Rationales for adaptation in EU climate change policies

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Abstract
This paper sets out a series of rationales for public policy related to adaptation to the impacts of climatic change in the EU. It begins by arguing that that both mitigation and adaptation are necessary parts of a coordinated policy response to the problem of climatic change. However, the 'problem structure' of adaptation is significantly different to that of mitigation. For instance, adaptation may generate private benefits that are likely to be experienced over the short term, relative to benefits associated with the impacts of mitigation actions on global climate which are public and experienced over the longer term. This divergence influences public policy rationales for adaptation and poses challenges for the integration of mitigation and adaptation in climate policies. Five key challenges facing climate adaptation are identified, and these are used as a basis for proposing rationales for policy action on climate adaptation. These relate to: information provision and research; early warning and disaster relief; facilitating adaptation options; regulating the distributional impacts of adaptation; and regulating infrastructures. The paper concludes by arguing that a more significant policy integration problem for adaptation policy relates to how it is embedded in other sectoral policies such as agriculture and transport, rather than how to achieve integration with mitigation policies.

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Introduction

All natural and social systems are, to a greater or lesser extent, adapted to the climates they experience. Climatic change imposes new pressures on those systems to adjust in response. In natural ecosystems these pressures will be experienced as new selection pressures, changing the structure and dynamics of populations. In social systems, these pressures will also be experienced as selection pressures, but in addition there will be scope for reflexivity, innovation and change as people and organizations adjust to remain sustainable.

Many of these adjustments will be made privately, by individuals, households and businesses, and they are likely to yield principally private benefits. However, there are good reasons to believe that private adaptation, by itself, will remain at a level below what might be deemed socially- or politically-desirable (IPCC, 2001b). This is due to spill-over effects (certain benefits of private adaptation may be shared inadvertently with others), uncertainty about the distribution of benefits and costs of adaptation, and the mismatch between the distribution of climate vulnerability and the capacity to adapt. These problems are manifested at local, regional, national, as well as international levels. In addition, there will be a range of adjustments that need to take place in the public sphere. These include changes to major infrastructures, as well as changes in standards and regulations that will give private actors the freedom and incentives to adapt. The need to respond to more rapid global environmental change may also influence patterns of national and international governance at a deeper level as well, as the value of diversity and flexibility in socio-technical systems grows.

For these reasons – that there will tend to be under- or mal-adaptation in the private sphere and because adjustments are necessary in the public sphere – there is a clear role for policy in motivating and shaping adaptation to climatic change. Although this was acknowledged in the IPCC TAR, and provisions for adaptation exist within the Framework Convention on Climate Change (FCCC),[1] adaptation has until recently failed to be given the same attention as mitigation in the development of climate policy, within the EU and internationally. A mature climate policy needs to find a place for both mitigation and adaptation.

This paper has three main aims:

1. To summarise some key ideas related to social and economic adaptation to the impacts of climatic change;
2. To explain the similarities and differences that exist between mitigating climate change and adapting to its consequences; and
3. To set out a rationale for policy intervention related to climate adaptation.

The first section outlines evidence of climate change and impacts. This is followed by sections dealing with the questions of who and what adapts to climate change impacts. Alternative models of how social and economic adaptation may occur are

[1] Art 2 argues that greenhouse gas concentrations need to be stabilized and that '…a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.'

then discussed, followed by a section comparing the similarities and differences between mitigation (the reduction of greenhouse gas emissions) and adaptation (adjustments made in response to climate change impacts, real or perceived). The final two sections attempt to set out a rationale for 'adaptation policy'. The primary scope of the paper is Europe, with the aim of illustrating problems that are more generic.

Climate change impacts and adaptation

Scientific evidence is accumulating that the global climate is changing. Over the last century average surface temperatures have risen by 0.6°C, and the Intergovernmental Panel on Climate Change (IPCC) reported in 2001 that most of this warming over the past 50 years was explained by increasing concentrations of greenhouse gases in the Earth's atmosphere (IPCC, 2001). The IPCC projected that average global temperatures would rise by a further 1.4-5.8°C over the next century. Even if anthropogenic greenhouse gas emissions were ended now, temperatures would continue to rise for three to four decades.

The main impacts of rising temperatures are expected to be rising average sea levels (by between about 10 and 90 cm), an accelerated hydrological cycle leading to increased precipitation, and the likelihood of greater climatic variability, including greater extremes of temperature, precipitation and storminess. Research suggests that these climatic changes will affect both natural systems and human activities. Indeed, there is already evidence from nature of responses to changing climate. Examples include shrinkage of glaciers, thawing of permafrost, lengthening of mid- and high-latitude growing seasons, poleward shifts of plant and animal ranges, and earlier flowering of trees, emergence of insects and egg-laying birds (IPCC, 2001: 3). We can see that climatic, terrestrial and marine systems are all being reshaped by a warmer climate, with multiple effects on human welfare.

Human and natural systems that are most strongly interwoven are also those that are most likely to be affected by climate change. These include: agriculture and food; forestry; freshwater resources; terrestrial and freshwater ecosystems; coastal zones and marine ecosystems; human settlement and industry; insurance and financial services; and human health. But impacts will be experienced beyond these sectors as well, to the extent that a changing climate may come to be seen as influencing most human activities, especially under more extreme warming scenarios. As with natural systems, we can already observe that societal actors are responding to the direct and indirect impacts of a changing climate. For instance, farmers in some temperate regions are taking advantage of longer growing seasons to increase crop yields, while water resource managers are building changing rainfall patterns into their forward plans. Such responses and adjustments are termed 'adaptation'.

Adaptation to social and environmental change is a feature of all human societies (Rayner and Malone, 1998). To some lesser or greater extent, societies are adapted to the climates to which they are accustomed, including a wide range of conditions from polar to desert climates. More recently, an argument has been made for considering the mutual interactions between human and environmental systems as the centrepiece of a 'sustainability science' (Turner et al, 2003). Sustainable societies

exist across of range of the Earth's climates. Each of these environments has familiar seasonal patterns of weather, and these influence many aspects of economic and social life, including diet, dress and settlement. Societies are also accustomed to dealing with the inherent variability of climate, and have a capacity to cope with extremes and weather-related disasters.

It is important to recognise that adaptation to changes in climate will occur in the context of many other changes and adaptations, in both natural and socio-economic systems (IPCC, 2001b). For instance, while temperatures have been rising slowly over the past century, there have been huge changes in the exploitation of natural resources, and in technological and social systems across the world. While changes in climate experienced over the past 50 years as a result of warming may have had impacts on human welfare and on the resilience of natural ecosystems, these are likely to have been experienced as background changes in the context of many other, more significant social, political and economic discontinuities. In future, the prospect is that climatic change will become more marked, with climate becoming a more significant driver of adaptive behaviour by people, organisations and countries, as well as challenging the capacity of these groups to adapt.

The crucial question is whether social and natural systems can change in response to a changing climate – implying both changes in mean conditions and in variability – and whether this can be achieved without suffering losses in overall social welfare or ecosystem functioning.[2] While more flexible and fast-changing aspects of social and natural systems will adapt relatively quickly and at low cost to a changing climate, more long-lived and inflexible features are likely to be more difficult and costly to adjust. In some parts of the world, whole economic sectors seem likely to be transformed. For instance, higher mean and peak temperatures around the Mediterranean may reduce its attractiveness as a summer holiday destination by the 2050s, while higher temperatures in northern Europe may make it more attractive. The question is whether such a change, over the period projected, can be accomplished without major social costs and disruption. We should also expect surprises, with thresholds being crossed, and sudden, much more rapid, climatic shifts and social responses occurring as a result.

Given this background, there are several reasons why we need to understand more about adaptation (see IPCC, 2001b: 890, for a similar list):

4. Climate change cannot be totally avoided, and is likely to be continuous for many decades (in a transient state) and could be more rapid and pronounced than expected;
5. The degree to which societal and natural systems are vulnerable to a changing climate will be influenced by whether they will or can adapt (see below);
6. Anticipatory adaptation is likely to be more effective and less costly than adaptation after the event;
7. There are immediate social and economic benefits to be gained through better adaptation to climate variability and extreme events.

[2] Note that this does not assume that adaptation is always at the service of maintaining the status quo. 'All socio-economic systems are continually in a state of flux in responding to changing circumstances, including climatic conditions' (IPCC, 2001: 889).

It is already clear that, at a global scale, the pattern of the impacts from climate change are likely to vary tremendously. For instance, some models suggest negative economic impacts in agriculture in tropical and sub-tropical regions of the world, even under low temperature increase scenarios (Mendelsohn et al., 2000). In contrast, yields in mid-latitudes could increase with moderate temperature rises (IPCC, 2001: 5-6). Even within the UK, while less precipitation is expected in the south-east, increased rainfall is projected for the north-west (Hulme et al., 2002). Likewise, the capacity to adapt will vary, with more affluent, knowledgeable and socially-cohesive societies generally being perhaps better able to respond. As the agricultural example shows, the greatest impacts may fall on societies that are currently least able to adapt effectively. We need to build our understanding of how these patterns of vulnerability and adaptive capacity intersect, and aim to focus our attention in these sectors and regions where the vulnerabilities are likely to be greatest.

Adapting to what?

In both natural and human systems, the range of environmental variability to which they are adapted has been termed the 'coping range' or resilience.[3] While it is often difficult to be precise about the coping range (or comfort zone) of an ecosystem, or of an organisation, the general idea is useful in describing the discomfort, costs and risks that come with needing to cope with conditions that are outside common experience. The closer you get to the edge of the coping range, the greater will be the effort to maintain welfare or function. So, for example, in a wet British summer, hotel owners need to work harder to attract customers, while still continuing to have a profitable business.

Four features of responses to climatic conditions stand out. First, climate is many-faceted – it is experienced as more than just a single distinct phenomenon, such as temperature or precipitation. Climatic conditions to which people or ecosystems respond and adapt are a combination of factors, and their particular effects on people are usually mediated by all sorts of socio-economic factors. So, for instance, cold, wet and windy would be experienced differently than cold, wet and still, and affect behaviours in particular ways, whether these are average conditions, or variable episodes. To give a more concrete example, precipitation experienced with higher wind speeds will influence the standards of water-tightness required in the construction of buildings – as is already being experienced in the southern UK – whereas higher precipitation alone might only have an influence on flood defence measures.

Second, the effects of varying climatic conditions (and on changes in these conditions) will differ across different social groups – a hot, dry summer may be

[3] Formally, coping range represents the range of critical environmental variables (including for instance, temperature or the price of a factor of production) across which a system can operate without loss of performance (Hewitt and Burton, 1971; Fukui, 1979). Once the characteristic degree of variability of these critical variables is exceeded, the system has to expend new resources to sustain characteristic levels of integrity and performance. A related concept is 'resilience'. Folke et al. (2002: 13) define this as '…the capacity to absorb shocks while maintaining function'. A difference may be that the resilience concept does not contain a definable limit to the capacity to absorb shocks, as implied in the notion of a 'range'. Resilience is a more graded concept in which 'thresholds' (Parry, 1986) or 'bands of tolerance' (Warrick et al. 1986) do not necessarily feature.

good for ice-cream sales, but may be much less welcomed by some farmers.[4] This means that in talking about impacts, care needs to be taken about identifying what group or system is being affected, and what range of conditions are being considered (see Table 1). Not all coping ranges will be equivalent, even within a similar sector, species or ecosystem, so that any given change in climate is likely to produce both winners and losers.

Table 1 Climate-sensitive sectors and systems (adapted from Easterling et al., 2004:3).

Socio-economic sectors	
Agriculture	▪ High sensitivity and exposure, but high capacity to adapt ▪ EU agricultural output likely to rise up to 2-3°C temperature rise; and to fall beyond this
Forestry	▪ High sensitivity, moderate capacity to adapt ▪ Substantial change in productivity and location of forests
Freshwater resources	▪ High sensitivity, moderate to high capacity to adapt ▪ More droughts and floods, major infrastructural investment needed
Coastal zones	▪ High sensitivity, variable capacity to adapt ▪ Increased costs of sea defence
Built environment	▪ Moderate sensitivity, variable capacity to adapt ▪ Locational change and climate-proofing of built environment costly
Tourism	▪ Variable sensitivity, variable capacity to adapt ▪ Possible changing seasonality of tourism across Europe
Natural systems	
Terrestrial ecosystems and freshwater aquatic ecosystems	▪ High vulnerability ▪ Substantial change in distribution of species; loss of biodiversity expected
Coastal and marine ecosystems	▪ High vulnerability ▪ Wetland areas substantially affected by changes in temperature and run-off

Third, social systems will adjust to the direct experience of climate change, but also with a host of indirect consequences that result from climatic changes. For example, the price of food commodities in the EU may vary as a result of harvest failures in another part of the world, or housebuilders may no longer develop on fluvial floodplains because insurers are no longer willing to insure properties in those areas. Fourth, climatic factors may have their greatest influence as sequences of events, as well as in the form of single catastrophic events. Natural and social systems often have the resilience to cope with single events, but become more vulnerable to the compounding effect of sequences of harmful events. A single event may place a system at the edge of its coping range, a follow-up event may push it outside this range. For example, water supply companies in the UK are able to cope with one or

[4] The hot dry summer of 2003 was responsible for major agricultural yield reductions in large parts of southern and eastern Europe.

even two dry seasons. Water resources become seriously challenged in parts of the south and east if a dry summer and winter are followed by another dry summer.

We take as given a familiar level of variability of climate, and assume that natural and human systems are more or less adapted to them. Climate change will impose a different range of climatic conditions on natural and human systems, exposing them to new stresses as a result. It is also important to recognise that it is likely that these changes will be more or less continuous for a long period. Even if greenhouse gas emissions are stabilised at a level that prevents atmospheric concentrations from more than doubling pre-industrial levels, global climate will continue to become less similar to our current climate for the next century or so. We therefore face not only a changed, but a continuously changing climate.

Who and what adapts?

To illuminate the complex interactions between climate and the development of natural and social systems, analysts have developed some concepts useful for understanding adaptation (see Box 1). An important conclusion is that the vulnerability of a system is tied to its adaptive capacity. An adaptive system is likely to be less vulnerable than one which is less able to make adjustments that maintain productivity, functioning or welfare. Adaptation is therefore a way of reducing vulnerability to climate change. Effective adaptation will reduce the costs of damages experienced as a result of climatic change, and will enable a system to take advantage of opportunities to improve performance that may arise from the changed conditions.[5]

Broadly speaking, there are three sides to adaptation:

8. Minimising sensitivity or exposure to risk
9. Developing a capacity to cope after damages have been experienced; and
10. Acquiring the means to exploit new opportunities that arise.

In practice, adaptation may include a series of adjustments that attempt to strike a balance between these three broad objectives. For instance, the costs of reducing exposures to climate-related risk may be prohibitive, therefore requiring some investment in contingency and recovery planning.

Here the difference between natural and social systems needs to be more sharply drawn. For plants, animals and ecosystems, environmental changes impose new pressures that increase or decrease their ability to survive and reproduce. Their capacity to adapt will typically be quite limited. Biological systems are constantly responding to changing environmental conditions and to genetic variety. Over longer time periods they become redistributed and evolve. Gradual changes in conditions may be accommodated by natural ecosystems, but more rapid changes can be disruptive, especially in already-stressed environments. Many of the world's ecosystems are already stressed by a variety of disturbances, including pollution, fragmentation and the invasion of exotic species (Easterling et al., 2004: 4). Climate change adds another stress.

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[5] US studies report that adaptation measures in agriculture may lead to reductions in adverse costs of climate change of between 29 and 60 percent (Tol et al., 1998).

People and organisations, in principle, have the capacity to make conscious and planned adjustments to the way they do things in response to climatic change. They can act to reduce their vulnerability and to make the most of advantageous changes in their environment. They can anticipate change, or they can respond to impacts, having assessed the alternatives. In general, adaptive capacity will be related to knowledge and awareness, access to resources, technology, social networks and attitudes to risk (Smit and Pilifosova, 2003). We would expect more knowledgeable, better-resourced, more equitable and more interconnected groups and organisations to have a greater range of adaptation options available to them, and to have a greater capacity to put these into practice. Likewise, we would expect those with a more precautionary attitude to adapt in anticipation of expected future impacts, while others prefer to 'muddle through' in reaction to experienced damages or opportunities. Much work is currently underway to improve the assessment of vulnerability and adaptive capacity in economic and social systems.

Vulnerability: a measure of a system's susceptibility to climate change - a function of the system's exposure, sensitivity and adaptive capacity
Exposure: the extent to which a climate-sensitive sector is in contact with climate.
Sensitivity: the degree to which a system is affected by climate change.
Adaptive capacity: how well a system can adjust to climatic changes to moderate potential damages (by changing exposure or sensitivity), to cope with the consequences of impacts (by recovering or maintaining welfare/system function in the face of climatic change) and to profit from new opportunities (assuming climate change affects agents differentially).

Box 1 Adaptation concepts (adapted from IPCC, 2001b)

Early research on adaptation to climate change impacts tended to make the broad assumption that the most urgent needs would be in the developing world, rather than in western industrialised countries. This was partly because global climate models predict that some of the most marked changes in climate will be in tropical (and polar) regions, but also because less wealthy societies are seen as more vulnerable in the face of all sorts of economic, social and environmental change. To give a simple example, while low-lying regions of Europe may be defensible against sea level rise, it is unlikely that all Pacific island states will be habitable by the middle of this century. This perception is now changing. Not only is it recognised that relatively less-developed societies may have considerable adaptive capacities based on indigenous knowledge, and societal ties and networks (Mortimore, 1989), but it has also become clearer that more developed societies may have considerable vulnerability to climate change, partly as a result of being more closely-connected with the rest of the world through global trade and investment. Tightly-coupled technological and economic systems in the industrialized world may also have a 'brittleness' that is exploited by the impacts of climate change. Adaptation is therefore a serious issue in Europe as well, and needs to be part of a response to climatic change as much as are efforts at mitigating climatic change through reducing emissions of greenhouse gases to the atmosphere.

Adaptation and mitigation

In developing an integrated climate policy, which includes provisions for adaptation to climate change impacts, as well as mitigation of greenhouse gas emissions, it is important to relate the two core objectives to one another. At an aggregate level, mitigation and adaptation can be viewed as being partial substitutes for each other. For instance, less effort on mitigation – by aiming for a higher stabilisation level for atmospheric CO_2 concentrations – will imply a greater effort at adaptation over the longer-term future. Part of the justification by some countries for not incurring high mitigation costs in the short-term draws on the expectation that the costs of adaptation in the medium- and long-term will be lower. This is because overall welfare will have improved with economic growth and because technological (and institutional) change is assumed to make adaptation easier. Conversely, one of the arguments for accepting the costs substantial mitigation effort in the short-term is based on the recognised uncertainty that exists around the costs of adaptation to more rapid and damaging climatic change. Given that the EU has committed itself to a target of a less than 2°C global temperature increase above pre-industrial levels in its climate policy, this also implies a certain quotient of climate change. This target implicitly represents a trade-off between mitigation and adaptation over the longer-term. There is also an important international political assumption underlying this construction. In very broad terms, under the FCCC, mitigation is to be carried out by more developed countries, while less developed countries are promised assistance both with pursuing less carbon-intensive development paths, and with adaptation to climate change impacts.[6]

Strategically, it is therefore clear that mitigation and adaptation are bound together, at least over the long-term. This has lead some commentators to consider the potential for synergies between the practical implementation of adaptation and mitigation (Wilbanks et al., 2003). While there are likely to be many opportunities for linkages between mitigation and adaptation actions, it is also important to recognise that some basic features of the two objectives that are divergent. Indeed, it could be argued that the 'problem structure' of adaptation is significantly different to that of mitigation.

First, while most mitigation will bring 'common good' benefits (typically at an international level), the benefits of adaptation actions will often be private or localised. Mitigation investments in renewable power generation capacity will contribute to lower atmospheric concentrations of carbon dioxide with gains in terms of reduced global climate change. Adaptation investments, even in major new infrastructures, such as raised sea defences, will bring benefits only to settlements and ecosystems protected directly by them. Many adaptation actions will be at a much smaller scale, and will be implemented because they are expected to generate mainly private benefits.[7]

Second, while the benefits of mitigation will typically be experienced over the long-run, since amelioration of climatic change through reductions in greenhouse gas

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[6] The National Adaptation Programmes of Action (NAPA) are the clearest articulation of this support by the global north for adaptation in the global south.

[7] The householder installing storm-proof tiles on the roof, for instance.

emissions will typically occur over decadal time-scales. On the other hand, benefits from adaptation may become apparent over the short-run, since they may be in response to already-experienced changes in climate. The time-profiles of mitigation and adaptation are therefore often likely to be difficult to reconcile.

Third, while adaptation is concerned with multiple adjustments related to manifold direct and indirect interactions between climate and human activities (and natural ecosystems), mitigation is concerned with the relatively more bounded problem of anthropogenic carbon dioxide emissions. Early research on adaptation shows that the assessment of climate vulnerability, as with many risk assessments, can often be an open-ended process involving many aspects of an individual's or organisation's activities. This complexity tends also to give rise to a wide range of adjustment options related to many aspects of these activities. Table 2 gives a summary picture of the wide range of adaptation options available, in principle, to UK house-builders. Many of these represent extensions of conventional practices and innovations in the sector (Hertin et al., 2002). While it is true that mitigation through reduced energy use can be achieved through technological as well as behavioural means, the measure of success is unitary – lower carbon emissions. Reduced vulnerability (or greater resilience) will tend to be more multi-dimensional, including for instance dimensions such as 'social capital' (Adger, 2003).

Table 2 Adaptation measures in the UK house-building sector.

Function	Commercial adaptation / business model	Technological adaptation	Financial adaptation	Information and monitoring
Buying Land	• avoid areas at risk from flooding and erosion • learn to manage flood risk	• improved use of decision-support tools (GIS etc)	• costing in potential climatic effects • increased option buying	• monitor climate change impacts on land prices
Designing Houses	• provide 'climate-proofing' options	• use higher standards and new materials • stronger foundations • designs suitable for off-site manufacture	• link mortgage conditions to climate-proof building design	• monitor climate change impacts on buildings
Building Houses	• increase flexibility of construction process • improve supply chain management	• off-site manufacture • use of weather-resistant techniques	• insure building-sites against weather damage	• monitor weather-induced conditions on building sites
Selling Houses	• sales strategies taking account of climate changes issues	• offer additional anti-flooding or storm-proofing options	• improve buildings insurance against weather damage	• monitoring customer perceptions in relation to climate change issues
Maintaining Houses	• move away from maintenance (e.g. sub-contract)	• retro-fit new technologies (e.g. improved roofs)	• financial reserve for maintenance costs (housing associations) • restrict and shorten warranty	• monitoring of climate change impacts on maintenance

Finally, and perhaps most obviously, while the energy sector will be the focus of mitigation, adaptation to the impacts of climate change will be occur in a number of different sectors (and ecosystems), many of them not substantial contributors to greenhouse gas emissions. The major adaptations to climatic change expected in the energy sector are those linked to climate mitigation policy. Having said this, many opportunities for synergy between mitigation and adaptation exist and these need to be exploited, where practicable.

Models of adaptation

Many accounts of adaptation in response to climate change have made assumptions about when and whether people will adapt. For instance, some assessments hold that people and organisations may not adapt at all, but will continue to operate as if nothing had changed (the so-called 'niave' or 'dumb farmer' assumption (IPCC2001: 887, Tol et al. 1998). Other assessments question whether people will adapt to anticipated impacts of climate change, and assert that they will react only once evidence of damage (or opportunity) exists (Mendelsohn et al, 2000). Still others assume levels of adaptation (Rosenzweig and Parry, 1994). While reactive adaptation has the benefit of happening in the context of less uncertainty (you know more about what you are responding to and what the benefits of adaptive action may be), there may be benefits from early action, such as the avoidance of certain losses.

Such assumptions are key to models that have tried to calculate the economic costs and benefits of adaptation (as compared with 'no adaptation' scenarios). The dumb-farmer case gives a 'worst case' for the costs and damages associated with climatic change, while an anticipatory strategy is often held to give a 'best case'. In all these assessments there often continues to be considerable uncertainty about the precise nature of possible impacts, about how vulnerability will be expressed and experienced, and also about the adaptation measures that may be taken by people and organisations, particularly in the medium and long-term future. Assumptions about how people will act, and about the economic consequences of these actions, are one way of coping with the limited evidence that exists (or can exist) about future social responses to climatic changes. While there are historical analogues to draw on, great care is needed in the lesson-learning for the present-day. What economic analyses do express is the idea that adaptation is likely to occur only when there is a perceived advantage to those who are adapting.

An alternative, more bottom-up, approach begins from the position of the people, organisations and institutions that are (or will be) adapting (adapting agents). One of the early findings of research on adaptation to climate change is that the actual and perceived vulnerability of adapting agents can vary a great deal, even in apparently similar contexts. For instance, among UK water companies there are important regional differences in the vulnerability to changing precipitation patterns as a result of climate change (Berkhout et al., 2004). In the north-west of England, water resources are likely to be put far less under stress than in the south-east where, with a rising population and limited surface storage capacity, there are already problems in matching supply with demand in some areas. Likewise, the capacity to adapt to reduce exposure to climate impacts, and to build resilience to cope with impacts, can vary considerably. A hotel by the beach in Brighton on the south coast of England

faces a different profile of climate risks than a hotel one kilometre inland, and the measures that might be necessary to build resilience (by taking out extended insurance cover against storm damage, for instance) would be far more costly for one than the other.

This means that, unlike policies and actions on climate mitigation, policies and actions related to adaptation often need to operate at the micro-level of individuals, households, businesses and localities. Vulnerability to climate change may be universal, as is the capacity to adapt, but the gradients of vulnerability and adaptive capacity that exist between adapting agents tend to be steep in many sectors. This variability, as well as the uncertainty that exists about the potential value of adaptation, means that it is very difficult to argue for a 'best' adaptation strategy for any given adapting agent. Even where there is general awareness of climate change and its possible consequences, some agents will choose to adapt and will employ a range of strategies, while others will not. Both may be rational and well-founded responses in the context of uncertainty. As more is known that helps us to evaluate vulnerability and the benefits of adaptation, we would expect greater convergence in adaptive behaviour.

Key problems in adaptation

If adaptation to variable environmental conditions is normal for all natural and social systems, and we can observe adaptive responses to changing conditions, it is not immediately obvious that there should be a role for government. We might take the view that natural systems –short of creating artificial climates around them - are for the most part difficult to protect against climatic changes. Likewise, if private actors can be relied upon to act in their own best interests, and the best adaptation is after-the-fact, then perhaps social learning and the market should be seen as the basis for adaptive responses. Indeed, by protecting people and organisations from the effects of change, some economists would argue that governments run the risk of encouraging maladaptation.[8]

On the other hand, such an analysis seems insufficient. Government is likely to play a number of roles in enabling, influencing and implementing adaptation to climatic change. At the highest level, the EU and member state governments have a role in determining the balance between mitigation and adaptation, as part of an integrated climate policy. But there is a range of other roles specific to adaptation that governments in Europe need to play, working independently and together through the EU and the international system. To understand what these roles will be, we need to highlight some of the key problems that have been identified in adaptation research so far:

11. *Awareness of climate vulnerability*: Understanding the exposure, sensitivity and adaptedness of a natural or human system to future changing climate is complex. Vulnerability assessment is a growing field and needs to provide practical tools and applications that can be used by people and organisations, and in the management of natural ecosystems. At the root of vulnerability assessment and management must be improved predictions of climatic change and impacts,

[8] An example of this might be the public funding of contingency planning in vulnerable regions like coasts exposed to intense tropical storms that encourage settlement on those coasts.

especially over the short- to medium-term future. Private actors generally will not pay for or be able to generate the science needed for the assessment and management of vulnerability.

12. *Awareness of adaptation options*: Although organisations are continually under pressure to change the way they do things, climate risk has been integrated into innovation processes in only a few cases. This is at least partly because organisations are not yet aware of the measures (technological, institutional and so on) that could be taken by them to moderate these vulnerabilities and risks. Adaptation needs to be integrated more widely, and may involve, over the short-run, only small adjustments to their procedures for many organisations.
13. *Uncertainty and motivation*: For many organisations there will continue to be considerable uncertainty about the precise nature and risks of changing climate and variability, about their climate vulnerability and about the benefits of adaptation. To a large extent this uncertainty will remain irreducible, but there can be a role for better climate prediction and more tailored information, especially for smaller organisations. There may also be collective, broad-scale benefits from adaptation which cannot be captured if private actors are not informed about and given incentives to adapt.
14. *Adaptation spillovers*: As with many forms of innovation and change, the benefits of an adaptation to experienced or perceived climatic changes may not be exploited entirely by the agent making the change. There may be other beneficiaries from the knowledge and experience that an innovator has invested in. These 'spillovers' can lead systematically to a collective underinvestment in innovation/adaptation, generating a rationale for policy and legal interventions, such as intellectual property rights and patenting regimes. In addition, climate adaptations that reduce the vulnerability (or conversely which generate opportunities) of one agent may generate either negative or positive consequences for others. As we have seen, vulnerability to climate change is likely to be unequally distributed across different groups in society, nationally and internationally. In general, we would expect better-informed and better-resourced groups to be able to moderate their vulnerability more effectively, often through transferring risks onto others. Adaptation may therefore lead to a deepening of already-existing inequities. There is a role for policy to protect both the innovative or the vulnerable.
15. *Constraints on adaptation*: Much adaptation will draw on resources (including capital, knowledge, technology, consent) that are not held by the adapting agents themselves. While some of the resources will be made available through the market, there are also likely to be scarcities and constraints – partly as a result of the problems of awareness listed above. Policy has a role in modifying and perhaps removing some of these regulatory, market or infrastructural constraints that exist to adaptation. It is likely that in giving adapting agents greater scope to adapt (extending their so-called 'adaptation space') new conflicts will be generated with other environmental, social or economic objectives. There may be 'win-wins, but we should also expect trade-offs, especially where new resources are required to modify vulnerability or improve adaptive capacity.

Roles for policy in adaptation

This assessment of some key challenges facing social and economic agents who may seek to adapt to climate change, provides a structure for discussing potential roles for government policy. As we have argued, adaptation needs to become a substantial and integral component of climate policy at the EU, member state and regional levels. A variety of rationales have been given for public policy related to climate adaptation. Klein and Tol (1997) argue that public policy related to adaptation should have four objectives: increasing robustness of infrastructures; increasing flexibility and adaptability of vulnerable managed systems; reversing trends that increase vulnerability; and improving awareness and preparedness.

Drawing on these insights and the arguments above, we argue that the primary objectives for government action could be: to inform the potentially vulnerable; to assist in the provision of disaster relief; to incentivise and enable adaptation; to regulate adaptation 'spillovers' and risk-shifting; and to plan and regulate long-term and infrastructural assets to reduce future vulnerabilities.

16. *Information, knowledge and learning*: Governments have played a major role in the sponsorship of climate science and in the provision of tools such as global, regional and national climate scenarios. This informational role is being continually expanded. Experience shows that awareness of climate impacts and vulnerability assessment is very patchy, being well-developed in some sectors like water services and insurance, and generally poor in many other sectors.
17. *Early-warning and disaster relief*: Most governments have in place plans, organisations and resources to alert people to weather-related disasters and to cope with the consequences, at home and abroad. These will need to be continually reviewed as the frequency, scope and intensity of weather-related disasters changes as a result of climate change.
18. *Facilitating adaptation options, guiding adaptation and enabling adaptive capacity*: There are strong 'public good' arguments for investing in scientific and technological resources that may be widely adopted in response to climate change. A rational response to greater uncertainty is to broaden the portfolio of adaptations that are available to vulnerable sectors. Beyond investing in innovations that may be applied by adaptors, there is also a clear role for regulators to signal the need to adapt to the private sector. The rationale for this is the potential for under-investment in adaptation by social actors confronted by high uncertainty about the likelihood and consequences of climate change impacts.
19. *Regulating distributional consequences of adaptation*: Unregulated, it is likely that the most vulnerable social groups will end up bearing many of the new social and economic risks that arise as a result of climate change. A simple example of this is the proposed reduction in the term (from 3 years to 2 years) of liability insurance covering new houses in the UK, partly as a response to heightened risks of storm damage. In this way the house owner, rather than the house-builders insurer comes to take on an increased risk.
20. *Infrastructure planning and development*: Water, transport and energy infrastructures are likely to be influenced by changing climate, as is the distribution of settlements, especially in coastal and fluvial flood plains. Modification of infrastructures and of spatial plans in response to experienced

and predicted climate impacts is another area in which Governments will play a major role. Difficult trade-offs are likely to be necessary between conflicting social, economic and environmental objectives as a result.

Conclusion

We have argued that adaptation needs to become a central feature of climate policy, having an independent status equivalent to greenhouse gas emissions reduction at the national, regional and local levels. If climatic changes are already observable, then adaptation is also likely to be occurring, and given the inertia in the global climate system, will continue to unfold over periods of several decades, no matter what is achieved on emissions reductions. Analysis of the costs and feasibility of adaptation will also come to underpin the politics of mitigation policy, by showing why mitigation is economically and politically necessary.

This paper has sought to outline some of the main problems to which 'adaptation policy' could be directed. These include the problems of awareness and uncertainty that will militate against adaptation by private actors, and the problems of negative and positive knowledge, vulnerability and economic spillovers that need to be managed collectively. In many cases, these are new expressions of well-understood economic and risk governance problems. They require new attention because climatic change is a novel environmental problem to which policy systems are themselves not yet well-attuned.

We have also sought to make an argument in relation to the question of climate policy integration. While at a strategic, though perhaps largely theoretical, level there are choices to be made between mitigation and adaptation, others have argued that, in the implementation of policy, mitigation and adaptation need to be integrated. We have argued that while there may be potential for synergy – such as with energy-use for space cooling in buildings – there are differences in the problem-structure of mitigation and of adaptation. It may therefore be more helpful to avoid confusing the two, and it is certainly a mistake to see adaptation as merely an appendage of mitigation policy. This also counts for the conduct of policy in relation to climate adaptation. While there may be some domains, such as disaster relief or infrastructure development, where it may be useful to think of a distinct field of policy action termed 'climate adaptation', in many other fields it would be more efficient and effective to seek to build adaptation measures into existing processes of policy analysis, implementation and evaluation in sectors that may not directly address climate as an issue. This means that adaptation policy will for a large part be adjustments in other policy domains, including agriculture, transport, water resource management, trade, science, technology and innovation (STI) and so on. This, of course, poses special challenges for policy development and coordination. As climate adaptation becomes a mainstream feature of climate policy, so the question of how far it can be integrated and how far it needs to stand alone, will need to be faced.

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References

Adger, W.N. (2003). Social capital, collective action and adaptation to climate change. *Economic Geography, 79* (4), 387-404.

Berkhout, F., Hertin, J. & Gann, D. (2004). *Learning to adapt: organisational adaptation to climate change impacts*. Working Paper 47, Tyndall Centre for Climate Change Research, UEA, Norwich, February.

Easterling, W.E., Hurd, B.H. & Smith, J.B. (2004). *Coping with Global Climate Change: the role of adaptation in the United States.* Pew Center for Global Climate Change, Arlington VA.

Folke, C. et al. (2002). *Resilience and sustainable development: building adaptive Capacity in a world of Transformations*. Edita norstedts tryckeri AB, Stockholm.

Fukui, H. (1979). Climate variability and agriculture in tropical moist regions. In *Proceedings of the World Climate Conference*. (ed). Geneva, World Meteorological Association Report No. 537. 426-479.

Hertin, J., Berkhout, F., Gann, D.M. & Barlow, J. (2003). Climate change and the UK housebuilding sector: perceptions, future impacts and adaptation, *Building Research and Information, 31* (3-4), 278-290.

Hewitt, K. & Burton, I. (1971). *The hazardous of a place: a regional ecology of damaging events*. University of Toronto, Toronto.

Hulme, M., Jenkins, G.J., Lu, X., Turnpenny, J.R., Mitchell, T.D., Jones, R.G., Lowe, J., Murphy, J.M., Hassell, D., Boorman, P., McDonald, R. & Hill, S. (2002). *Climate Change Scenarios for the United Kingdom: The UKCIP02 Scientific Report*. Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, UK.

IPCC (2001a). *Climate Change 2001: Synthesis Report. Summary for Policymakers*. Geneva.

IPCC (2001b) *Climate Change 2001: Impacts, Adaptation and Vulnerability*, Cambridge University Press, Cambridge.

Klein, R.J.T. and Tol, R.S.J. (1997) Adaptation to Climate Change: Options and Technologies: An Overview Paper. Technical Paper FCCC/TP/1997/3, UNFCCC Secretariat, Bonn, Germany (available online at http://www.unfccc.int/resource/docs/tp/tp3.pdf)

Mendelsohn, R., Morrison, W., Schlesinger, M.E. & Andronova, N.G. (2000). Country-specific market impacts of climate change. *Climatic Change, 45* (3-4), 553-69.

Mortimore, M. (1989). *Adapting to drought: Farmers, famines and desertification in West Africa.* Cambridge, Cambridge University Press.

Parry, M.L. (1986). Some implications of climate change for human development. In Clark, W.C. & Munn, R.E. (ed). *Sustainable development of the biosphere*. (pp. 378-407). Cambridge, Cambridge University Press.

Rayner, S. and Malone, E.L. (eds) *Human Choice and Climate Change. Volume 3: The Tools for Policy Analysis*. Batelle Press, Columbus, OH, USA.

Rosenzweig, C. and Parry, M.L. (1994) Potential impacts of climate change on world food supply, *Nature*, 367: 133-139.

Smit, B. & Pilifosova, O. (2003). From adaptation to adaptive capacity and vulnerability reduction. In Smith, J.B., Klein, R.J.T. & Huq, S. (ed.) *Climate Change, Adaptive Capacity and Development.* (9-28). Imperial College Press, London.

Tol, R.S.J., S. Fankhauser & J.B. Smith (1998). The scope for adaptation to climate change: what can we learn from the impact literature? *Global Environmental Change - Human and Policy Dimensions, 8* (2), 109-123.

Turner, B.L. et al. (2003) A framework for vulnerability analysis in sustainability science, *Proc. Nat. Acad. Sci, 100* (14), 8074-8079.

Warrick, R.A., Gifford, R.M. & Parry, M.L. (1986). CO_2, climatic change and agriculture. In Bolin, B., Doos, B.R., Jager, J. Warrick, R.A. (ed), *The greenhouse effect, climatic change, and ecosystems*. (393-473). New York, Wiley.

Wilbanks, T.J., Kane, S.M., Leiby, P.N., Perlack, R.D., Settle, C., Shogren, J.F. & Smith, J.B. (2003). Integrating mitigation and adaptation - Possible Responses to Global Climate Change, *Environment*, June.