is to examine best practice, current practices and identify gaps to be considered in the development of future local adaptation plans. A desktop research approach has been utilised to collate information from published reports and documents from various sources including governments, research institutes and non-governmental organisations. Recent Local Development Plans have been examined for the inclusion of adaptation policies in local authority policy.

The paper will begin by highlighting adaptation issues and impacts that are specific to Ireland's unique climate, geography and infrastructure, as well as providing background information on current adaptation policy. Then the various adaptation issues are presented in three chapters on water, biodiversity and agriculture, and infrastructure, with each covering a set of related and often overlapping topics. In each of these chapters, adaptation practice and policy is examined using a consistent framework. Firstly, a general background on each topic is provided. This is then followed by an exploration of international best practice in adapting to climate change. Through examining international examples, practical actions are identified that Ireland may be able to adopt in preparing for, protecting against and reacting to the various effects of climate change. These are discussed in line with practices currently being implemented in Ireland to identify gaps and potential future strategies.

The paper focuses on local government and adaptation, exploring what adaptation measures local authorities and councils are implementing. It is in local communities that the impact of climate change will be felt and many of the consequences of climate change will be addressed by local authorities. There are 34 local authorities in Ireland in total, including twenty nine county councils and five city councils. This paper examines adaptation issues in six Local Development Plans drawn up by local authorities in Ireland. A careful approach was taken in choosing the sample with a

number of predetermined factors considered. Each plan chosen was published in or after 2005, as it was felt that any plan published more than four years ago would not reflect the prominence of climate change issues in the media and global policy arena since then and would be somewhat outdated for this paper's research purposes. The plans were also selected in terms of geographical location of the county, population density and the urban and rural split of each county. A reasonable attempt was made to select a good mix of inland and coastal areas from different provinces. The close of the paper lists further strategy and policy recommendations on adaptation actions for Ireland. While this paper focuses on adaptation actions at local level, national recommendations have been included in the appendices.

1.1 What is Adaptation?

The IPCC (2007) has warned that the warming of the planet is unequivocal, with increased temperatures in global average air and ocean temperatures, melting of snow and ice and rising mean sea levels. While global average temperatures have always risen and fallen, the recent rate of global warming does not reflect natural climate changes. The rising average temperatures are due to increases in greenhouse gas concentrations. Greenhouse gases, such as carbon, keep the planet warm by absorbing and re-emitting infrared radiation that would otherwise escape into space. Over the last 400,000 years carbon dioxide levels in the atmosphere have been between 200-300 parts per million. Due to land use changes and excessive use of fossil fuels since the industrial revolution, carbon dioxide levels are now at their highest point for 800,000 years, at over 380 parts per million (Greater London Authority 2008).

The prevention of severe climate change through global cuts in greenhouse gas emissions is the central focus of the EU's climate change policy. The aim is to keep global average temperature increases below 2°C compared to pre-industrial levels. If temperature increases break this threshold then the risk of dangerous and unpredictable climate change increases significantly. However, even if emissions of greenhouse gases stop today, carbon dioxide levels would take 50-150 years to reduce. Carbon dioxide emitted in the last century will not be absorbed back into the

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oceans and forests until the middle of the 21st century and are still present in the atmosphere today. Gases build up in the atmosphere due to time lags in the response of climatic and oceanic systems to changes in the atmospheric concentration of the gases. For this reason, mitigation measures must be combined with adaptation actions to allow societies worldwide to adjust to the inevitable impacts of climate change (Greater London Authority 2008).

The International Panel on Climate Change (IPCC) defines adaptation as “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities” (Adger et al. 2007). Adaptation actions are taken to cope with a changing climate in the present or, importantly, to anticipate such changes in the future and plan accordingly. Such actions include using scarce water more efficiently, constructing flood walls, raising the level of dykes against sea level rise and developing drought-tolerant crops/forestry species and practices that are less vulnerable to storms and fires. All of these measures are in response to the increased rainfall, higher temperatures, scarcer water resources and more frequent extreme weather events that climate change brings (IPCC 2007).

The European Environment Agency (EEA 2005) has identified four main challenges in making progress in relation to climate change adaptation. Firstly, it is impossible to predict the exact effects of climate change, which makes strategic planning difficult. Climate change models and regional indicators are necessary to reduce some of the uncertainty surrounding the effects of climate change. Secondly, there are significant gaps in our current knowledge about adaptation, responses and long term planning needs. This is confounded by a lack of policy guidance and institutional support. Finally, there is insufficient co-ordination between different government departments, sectors in society and different countries. There is a need to share information and best practice. To this end, some global examples have been collected in order to examine how Ireland can best adapt.

Chapter Two – Adaptation Policy and Governance

2.1 Adaptation Policy in the EU

In 2000, the United Nations Economic Commission for Europe (UN ECE 2000) published a report on sustainable flood prevention. This document highlighted the need to manage flooding risk, as opposed to relying on delayed reaction. In 2004, the Water Directors of the EU built on this document and examined best practice for flood prevention. Significantly, this document presented a foundation for an EU Directive on flooding².

The European Commission (2007) has published a green paper on the subject of adapting to climate change. This document focuses on the inevitability of adverse impacts of climate change and the need to introduce adaptation measures to lessen these effects. Furthermore, it recognises more diverse effects of climate change than explicitly water issues. The Green Paper sets out four pillars or priority areas for action.

The first priority is early action in developing adaptation strategies, especially in areas where current knowledge is insufficient. Preventative action based on the precautionary principle is preferable to ad-hoc, incremental reactions. In addition, strengthening natural resilience is preferable to engineering solutions. The paper recognises key sectors for early action such as agriculture, industry, energy, transport, water, marine and biodiversity. Adaptation must be factored into the conceptual stage of all new policies and must also be integrated into existing policies and funding instruments. The second priority is the integration of global adaptation needs into the EU's external relations and the necessity to build new alliances with partners around the world. Adaptation is important for the achievement of UN

² In 2007 Directive 2007/60/EC which addresses the assessment and management of flood risk came into force. **This Directive requires member states to assess if all water courses and coast lines are at risk from flooding, to map the flood extent and assets and humans at risk in these areas and to take adequate and co-ordinated measures to reduce this flood risk. For more information see:**
http://ec.europa.eu/environment/water/flood_risk/index.htm

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Millennium Development Goals, especially in sub-Saharan Africa. The third pillar relates to filling knowledge gaps on adaptation through EU-level research. The EU holds an important position in co-ordinating research through the seventh Framework Programme for Research, which has a strong focus on climate change. The Green Paper highlights areas where adaptation could be integrated into existing and upcoming legislation. The final priority is to set up a European advisory group, involving EU society, business and the public sector, which will analyse co-ordinated strategies and actions on adaptation to climate change.

Comhar SDC made recommendations on the EU Green Paper on adaptation in 2007. The EU is moving towards developing a white paper on adaptation to climate change, which is due to be adopted in autumn 2008. Ireland needs to plan how to implement such concerns at national and local level.

2.2 Adaptation Policy in Ireland

The main report addressing climate change in Ireland is the second National Climate Change Strategy 2007-2012, which was published by the Department for Environment, Heritage and Local Government (DOEHLG 2007). This paper briefly addresses adaptation. It outlines some of the predicted impacts of climate change in Ireland and discusses some measures for tackling these effects. It mostly concentrates on flooding and refers to the report of Flood Policy Review Group (Flood Policy Review Group 2004). There is also consideration of the Planning and Development Act 2000. This legislation empowers planning authorities to regulate, restrict and control development in areas at risk of flooding. However, other areas need to be incorporated into national strategies, such as food production, forestry, biodiversity, industry, energy, transport, communications, land use, health, tourism, recreation and extreme events planning.

The review of the first National Climate Change Strategy by the Department of Environment, Heritage and Local Government in 2006, 'Ireland's Pathway to Kyoto Compliance', recognised the urgent need to develop action and policy on adaptation, to support mitigation efforts. A future aim is to integrate climate change

considerations in policy making and provide a framework for policy makers, in the same way that the potential impact of insurance and operational costs are considered in today's policy proposals. The Government is committed to developing a comprehensive National Adaptation Strategy over the next two years. The intention of the proposed strategy is to provide a framework for the integration of adaptation issues into decision-making at national and local level. The Department of Environment, Heritage and Local Government published a draft set of guidelines on adapting planning and development practices for local authorities in 2008. This will feed into the National Adaptation Strategy; there is currently no Adaptation Strategy in place for Local Authorities.

2.3 Local Governance in Ireland

Local government in Ireland is currently composed of twenty nine county councils, five city councils and eighty town councils, as well as eight regional authorities. Local elections are held every five years. In these elections citizens vote for councillors, the elected representatives of the local authorities that collectively make up the council. The council is responsible for policy making and financial matters within local authorities. The everyday administration is conducted by the executive. However, in practice these roles overlap. Local government in Ireland has a more limited range of statutory functions than local government in most other European states and the relationship between local and national government is centralised in nature. Local Authorities play a direct role in addressing adaptation to climate change through housing, planning procurement activities, awareness raising, and other statutory functions, for example street and traffic lighting (DOEHLG 2008a). Local governments can also facilitate this process through their capacity to network with local communities.

Working alongside local authorities are local development agencies such as Area Partnerships, Leader groups and County/City Enterprise Boards³. Local authorities and local development agencies are linked through County/City Development

³ County/City Enterprise Boards offer support for micro-enterprises. They are comprised of representatives with local interests to cultivate and expand local enterprise.

Boards, which were established in 2000 to address the challenge of improving the co-ordination of public services at local level. The thirty four boards, led by local government, are made up of representatives from local government, social partners, state agencies and local development agencies (DOEHLG 2008a).

While local authorities have a significant role to play in adaptation actions, in order to ensure progress, legislation and national policy are essential. A worldwide survey conducted by the International Council for Local Environmental Initiatives (ICLEI 2002) on the success of Local Agenda 21⁴ (LA21) initiatives found that complementary national policy correlates positively with the amount of local processes implemented. In an Irish survey on LA21, support from senior management and central government were cited as essential in securing progress (Centre for Cross Border Studies 2004).

2.4 Local Government Adaptation Policy in Ireland

In general, the concept of sustainable development is dealt with in local development plans. Some of the key issues at local level include land use changes, sustainable agricultural development, encouraging biodiversity, controlling pollution in waterways, developing native forests, encouraging the use of public transport over private transport and developing the built environment in a sustainable way through layout, density, design, technical specification and the re-use of material.

Climate change is also addressed in some of the development plans reviewed but less comprehensively. A recent development plan has incorporated recommendations from the most recent climate change strategy 2007-2012, including addressing issues such as reducing travel distance from home to work and maximising access to public transport. In terms of climate change, energy plans are very developed. Dublin City Council have led the way and developed a climate change strategy which deals with waste, transport, planning, energy and biodiversity.

⁴ LA21 is a management framework that encourages local authorities to develop more environmentally friendly and socially focussed policies and practices. LA21 emerged from an inter-governmental agreement at the UN conference on the environment and development in Rio de Janeiro in 1992.

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Adaptation as an issue is not dealt with as well. In terms, of policy it is relatively new, first addressed in Europe in terms of green paper in 2007 and is being developed nationally at the current time. The need to develop comprehensive adaptation plans has not filtered to local level as of yet. However, some aspects of adapting to climate change; especially in relation to water issues are recognised in some development plans. In addition, some adaptation measures are mentioned, although they are not linked to climate change as an issue.

For example,

- Plans have considered the effect of building on floodplains and set out guidelines in that regard.
- One of the newer plans reviewed applies a multiplication factor in designing surface water proposals to account for future changes.
- Every plan reviewed had provisions for growing native species of tree.
- All of the plans reviewed proposed the development of green areas for amenities. Green areas are also valuable in reducing flood risk, especially in urban areas.
- A number of plans promote the natural role of flood plains as flood defence.
- Several plans recognised the need to protect wetlands from development.

Chapter Three - Measurement and Modelling Adaptation to Climate Change in Ireland

To effectively manage the effects of climate change, it is important to be able to predict likely scenarios. Although future events can never be predicted without uncertainty, outlining expectations is incredibly valuable in long-term, strategic planning. Predictions are accomplished through modelling techniques that provide a numerical description of the processes that influence the climate. They mimic how the Earth's atmosphere is affected by the various processes that drive weather, including the carbon cycle, variations in solar intensity, and man-made greenhouse gas emissions. There are four main sources of uncertainty associated with climate models (Greater London Authority 2008);

- **Natural variability:** Climate describes the average weather conditions and its variability over a long period of time. There will be years that deviate from average or predicted trends. This reflects the complexity and natural variability of the climate, which must be incorporated in adaptation actions.
- **Modelling methodology and computing:** Models rely on assumptions and are therefore always imperfect.
- **Future emissions:** These cannot be ascertained with great certainty. Indeed, often several scenarios are modelled.
- **Scaling:** It is more difficult to predict local changes as opposed to global and regional changes (Greater London Authority 2008).

In Ireland, modelling work is overseen by the Community Climate Change Consortium for Ireland Project (C4I), which was established in 2003. Its main objective is to strengthen and support Irish climate change research. C4I hopes to achieve this aim through building the necessary capacity for carrying out regional climate modelling in Ireland and through providing support to Irish researchers employing climate model output in their work. It is based in the headquarters of Met Éireann, the Irish National Meteorological Service. C4I has recently published a report highlighting the possible effects of increasing temperatures in Ireland (C4I 2008).

C4I is currently involved in the development of Regional Circulation Models (RCM) which can be used to strengthen our understanding of the effects of climate change both nationally and regionally in Ireland. These RCMs are initially developed from General Circulation Models (GCM). GCMs model atmosphere, coupled with an oceanic counterpart, and provide climate information on grids with a horizontal spacing of typically 100-300 kilometres (C4I 2008). The GCM projections are of clear interest to planners and developers but, for many applications, the information does not provide adequate detail. This is where regional climate models come into play. A RCM provides a greater level of detailed output. It does this by focusing attention on a localised area, marked out on a much finer grid than the global model. As the regional model does not need to process data from the entire globe the computational load is greatly reduced and horizontal resolutions of 10-15 kilometres can be achieved. The RCM used by C4I was largely developed under the HIRLAM project, with Met Éireann as a partner, and was further developed for climate work by the Rossby Centre in Sweden, with contributions from C4I (C4I 2008).

Met Éireann is a partner in the ENSEMBLES project that is funded under the European Commission's sixth Framework Programme (Ensembles). The project's aim is to both quantify and reduce uncertainty associated with climate modelling in Europe. To achieve this aim, the project is employing both global and regional climate models using an ensemble approach. Met Eireann is also a partner in the EC-EARTH project. EC-EARTH aims to develop a state-of-the art Earth System Model that will precisely explain the variety of feedbacks between climate components. On completion the project will provide modellers with more accurate forecasts of the Irish climate (DOEHLG 2007).

3.1 The Effects of Climate Change in Ireland

Ireland is already experiencing the consequences of global warming. It is now on average 0.7°C warmer than a century ago and six of the ten warmest years have occurred since 1995. We now have fewer frost days, and a shorter frost season (EPA 2007). In the future, the most important factors in Ireland will be our changing rainfall

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patterns and rising sea levels. These changes will have a significant affect on our water supply, ecosystems and agriculture, and increase the risk of flooding and coastal erosion. Overall Ireland can expect more seasonal rainfall, with wetter winters and drier summers on average (IAE 2007). By the 2050s, winter rainfall in Ireland is projected to increase by approximately 10%, and summer rainfall to reduce by 12-17%. By 2080s, winter rainfall will have increased by 11-17% and summer rainfall will have reduced by 14-25%. The largest percentage winter increases are expected in the midlands. Indeed, there will be varying climate change effects throughout the country. The north and west can expect even wetter conditions and the south and east will be on average drier. By the 2050s, southern and eastern coasts could have 20-28% less rain in summer and 30-40% less by the 2080s. Longer heatwaves, lengthier rainfall events in winter and more intense downpours in summer are all projected (Sweeney et al. 2007). Climate change will also impact on the frequency and intensity of extreme weather. Weather events that typically occur once in one hundred years could become more prominent and a new intensity will characterise a one in one hundred year event (Greater London Authority 2008). Warmer water will impact on the frequency and intensity of sea storms and sea surges. This will have an effect on vulnerable coastal areas around Ireland (C4I 2008).

3.2 Risk Management

Due to the natural variability of the climate and the uncertainty inherent in forecasts, a risk-based approach must be employed in deciding how and when to act and react. There are three components of risk; the probability of an event occurring, the consequence of the event and the vulnerability of those affected by the event. The Greater London Authority (2008) report provides a detailed example of how this model can be used to assess risk. Responses to climate change should be sustainable and consider the wider implications of the action.

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Good risk management involves beginning with proactive measures and becoming increasingly reactive in later stages. The Greater London Authority (2008) suggests a four step process;

- Prevent: actions taken to reduce the probability of an impact. The key preventative action in tackling climate change is reducing greenhouse gas emissions.
- Prepare: actions taken to better understand the risk/opportunity ahead of the change occurring and to proactively enable an effective response and recovery.
- Respond: actions taken in response to an event to limit the consequence of the event.
- Recover: actions taken after an event to enable a rapid and cost-effective return to normal or more sustainable state.

Chapter Four - Water

In Ireland, the most significant effects of climate change relate to the water environment. One of the most important factors for Ireland will be our changing rainfall patterns and rising sea levels. This will affect our water supply, ecosystems and agriculture and will put us at greater risk of flooding and coastal erosion. The following chapter explores some of the most critical water-related adaptation issues in the Irish context including flooding, water supply, coastal management and drainage.

4.1 Flooding

Due to rising sea levels and more intense rainfall Ireland will face more flooding. All catchments will show increases in surface water in winter and spring and decreases in late summer and autumn. In winter, the level of water flowing in rivers is expected to increase by 12-15% in the majority of catchments by mid-to-late century. In the Boyne river catchment for example, by the end of the century, the levels of flooding currently expected to occur every 50 years could occur every three years (Smyth 2007). Similar trends are expected in all catchments.

These changes would have significant impacts in terms of;

- Loss of life and personal injury
- Damage to property and infrastructure and utilities
- The reliability of flood defences
- Contamination and disease from flood and sewer water
- Break up of communities and social connectivity
- Insurance costs
- Damage to land and development (Greater London Authority 2008)

Under the EU Flood Directive, the Government must carry out a national preliminary flood risk assessment by 2011. By 2013, flood risk maps of these areas must be produced. These will form the basis for flood risk management objectives and area

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flood plans. Land use management and spatial planning are crucial factors in this directive (DOEHLG 2008b).

Plans dealing with the assessment and management of floods should focus on prevention, protection and preparedness. In Ireland, the OPW is the lead agency in flood prevention and protection. Active steps have been taken to manage flood risk as opposed to reacting in an ad-hoc manner. However, there are many actions related to adaptation and water issues that are not within their remit such as engineering flood relief measures and the protection of vulnerable habitats and species including wetland birds. Such actions are carried out by the OPW and the National Parks and Wildlife Service (NPWS) respectively (Flood Policy Review Group 2004). However, Local Authorities have the ability to ensure that proper flood planning takes place due to their role in planning and development. The Department of Environment, Heritage and Local Government (2008) published guidelines for local authorities with regard to flooding after several extreme flooding events occurred in 2008. They highlighted the role of city and county development plans in assessing overall flood risk and implementing protection provisions. In the future, planning authorities will be obliged to conduct a flood risk assessment as an integral and leading element of development planning functions.

A key recommendation for managing flood risks is the preparation of general flood management plans which incorporate inventories of risk sites which suffer the most from floods (Finnish Government 2005). A thorough assessment of flood risk necessitates examination of where the water comes from, how and where it flows and the people and assets affected by it (Greater London Authority 2008). It is also essential to estimate the probability of flooding occurring, to assess the hazards that will arise and to examine the vulnerability of the people and assets in the surrounding area. The OPW is currently running a series of Catchment Flood Risk Assessments and Management Studies (CFRAM) for rivers, including the Dodder, Lee and Suir. The studies, which began in 2007, include hydrological⁵ assessments that factor in changes in the climate. As part of the CFRAM process, the OPW intends to develop a flood asset register to identify walls and embankments that provide some level of

⁵ Hydrological refers to the hydrological cycle or water cycle. This cycle describes the continuous movement of water on, above, and below the surface of the earth

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flood protection, assess the level of protection they offer and assess their performance in light of predicted changes.

The OPW maintain a website which maps out areas prone to flooding to aid planners in making decisions on development. The OPW has identified a number of areas that need more work. For example, they plan to assess existing and likely future flood risk. This information can then be used by planning authorities in preparing development plans, local area plans, and deciding on individual planning permission in their areas (Smyth 2007). However, it is up to these agencies and organisations to ensure they are updated with information. Once the data is published there is currently no designated body certifying that the information is utilised. There are issues involved with publishing this data to a greater degree, as it would have an effect on house prices and individual's personal situations. This is in contrast to other countries that abide by a 'no-regret' strategy, which ensure such issues are fully considered before development.

Some adaptation actions in Ireland require more work and necessitate cross functional agreements. These include ensuring that emergency procedures and equipment are in line with currently available information on local flooding risks (SMEC 2007) and ensuring the functioning of water services in emergency situations, such as during floods, heavy rains, drought (Finnish Government 2005).

Implementing such actions efficiently requires the regular and timely transfer of information between local authorities, climate predictors, the OPW, emergency services and providers of essential communication and energy services. In Ireland, principal response agencies, like An Garda Síochána, the Health Service Executive and local authorities must be prepared for events such as major flooding and must act in a co-ordinated way, under the 2006 Framework for Major Emergency Management. A set of guidelines for dealing with flooding, developed in conjunction with the OPW, is available at <http://www.mem.ie> (DOEHLG 2008b).

The report of the Flood Policy Review Group (2004), which outlined Ireland's response to flooding issues, recommends a shift away from solely structural or constructed flood defence measures to include non-structural measures, emphasising a risk management approach. Structural defences can potentially raise

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upstream flood levels when used on riverbanks and shift coastal erosion and damage further down coastlines when used as sea defences. Soft non-structural measures use natural processes to reduce flood risks. Some examples include working with wetlands, promoting sustainable land use, using Green Alley⁶ Technology and ensuring that spatial planning limits exposure and vulnerability (European Commission 2007). Dublin City Council (2008) will provide new wetlands and semi-permeable paving throughout the city and employ soft engineering solutions where possible. However, hard structural flood defences will continue to be important to cope with extreme flooding (European Commission 2007).

The OPW has tried to implement soft engineering practices. However, their mandate does not extend to the national spatial strategy, land development or regulating land use. These functions are conducted by different bodies, meaning there is a great degree of variation in actions being taken around the country. There is a need to devise clearly defined and comprehensive policy approaches to flooding nationally, with comprehensible definitions of the roles and responsibilities of various stakeholders.

The social impacts of flooding must not be neglected, such as protecting vulnerable people who may be more prone to death or illness and protecting those who may have financial problems as a result of flooding. The impacts of a flood last long after the flood has gone. Local authorities need to engage in community recovery, including housing displaced people providing assistance with insurance claims, and managing the impacts of possible increased local unemployment. There may also be long term clean up costs in both public and private land and buildings (Greater London Authority 2008). The Department of Environment, Heritage and Local Government (2008) recognises that there is growing interest in community-centred approaches that incorporate the particular circumstances of community and social groups.

All the Local Development Plans from our sample note the importance of minimising development on flood plains, in the effort to prevent localised flooding. Monaghan

⁶ Green Alley Technology refers to infrastructure projects that endorse permeable pavements and road surfaces. See: <http://www.stormh2o.com/october-2008/chicago-green-alleys.aspx>

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recommends the completion of a Flood Impact Assessment before significant development is carried out on a site that the council considers prone to flooding. The Wexford plan considers the importance of Sustainable Urban Drainage Systems (SuDS) in addition to a Flood Impact Assessment. Kilkenny specifies that development must strive to reduce the rate and quantity of run-off in any design. They recommend that hard surface areas, such as car parks, should be constructed using permeable or semi-permeable materials.

Kilkenny and Clare both highlight the value of appropriately designed development and the consideration of future flooding patterns in construction design. These councils recommend that development in flood plains or marginal areas, which are not sensitive to the effects of flooding, may be permissible, so long as any such development does not reduce the flood plain area or restrict flow across it. They cite the development of park areas, sports pitches and certain types of industry designed to be flood resistant as appropriate. Measures to cope with the ever existent flood risk must also be put in place. Both councils recommend that all new development must be designed and constructed to meet minimum flood design standards. They specify that in urban areas where future development is planned, possible severe flood events that normally have a one in one hundred year frequency need to be considered. For rural development this is dropped to a one in twenty five year frequency and for coastal and estuarine development a two hundred year tide level should be considered.

4.2 Water Supply

Ireland has currently one of the highest rates of water availability in Europe. However, increased temperatures will reduce water availability, which is essential for domestic consumption, industry, agriculture and maintaining biodiversity (Philips 2007). In summer and autumn, when water demand is at its peak, the greatest reductions in surface water resources are also most likely, and evaporation leads to greater losses from storage reservoirs. Over 70% of the population draws its water supply from surface water from freshwater lakes, reservoirs and rivers (IAE 2007). In addition, the places where water availability is greatest and where water is most

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needed tend to be at opposite sides of the country. The west has 1,000 -1,300 mm of rainfall per year and over 2,000 mm per year in many mountainous areas compared to 750-1,000 mm of yearly rainfall in the east. Under current climate conditions, demand is projected to be at the limit of projected supply capacity in the greater Dublin area by 2015. With changing rainfall patterns we may have to investigate the possibility of storing water when precipitation levels are high to meet future demand. Aquifer storage and recovery technology may help some regions bridge the gap between supply and demand (Philips 2007).

Soil moisture and groundwater will also be affected by climate change. About 30% of Irish water supply is sourced from groundwater. This is considerably less than in other countries. The average in North America is 51% and in Europe the average is 75%. Groundwater in Ireland is generally of good quality, requires less treatment and is cheaper to develop and distribute than surface abstraction. However, there are issues of poor microbiological quality and elevated nitrate concentrations occurring in certain areas, particularly the southeast (Philips 2007). In addition, 70% of Ireland is underlain by 'poorly productive' bedrock aquifers, bedrock which is limited in its ability to accept, recharge and transmit groundwater laterally. As a result, wetter winters will not contribute to greater recharge (IAE 2007).

Since existing local authority supply systems are regularly near capacity, new housing developments are often required, as part of their planning permission, to ensure that there is an independent water supply. This is frequently met with groundwater (IAE 2007). Under current conditions the late autumn and winter recharge period is critical to sustaining groundwater levels throughout the year. By mid to late century, significant reductions in storage during this time will increase the risk of severe drought and a dry winter may result in prolonged drought periods where the groundwater system is unable to recharge. The areas likely to experience the most significant reductions in groundwater storage, mostly on the east coast, are also where future demand for water is likely to be the greatest (Philips 2007). Quantitative estimates of how climate change will affect the groundwater environment and its dependent ecosystems are crucial for future planning. Further research in key areas, especially physically based research into recharge

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mechanisms is needed to verify and improve current mapping. It is also needed to develop and protect future water supply needs (Williams and Lee 2007).

Within the EU, the Water Framework Directive (Water Directors of EU 2004) provides a consistent framework for integrated water resources management. It does not, however, address climate change directly. The challenge will be to incorporate measures to cope with climate change as part of its implementation, starting with the first planning cycle for 2009 (European Commission 2007). The directive places responsibility for managing water environments with each member state, which must be conducted in conjunction with environmental monitoring and scientific investigation. Water must be managed based on natural river basin districts which necessitates cross border plans in some cases. The aim of the directive is to reach 'good status' in all natural waters by 2015. The directive was brought into Irish law in 2003, and so far Ireland has completed each task set by the required deadline. Eight river basin districts have been assigned and a character report of each one has been drawn up.

A study conducted by Kenney et al. in 2008 recorded and analysed people's water use and reaction to various policies. They found that demand for water is consistent with price, non-price demand management programmes, weather and climate. Pricing policies that make water saving a priority and outdoor water restrictions were found to be very successful methods in reducing domestic water consumption. In addition, real time information was extremely efficient in helping consumers reach targets. Sustainable demand management incorporating such measures is of utmost importance. Inadequate water pricing, inconsistent land use planning and bad water allocation automatically lead to overuse. The EU recommends that economic instruments and the user pays principle should be applied across all sectors, including households, transport, energy, agriculture, and tourism, providing strong incentives to reduce water consumption and increase efficiency of use (European Commission 2007).

While there are commercial water charges in Ireland, domestic consumption from public sources has been free since 1997. The re-introduction of water charges would most likely be met with resistance. However, the effective communication of possible

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water scarcity and droughts and the need to maintain good water quality may aid the acceptance of such measures. The measures need to be implemented along with education on reducing water consumption, for example through providing community education on water efficient garden planting and watering and through identifying potential water conservation incentives (SMEC 2007). There are various Irish campaigns educating people about water conservation which could be harnessed to achieve these aims, such as www.taptips.ie developed by a group of Leinster County Councils and Galway City Council's www.slowtheflow.ie. Dublin City Council also provides information and links on <http://www.dublin.ie/environment/water.htm>.

In addition to reducing water consumption other strategies can be adopted to increase water provisions and to conserve water. They are actions that can be adopted on a large scale by local authorities and developers or on a smaller scale by individuals and organisations without needing national policy guidance. Greywater⁷ reuse and supplementing existing supplies with recycled water where possible is a very efficient practice (SMEC 2007). Almost a quarter of our daily domestic water consumption does not require water that is of drinking quality standard. This water can be utilised for toilet flushing and outdoor water uses. The creation of small water harvesting structures such as low cost farm ponds, percolation tanks, ground water recharge measures and the use of water harvesting also increases water availability (Bhandari et al.).

Policies which ensure that the water resource implications of new developments are assessed are needed. These policies should cover water sensitive urban design at formulation and development assessment stages of the planning process (SMEC 2007). The National Spatial Strategy does specifically consider sustainable development and the role of our natural resources in future economic and social development. It observes that water services are a key driver in future development, as they are an essential service for both business and residents of an area. Areas with rich water reserves are recognised as areas for strategic food production and as a 'green lungs' for surrounding urban areas. However, stronger guidelines and

⁷ Greywater is defined as the wastewater produced from baths and showers, clothes washers, and lavatories. The wastewater generated by toilets, kitchen sinks, and dishwashers is called blackwater.

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legislation need to be drafted, addressing the conservation and supply of water at all stages in Ireland's planning and development process.

DCC has led the way in this regard, with the 2008 publication of a draft Climate Change Strategy for Dublin City. The document outlines adaptation measures including the development of water conservation concepts and the development of a long term supply source of drinking water for the Dublin region (DCC 2008). This needs to be completed at a national level. In Holland, the National Spatial Strategy incorporates water management issues and potential adaptation measures. It also includes policy for water management and protection against floods in rural areas (EEA 2005).

Water supply issues receive good coverage in all our reviewed development plans⁸. Every council discusses a number of schemes and policies currently in place or in the development process that are designed to cope with the issue of water supply and scarcity. References are made to groundwater protection policies, phosphorus regulations, wastewater infrastructure schemes, source water protection plans and rural water investment programmes. Some of the most notable developments include the expansion of public/private partnership arrangements, compulsory buffer zones around water sources, leakage detection work and holistic water environment management.

Wexford and Sligo both cite the development of private/public partnership projects relating to wastewater treatment plants and sewerage treatment schemes as useful in improving the overall quality of water in their jurisdictions. Buffer zones around certain specified water sources are compulsory for Monaghan. This council restricts development within two hundred metres of any lake supplying drinking water, where that development has the potential to pollute the lake.

Leakage detection work is critical when it comes to protecting water supply. The Department of Environment, Heritage and Local Government's National Water Study (2000) found that up to 47% of all water produced by treatment plants surveyed is

⁸ Please see Appendix II for a table of our reviewed development plans

unaccounted for and that in some areas of the country this level is much higher. Therefore, there is strong evidence that preventing water leakage is a practical, realistic and economic way of meeting much of the extra demand for water. Sligo and Kilkenny cited leakage prevention as an integral part of any water infrastructure scheme. Public awareness raising around the issue of leakage is also discussed in their plans.

A holistic water environment management approach is adopted by a number of councils. Kilkenny outlines its vision to protect and enhance the natural heritage and landscape character of waterway corridors and wetlands and to maintain them free from inappropriate development. In realising this aim, it intends to go into partnership with the National Parks and Wildlife Service, Waterways Ireland and other relevant stakeholders. This partnership will facilitate public access to, and understanding of, waterway corridors and wetlands where feasible and appropriate. It also proposes to consult with the Southern Regional Fisheries Board and the NPWS prior to undertaking, approving or authorising any works or development which may have an impact on rivers, streams and waterways. The aforementioned CFRAM studies underpin any holistic water environment approach.

4.3 Coastal Management

Direct impacts from sea level rise include flooding and displacement of wetlands, coastal erosion, increased salinity in estuaries and coastal aquifers, and blocked drainage. Potential indirect impacts include changes in the distribution of sediment, changes in the functions of coastal ecosystems and impacts on human activities (EEA 2005). In the climate change scenarios outlined in the IPCC's report, mean sea level is expected to rise by up to 0.59 metres over the next century, about three to four times the current globally averaged rate of mean sea level rise (Adger et al. 2007). This is tied in with the fact that we are experiencing more frequent and severe coastal storms and a significant increase in the risk of coastal erosion and flooding. Even with a modest 0.4 metres rise in mean sea level, equivalent to the flooding that occurred in Dublin in February 2002, currently expected to occur about once a century, will occur at least every five years, if not more often.

Coastal erosion occurs when the sea progressively encroaches upon the land. The findings from a number of studies carried out over the last century suggest that about 20% of Ireland's coastline is at risk from erosion, with erosion rates reaching a maximum of 2 metres per annum on parts of the east coast (Farrell 2007).

To protect citizens living in coastal areas, it is crucial to integrate risks associated with coastal erosion into planning and development and the National Spatial Strategy (Farrell 2007). In Germany, coastline developments are carefully monitored and evaluated to ensure quick responses to changes (EEA 2005). Ireland does not have any formal system for forecasting sea surges or for circulating coastal flood warnings. These systems are necessary to ensure quick emergency responses and reduce flood damage and social disruption. A reliable controlled tide-gauge network with a data processing and archiving system needs to be established in Ireland in order to monitor sea level changes and provide data for numerical model calibration and real time feedback to a coastal flood warning system (Farrell 2007).

In Ireland development has, in the main, proceeded in an ad-hoc manner and is grounded in legislation relevant to various sectors, for example fishing, water quality and coastal protection. There are huge differences in the practices carried out by different local authorities, one the main bodies responsible for coastal management and protection⁹ (O'Hagan and Cooper 2002). A coherent and integrated approach to coastal planning and management would provide a context for synergies and address potential inconsistencies between economic development of coastal zones and necessary adaptation to climate change. The EU follows the Integrated Coastal Zone Management¹⁰ (ICZM) recommendation, which calls for a strategic approach to coastal planning and management (European Commission 2007). This is not being conducted in a formalised manner in Ireland at the moment and NGOs such as Coastwatch Ireland are calling for its implementation as soon as possible.

One reason for the lack of consideration of risks in coastal planning is the fact that there is no single institution responsible for managing or coordinating action the

⁹ Local property owners and central Government also carry out certain practices

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coast. A number of government departments have statutory responsibilities e.g. DOEHLG and the Department of Agriculture Food and Fisheries. Each local authority looks after the coasts in its remit. There is a focus on preventing damage where housing and development exist, but there is less consideration of planning and development that may pose problems in the future. In essence there is little examination of the long term implications of coastal development. A standard approach to designing, building and maintaining development would ease this problem. Data on high risk areas combined with strong national leadership would greatly improve Ireland's ability to adapt to the effects of climate change on coasts. Guidance should be given for planning and management and best practice should be applied when developing approaches and strategies (O'Hagan and Cooper 2002). However, it is difficult to point to an existing body that could be responsible for a standardised design and building methodology. There is clearly a need for an overarching advisory body to coordinate such standards.

Some local authorities have begun work without national instruction. Dublin City Council (DCC 2005) has initiated a new tidal early warning system to deal with coastal tidal surges and a pre-feasibility study for Project 2030; a plan that will investigate the potential for tidal barrages to protect the city and region. National government did produce a draft plan in 1997 outlining coastal zone management procedures; although, this is yet to be published (Gov 1997). However, The Marine Institute has just published (November 2008) Guidelines of Best Practice for Coastal Zone Management (2008) which was collated as part of the EU AquaReg Coastal Zone Management Project.

All councils with a coastline should put detailed policies and measures in place that endeavour to prevent coastal erosion. Wexford prohibits any new building or development including caravans and temporary dwellings within 100m of soft shorelines. It also ensures that no new habitable structures are permitted 3 metres below Malin Head in the interests of public safety, the protection of property and residential amenity. Sections of County Wexford's 264 kilometre coastline are severely affected by erosion, losing an average of one metre per year. Wexford's coastal defence works are thus only considered at locations where need is greatest and subject to the availability of necessary finance.

As part of its Coastal Zone Management policy Sligo county council intends to achieve a more efficient and sustainable use of the coastal resource. They build on the Governments 1997 discussion document “Coastal Zone Management – A Draft Policy for Ireland” in generating their coastal development strategies. Sligo proposes to work with the marine and fisheries industry to facilitate development associated with job creation while striving to increase environmental sustainability.

The issue of aggregate extraction also arises in Sligo’s development plan. Aggregate extraction refers to mineral extraction and quarrying activity. Sligo County Council state that any proposals for future marine extraction shall only be considered following detailed Environmental Impact Assessment and consultation with the Department of Communications Marine and Natural Resources, where appropriate. Sligo also describes its coastal protection works in some detail. The aim of the works is to reduce land loss and the frequency of flooding. They favour soft engineering techniques, such as dune stabilisation and planting to hard engineering works, which tend to impose armoured defences along the shoreline that can often have net negative effects on the coast. Hard engineered structures often prevent coastal erosion or flooding in one place only to shift it to another further along the coastline.

4.4 Drainage

Providing and repairing public drainage systems in Ireland is the responsibility of local authorities. Houses in rural areas that cannot be networked to a public drainage system are served by a septic tank system. Increased rainfall intensity means potentially more frequent incidences of drainage problems. Drainage management plans that optimise active storage capacity to alleviate flood peaks are a good strategy for dealing with this problem. These drainage systems should be linked to the relevant catchment to avoid impacting on other areas. The systems should be based on climate change scenarios to prevent overflow events from wetter than normal weather (SMEC 2007).

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Drainage systems should be complemented by ongoing and periodic reviews of sewerage system strategies and operations to address hydraulic constraints, overflow risks, sewer rehabilitation and cleaning regimes (SMEC 2007). In addition, the inclusion of Sustainable Drainage Systems' (SUDS) into new developments, to restrict leakages into streams and rivers, is recommended. This would both reduce the flood potential of the development and protect groundwater levels. Natural solutions, such as increasing permeable land in urban areas and increasing wetland areas are very effective in preventing drainage problems through alleviating pressure on drainage systems. Permeable pavements are constructed from porous tarmac or solid block pavers with gaps that allow the flow of water into the underlying layers (DOEHLG 2008b). The Department of Environment, Heritage and Local Government recognises the problems caused by the paving over of residential garden areas. They are currently reviewing development regulations in this regard, only allowing development for those that comply with sustainable drainage principles.

DCC has implemented the Greater Dublin Strategic Drainage Study (GDSDS). The GDSDS is a proposal for the advancement of drainage services and flood protection in Dublin over the next twenty five years. It ascertains the infrastructure that will be required for managing storm water and foul effluent in existing and new developments (DCC 2005).

Drainage is an area that is less well covered than other water issues by the councils in our sample of Local Development Plans reviewed. This could be because it is interlinked with flooding, coastal management and to some extent with water supply issues. Kilkenny is arguably the most progressive when it comes to drainage issues. In their development plan they stipulate that all drainage proposals need to be sustainable. They also explicitly discuss climate change issues when designing surface water drainage schemes. They employ quantifiable multiplication factors to aid them in their task. To give adequate allowance for climate change in designing surface water proposals a multiplication factor of 1.2 is applied to all river return periods up to 100 years. In circumstances where the OPW have provided advice, this figure is used. In the case of rainfall, a multiplication factor of 1.1 shall be applied to rainfall intensities to make allowance for climate change requirements. While such multiplicative factors are viewed as a positive response in accounting for potential

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future river return periods it is essential that their calculation is based on dynamic modelling techniques if they are to be of significant value to Local Authority planners. Kilkenny also refers to the Greater Dublin Regional Code of Practice for Drainage Works when designing their surface water drainage systems. Wexford and Sligo both stipulate that developments must be kept at an appropriate distance from watercourses to protect them from contamination, allow for natural drainage and facilitate channel clearing maintenance.

Chapter Five – Natural Resources

5.1 Agriculture

The changes in temperature and rainfall, as well as the growing frequency of extreme weather phenomena will have a profound effect on agriculture, which is particularly sensitive to climate change. As yield variability increases due to climate change, global food supply will be at increasing risk (Finnish Government 2005). The Food and Agriculture Organisation of the United Nations (FAO) contends that climate change impacts on agriculture can be organised into two rough overlapping groups (FAO 2007). The first grouping includes the biophysical impacts, including physiological effects on crops, pasture, forests and livestock, alterations in land, soil and water resources, increased weed and pest challenges and changes in spatial and temporal distribution of impacts. The second category includes socio-economic impacts, such as a decline in yields, reduced marginal GDP from agriculture, fluctuations in world market prices, changes in geographical distribution of trade regimes, increased number of people at risk of hunger and food insecurity, migration and civil unrest (FAO 2007).

Potential consequences for agriculture and the landscape in Ireland as a result of climate change were outlined in the 2008 report 'Changing Shades of Green' (The Irish American Climate Change Project 2008). Some of the predicted impacts are as follows; altered climate conditions mean that the potato may no longer be a commercially viable crop over much of Ireland; bog bursts will be more frequent; brown dried grass will occur more frequently, especially in summer and autumn and Ireland's livestock, which currently relies on open pastures for silage, will need to be supplemented with grain from row crops. Having said this, agriculture in Ireland may benefit in some ways as the changing climate may suit the growth of new crops.

To deal with these effects and implement successful adaptation strategies and measures the FAO (2007) report outlines key areas for action in agriculture. The first addresses policy and planning elements. Government needs to execute timely risk

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assessment through effective monitoring and analysis. This will allow strong strategy formulation and sectoral measures. Planned adaptation measures, including purposeful crop selection and distribution strategies across different agri-climatic zones, are necessary. This kind of action needs to be multi-sectoral in nature and implemented at the national level in order to alter the adaptive capacity of the agricultural system and facilitate specific adaptations (FAO 2007). In essence, the Government needs to pay attention to breeding, cultivation and production methods and regional aspects in setting the long-term objectives for agriculture (Finnish Government 2005). There is currently no long term national strategy in place to protect farmers and food growers from the effects of climate change. While introducing such issues into policy needs to take place at national level, it should consult relevant parties at the local level to ensure the development of locally relevant plans. Such policies could be implemented through local authority adaptation actions and local education schemes.

The second area is livelihood elements, which includes food security, hunger, poverty and non-discriminatory access to food (FAO 2007). The preparedness of national food production to respond to global environmental changes needs to be maintained (Finnish Government 2005). Food security is increasingly publicly recognised as a potential future problem in Ireland by various non-governmental organisations. The average food basket bought in Ireland has travelled over 2000 miles (Bouchier 2005) and supermarkets only carry enough stock to last a few days (The Sunday Times 2008). The food chain is a long, linear, vulnerable one. In the event of a natural disaster due to climate change, many Irish communities may not have access to adequate amounts of food. This issue could be resolved through more locally grown food.

This also applies to urban areas, which are particularly at risk due to their dependence on imported food products from other countries and counties. Allotments, community gardens and urban vegetable growing would strengthen urban resilience.

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The Dublin Food Growing Network is committed to tackling the issue of food security through advocacy, research, policy, networking and education. Local Authorities could act in this regard by allocating land to community gardening programmes.

The final area for action relates to protecting soil, water and other resources. Integrated farming systems¹¹ and integrated cropping systems can vastly increase our adaptive capacity. Effectively managed, good quality soil can absorb higher amounts of water to deal with increased precipitation. This reduces surface run off and soil erosion, which can result in flooding further down stream. The increased volume of water stored in the soil also reduces the impacts from drought. Techniques that aid in improving soil quality include conservation agriculture, organic agriculture and risk-coping production systems that incorporate crop rotations, agro-forestry, crop-livestock associations, crop-fish systems and low tillage methods that maintain permanent soil cover. To execute these practices high quality data and information on climate, agricultural and environmental systems are necessary (FAO 2007). Teagasc, the Agriculture and Food Development Authority of Ireland, has extensive research facilities and has begun to conduct research on more sustainable agricultural practices. They encourage organic farming and have a national research centre dedicated to increasing knowledge on soils and the environment in the context of agriculture. Liaisons between local authorities and Teagasc are essential for adapting agriculture to climate change. Guidelines of measures that farmers and food growers can implement and the promotion of sustainable agriculture should be a key priority for both national and local government in considering future adaptation capabilities.

From a review of the local development plans, it is clear that, in general, there is not a wide focus on organic production methods or a strong emphasis on alternative farming methods to intensive large scale agriculture. However, tentative first steps are being taken. Irish farmers have, in the past, received a huge percentage of their income from the EU funded CAP system. However, these subsidies were based on

¹¹ Integrated Farming Systems consider the production of food in a circular rather than linear manner. It looks at the interconnections between farming, the eco-system, the local area and the wider community. It also attempts to transform some of the waste and outputs of farming into inputs. For example, using manure from livestock to fertilise crops, and using some crops to feed livestock. Integrated cropping systems follow a similar philosophy in the production of crops.

quantities and as a result often promoted unsustainable agricultural practices. European funding is being allocated to farmers engaging in more environmentally sound agricultural practices and requires a greater focus on environmental management of the farm and its landscape. This provides a valuable chance to encourage landscape conservation management.

The councils also realise the need to protect soil, groundwater, wildlife habitats, conservation areas, rural amenities and scenic views from adverse environmental impacts as a result of agricultural practices. Kilkenny has aims to preserve the maximum possible number of family farms. Sligo is progressive in that it overtly does not support the development of genetically modified crops and aims to advance the use of organic and traditional methods of farming within the county.

5.2 Fisheries

Climate change can affect the distribution patterns, migration patterns and abundance of species from plankton to top predators, which may result in major changes in ecosystem functions and geographical ranges in aquatic stock. The increased intensity of storms may cause damage to coastal habitats and fish nurseries. Alterations in river discharges and increasing sea level will affect near-shore salinities, sediment loading and distribution which would have consequences for near-shore food production (Bolens et al. 2005). Ireland's famed inland fisheries, which provide some of Europe's best salmon and sea trout fishing will be severely affected by reductions in summer rains and increases in summer and autumn temperatures (The Irish American Climate Change Project 2008). Significant changes in water temperatures and pollution will also have an impact on aquatic animal farming and wild fish numbers.

In addition

Over-exploitation is one of the most threatening factors in sustaining fish stocks in Europe. The EU is planning on implementing a marine strategy and related legislation (European Commission 2007). Fishery systems should be built on monitoring and feedback management strategies in which fishing effort and catches

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are regularly modified based on the level and strength of the stock. This will require flexibility on the part of fishermen to absorb the changes in resource abundance through flexible technologies such as multipurpose boats, flexible processing chains, or the ability and opportunity for alternative livelihoods during lean periods. These are necessary to avoid both short and long term negative ecological, social or economic impacts (FAO 2007).

The National board for sea fishing in Ireland is Bord Iascaigh Mhara. Their key aim is to encourage sustainable development of the seafood industry. They set environmental standards based on eco-certification to identify fish caught in a sustainable manner. These industry standards are independently audited and certified by a European Standard accredited body. They must conform to European fishery policy which limits fish catches and sets other restrictions. They have adopted some good initiatives in conservation through their Co-ordinated Local Aquaculture Management Scheme (CLAMS) which integrates operations into coastal zones to promote co-operation between fishing and conservation. Clare County Council is partner in a coastal zone management scheme for the Shannon estuary and employs CLAMS initiative management.

Local authorities are not generally responsible for fishing concerns per se. Inland fishing is managed by the Central Fisheries Board, which supports the regional fishery boards. However, actions in the local authorities' sphere of activity can impact on fish stocks, for example fresh water quality can be affected by development and drainage flooding. At the time of review, the councils had developed various policies on protecting water quality and conserving resources important to the establishment and growth of the aquaculture industry. Sligo, however, does not generally encourage growth of commercial aquaculture, due to environmental concerns and a limited capacity within inland lakes, which demonstrates a primary focus on sustainability in this regard.

5.3 Forestry

The first signs of forest climate change impacts are visible globally as forests decline on former permafrost soils in Canada and Alaska and in the tropics. There are also more frequent and severe forest fires world wide, alterations in the timing of seeding and increased pest and disease outbreaks. In addition to forests being affected by climate change, forests can help human societies adapt to climate impacts (FAO 2007). Forestry management has a major role to play regarding, among others, efficient water use in dry regions, protection of water courses against excessive nutrient inflow, improvement of flood management, and maintenance and restoration of multifunctional landscapes such as high nature value grassland. There is a need to protect permanent grasslands and forests that provide habitat and assist migration for numerous species, as well mitigate carbon emissions (European Commission 2007).

Afforestation can be achieved through developing block plantations, agro-forestry and horticultural development (Bhandari et al.). However, more preventative forest management measures such as, wood harvesting and prevention of forest damage should be developed to adapt to climate change (Finnish Government 2005). In general, resilient forest management and soil management measures related to maintenance of organic carbon need to be promoted (European Commission 2007). The EU Forest Focus programmes (2003-2006) included studies on predicting changes in forest growth, carbon stocks and tree species migration. Community wide forest and soil monitoring programmes must be supported as their results should be used as a basis for the development of response measures. The Forest Action Plan includes research and training on adaptation, assessment of impacts, and exchange of practices. It promotes more carbon-conscious forest management, similar to soil management in terms of both mitigation and adaptation (European Commission 2007). In France, efforts have been made to improve the resilience of forests and develop biodiversity in terms of tree species, other wildlife and gene pools. They are examining species which are best adapted to today's and future conditions to ensure resilience. Also, more holistic forest management techniques and tools are being introduced. For example, in order to deal with wind storms and reduce water needs wider spacing and early thinning measures have been utilised. Managers are actively

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encouraging techniques that increase under story vegetation which has a positive impact on improving soil protection, reducing mineral leaching and increasing biodiversity (EEA 2005).

The organisation responsible for forest management in Ireland is Coillte. It is a state owned organisation with commercial, environmental and social functions. It owns 445,000 hectares of land in Ireland (around 7% of land cover), of which 79% is forested. Since May 2001, Coillte forests have been certified by the Forest Stewardship Council (FSC), which requires it to meet strict standards. It is subject to review at frequent intervals. The organisation has ambitious targets to increase the amount of land forested in Ireland, plant more native species and improve its conservation effort. It has also recently undertaken two significant bog restoration projects on raised and blanket bogs in Ireland. Bogs, like forests, also act as natural carbon sinks. Other measures in Ireland include the Forest Environment Protection Scheme (FEPS). FEPS combines forestry responsibilities with agriculture and encourages farmers taking part in REPS to establish woodland (DOEHLG 2007). However, Ireland is not meeting targets for afforestation. The Strategic Plan for the Development of the Forestry Sector - Growing for the Future (1996), set a target of 25,000 hectares per annum, which was to move to 20,000 per annum from 2000. The average planting between 1997 and 2007 was 11,560 (Malone 2008).

All of the councils support the preparation of a National Indicative Forest Strategy¹² and are organising themselves to set up a County Indicative Forestry Strategy, generally in consultation with the Forestry Service, the Forestry Industry and local communities. The purpose of the strategy is to inform decisions and highlight potential locations for future forestry planting in the county. They are also striving to ensure a proportion of all new forestry development consists of native hardwood species. Sligo discourages coniferous forestry plantations in water quality sensitive areas and in designated sensitive rural landscapes. Both Galway and Kilkenny plan

¹² The Indicative Forest Strategy is a GIS based system that offers national guidance on afforestation issues, through identifying areas most suitable for planting primarily on the basis of environmental considerations and soil-productivity. It provides direction in the establishment of sustainable forests serving a variety of purposes including timber production, enhancement of the environment, mitigation of climate change, forest industry development, creation of alternative off farm incomes and opportunities for tourism and amenity use. For more information;
http://www.agriculture.gov.ie/index.jsp?file=forestry/pages/indicative_forest_strategy.xml

to make Tree Preservation Orders, as appropriate, to conserve important trees, groups of trees and woodlands.

Most of the councils prioritised the management and development of woodlands in their ownership. They also aimed to facilitate afforestation in appropriate locations, in co-operation with the Forest Service and Coillte. Kilkenny County Council intends to advance the expansion of farm forestry as a means of promoting rural diversity and strengthening the rural economy. In terms of development, two major steps are being taken by some local authorities. The first step relates to assessing the impact of housing, infrastructure and other developments on surrounding woodlands, trees and hedgerows. The second involves incorporating existing trees on development sites and requiring tree planting for new developments.

5.4 Biological Diversity

Climate change will significantly affect economies and societies through its impacts on ecosystems, more specifically on natural capital, biodiversity and the flow of ecosystem services in terrestrial, freshwater and marine ecosystems. In recent times, species have become extinct at rates 100 to 1,000 times greater than what is considered to be normal (EEA 2005). The diversity of life on earth has substantially and, in many cases, irreversibly decreased. Relatively small changes in climate, for example less than 1 °C, can have an effect on ecology, as temperature and climate determines whether a species can survive in a certain area. A 2 °C change would have significant impacts on biodiversity, including vast losses in habitats (EEA 2005).

The main impacts that climate change will have on birds and wildlife can be classified into five main headings (Backer et al. 2006). The first implication is species distribution, whereby species will typically move north and uphill, to adapt to a warmer climate. Secondly, changes in the timing of seasonal events will influence the availability of food and other resources. More extreme climate events will also be experienced. In addition, there will be changes in the 'links' between species and community ecology for example, changes to competitive advantages between species, changes in the spread and impacts of diseases and increasing numbers of

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invasive species. The final effect relates to changes in land use as humans adapt to climate change.

In Ireland, wet lands, such as bogs and salt marshes will experience problems due to reduced rainfall in the summer. Wetlands are extremely important in holding water to be released back into the river system slowly. They have a valuable function in both storing water and completing the water cycle. The Department of Environment, Heritage and Local Government (2008) highlighted the need for local authorities to preserve wetlands as natural defences against flood risk. In addition, increased rain in winter may weaken soil cohesion and can cause nutrients to leach from the soil, affecting fertility (Sweeney et al. 2007). We need to conserve and restore biodiversity and ecosystem services in the wider countryside and marine environment.

Healthy ecosystems are more resilient to climate change and more able to maintain the supply of natural resources on which our prosperity and wellbeing depend. They lie at the centre of any adaptation policy (European Commission 2007). The Greater London Authority (2008) outline the main eco-system services we rely on to adapt to climate change.

Ecosystem service	Green roofs/walls	Street trees	Wetlands	River corridors	Woodlands	Grasslands
Reduce flood risk	✓✓	✓	✓✓✓	✓✓✓	✓✓	✓✓
Offset urban heat island	✓✓	✓✓	✓✓	✓✓	✓✓✓	✓
Reduce energy demand	✓✓	✓✓			✓	
Reduce noise/air pollution		✓✓*			✓✓	
Support biodiversity	✓✓	✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Recreation/leisure	✓		✓	✓✓	✓✓✓	✓✓✓
* note that some tree species can release chemicals that help the formation of ozone						

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EU legislation and policies are in place, or in the pipeline for water, soil, air and biodiversity. They will need to be implemented on schedule to allow early action to strengthen ecosystem resilience to climate change. Effective implementation of the 2006 Biodiversity Communication and its 'EU Action Plan to 2010 and beyond' will make an important contribution to safeguard and restore biodiversity and ecosystems (European Commission 2007). Climate change makes natural resources scarcer and aggravates the environmental impacts of resource use. The forthcoming EU Sustainable Consumption and Production Action Plan will consider actions to improve the coherence of existing policies and to use less resources and energy (cited in European Commission 2007). The Soil Strategy and its related legislation aims to protect soil functions across the EU. Areas at risk of organic matter decline will have to be identified so that climate change can be taken into account in the programmes designed to reverse unsustainable trends. Net loss of organic soil matter in a warming climate is a major concern as soil is the largest terrestrial pool of sequestered carbon (European Commission 2007). There are a number of other policy instruments such as the Habitats and Birds Directives, the Water Framework Directive, Strategic Environmental Assessments and Environmental Impact Assessments.

At the national level, the Government is devising a second National Biodiversity Plan, which will outline various actions that need to be taken to halt biodiversity loss by 2010. In addition, the Department of Environment, Heritage and Local Government (2008c) has published a document outlining the economic costs and benefits of biodiversity, which is invaluable in a situation where many decisions are made on cost benefit analysis basis. Many organisations are involved in halting biodiversity loss in Ireland, depending on the specific habitat or area, such as the National Parks and Wildlife Service, Central Fisheries Board, Coillte, various government departments, local authorities and other non-governmental organisations. A biodiversity policy unit has been created, which reports to the director of the National Parks and Wildlife Service of the Department of the Environment, Heritage and Local Government. Legislation is a powerful way of implementing change. Liechtenstein is a mountainous country and is highly dependent on maintaining a stable eco-system. It has introduced many legislative documents to preserve and protect its landscape (EEA 2005).

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Regional and territorial development should be compatible with biodiversity (European Commission 2007). In addition, local biodiversity plans should be developed. These should implement conservation management plans and encourage private land conservation (SMEC 2007). Action 10 and 11 of the first National Biodiversity Plan referred to biodiversity at the local level. These actions called for each local authority to prepare a local biodiversity plan and assign an officer to oversee conservation issues in the area. The preparation of local biodiversity plans which allows for the development of policy relevant to local culture was also recommended by Agenda 21 (DCC 2008). As of the 2005 review, 27 local authorities had designated a Heritage Officer and the remaining local authorities had a contact officer for conservation matters.

Draft guidelines for the production of Local Biodiversity Action Plans (LBAP) were developed by the Department of the Environment and The Heritage Council. Heritage officers are utilising these guidelines and a number of local authorities have initiated the production of a LBAP. However, further action is required. It is recognised that resources were an issue for local authorities in meeting these targets. LBAPs are advantageous in that they provide a local framework for the conservation of biodiversity and allow locally developed projects to impact on common national objectives and targets (DOEHLG and THC 2002). The local authorities reviewed had not developed local biodiversity plans at the time of writing but were preparing to do so. DCC (2008) has published a strategic plan for increasing wildlife in the city and conserving certain species, which could be useful as a framework for other counties. DCC also plan to use their position to influence the public in their administrative area, harnessing the collective energies of concerned citizens. Along with preparing a LBAP, local authorities must also produce a Local Heritage Plan. In the future the LBAP will become a central feature of the Local Heritage Plan and will be prepared by a biodiversity working group, where one exists (DOEHLG and THC 2002).

There are three main areas that need to be considered in adapting to climate change and conserving biodiversity. The first is to develop the resilience of current ecosystems against climate change. Protected areas are vital to biodiversity conservation. Ireland needs to ensure the integrity, coherence and connectivity of the

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Natura 2000 network (European Commission 2007). The local authorities aim to conserve and manage areas of natural environmental value that have been identified under the EU Habitats Directive, EU Birds Directive, the Wildlife Act and the Flora Protection Order. The boundaries and jurisdictions of these sites are continually revised and adjusted and new sites are added. Kilkenny note the need to keep up to date on these changes. Over time, the protected areas should be adapted and extended to accommodate the movements of species (European Commission 2007).

Protected areas do not represent the full extent of our natural heritage. There are other sites, habitats and wildlife species of international, national and local importance. Local authorities need to continue to take responsibility, in co-operation with the relevant statutory authorities and other relevant groups, in identifying and protecting these areas.

Many activities can be utilised to reduce stress on eco-systems, such as reducing degradation through intensive agriculture or fragmentation through infrastructure development. There is also a need to plan for future water availability, adjust grazing and mowing regimes to suit the changing phenology of growing seasons and develop sheltering mechanisms to counter the impacts of extreme weather (Backer et al. 2006). In addition, the assessment and monitoring of the impacts of climate change needs to be incorporated into projects and programmes concerning the protection and management of biological diversity (Finnish Government 2007). The Quaggy River flood alleviation scheme in the UK has utilised adaptation measures to increase biodiversity, which will in turn increase resilience to climate change. It has linked the river with its flood plains to create a more natural riverbed with areas of deep and shallow water. Baseline surveys were used to monitor the impact on flora, trees, bats, fish, birds and mammals. These surveys were invaluable in identifying the key environmental features and retaining them where possible (CABE 2008).

The second element essential in adaptation policy is accounting for distributional change among species as their areas of suitable climatic conditions shift. It may be necessary to develop nature reserve management practices to encourage the arrival of particular incoming species or to increase landscape connectivity in order to link fragmented habitats by designating 'adaptation zones' (Backer et al. 2006). In

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Germany, they plan to establish a network of interlinked biotopes¹³ that cover at least 10% of the total area of each federal land. This will consist of core areas connected to each other. These designated sites will be legally secure and protected from any planning and development (EEA 2005). Kilkenny, Sligo and Galway councils recognise that sites should not be viewed as stand alone but need to be seen in the context of the wider landscape. Corridors or stepping stones that link sites and allow for the movement of species are important in dealing with fragmentation. These connections offer the most promising opportunities for species migration, dispersal and genetic exchange.

Invasive alien species are a threat to biodiversity. Pest, weed and invasive species management policies and strategies that take changing climatic conditions into account need to be developed and implemented (SMEC 2007).

The final aspect is ensuring that biodiversity concerns are not just relegated to a few select organizations and individuals. Biodiversity needs to be a primary concern for all citizens. Biodiversity needs to be linked to agricultural, marine, fishery and infrastructure development practices in a more coherent manner. Compensatory measures are important to ensure that development projects preserve the natural capital (European Commission 2007). Comprehensive cost/benefit analyses and impact assessments should gradually and systematically internalise the environmental costs of declining ecosystems (European Commission 2007).

The local authorities have observed the need to consult with the National Parks and Wildlife Service and other relevant bodies regarding development in close proximity to protected sites and in approving development that could potentially affect plant, animal or bird species protected by national or European legislation. Hedgerows are another consideration in relation to development and the local authorities must continue to incorporate existing hedgerows into any new developments. They are also obliged to be aware of and follow the provisions of the Wildlife (Amendment) Act 2000, which seeks to prohibit the cutting of hedges within the bird nesting period (1st March until September 1st). In terms of research and monitoring activities, Kilkenny

¹³ A biotope is an area that provides living space for a particular set of plants and animals. It involves the preservation, regeneration and construction of natural environmental areas.

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is aiming to carry out surveys of significant trees and hedgerows in the county developing a Hedgerow Management Awareness and Conservation Strategy. They aim to integrate the conservation of biodiversity into Council plans, programmes and activities.

Chapter Six – Infrastructure

6.1 Infrastructure

In Ireland, more rainfall will increase the risk of flooding of roads, houses and infrastructure located in flood plains or in coastal areas. This will be prominent in areas near embankments and in urban areas with lower permeability due to the natural ground being covered by roads, hard standings and buildings (DOEHLG 2008b). In addition, planning and development is an essential consideration in flood risk management, especially in relation to avoiding or minimising future increases in flood risk.

Major infrastructure, such as bridges, ports and motorways have lifetimes of 80-100 years, so today's investments must take full account of the conditions projected for the end of the century. Buildings and other infrastructure designed to last 20-50 years will also have to withstand future climate conditions. Investments that are optimal under current conditions may not necessarily be economically viable under future climatic conditions or when their impacts on the health of ecosystems are taken into account. For example, seasonal changes in soil wetting and drying will increase the potential for subsidence/heave¹⁴ which will affect the design of infrastructure foundations (SMEC 2007). Therefore medium and long-term investments should be "climate proof". For example, in the Netherlands, state-of-the-art knowledge on the effects of climate change on river flows and sea level rise is already taken into account in infrastructure design. In the US, architects assume a one metre sea level rise when designing bridges in coastal areas (European Commission 2007). It is also recommended that infrastructure developments with a lifetime greater than 50 years will be designed for staged construction to allow future climate change impacts to be taken into account (SMEC 2007). In Ireland, most measures are reactionary and temporary in nature, such as using dam bags to protect infrastructure. While some

¹⁴ Subsidence is a downwards movement of the ground supporting the building. Heave is where the ground moves upwards.

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local authorities have drafted guidelines for climate proofing coastal developments, this needs to extend to all developments, especially those at more risk of flooding and other effects of climate change.

Ireland has a lot of work to do in preparing adaptation strategies in planning and development. The National Spatial Strategy recognises the importance of protecting the environment and acknowledges Ireland's need to mitigate carbon emissions and adopt more sustainable practices in order to retain natural landscapes, air and water quality and biodiversity. However, adapting to the effects of climate change is not comprehensively considered. Adaptation guidelines need to be drafted and incorporated into the National Spatial Strategy. The Department of Environment, Heritage and Local Government published a draft set of guidelines for dealing with flooding in relation to planning for Local Authorities. This document outlines how flooding risk can be integrated into the planning process through both the spatial planning process and in the assessment of development proposals (DOEHLG 2008b).

Spatial planning should provide an integrated framework to link up vulnerability and risk assessment with adaptive capacities and adaptation responses, thus facilitating the identification of policy options and cost-efficient strategies (European Commission 2007). Land use planning should take the possibility of floods caused by heavy rains and other flood risks into account in town and county planning. In addition, it is necessary to study the vulnerability of municipal technology, such as energy and water supply, wastewater treatment, and improvement of risk management (Finnish Government 2005). Information on flood risk areas is already available through the OPW's flood maps website. In addition, Ordnance Survey Ireland has developed a reporting system consolidating data collected by three organisations – Ordnance Survey Ireland, the Environmental Protection Agency (EPA) and the Geological Survey of Ireland (GSI). The report contains detailed information on land use, site history, soil stability, water history and statutory licences. It is a significant document for people who own or intend on purchasing a property, as well as planners, architects, engineers, and the legal profession¹⁵.

¹⁵ News report http://www.1spatial.com/news_events/news/news.php?news=270

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Ireland needs to devise appropriate measures and legislation for planning and development based on predicted climate changes at the national and local level. These measures should include developments by local authorities, infrastructure funded by the National Development Plan and private developments. Financing arrangements dedicated to adaptation are necessary to support the implementation of co-ordinated adaptation strategies, especially in the most vulnerable regions and sections of society (European Commission 2007). Appropriate measures include;

- Identify land for current and future flood management in Development Plans and Local Area Plans.
- Resist development in flood risk areas, particularly floodplains, except in certain circumstances where particular precautions are taken.
- Utilise a sequential approach to flood risk management through first avoiding risk, then reducing risk and finally mitigating flood risk.
- Incorporate flood risk assessment into the process of making decisions on planning applications and planning appeals. (DOEHLG 2008b)

Based on current predictions, flooding and more extreme weather events are two of the most significant issues affecting land use and planning in Ireland in the next 50 years. However, rising temperatures may also have an effect, although this will be more pronounced in other countries.

Green spaces are an important tool in adapting urban areas to climate change as they store more water and are a significant tool in modifying urban temperatures. Large deciduous trees have particular value in cooling the air through shading buildings in summer. They also capture carbon, simultaneously mitigating carbon emissions and allowing us to adapt to climate change. Chiswick Park in London is an award-winning business park that incorporates a large area of high-quality open space. The design of the area favours people over vehicles and is arranged around a water feature bordered by plants and trees. It incorporates biodiversity corridors, buildings with external shading, fabric blinds, a no pesticides rule, composting on site and work with the community (CABE 2008). CABE outline a number of steps that are essential in constructing sustainable spaces that increase our adaptive capacity.

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- Firstly, it is essential to be able to understand and quantify potential climate effects.
- Baseline information must be collected to ensure that both the risks and opportunities are considered.
- Work should be conducted in multi-disciplinary teams across council departments bringing together a wide range of skills and knowledge.
- Plans should consider both long and short term implications.
- Adequate funding is necessary. A management trust may be needed to safeguard funds.
- The local community should be included in the design process, which has the added benefit of increasing buy-in.
- Available space should be maximised and vacant and redundant space should be utilised.

6.2 Transport

Adapting existing transport infrastructure to changing climate conditions, while ensuring its continued and safe functioning, will require substantial additional investments. New transport infrastructure and related transport means should be made climate proof from the early design phase. This means assessing the risks, disturbances and structural impacts caused by climate change in each form of transportation- road transportation, sea traffic, railways, air traffic and communication networks (Finnish Government 2005). Introducing the avoidance of flood-sensitive areas is one general principle into the planning of road and rail networks (Finnish Government 2005). There is also a need to study the safety risks caused by extreme weather phenomena to air traffic and seafaring vessels (Finnish Government 2005).

Local authorities are not transport providers but are responsible for regional planning guidelines which should align land use planning with transport investment. The Cork Area Strategic Plan is a good example of this, where development is linked to existing urban areas and transport facilities. It recognises the areas that will see further growth and improves access to public transport, jobs and services and

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amenities. This is essential in creating sustainable places to live, work and visit, and allowing people to move about in the event of extreme weather as a result of climate change. From a review of the development plans, all the local authorities acknowledged the importance of proper transport infrastructure and its inherent link with planning and development.

Conclusions

Water

Water infrastructure schemes must be flexible, adaptable and subject to rigorous risk assessment. A long-term holistic national plan to provide the necessary infrastructure in a timely and appropriate way should be prepared. A well resourced lead organisation would be useful in managing this task. This plan should incorporate all water sources across the country through an all-island water management approach. All local authorities should set maintenance and leakage targets to be achieved in specified time periods.

[There is a need for innovative, state of the art methods in river flood prevention. The majority of present flood prediction methodologies are based on statistically stationary population samples of flood events. This means that their estimations do not accurately portray predicted future levels. New methodologies, incorporating dynamic hydrological modelling will have to be developed to allow engineering calculations and estimates to account for potential future flood levels. Such methodologies will need to be employed by local authorities if they hope to ensure the best planning and development strategies for their localities.

There is a striking need to adapt short-term 15-25 year flood protection measures to more comprehensive 25-50 year measures in local authority development plans. These should be capable of responding to climate change effects predicted for that period. The employment of catchment-wide land use planning, to reduce flood risks in centres of population is an important measure to achieve this aim. Flood maps, where already in place, should be consulted in every planning decision. To reduce flood levels wetlands, bog restoration or setting aside upstream areas of land to act as flood storage are needed. In addition, the employment of aquifer storage can help to reduce flood events and protect water supply. The use of soft defensive measures, semi-permeable materials and SUDs should always be utilised, where feasible. With these methods, flood peak may be kept at or below its present level, reducing risk to

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populated areas, even with increased rainfalls. This also has the added benefit of improving the wildlife and biodiversity of a river catchment.

We recommend the use of Water Demand Management to ensure the availability, accessibility, use and conservation of water and to promote innovative technologies and practices. There is no need to ration or regulate the use of water if we price it properly.

In relation to surge-induced coastal flooding, we recommend that risk and cost benefit assessments are carried out in order to facilitate choices for flood protection for the larger coastal settlements, particularly Dublin, Cork, Limerick, Waterford and Wexford.

Risk data needs to be integrated into planning and development to prepare for the threats posed by climate change to the Irish coast. Ireland does not, as yet, have a system for surge forecasting and for disseminating coastal flood warnings. There is a need to monitor sea level changes and provide data for numerical model calibration and real time feedback to a coastal flood warning system. With such a system in place, early warnings could allow more efficient emergency responses and significantly help to reduce flood damage and social disruption.

Development of Eco-system Services

The Agriculture sector, which is highly exposed to climate change, must work towards reducing vulnerability and increasing sustainability from both an environmental and economic perspective. In the EU, funding is provided to farmers engaging in more environmentally sound agricultural practices through the revised CAP programme. Assistance should be provided to move agriculture into this direction, simultaneously aiding in the mitigation of and adaptation to climate change. Policy needs to be developed on breeding, cultivation and production methods, as well as regional aspects in setting the long-term objectives for agriculture. On-going communication efforts between local authorities, farmers and Teagasc could be beneficial in this regard.

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As a result of climate change, we will face ever growing food security issues. Local authorities could play a significant role in increasing food security and strengthening resilience through encouraging more locally grown food with provisions for allotments, community gardens and urban vegetable growing.

In terms of fish stocks, climate change can affect the distribution patterns, migration patterns and abundance of fish species. While local authorities are not directly responsible for ensuring the maintenance of fish stocks, actions under their remit can impact on fish numbers. Protecting water quality and safeguarding water resources are essential actions in conserving marine and fresh-water life. Counties with significant waterways and coastal areas should work with relevant bodies with regards to water management and planning and development, where necessary.

Several techniques have been used to deal with the effects of climate change in forestry. For example, wider spacing and early thinning increases resilience to wind damage, while increasing under-story vegetation reduces mineral leaching and increases biodiversity. All forested areas under local authority governance should be protected and should be nurtured using natural resilience enhancing techniques. The use of native hardwoods is also strongly encouraged.

It is important to increase tree numbers in urban areas and assess the impact of housing, infrastructure and other developments on surrounding woodlands, trees and hedgerows. The National Indicative Forest Strategy and County Indicative Forest Strategy are essential in devising effective plans for combating deforestation and increasing tree numbers.

Biodiversity needs to be a primary concern for all citizens and sectors due to its high intrinsic value. Local Biodiversity Plans need to be developed as quickly as possible to conserve unique local species and ensure genetic variation. These plans should incorporate a commitment to protect the Natura 2000 network and other sites, habitats and wildlife species of international, national and local importance.

Intelligent Planning and Design

Zoning decisions should be based on good information that account for future climate conditions and should encourage innovation. It is crucial that spatial strategies and infrastructure plans are climate proofed. Land use planning should connect vulnerabilities with adaptive capacities and adaptation responses. Information data bases such as the OPW's flood maps should be used from the early planning stages and future adaptation needs should be identified.

There is a need for the improvement of flood resilience in building design and construction to help meet future climate change scenarios. Statutory development plans should be independently audited and monitored regularly to ensure they meet high standards.

It is recommended that Sustainable Urban Drainage Systems are incorporated into new developments to limit discharges into streams and rivers. This would have the dual effect of limiting the flood potential of the development and protecting groundwater levels.

Local authorities should devise development plans that align land use planning with transport investment.

The Irish people need to reduce fossil fuel consumption and dependence in general in order to be less dependent on imported fossil fuels. It is also necessary to switch to renewable energy sources such as wind power, hydro-power, solar power, tidal and wave power, bio-energy and energy from waste. This needs to be promoted in private homes and public buildings. Local Authorities play an important role in green energy procurement and through granting planning permission for the development of renewable energy, where appropriate.

Final Thoughts

One of the key findings that emerged from this process was that Ireland lacks a comprehensive strategy for coping with the effects of climate change, although a National Adaptation Strategy is currently being drafted by the Department of Environment, Heritage, and Local Government. In the absence of tight national, regional, local and municipal authority co-ordination, it is doubtful that adaptation actions and flood management will ever be more than reactive. At the moment agencies and authorities are competing on a case by case basis with each other for scarce central government funding of what may well prove to be relatively short-term (and therefore cost-inefficient) adaptation measures. In addition, local authorities will require expert guidance on adaptation from a central body if they are to devise local adaptation plans.

In addition, there is no over-arching advisory body dealing with adaptation measures and little formal communication between the bodies responsible for various actions. In some cases, there is no designated body responsible for implementing essential adaptation measures. The effects of climate change impact different sectors simultaneously and the response of one sector can have an effect on another. For this reason, it is necessary to designate responsibility to one well-resourced co-ordinating body. This high-level strategic adaptation body should collaborate fully with counterparts in the North.

This paper recognises the need for careful and well thought out planning in relation to all areas of the built environment in Ireland. Adaptation measures in Ireland should be co-ordinated and forward thinking rather than ad-hoc and reactionary.

While climate change will have devastating effects, it will also bring about some benefits. For example, possible increased tourism due to better weather and longer growing seasons. The benefits of climate change should be identified and taken advantage of.

A full impact assessment which examines the effects of climate change on economic and socio-economic factors needs to be conducted. This assessment should bring

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together research on all of the effects of climate change to provide a comprehensive overview of the key issues we face going into the future. Some additional potential issues, beyond what has been mentioned above, include the effects of climate change on health, tourism, insurance, enterprise, individual well-being and people in poverty.

We highlight the key role which local communities play in adapting to climate change. Therefore, we call for the implementation of integrated sustainable urban, regional and rural development strategies.

We would like to emphasize the importance of strong interconnectivity between adaptation and mitigation effects. It is our belief that only through the examination of synergies between both mitigation and adaptation for limiting consequences of climate change that a clear holistic strategy can be developed.

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Appendix 1 – National Strategy

The EU Green Paper on adaptation recognises four priority areas for action. The first priority is early action in developing adaptation strategies especially in areas where current knowledge is insufficient. This paper has examined early action and possible adaptation strategies in sectors relevant to local government. However, other sectors, which may not be relevant to local government, are significant in developing a National Adaptation Strategy. These national concerns are explored below.

The second pillar examines the integration of global adaptation needs into external relations and the need to build new alliances with partners around the world. The third pillar relates to filling knowledge gaps on adaptation through research. The final pillar suggests the development of an advisory group, involving society, business and the public sector, on adaptation to climate change to analyse co-ordinated strategies and actions.

Pillar One: Early Action

Health

Climate change has detrimental impacts on health through heat waves, cold spells, natural disasters, air pollution and infectious vectorborne diseases¹⁶. In addition, waterborne, foodborne and zoonotic¹⁷ diseases in humans can potentially be affected by increased temperatures and changes in rainfall patterns. These effects can be amplified by other stressors, for example exposure to ozone and fine particles during a heat wave. Long-term exposure to fine particles in ambient air worsens a number of health problems, such as chronic obstructive pulmonary disease, which makes people more susceptible to further climate induced stress. There is a serious need to improve alert systems for the possibility of disease outbreaks and educate residents about disease risks, precautions and symptoms. As well as monitoring and reporting disease incidence, schemes to control disease vectors, including elimination of

¹⁶ Vector borne diseases are infections transmitted by a vector, such as a fly, mosquito, tick or lice. The vector can either harbour the infection inside its body, like in the case of a mosquito. Alternatively, it can carry the pathogen outside the body and transmit it in a passive manner.

¹⁷ Diseases transmitted or shared between humans and other animals.

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disease vector breeding sites, could be put in place. A possible increase in the risk of waterborne diseases could be tackled through increased monitoring for diseases, such as E. coli, toxic algae, and viruses (SMEC 2007).

Increased temperatures will raise the possibility for increased sunburn and heat stress to older people, economically disadvantaged groups and vulnerable communities (SMEC 2007). This will not be as pronounced for Ireland as other countries; however, Ireland will experience warming, particularly in the summer months. To tackle this there needs to be increased community education on awareness of dangers of sun exposure and the symptoms of heat stress. The treatment of sunburn and heat exposure can be reduced through providing more shade in public recreational areas and improving ventilation of public and private buildings. Innovative schemes, such as reducing user fees for swimming pools and providing outdoor drinking facilities could be successful in reducing health problems. These strategies would require joint effort between different departments and affiliated bodies.

It is recommended that the Government develops a Public Health Plan that looks at the current health and wellbeing of communities. The development of Wellbeing Indicators is necessary so that the programme can be assessed over future years (SMEC 2007). Councils and public health authorities can utilise demographic profile and social analysis of council areas to assess health vulnerability and identify affected communities and needs (SMEC 2007).

There is a need to examine the different aspects of mortality and morbidity due to climate change, including the changes in the means of transmission of certain infectious diseases affecting human and animals, changes in the dissemination of airborne allergens due to atmospheric changes and the risks due to ultraviolet radiation as climate change delays the recovery of the stratospheric ozone layer (European Commission 2007).

Tourism

Ireland has a strong tourist industry which relies on its natural landscapes, fish stocks and other natural resources. They must be protected at all costs. With climate

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change, there are both risks and opportunities for tourism, which means that supplementary activities could be developed (Finnish Government 2005). Due to warmer climate in other parts of Europe, Ireland may be a more attractive destination in summer for people from southern Europe. Failte Ireland (2007) have produced a background on tourism and the environment, which outlines how Irish tourism relies on our natural resources and heritage.

Insurance

Climate change and the effects it generates, in terms of property damage, business interruption and forest fires, presents a substantial financial risk for individuals, companies and the financial sector. We need to measure potential economic risks and mitigate the economic risk to insurance institutions through bonds and derivatives (SMEC 2007) and develop insurance systems for damages caused by extreme weather phenomena. There needs to be clarification in relation to the division of tasks and responsibilities between public and private insurance. Studies are currently taking place in the Netherlands to evaluate adaptation options for insurance companies. In the UK the insurance sector has introduced a variety of measures to adapt, including- appointing senior staff with specific responsibility for work related to climate change risk and commissioning a major research initiative to explore the impacts of climate change upon the sector (EEA 2005).

Industry

Industry will need to adapt to changing conditions, but at the same time, co-benefits between mitigation and adaptation measures should be exploited. Being an early mover into a new business area can provide substantial opportunities for ambitious organisations (European Commission 2007). For example, there are opportunities for new design skills and new environmental technologies in the adaptation of buildings and infrastructure. Ireland may attract more tourism due to hotter temperatures in the Mediterranean. There may be more scope for market garden products like salads and fruit, which may not be able to grow as well in traditional growing areas. In the UK, the National Farmers Union (NFU) has identified opportunities for farmers with appropriate land holdings to create small reservoirs for the storage of increased winter rainfall that could be used during the hotter drier summers (EEA 2005).

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There is a need to study of the impacts of climate change in different sectors and a need to develop concrete adaptation measures. These measures must take account of the necessary scale of adaptation actions, cost effects and possible implementation times. A survey of the location of industrial plants to flood sensitive areas and areas where seawater may rise is essential in order to prepare the necessary flood protection instructions (Finnish Government 2005).

Partnerships with different levels of government and business are an essential mechanism for increased implementation of adaptation actions. Partnerships enable the sharing of resources, existing knowledge and avoid the “reinvention of the wheel” by different levels of government (SMEC 2007). Communication with industry representatives, such as IBEC and funding agencies, such as enterprise Ireland would be an ideal way for government to work with industry to raise awareness for adaptation practices, develop a lucrative adaptation market and ensure demand for products related to adaptation is met.

Integrating Adaptation into External Actions

Climate change is a serious challenge to poverty reduction in developing countries and threatens to undo many development achievements. Poor communities in these countries depend highly on the direct use of local natural resources. They have restricted choice for their livelihoods and limited capacity to cope with climate variability and natural disasters. The least developed countries in Africa, parts of Latin America and Asia, and small island states will be hit hardest. Being responsible for most of the historic accumulation of greenhouse gas emissions in the atmosphere, developed countries will need to support adaptation actions in developing countries (European Commission 2007). Irish Aid and various independent charities are involved in providing aid to developing countries affected by climate change.

Ireland needs to operate on an all Ireland basis to adapt to climate change, especially with regard to cross-border issues such as regional seas, river basin management, ecosystem functioning, research, biodiversity and nature, disaster

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management, human health, economic transition, trade and energy supplies (European Commission 2007).

Impact analysis and good adaptation practices should be exchanged between industrialised regions facing similar problems. Co-operation strategies with these countries should be further elaborated (European Commission 2007).

Reducing Uncertainty and Expanding Knowledge Base

There is an obvious need to strengthen policy relevant research and development relating to the impacts of climate change and adaptation. In addition to general research on future climate conditions, research should focus on the processes of climate change adaptation, the costs of climate change and sector specific studies. There is also a need to enhance the use of research information and increase the sharing of data between different administrative sectors (sectoral authorities and regional and local authorities), institutes and other actors. In its first stage, the mainstreaming of climate change impacts and adaptation calls for the development of research and assessment methods. At the same time, relevant aspects of climate change may be incorporated into environmental planning, environmental impact assessment and risk management (European Commission 2007).

Efforts need to be advanced on the science of adaptation and on mobilising research. Some key research needs are detailed below;

- Specialist engineering skills in hydrology and river engineering will be required. This research need has been identified by the institution of Civil Engineers (ICE) in the UK as a critical issue.
- Quantitative estimates of how climate change will affect the groundwater environment and its dependent ecosystems are crucial for future planning.
- Further physically-based research into recharge mechanisms are needed to verify and improve current mapping and understanding.
- There is a need to carry out an examination of the socio-economic dimension and predictable consequences for the Irish population in relation to climate change.
- An economic study of adaptation, to develop scenarios establishing a balance sheet of adaptation costs and benefits to stimulate and anticipate economic action

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is needed. In such a study the importance of a sectoral bottom-up approach should be emphasised.

- There is also a clear need to employ independent cost/benefit analyses of future flood protection defences. This research should be informed by expert climatologist advice in advance of recommendations for any future expenditure on hard-engineered municipal defences

Involving society, business and public sector

Adaptation needs to be integrated into policy. Within the EU, certain sectors (for example agriculture, water, biodiversity, fisheries and energy networks) are largely integrated at EU level through the single market and common policies. It makes sense to integrate adaptation goals directly into these sectors (European Commission 2007). However, adaptation also needs to be integrated into other sectors and at other levels. The development of specific technical guidance documents, case studies and good practice should be considered (European Commission 2007). Australia has outlined plans at the local level. It plans to undertake a risk assessment for local government to identify the most significant areas of risk and to establish priorities and incorporate potential climate change adaptation actions into strategic planning where appropriate (SMEC 2007). In order to reach local authorities in France, a club is being established. The club aims to pool together knowledge on the link between management and funding of infrastructure and climate change. It will focus on possible mitigation and adaptation measures involving urban infrastructure and its funding. Three annual meetings will be set up with the participation of French local authorities, companies providing development services (energy, building, transport, water) and infrastructure economics experts.

The need for adaptation could provoke significant restructuring in some economic sectors that are particularly weather dependent, for example agriculture, forestry, renewable energy, water, fisheries and tourism. Restructuring will also be necessary in areas specifically exposed to climate change, for example ports, industrial infrastructure, urban settlements in coastal areas, floodplains and mountains. There should be dialogue between the parties and civil society to explore these challenges systematically (European Commission 2007).

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Behavioural change within societies and communities depends largely on awareness of the problem. Citizens and actors may not yet be aware of the scale and magnitude of what is to come, as well as the impacts of their activities. For example, detailed land management and land use practices could be explored in partnership with farmers to prevent erosion and mud streams reaching houses and settlements (European Commission 2007). Adaptation will require the support of education and communication through the involvement of the mass media and through citizen's participation in environmental issues.