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**Review of Key National and Regional
Policies and Incentives to Support
Adaptation and Adaptive Capacity
in the Agricultural Sector**

Research Paper

Review of Key National and Regional Policies and Incentives to Support Adaptation and Adaptive Capacity in the Agricultural Sector

Research Paper

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Executive Summary

Adaptation to climate change impacts is increasingly recognized as a key priority among the challenges that the agricultural sector is facing. In four OECD countries that were analyzed, as well as at the European Union (EU)-level, the focus is on reducing risks and vulnerability and increasing overall resilience of agricultural systems so that they are better able to respond to an array of challenges, including climate change. There are two predominant approaches or frameworks that are used to guide policy development: vulnerability- and risk-based. Risk-based frameworks assist decision-makers in evaluating risks due to climate change impacts and associated consequences, giving consideration to the context of uncertainties and identifying measures to reduce risks. The vulnerability-based frameworks are centered on identifying the vulnerability of agricultural systems in the context of current and future changes, giving consideration to exposure (including to climate impacts), sensitivity of agricultural systems and the available capacity of systems to address the exposure. Compared to risk-based frameworks, approaches centered on vulnerability assessment predominantly aim to increase capacities of agricultural systems and thus reduce its sensitivity to multiple stresses including climate change.

In this paper we specifically examined the types of policies and measures that are being considered, designed and implemented in select OECD countries to support adaptation in the agricultural sector: the UK, Finland, Germany and three US states. This includes efforts aimed at increasing adaptive capacity and defining specific adaptation measures for the agricultural sector. The types of processes and mechanisms used to develop these policies and measures were also investigated. We based our findings on analysis of published literature and a review of policies and measures that are being implemented or have been outlined in major policy documents, as published on websites, in reports and in policy briefs. To complement this information, we conducted ten interviews with policy-makers and researchers involved in designing adaptation policies in the studied countries and at the EU-level.

General policy directions identified in this review include: reducing sensitivity, increasing adaptive capacity, addressing specific risks related to climate variability and climate change, exploring sector-specific opportunities in the context of a changing climate and promoting communication and research. In the state- and country-level examples, governments play an important role in identifying risks and vulnerabilities to climate change and prioritizing adaptation by committing to a National Adaptation Strategy (NAS) that includes a framework and key policy priorities. The national level also provides a platform for cross-sectoral collaboration and ensuring adequate integration with other national priorities and programs. National strategies as well as longer-term sectoral strategies and visions have an important role in guiding specific sectoral policies. At the sectoral level, organizations play an important role in specific policy formulation for the sector, identifying the main approaches to be employed and facilitating implementation. As adaptation policies are still in the early stages of development, there is limited information about monitoring and evaluation procedures. Both monitoring and evaluation will become more important as countries invest more

resources into adaptation and, in consequence, the effectiveness of these resources will need to be assessed.

Presently there are eight EU Member States that have already adopted their own NAS. The first was Finland in 2005, followed by France and Spain in 2006 and 2008 respectively. NASs have also been adopted in Denmark, Hungary, Netherlands, United Kingdom and Germany. Countries such as Belgium, the Czech Republic, Estonia, Latvia and Romania have indicated that they plan to adopt NASs by 2012. All the countries that have already adopted NAS, or plan to, specifically address agriculture, water resources and forestry in their strategies. A recent, detailed assessment of European adaptation initiatives (Swart et al., 2009) identifies a number of drivers that could speed-up the development and adoption of NASs. These drivers include demands from society members (including NGOs, scientific community, media and private sector interests) for actions on adaptations. It could also be influenced by countries experiencing negative impacts, by interest in exploring potential opportunities and by policy pressures and incentives from international and higher levels of governance such as the EU-level for Member States.

At the EU, the EU's Common Agricultural Policy (CAP) with its Pillar II (which funds amongst other things agri-environment schemes such as Environmental Stewardship), is well placed to bring about change on climate change issues, because it provides a framework of common rules while allowing discretion at the member state level to implement actions locally, such as what types of programs and actions will receive subsidies. When the EU issued its guidance documents on adaptation strategies in the context of the CAP, it provided direction for those countries that had not begun developing their own strategies, and an incentive for countries to begin linking adaptation actions to EU funding mechanisms. In the US, individual states have taken the initiative to develop adaptation strategies. These efforts were motivated largely by concerns about the possible negative impacts of climate change on agriculture and were explored by policy-makers and researchers, in conjunction with stakeholder consultation processes.

Agriculture was addressed in all of the analysed NAS documents¹, and was recognized as a priority area. Most focused on establishing horizontal working groups to address the major challenges that arise across sectors such as agriculture, water resource management, forestry, biodiversity and rural development. Specific activities that are promoted or being implemented include developing consortia of climate modellers and agricultural specialists to link climate information with potential consequences for agriculture; reviewing applied schemes for pest and disease management; reviewing insurance needs; identifying financial sources needed to support adaptation; and also developing monitoring, research programs and outreach and communication strategies about climate change. At the sectoral level, the focus was on creating working groups or coordinating bodies to increase capacities in developing specific adaptation measures focused on changes in crops, water-use and irrigation and soil protection; and exploring linkages between agriculture, environment and rural development.

Based on this assessment we propose the following priorities for agencies concerned with adaptation in the agricultural sector:

Policy development process and institutional involvement

- *Establish advisory bodies and working groups* that include researchers, policy-makers and key stakeholders representing different agencies and sectors so that adaptation policies can be more easily integrated into diverse sectoral priorities and possible trade-offs can be addressed.
- *Involve stakeholders in all stages of policy development* to enhance two-way awareness and knowledge development; relevancy of policies and proposed actions and to improve buy-in by those actors that will be central to implementation. Include a mix of researchers, experts, policy-makers, agricultural organizations, farmers and the public.
- *Explore the question “what is agriculture for?”* Devote time in the early stages of the process to build understanding of adaptation and its implications for agriculture and to decide on objectives and values that will guide development of agricultural adaptation policy.
- *Decide on a vision and/or framework to guide integration of adaptation policy* with existing policy and across sectors and various objectives.

Developing adaptation strategies and policies

- *Conduct vulnerability assessments of agricultural systems in the country* to better understand those areas (both issues and locations) where sensitivity is high and capacity is lacking, and areas where opportunities may exist. Specifically consider how changing global markets may contribute to risk and opportunities locally.
- From this, *identify no-regrets options* (i.e. options that provide benefits even without impacts of climate change) for capacity development.
- *Conduct reviews of current management standards, practices and plans* – especially those dealing with pests and disease control, infrastructure standards and risk-insurance policies – to incorporate potential impacts of current climate variability and climate change.
- *Look at the implications of longer-term agricultural priorities* (in legislation and policy) for adaptation and capacity development policies, and vice versa.
- *Consider adaptation needs in the agricultural sector concurrently with other priorities* including:
 - Supporting ecosystem services and co-benefits that agriculture provides for society
 - How agriculture can contribute to or hinder other sectoral adaptation efforts
 - Other vulnerabilities and opportunities facing the agricultural system
 - Potential for win-win actions that address both adaptation and mitigation
 - Which adaptation options can provide the broadest range of potential benefits to society
- *Start with existing practices and programs when developing adaptation options.* Many initiatives currently exist that can be enhanced, adjusted or provided with more support or funding.

- *Explore the use of innovative policy tools for incorporating adaptation.* For example, use adaptive policy-making to be able to incorporate outcomes from climate change impact models and forward-looking methodologies to envision preferred future pathways and to promote flexibility in policy-making

Towards implementation

- *Spearhead pilot initiatives to broaden the impact and uptake of adaptation options.* For example, research and implementation of adaptation actions relating to farming techniques, crop varieties and livestock management so that their viability is tested and demonstrated to farmers and agricultural producers.
- *Highlight existing actions by agricultural stakeholders and involve stakeholders in policy development* to enhance relevance of policies and improve buy-in.
- *Develop a suite of adaptation options* that can be adjusted to particular contexts at a farm, ecosystem, community and regional level.
- *Establish extension agencies, communication strategies and dialogue with agricultural producers and farmers* to assist in integrating climate data and possible adaptation actions into their practices.
- *Provide for ongoing research into climate change impacts, adaptation options and implementation issues* (funding, procedures, assessment, etc) as they relate to the agricultural sector as well as other sectors.

Introduction

Climate change is a reality, and even with significant emission reduction initiatives in the future we are committed to impacts of a changing climate due to the long lifespan of the greenhouse gases (GHGs) in the atmosphere (IPCC, 2007). While earlier stages of debate on climate change focused on reducing the emissions of harmful GHGs, it is now recognized that adaptation to the impacts of climate change is equally important. Adaptation is defined as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, in order to reduce harm or take advantage of opportunities. Some examples include raising river or coastal dikes, promoting more temperature-shock resistant plants instead of sensitive ones, or improving the effectiveness of pest management practices (IPCC, 2007). In order to take action, adaptive capacities need to be available. This refers to the capabilities, resources and institutions available to a country or region to implement effective adaptation measures (IPCC, 2007). Adaptation to climate change is gaining stronger interest not only among scientists focusing on climate change but also among policy-makers. Witnessing the slow progress to date with reducing GHGs and at the same time experiencing changes in current climate variability ‘on the ground’ drives home the necessity of promoting adaptation.

Impacts of climate change on agricultural systems have been addressed in a number of regional, country-specific and global studies.² In most regions agriculture has been exposed to various severe weather events and their consequences, including periods of drought, heavy rainfall, hail and diseases. In the context of increasing variability of weather patterns coupled with other pressures such as economic stresses, the vulnerability of the agricultural systems as a whole is increasing, raising concerns about

their potential to cope with impacts of climate change and climate variability (Sauchyn and Kulshreshtha, 2008). In general, agricultural producers and farmers have the ability to reduce these adverse effects or seize opportunities by adapting to the changing conditions. Adaptation as a response to climate change depends on the capacity of agricultural systems to respond to changed conditions as a function of not only climate, but also of socio-economic conditions, technological developments and agricultural markets. Since historic times, farming systems have adapted to changing economic conditions, technologies, resource availabilities and population pressures.

There is a growing body of literature on the adaptation responses and capacities that are used by farmers when facing climate variability and climate change.³ Based on this research investigating the experiences of farmers, we have gathered better insights into what capacities are needed to support adaptation. This includes access to technology, insurance, irrigation, and soil and pest management techniques that are needed to respond to weather-related events. That research has also helped to identify needs for institutional capacities and extension agencies that can help to deliver information about climate change projections, seasonal forecasts and extreme weather events to farmers. In the case of farmers, adaptive capacity depends in part on the flexibility of the cropping system, the willingness of society to make policy interventions and the state of institutional development (Berry et al., 2006). In this paper, we will focus on examining frameworks, policies, incentives and measures that are being adopted by selected OECD countries in order to encourage adaptation actions and development of adaptive capacity among farmers and other agricultural producers.

Approach

This paper focuses on the agricultural sector.⁴ It discusses suggested approaches for the integration of adaptation into national and sectoral policy-making and presents examples of responses that have been developed in select OECD countries. Finland, Germany, the United Kingdom and the US (California, Minnesota and Washington states) were selected due to their progress in developing agricultural adaptation strategies, and for their similarities climatically to Canada. The purpose of the paper is to generate insights about the types of policies and measures that are being implemented and the institutional arrangements being developed in these countries, to inform work being done by Canadian agencies.

The major research questions of this project are:

1. What types of national and regional policies and measures are being considered, designed and implemented in the studied countries to increase both the adaptive capacity and actual adaptation for the agricultural sector?
2. What were the major processes and mechanisms applied in the studied countries to develop these policies and measures?

The research questions were explored in two stages. First we looked at the possible roles of national governments and sectoral bodies in strengthening adaptive capacity and adaptation, with a focus on the agricultural sector. This analysis was based on published literature and a review of policies and measures, as published on websites, in reports and

in policy briefs. To complement this information, we conducted ten interviews with policy-makers and researchers involved in designing adaptation policies in the studied countries. A list of the interviewees is presented in the Appendix.

In this paper, first we provide a brief description of agricultural adaptation and general approaches to policy-making for adaptation. Then we follow with the main elements of adaptation strategy development in the studied countries and states. This review is based on the literature review and interviews.⁵ Finally, we look at the key characteristics of adaptation strategy development across the reviewed cases and formulate conclusions and potential priorities for action emerging from this empirical work.

Impacts of Climate Change and Key Types of Adaptation in Agriculture

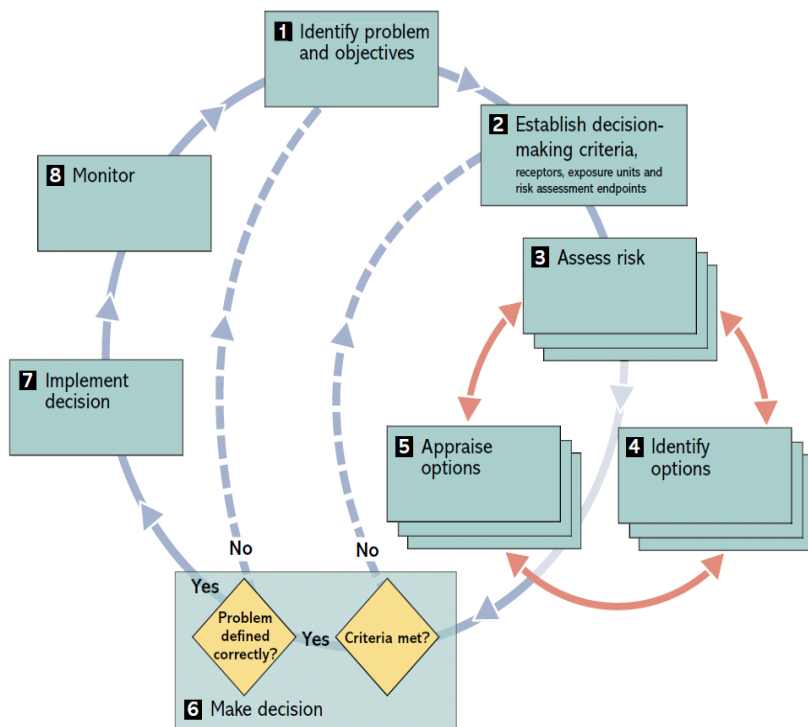
Impacts of climate change on agricultural systems vary by location, and while some areas will be affected by significant water shortages others will face heavy rainfall; most of them will increasingly experience extreme weather events (Fields et al., 2007). In general, it is projected that: the average temperature will rise by around 1 to 7°C by 2100 with seasonal differences affecting temperatures in summer more than in winter; increasing precipitation during winter will fall as rain rather than snow, causing wetter and warmer winters⁶; sea level rise will affect coastal areas; and there will be an increased frequency of extreme events such as hail, storms, heat waves and droughts (IPCC, 2007). For many agricultural regions major impacts will relate to changes in water availability and heat stress. This will affect both crops and large-livestock productions, especially in areas with growing farm sizes and livestock numbers, leading to a lack of water for irrigation and livestock as well as reduced soil moisture.⁷ Finally, changes in pests and diseases (including animal diseases) are also expected. A likely response will be increased pesticide inputs in colder, Northern areas (Easterling et al., 2007).

When analyzing impacts of projected changes in climate, less attention has been spent on exploring potential opportunities for agriculture as a consequence of a changing climate. Early studies have been completed about these opportunities, especially focused on Northern Europe (Hildén et al., 2005), that could be relevant for areas in Canada. These studies identified CO₂ fertilisation of plants, longer growing seasons and new cropping opportunities (Olesen and Bindi, 2004) as potential advantages for agriculture in these areas. Ideally, policies and measures encouraging adaptation to climate change will be able to explore these potential opportunities while dealing with the projected negative impacts. However, the actual extent of positive impacts will depend on the extent of yield increases, impacts of technological progress and possible changes to agricultural production in other areas (Hilden et al., 2005).

Evaluating potential climate impacts and their consequences for society can be done using a variety of methods. Two of the more common approaches, which are often closely related⁸, are the use of risk assessment or vulnerability analysis. Risk assessment as applied to climate change impacts and adaptation can take a variety of forms, depending on the desired outcome of the assessment and the types of potential hazards

being investigated. A risk evaluation approach aims to identify, often quantitatively, a measure of potential hazards in terms of both their magnitude and probability. This is developing as one of the ways of dealing with uncertainties in projections of climate and societal responses (IPCC, 2007b). While it may incorporate elements of non-climatic risks, it typically places less of an emphasis on this than a vulnerability analysis. As applied to policy making, specification of the societally-acceptable risk tolerance level for a particular hazard is also required, in order to proceed to developing potential adaptation options. A prominent example of a risk-based framework for climate change adaptation decision-making is the “Risk, Uncertainty and Decision-Making Framework” developed by the UK Climate Impacts Programme (see Figure 1; Willows and Connell 2003).

Figure 1 - Risk, Uncertainty and Decision-making Framework Developed by the UK Climate Impacts Programme



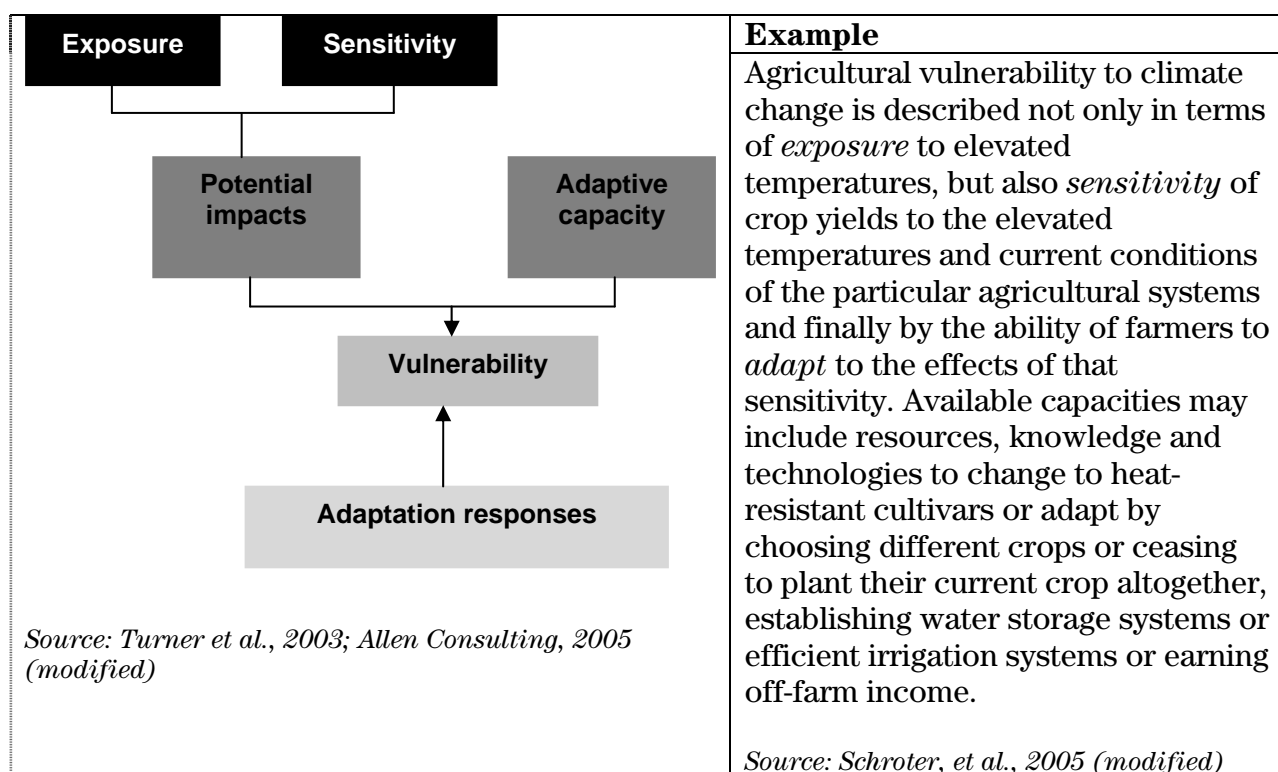
Source: Willows and Connell. 2003

Identifying the actual consequences of climate change and need for adaptation depends also on the overall vulnerability of farms and agricultural systems, combined with projected changes and possible responses (elements of vulnerability are presented in Figure 2). Vulnerability has emerged as a crucial concept both in environment, development, and global change discourses as well as in practical decision-making (Turner et al., 2003). It is becoming apparent that systems already vulnerable due to socio-economic challenges (such as lowering market prices, increasing input prices, debts, marketing challenges in competing on local and international markets) are more

sensitive to impacts of climate change. Such increasing vulnerability is probably greater in declining rural areas that are struggling with challenges that affect their overall capacity to adapt.

Linkages between vulnerability to climate change, sensitivities of the agricultural systems and their capacities to adapt are increasingly recognized. Since its appearance in the literature, the concept of adaptive capacity⁹ has been closely linked to levels of economic development, based on factors such as the range of technological options available, the availability of resources, and the stock of human capital (Yohe, 2001). More recently, and especially when we focus on policy development, other factors have been emphasized such as the structure of critical institutions, risk perception, and patterns of decision-making authority (Yohe, 2001; Burch and Robinson, 2007). Therefore, the goal of promoting effective adaptation responses and increasing adaptive capacity should be to reduce vulnerability and increase overall resilience of agricultural systems, including their socio-economic and institutional characteristics.¹⁰

Figure 2 - Components of Vulnerability to Climate Change



There are still significant uncertainties in the models of projected impacts and there are differences between local and regional capacities. Thus, adaptation options need to be adjusted to specific impacts and local situations. When it comes to actual adaptation options, a number of ideas have developed based on farm-level studies. Some of the recommended options for developed countries include (Easterling et al., 2007; Bizikova

et al., 2009; EC, 2009a and b; Rosenzweig and Tubiello, 2007; CNRA 2009; Macgregor & Cowan 2010):

Measures focused on economic performance:

- Provide financial incentives/mechanisms for increasing resiliency, removing impediments, and improving information systems (e.g. concessional credit lines to support agricultural equipment purchases)
- Ensure market linkages and integration to strengthen response capacities and share risks
- Diversify income by integrating other farming activities such as livestock raising

Measures focused on farming techniques:

- Fallow fields (i.e. leave agricultural fields to rest and accumulate moisture every other year)
- Rotate crops
- No or limited tillage
- Introduce new crops and new management techniques
- Increase inputs of organic matter to improve soil fertility, enhance soil water holding capacity and reduce soil erosion
- Changing field design to increase ground cover in some cases, expanded field margins
- Putting back natural features such as hedgerows to help reduce erosion
- Review of irrigation practices: their effectiveness and sustainability and opportunities for introducing water-saving measures and to reuse grey water for agricultural and horticultural irrigation; managing water to prevent waterlogging, erosion, and nutrient leaching where rainfall increases
- Suitable upland farm or land management so that upland areas are used to slow run off and reduce peak water flows
- Improve the effectiveness of pest, disease and weed management practices through wider use of integrated pest management, development and use of crop varieties and species resistant to pests and diseases, and improvements in quarantine capabilities and sentinel monitoring programs
- Continuously match livestock rates with pasture production, altered rotation of pastures, modification of times of grazing, and timing of reproduction, alteration of forage and animal species/breeds, altered integration within mixed livestock/crop systems including using adapted forage crops

Monitoring, research and communication of types of measures:

- Review breeding programs to develop better drought- and heat-resistant varieties
- Monitor soil changes and develop land management practices to adapt to these changes
- Monitor pests and diseases and develop sustainable farming practices that minimize susceptibility to pests and diseases e.g. by practicing land rotations and avoiding monocultures
- Review and pilot test 'greener' means of productions
- Focus on translation and communication of identified impacts of climate change to the application that matters to the users, including disease occurrence, impacts

on relevant crops and effectiveness of current practices under changing climatic conditions

Integrated measures:

- Where possible, consider both the mitigation and adaptation benefits and costs of potential adaptation options. Suggested measures include: tree planting, maintaining and restoring peatlands, soil and tillage practices to maintain or increase organic carbon held in soils, organic farming practices that reduce fossil fuel-based fertilizers while often enhancing diversity and ecosystem functioning for resilience.
- Identify common interests and potential conflicts across sectors, in order to develop appropriate measures and use resources efficiently. Suggested measures include: watershed-level management of water resources; development of local and regional markets; identify voluntary floodplain easements on agricultural lands where production is compatible with flood conveyance; joint programs (eg: with forestry, fisheries, water management) for monitoring, prevention and management of invasive species and pests; farmland protection to enhance ecosystem services; community land use planning to manage the agricultural-urban interface.

These adaptation options may be designed and implemented in different ways, at different levels and by different stakeholders. The research community distinguishes many types of adaptation. Adaptation actions could be anticipatory or reactive, supply-side or demand-side, top-down (national or global scale) or bottom-up (specific place-based measures), and autonomous or non-autonomous (planned). Adaptation measures may occur at national, regional, community, personal, or production system levels. However, these categories are not mutually exclusive and adaptation options could be part of more than one category at the same time. For the focus of this paper, we only outline those that are most relevant including autonomous and planned actions regulating both supply and demand-side of the agricultural systems (for details see Table 1)

To conclude, there are still significant uncertainties in models projecting climate change¹¹, in estimating the consequences of changes in climatic variables for agricultural systems and also about the effectiveness of adaptation responses. On the other hand, many adaptations to climate change are already being applied, at least as autonomous responses. Furthermore, actions that are needed to improve adaptive capacities are also relevant to addressing vulnerabilities and risks that agricultural systems are facing currently, even before factoring in the potential impacts of climate change. In the next sections we will explore development of policies focused on adaptation and adaptive capacity and current adaptation policies in the EU and select OECD countries with a specific focus on agriculture.

Table 1 - Relevant Types of Adaptations, their Definitions and Examples with Focus on Agriculture

Type of adaptation		Definition	Examples
Autonomous		Actions that can be taken by farmers and communities independently of policy, based on a set of technology and management options available under current climate.	Crop calendar shifts (planting, input schedules, harvesting) Cultivar changes Crop mix changes
Planned (non-autonomous)		Actions that require concerted action from local, regional and/or national policy.	Land use incentives Pollution control form inputs Water costing Germplasm Development Programs
Two types of planned adaptations:	Supply-side	Influencing the accessibility of resources and inputs	Building water reservoirs to collect rainwater Expanding drainage infrastructure as a major way to accommodate heavy precipitation events
	Demand-side	Influencing behaviour of individuals and organizations towards certain behaviour	Water-metering to support water conservation Changing standards, such as construction codes, limits per unit of production, or environmental standards to address changes in climate

Sources: Rosenzweig and Tubiello (2007); Bizikova et al., (2009)

Integration of Adaptation into National and Sectoral Policy-making

Beyond focusing on the projected impacts of climate change, we also need to investigate major vulnerabilities and risks to agricultural systems. This includes identifying areas where capacity is lacking, which may be different even within countries and regions. Currently, we can see that adaptation studies of this kind have become more holistic, aiming to promote resilience rather than being climate-parameter specific. In these studies climate variables represent only one set of factors affecting the adaptive capacity or resilience of systems. Among the many other challenges facing society are environmental change, migration, market fluctuations and globalization, and thus we will have to adapt to many challenges simultaneously (Leichenko and O'Brien, 2000; Sygna et al., 2004). Adaptation policies will also need to be integrated with other sectoral and cross-sectoral priorities from the local to national and even international level; this raises a number of challenges.

Specifically, at the highest level, the number of policies, measures, treaties and agreements at international and national levels increased during recent decades, leading to a considerable increase in institutional density (Kok et al., 2007; Swart et al., 2009). Adaptation to climate change is relevant to many of them, but when it comes to their operationalization at the country and regional level, institutions could be overloaded by coordination, integration and monitoring requirements. Secondly, existing policy frameworks are usually not designed to promote integration of future climate projections and their uncertainties with sectoral priorities and measures at different levels and across different organizational structures and stakeholders (Auld et al., 2007). Policies and measures based on past data are difficult to link with projections into the future that are also linked to other challenges that the stakeholders are facing. Thirdly, communities operate on different spatial and time scales, have different priorities and may need different incentives to increase their capacities to respond to climate change. This is even more challenging given that climate change is a long-term problem characterized by intrinsic uncertainties. Finally, it needs to be acknowledged that climate change adaptation is not always synergistic with other policy areas (Kok et al., 2007 and Swart et al., 2009). Between climate change and agriculture for example, clear trade-offs can be identified for countries with underdeveloped infrastructure for agricultural production or countries focusing on crops that are highly vulnerable to climate change. It is not always possible to choose “no-regrets” options.

Notwithstanding such challenges, some basic policy directions for adaptation have been identified:

- reducing sensitivity to climate change and other pressures
- increasing adaptive capacity
- addressing specific risks related to climate variability and climate change
- exploring sector-specific opportunities in the context of a changing climate
- promoting communication and research

These policy directions are connected, and reducing vulnerabilities and improving capacities will probably improve the prospects of actual adaptation and also the ability to explore opportunities that arise. Some of these directions, especially those focusing on communication, research and monitoring, are cross-cutting measures and should be included in all strategies. For the agricultural sector specifically, key policy directions can be characterized as follows (IPCC, 2001; Howden et al., 2007; OECD, 2009, McGray et al., 2007; Massey and Bergsma, 2008):

- *Reducing sensitivity of agricultural systems:* Providing greater focus on areas that struggle to cope with current socio-economic challenges and current weather patterns and variability. The primary focus here is to reduce major underlying causes of vulnerability ;
- *Enhancing elements of adaptive capacity of agricultural systems:* Introducing new, flexible technologies, management strategies, insurance schemes and economic incentives that allow for adjustments based on impacts that may occur currently and/or in the future (targeting both the supply and demand side of agricultural production systems);

- *Reducing and managing risks related to climate variability and climate change by promoting the implementation of specific adaptation options:* For example, promoting pest, disease and weed management practices, revising codes and standards for infrastructure, introducing new crops, planning transitions (such as developing alternative livelihoods, or financial and technical contingency plans) in areas where agriculture will have a limited role. This should also include actions aiming to alleviate major losses in agricultural production due to climate variability and climate change (i.e. drought relief, insurance for crop losses due to hail etc.);
- *Exploring sector-specific opportunities and the feasibility of pursuing them:* These opportunities will arise in some regions because of milder weather and changing climate variability for the agricultural sector. For example, expanding agriculture and suitable crops into areas that have not been used for production because of unfavourable climatic conditions (low temperatures, length of growing season etc.); and
- *Promoting research, communication, institutional development and extension agencies:* Assist in changing management practices in the agricultural sector, for example, through the use of climate projections, identifying linkages between impacts and adaptation, and drawing on lessons learned from other countries. Furthermore, Howden et al. (2007) specifically emphasize that here the focus should be on working with managers so that they are convinced that projected climate changes are real, are likely to continue with measures, and are confident that the projected changes will significantly impact their enterprise so that they are willing to change or revise their management decisions and practices. This could be facilitated by policies that translate monitoring outcomes into issues that matter to producers and managers (such as pest occurrence and water availability), and by communicating information effectively.

In terms of the processes that help to transform these policy directions into actual policies and actions, coordinated measures at the national, sectoral and project level are required. This could include *establishing institutional mechanisms* for guiding and implementing adaptation, *formulating policies* for developing capacities and adapting to climate change and other vulnerabilities or *reviewing existing policies* to take adaptation into account, *allocating budgets* for actual actions and *monitoring and evaluating* the effectiveness of the adopted policies and actions (Gagnon-Lebrun et al., 2007 and OECD, 2009). It is also emphasized in a number of publications (Gagnon Lebrun et al., 2007; Howden et al., 2007; OECD, 2009; Swart et al., 2009) that the prerequisites for progress in policy development include improving national and regional information related to climate change impacts; gathering and creating information on vulnerability to climate change, including current and future impacts; and connecting past data collected by meteorological offices with projections focused on future changes. At the different levels of governance these overall suggestions require specific actions as outlined in the following paragraphs (OECD, 2009).

National Level

In terms of *policy formulation* climate change adaptation needs to be mainstreamed into national governance. This will require adjustments to the national governance framework – its structures, policy formulation processes, systems and procedures – to make it responsive to the new challenges created by climate change. Key processes at the policy formulation stage include building on long-term visions and national development strategies as well as shorter-term national policies to provide the overarching framework for the development of operational plans and resource allocation. Specific interventions within the national policy cycle would consist of clear recognition of climate risks and the need for adaptation within relevant national policies; adopting an adaptation policy framework and strategy, and proactive actions on programs or projects specifically aimed at enabling adaptation to climate change; and reallocating funding to more vulnerable sectors or regions, and for specific adaptation plans or activities.

For *institutional development* it is critical that the co-ordination of adaptation is done from centres of power in the national government (with involvement of key senior figures in the government) and that it is adequately integrated into national economic planning. Finally, national initiatives that are co-ordinated across ministries have a better chance of addressing the often cross-sectoral issues of adaptation actions and capacities.

Sectoral Level

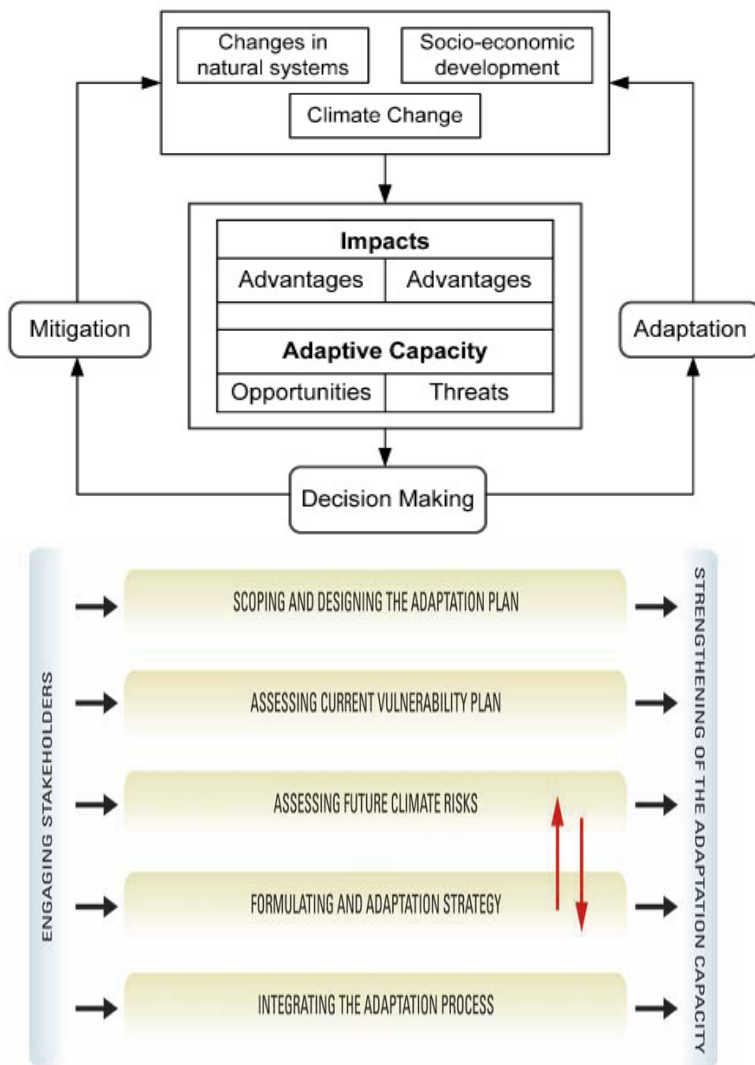
When focusing on *policy formulation*, policy decisions taken at the sector level directly affect activities within this sector, and potentially other sectors indirectly. Agriculture is one of the sectors that is particularly sensitive to climate variability and therefore needs to factor climate change into sectoral policy and planning as a matter of priority. The policy formulation stage sets out the broad objectives to be pursued in a given sector (*e.g.* development of irrigated agriculture in a given portion of the country for the production of commercial crops for export) over a given time-span; the main approaches to be employed (*e.g.* a mix of smallholder and commercial-scale operations); and the associated policies to be implemented to facilitate reaching these objectives. This is the stage where national policy directions are translated into sector-specific policy options, which then provide the basis for designing operational plans and mobilising resources to implement them. In terms of *institutional issues*, some of these policies may be within the authority of the sectoral ministry concerned (*e.g.* Ministry of Agriculture regulations concerning the approval, certification and commercialisation of certain seeds and phytosanitary inputs) while others may be beyond its control (*e.g.* implementation of transport or irrigation infrastructure programmes, fiscal treatment of key inputs, land tenure taxation) requiring cross-sectoral co-ordination.

Finally, because countries are still in the early stages of implementing actual adaptation actions, there is limited information on specific **monitoring and evaluation** issues.

There are an array of reporting tools, including budget execution reports and governance performance measures under sector budget support (OECD, 2009).

Specific Examples of Approaches and Initiatives in the OECD and Selected Countries

Figure 3 - Examples of Frameworks Guiding Adaptation Policy Development in Finland and Spain



Source: Brooks et al., 2009 and PNACC, 2006

Adaptation Policy Frameworks

During the last decade many adaptation planning frameworks have been developed with contributions from social and physical scientists, decision-makers and other stakeholders, which attempt to provide a comprehensive approach to planned adaptation. We can distinguish two major approaches to overall adaptation frameworks: one based on risks related to climate change and the other based on vulnerability to climate change. Both approaches are process-focused, emphasising policy development and what information and approaches are needed to support it, rather than being based primarily on the science of climate change and models.

Specifically, at the OECD level, a four-step approach is advocated that is similar to a climate risk management approach, as it starts with consideration of current and future climate risks. The four steps include identifying current and future vulnerabilities and climate risks, identifying adaptation measures, evaluating and selecting adaptation options and evaluating success of adaptation measures (OECD, 2009). In the EU, a White Paper was adopted (EC, 2009a) that presents a framework for adaptation measures and policies aimed at reducing the European Union's vulnerability to the impacts of climate change. It focuses on enhancing resilience and reducing vulnerability, to deal with the impacts of climate change while respecting the principle of subsidiarity and supporting overarching EU objectives on sustainable development (EC, 2009).

At the country level (Figure 1 and 3), for example, Willows and Connell (2003) developed the risk-based framework for the UK that enables decision-makers to recognize and evaluate the risks posed by a changing climate by making the best use of available information about climate change, its impacts and appropriate adaptive responses. Similarly, a risk-based framework was adopted by Australia that aims to incorporate future uncertainty and provides strategies that are intended to cope with a range of possible local climate changes. They also suggest that its application should initially be focused on equipping primary producers with alternative adaptation options suitable for the range of uncertain future climate changes and developing the capacity to evaluate and implement these as needed, rather than focusing too strongly on exactly where and when these impacts and adaptations will occur (Stokes and Howden eds, 2008). On the other hand, Finland is using a framework based on the concept that vulnerability is enhanced by climate change, and aims to build in both autonomous adaptation actions and planned adaptation policies (Marttila et al., 2005). A similar approach was adopted in France as well (Brooks et al., 2009). Finally, Spain has developed a process-based framework aiming first to scope vulnerability, then include an assessment of future impacts, and finally develop adaptation options and integrate these with other sectors and policies (PNACC, 2006).

National Adaptation Strategies (NAS) and Sectoral Level Initiatives

European Union

Adaptation frameworks are part of **national adaptation strategies**; they tend to cover multiple sectors and outline key priorities for the country in terms of risk and vulnerability reductions and adaptation. The fight against climate change has been retained as one of the major political priorities by the new European Commission in its 2020 strategy. Specifically, at the EU level, key policy directions for the European Community specifically list agriculture as a priority, promoting “early action in areas from agriculture to trade that are backed by EU policies¹² and available Community funds.” Other priorities include integrating adaptation into existing EU external actions (in particular, promoting adaptation in developing countries), intensifying climate research (especially research into the impacts of climate change and technological innovation), and lastly involving all segments of society, business and the public in further development of adaptation strategies (EC, 2009a and b). Additionally, specific priorities for agriculture are included such as (2009a):

- Ensure that measures for adaptation and water management are embedded in national rural development strategies and programmes for 2007-2013.
- Consider how adaptation can be integrated into rural development and give adequate support for sustainable production, including how the CAP contributes to the efficient use of water in agriculture.
- Examine the capacity of the Farm Advisory System to reinforce training, knowledge and adoption of new technologies that facilitate adaptation.

These priorities have been recently outlined in the ‘White paper’ published in 2009 (EC, 2009a) which refers to the previously published ‘Green paper’ on adaptation from 2007 (EC, 2007). In the preparation of the CAP for post-2013, and in the light of the results of the international negotiations on climate change, the European Commission will examine ways to further and better integrate adaptation and mitigation objectives into CAP instruments, to be proposed to the Council of Ministers of the Member States and to the European parliament.

Presently there are eight EU Member States that have already adopted their own NAS. The first was Finland in 2005, followed by France and Spain in 2006 and 2008 respectively. NAS have also been adopted in Denmark, Hungary, Netherlands, United Kingdom and Germany. Countries such as Belgium, the Czech Republic, Estonia, Latvia and Romania have indicated that they plan to adopt NAS by 2012. All the countries that have already adopted NAS, or plan to, specifically address agriculture, water resources and forestry in their strategies.

A recent, detailed assessment of European adaptation initiatives (Swart et al., 2009) identifies a number of drivers that could speed-up the development and adoption of NAS. These drivers include demands from society members—including NGOs, the scientific community, media and private sector interests—for actions on adaptations. Strategy

development and adoption could also be influenced by experiencing negative impacts, interest in exploring potential opportunities and policy pressures and incentives from higher levels of governance such as the EU-level for EU Member States.

In most of the OECD and the EU countries, significant efforts to address adaptation to climate change in agriculture are housed at **the sectoral level**. In some cases there are examples of actions that are already being implemented. Many of these actions are supported by current research, which is listed in the appendix.

At the EU level, promoting resilience and reducing vulnerability of the agricultural system specifically includes attention to the following priorities (EC, 2009a):

- Farm characteristics such as production type, size of the farm, level of intensity;
- Diversity of cropping and livestock systems, and the presence of other income sources apart from agriculture;
- Access to relevant information, skills and knowledge about climate trends and adaptive solutions;
- The role played by advisory services in facilitating adaptation;
- General socio-economic situation, farmers with limited resources or living in remote rural areas being most vulnerable; and
- Access to available technology and infrastructure capacity.

At the policy level that implies a need to examine changes outlined in the EU's Common Agricultural Policy (CAP) and under the Rural Development Regulation to address needed adaptation and capacity development challenges. Although the CAP policy instruments do not explicitly address adaptation, Member States can use the measures already in place within the rural development policy to help alleviate climate change impacts on the sector (ECCP, 2006). The Rural Development mechanism provides a framework to deliver adaptation measures in agriculture (and forestry). There is a limited budget available for this mechanism – in a recent policy change, all farmers that had been receiving direct aid will now have their payments reduced by 5 percent, with that money being shifted into the Rural Development budget. By 2012, that rate goes up to 10 percent, while payments in excess of €300,000 a year will receive an additional 4 percent cut. The funding obtained through this shift may be used by Member States towards programs addressing climate change, renewable energy, water management, biodiversity and innovation linked to these areas (EC 2009d).

Beyond these direct references to adaptation in agriculture (ECCP, 2006) the following policies, regulations and directives also have implications for this issue:

- Common Agricultural Policy (CAP) including the 2003 review
- Communication on risk and crisis management in agriculture COM (2005) 74 final, and Report on risk management tools for agriculture
- Rural Development Regulation 1698/2005 and Community Strategic Guidelines for rural development (2007-13)
- The Water Framework Directive (WFD) Directive 2000/60/EC
- Habitats Directive (92/43/EEC)
- Birds Directive (79/409/EEC)

- Community programme on the conservation, characterisation, collection and utilisation of genetic resources in agriculture (Council Regulation (EC) No 870/2004)
- Report on risk management tools for agriculture

In most of the analyzed countries and at the EU level, considerable effort is devoted to research on issues related to adaptation. Areas of research are now extending from a common focus on projections of impacts into more specific work on adaptation options, policy and issues around implementation. Examples of research activities in the EU and selected countries are outlined in the Appendix.

Finland

At the country level, Finland was one of the first European countries to initiate a comprehensive NAS in 2005, building on a **national strategy** from 2001. In 2001 when the government submitted a national climate strategy to parliament, parliament indicated that there was a need for an adaptation programme (in addition to mitigation, which was the focus of the 2001 strategy). So the need for a NAS came from parliament's reply to government's submission of 2001 climate strategy. The NAS is a comprehensive and high-level national strategy that aims to address the negative consequences of climate change and to take advantage of potential opportunities in sectors including agriculture and food production, forestry, fisheries, reindeer and game husbandry, water resources, biodiversity, industry, energy, transport, land use and communities, building, health, tourism and recreation, and insurance (Swart et al., 2009).¹³ Proposed adaptation actions for the agricultural systems are listed as follows (Marttila et al., 2005):

- Conceptualisation of climate change and its risks;
- Attention to production methods adaptable to climate change, production structure and locations in support policy;
- Development of animal disease monitoring systems;
- Development of plant disease and pest monitoring systems;
- Development of new technologies and cultivation methods and providing information on them;
- Integration of changed climatic conditions and plant protection requirements into plant improvement programmes;
- Minimising the disadvantages of the potentially increasing use of pesticides; and
- Assessment of the revisions to water protection guidelines.

At the institutional level, cross-sectoral and ministerial groups were created to collect information, including from ongoing research initiatives¹⁴, and start developing the NAS. The Ministry of Agriculture and Forestry led the working group that began drafting the NAS, with the support of a working group of representatives from several ministries: Environment, Trade and Industry, Transport and Communications, Foreign Affairs and Social Affairs and Health. In addition, two research institutes – the Finnish Environment Institute and the Finnish Meteorological Institute supported this process (Marttila et al., 2005). The development of the NAS involved diverse stakeholders and researchers in developing background information to the draft strategy. The draft strategy was also

presented in a public seminar and it was open for comments from stakeholders and the public.

With specific focus on the **sectoral level**, the Ministry of Agriculture and Forestry plays a strong role in guiding their overall NAS and sectoral work as well. To better understand the implications of changing socio-economic conditions and climate change, a dynamic regional sector model of Finnish agriculture (DREMFLA) was developed to look at technological changes and production decisions. A number of scenarios extending to 2020 were developed. Other specific measures led by Ministry of Agriculture and Forestry include (Ministry of Agriculture and Forestry of Finland, 2009):

- a contingency plan for bluetongue disease, a catarrhal fever in ruminants spread by midges
- a joint Nordic plant breeding project that has been launched
- preparation of a national action programme required under the framework directive on sustainable use of pesticides
- establishing the Coordination Group for Adaptation to Climate Change (comprised of government ministries, research institutes, research funders, regional actors)
- participation in a regional collaboration on climate change adaptation research (CIRCLE ERA-Net)

They also are investigating barriers to adaptation in existing policy. For example, the current legislation in Finland restricts the land tenancy period to ten years only, while in many other EU countries such short tenancy periods are exceptional. The short tenancy period in Finland results in land tenure insecurity and provides little incentive for investments in drainage systems of fields or in improving soil quality (Hildén et al., 2005).

Currently, the country is beginning to look at action plans developed by Ministries; translating the strategy into specific actions and implementation strategies; mainstreaming; monitoring and also exploring higher-level priorities about the role of the agricultural sector in society.

United Kingdom

Nationally, the United Kingdom (UK) has passed **national legislation** that establishes powers for government relating to climate change adaptation. Their Cross-government Adapting to Climate Change Programme will take place in two phases, and is broken into four workstreams: providing evidence; raising awareness and helping others to take action; ensuring and measuring progress; and government policy and process: embedding adaptation.

At the **sectoral level** agriculture was recognized as one of the first sectors in the UK to be affected by climate change. Since 2008, the Department for Environment, Food and Rural Affairs (Defra), as part of its Farming for the Future programme, has been working with Natural England, the Environment Agency and the Forestry Commission on a project specifically addressing adaptation in agriculture. The aim is to identify actions and policy responses that will help to increase the resilience to climate change of both

agricultural production and the natural ecosystems that underpin farming. This will serve to maintain a sustainable supply of food and to provide other vital ecosystem services that will be essential to help buffer society from the effects of a changing climate. Each government department, including Defra, is developing an adaptation plan. Defra published its climate change plan in March 2010 (Defra, 2010). The UK Climate projections report in June 2009 provided impacts information. Several workshops with stakeholders have been held to help identify likely consequences for agriculture and to develop and validate priority adaptation measures.

The key objective of the strategy is to maintain, and enhance where possible, the wide range of social, environmental and economic benefits that agricultural systems provide to society. Applying the risk-based framework to the farm-level, it distinguishes the following key areas (Defra, 2010):

- Production risks such as pests and diseases (animal and plant), and weather effects.
- Market risks such as volatility in the costs of inputs and the price of outputs.
- Finance risks such as variability of interest rates or value of financial assets and availability of credit.
- Institutional risks, including trade issues such as import bans/restrictions by other countries, or regulatory changes that can affect costs or returns.

To address these challenges Defra outlines the following high-level activities (Defra, 2010):

1. Defra and DFID are jointly sponsoring a Foresight study on Global Food and Farming Futures, which will include consideration of key climate impacts on the global food system up to 2050.
2. Defra will make further information available through the UK Food Security Assessment, and review risks as new evidence becomes available including climate risks to harvests and the potential for more volatility in supplies and prices, as well as new animal disease and food safety risks.
3. The Government will continue to work with the food industry to promote business continuity planning and resilience to flooding and other climate threats.

At the horizontal level within the government, Defra provides a “challenge fund” to encourage use of the projections and other climate information to inform policy and service delivery across government (Defra, 2009). It also developed partnerships with organizations through mechanisms that include (Defra, 2009):

- The Rural Climate Change Forum. This body convenes key organisations with an interest in the rural sector to raise awareness of climate change, coordinate their work and to advise on policies and research priorities.
- Providing funding for Farming Futures in 2009/10. This organization works to raise awareness among farmers and to provide practical advice on adaptation and mitigation.¹⁵
- Establishing a Local and Regional Adaptation Partnership (LRAP) board to share best practices, advise local authorities and work on how to measure progress.

- Supporting nine independent Regional Climate Change Partnerships which have carried out a range of awareness raising and research projects.¹⁶
- At a national level, forming a Partnership Board to bring together public, private and third sector organizations.

Finally, climate change is now an overarching objective of Environmental Stewardship, the most important of the agri-environment schemes that now cover a large proportion of English agricultural land.¹⁷ By supporting biodiversity and resource protection, Environmental Stewardship already supports the adaptation of the natural environment to climate change and is likely to make an important contribution to adaptation for agricultural systems. Natural England and Defra have started a process of further embedding climate change in Environmental Stewardship to maximize its contribution to adaptation.¹⁸

Germany

In Germany, the **NAS** was adopted in 2008, providing a strategic framework for adaptation to climate change that aims to integrate the work already in progress in various ministries into a common approach (Swart et al., 2009). To support implementation of the German Strategy for Adaptation, the government has taken a variety of measures including (Federal Government of Germany 2008):

- Establishing an inter-ministerial working group on adaptation to climate change
- Continuing the federal-state dialogue on adaptation to climate change
- Development of the Competence Centre on Climate Impacts and Adaptation (KomPass) to provide technical and environmental advice and make information widely available
- Supporting the Climate Service Centre of the Helmholtz Association of German Research Centres to accelerate knowledge diffusion, scenario building and modelling functions in the form of data and advisory services
- Developing research programs on impacts, vulnerability, indicators, costs and benefits, forecasting, monitoring, regional adaptation and sectoral adaptation

In cooperation with the Länder (states), a national Climate Adaptation Action Plan is being written in Germany. This will address (Federal Government of Germany 2008):

- Principles and criteria for identifying and prioritising action needs
- Prioritising federal measures
- Overview of concrete measures by other stakeholders (on the basis of the dialogue and participation process)
- Information on financing
- Proposals for progress review (indicators)
- Further development of the German Adaptation Strategy and specification of next steps

Finally, Germany is also one of the countries with a focus on the agricultural sector in their national strategy, and have taken various steps to focus on the unique challenges to this sector. In Feb 2010, Parliament held an expert hearing on climate change and

agriculture (adaptation and mitigation) and roundtable stakeholder meetings have been held at the ministerial level. Specifically for agriculture, the priorities are the following (Federal Government of Germany, 2008):

- Animal and plant breeding (crop nutrient balances, resistance properties, quality characteristics, taking into account yield potentials and genetic diversity of plants in interest of broader crop rotation)
- Agricultural advisory services
- Multi-risk insurance policies
- Growing renewable primary resources to expand choice of plant species, for the positive contribution to agro-biodiversity and more flexible crop rotation
- Policies encouraging conservation and sustainable use of genetic resources
- Analysis of contribution of agro-biodiversity in order to maintain and strengthen it

At the **sectoral level** in Germany, the focus is on actual measures and innovations related to agriculture and communication and knowledge exchange. This includes (Federal Government of Germany 2008):

- Continuing effective species protection legislation enabling plant breeders to develop appropriate crop varieties and, if necessary, to perform breeding work on other crop species.
- Promoting water retention in drought-risk farm and forestry landscapes through the “Joint Task for the Improvement of Agricultural Structures and Coastal Protection” (GAK).
- Promoting irrigation infrastructure via the GAK.
- Promoting methods of improving soil fertility, soil structure and natural regulatory mechanisms as part of agro-environmental measures.
- Promoting animal breeding and management measures in livestock farming.
- Promoting innovations in plant breeding by means of the innovation programme.
- Specific activities focusing on knowledge transfer with experts from the Länder (states) especially with regard to adapted forms of land management, livestock farming, animal nutrition and animal health.
- Raising awareness about the impacts of climate change and the need for adaptation measures.

Finally, at the level of actual Länder (states), the following activities are occurring (Federal Government of Germany 2008):

- In Mecklenburg-Western Pomerania: the development of soil management techniques that prevent water and wind erosion through expansion of water-saving cultivation methods, and experimentation with the cultivation of thermophilic plants (soy).
- In Saxony, among others: soil management, experiments with crop rotation, and monitoring of pest occurrence.
- In Brandenburg: encouraging irrigation and drainage, and a program to create cultural landscapes (Kulturlandschaftungsprogramm, KULAP).

United States of America

While the national level plays a limited role in supporting responses to climate change (both adaptation and mitigation), an increasing number of local jurisdictions have begun taking action. By August 2008, there were 850 mayors from 50 states representing a total population of almost 80 million citizens, who have signed the US Conference of Mayors Climate Protection Agreement.¹⁹ From these, 40 jurisdictions have already adopted concrete local climate change (mitigation) action plans (Tang et al., 2010).

On the subject of adaptation, a number of states have started to take the lead on developing strategies. One of the more progressive states in responding to climate change is California. A Governor's executive order issued in November 2008 specifically asked the Natural Resources Agency to identify how state agencies can respond to rising temperatures, changing precipitation patterns, sea level rise, and extreme natural events. In response, the 2009 California Climate Adaptation Strategy summarizes the best known science on climate change impacts in seven specific sectors and provides recommendations on how to manage those threats. The first iteration of this strategy was completed with a 45-day public comment period that closed September 17, 2009.²⁰

The adaptation strategy emphasizes that California's agricultural sector plays a large role in the state's economy and culture and that the strategy aims to enhance the critical nature of the relationship between food security and the agricultural impacts of climate change. Six key areas of adaptation in agriculture include (2009 California Adaptation Strategy):

- Water Supply and Conservation Support;
- Preventing, Preparing for, and Responding to Agricultural Invaders, Pests, and Diseases;
- Land Use Planning Practices;
- Promote Working Landscapes with Ecosystem Services to Improve Agrobiodiversity;
- Farm and Land Management Initiatives; and
- Building and Sustaining Institutional Support.

The approach in California was a state government initiative; thus, it was confined to describing actions that could be carried out by state agencies (ie: given the authority and expertise available within state government). Other criteria included the need to be fiscally and technologically feasible (ie: possible with current technology and financial capacity)²¹ and the strategy also distinguishes between things that can be done immediately, and priorities that require more research, funding and institutional development or change over the longer term. Much of the strategy builds on actions, programs and initiatives that are already in place, run by the state or sectoral actors. Highlighting and drawing on initiatives by proactive producers in the state has reportedly had a positive impact on buy-in by stakeholders in the agricultural sector. Finally, the involvement of the Land Resource Protection Division (Department of Conservation) in developing the agriculture strategies has established issues of land conservation in the discussion of potential adaptation strategies in California. This has significance in terms of tradeoffs over land use priorities in the State.

In the initial stages of developing this strategy, agriculture was not recognized as a priority area. As a result, a specific chapter on agriculture was not initiated until several months into the process. This led to a shortened consultation process with selected agency and non-agency stakeholders. Feedback from stakeholder groups and the public following release of the draft strategy led to a second consultation process for the agricultural chapter alone. This process was open to anyone who had expressed an interest or concern in being involved, and additional comments were received through the website.

In **Washington State**, in 2007 each sector produced a white paper on preparation and adaptation to climate change, which included consultation with representatives from across the relevant sector. This was followed by legislation passed in 2009, requiring that a state-wide adaptation strategy be developed. For this phase, agriculture is included in the “Working Lands” group, along with forestry and aquaculture. A separate climate advisory panel informs policy development for all sectors from the climate science perspective. The process for Working Lands is supervised by an advisory group comprised of two research institutes, six executive agencies (including agriculture), federal agencies, the conservation commission, industry groups and growers—the intent was to go as broad as possible while maintaining a group of manageable size. It was also noted that experience gained through working on the white papers, along with the formal legislative basis for developing a state-wide strategy, have contributed to greater interest among agency and non-agency stakeholders in working together.

The approach begins by identifying vulnerabilities of the agricultural sector in the context of a changing climate and global markets. In order to explore such issues, they are taking an integrated approach so that different working groups are required to work together. This encourages those with different perspectives to work out policy issues along the way. The identified focus areas for the agricultural sector are: impacts of potential changes in water availability; occurrence of invasive species or pests; and interactions with changing global markets.

In **Wisconsin**, work on adaptation has begun as a voluntary effort sparked by an exchange between university researchers and legislators. This interaction highlighted the need to focus on generating information on impacts of climate change at a scale relevant to decision-making jurisdictions. A team of researchers from the University of Wisconsin-Madison will independently produce the first assessment report (in what is hoped to be an ongoing series) by the summer of 2010, which will be presented to the legislature to get feedback on where this could go in terms of policy. The initiative is structured into a series of working groups focusing on either a natural resource issue or a geographical area. While the project has no formal ties to government, it is linked through an advisory group to representatives of major political and economic interests in the state. The need to create a specific agriculture working group was pushed by representatives from the Professional Dairy Producers of Wisconsin, who are part of that advisory group. By developing strong scientific information about impacts at an appropriate scale, and with involvement of agency representatives, researchers hope to provide a basis for state-level policy making to occur. A science-based, participatory approach is seen as essential in a context where climate change is a contentious issue.

Specific Processes, Challenges and Opportunities in Adaptation Policy Development

Issues Specific to Policy-making for Adaptation

In many ways, designing policies focused on adaptation is similar to other policy development processes. However, there are a number of issues unique to policy-making for adaptation.

A common message from respondents was that more time is needed in the early stages of policy development to improve familiarity and understanding of adaptation as a starting place for developing adaptation strategies. Both the science and the policy implications of climate change are complex. Therefore, it may be necessary to engage in internal capacity-building and awareness-raising for the staff of government agencies and other involved organizations to better understand the implications of climate change for the agricultural sector, along with potential adaptation options and how these can be developed and implemented. As well, to encourage understanding of adaptation and involvement of stakeholders it was suggested that policy-makers identify and build on existing measures that, although not originally implemented with climate change in mind, are already being used, or have the potential to be used, to promote resilience in the agricultural sector. In the agricultural sector, adaptation to weather and market-related changes has always occurred. Thus, there are lots of examples that can be used to help policy-makers and stakeholders familiarize themselves with adaptation. A number of countries are also adding climate change education to the mandates of agriculture extension agents.

Climate change projections have inherent uncertainties and most often focus on long timescales (eg: 20, 50 or 100 years in the future), making it difficult for policy-makers to incorporate this information into their planning. Access to specific information on impacts and their consequences are an important basis for policy development. For the majority of countries reviewed, respondents emphasized that further research was needed to cover such gaps, including regional projections (to account for differences in even smaller regions), estimations of impacts on particular crops and other agricultural products in specific areas, changes in the occurrence of pests and diseases and projections on a timeline that is more relevant for policy-making (eg: 5 to 20 years).

Adaptation is unusual in that it is inherently a cross-cutting issue and cannot be dealt with in pieces, or through discrete actions or policies. Consequently, it was suggested that addressing adaptation in agriculture requires a holistic and integrated approach from the early stages of policy development to establish objectives and underlying values, and address linkages with other areas. Therefore, specific attention is needed to ensure that agriculture meets other goals in addition to those focused on economics. Considerations may include:

- supporting ecosystem services that agriculture provides for society;
- rethinking how we prioritize and evaluate benefits of actions (eg: recognizing co-benefits);

- looking at how agriculture can contribute to, or hinder, other sectoral adaptation efforts; and
- evaluating potential options to address consequences of climate change within the context of other vulnerabilities and opportunities for agriculture.

Notably, increasing overall resilience of the sector was suggested by most of the respondents as a useful approach, particularly as a means of building the capacity to cope with a range of possible futures in the face of inevitable uncertainty about specific impacts and their timing. Due to the cross-cutting nature of adaptation, it is not possible to identify a single policy that would increase resilience; rather, a suite of options will likely be necessary, which can be adjusted to particular contexts at a farm, ecosystem, community and regional level.

In some cases this is approached by clarifying the desired roles for agriculture in society, and developing a long-term vision for the sector. In addition to the types of questions mentioned in the previous paragraph, as a starting point for adaptation it is important to ask: what is the role of agriculture in contributing to food security, environmental protection and benefits, climate change mitigation, different types of food production, consumer policy and so on? Establishing a shared vision at the outset provides a reference point for identifying important vulnerabilities, prioritizing potential actions and considering how agricultural adaptation policy will contribute to preferred future pathways in the context of a mix of other priorities and the need for overall sustainability. Longer-term or cross-cutting strategies based on a shared vision can also help to support development of capacities and actions that are in the line with other policy goals, rather than working at cross-purposes. By recognising the role of agricultural land beyond just food production, such overarching visions and strategies can also help identify and prioritize specific actions that contribute public goods such as farmers making land available to accommodate flood waters. Finally, these types of strategies can also be useful for guiding the exploration of potential opportunities for agriculture that may arise as a result of changing climatic patterns.

Leadership in Policy Development and Coordination

In EU Member states, agricultural policies are set at a national level, but are directed principally through the EU's Common Agricultural Policy (CAP). The CAP, and in particular the Rural Development Regulation (which funds, amongst other things, agri-environment schemes such as Environmental Stewardship), is well placed to bring about change on climate change issues. In particular, it provides a framework of common rules while allowing discretion at member state level to implement actions locally, such as what types of programs and actions will receive subsidies. This is particularly important right now with discussions under way across Europe on the shape and size of the next CAP funding period (2014-20) and the key issues that it will seek to address. Measures for climate change adaptation and mitigation are likely to feature prominently in these discussions. When the EU issued its guidance documents on adaptation strategies, it provided direction for those countries that had not begun developing their own strategies, and an incentive for countries to begin linking adaptation actions to EU funding mechanisms.

In the US, individual states have taken the initiative to develop adaptation strategies. These efforts were motivated largely by concerns about the possible negative impacts of climate change on agriculture and were explored by policy-makers and researchers, in conjunction with stakeholder consultation processes.

Adaptation strategy development is often led by a combination of ministries, including agriculture, environment and natural resources. Cross-sectoral collaboration was emphasized in particular as an important (albeit challenging) precondition for effective adaptation strategies. This ranges from simply sharing information between different sectors or agencies, to creating joint advisory committees and working groups or crafting stakeholder consultation to look at linkages between agriculture and other sectors.

Stakeholder Participation

Involvement of stakeholders is often an integral part of policy development. But adaptation may require more out of consultation processes, in terms of the diversity of stakeholders involved and the time required. In general, stakeholders should be involved in all stages of the policy development, including:

- developing background materials at early stages of the policy development;
- creating public forums to discuss and comment on a draft strategy;
- keeping the draft strategy open for comments after its release;
- involvement of researchers, policy-makers, sector stakeholders, extension agents, producers and other experts in drafting and reviewing the strategy; and
- involvement of extension agencies, farmers groups, producer organizations and producers to learn about best practices, and to test and disseminate information within their networks.

For example, since 2008 the Department for Environment, Food and Rural Affairs (Defra), along with Natural England, the Environment Agency and the Forestry Commission, has been working on a project with input from various other partners in the Rural Climate Change Forum (such as agriculture industry bodies and environmental organizations) to identify priority adaptation measures for agriculture and work out how best to encourage farmers to put these into practice. Workshops with stakeholders have been held to help identify likely impacts and consequences of climate change in agriculture and validate potential adaptation measures. Finland engaged in multiple steps with various stakeholder groups in development of their strategy. Researchers and stakeholders were involved with developing background materials. At the time (2003-2005) it was difficult to engage stakeholders as there was less awareness of climate change and its potential impacts. The resulting draft strategy was presented in a public forum, followed by an open comment period to receive feedback. In addition, informal consultation occurs in an ongoing fashion with key actors. In California, stakeholder consultation plays a key role in agricultural policy development generally. But in the case of developing the adaptation strategy, a much more targeted consultation process was used (due to the shorter timeline), which was not well received by various stakeholders and some of the public. At public workshops held to review the full draft strategy, a large number of the comments related to agriculture. Subsequently, a broader consultation

process was held. Action in Wisconsin is led by university researchers and guided by a multi-stakeholder advisory group. The project promotes a participatory approach to the production of science so that it is directed by stakeholders and citizens. The intention is that outcomes of the project will be relevant for use by policy-makers, and will have already established some buy-in across participants.

Of note, a number of respondents talked about the challenge of engaging stakeholders in discussion about climate change adaptation given that the occurrence of climate change is not universally accepted, or the importance of adaptation may not be recognized. Thus, effort to establish communication at the outset may be required, in order to build a willingness or interest among stakeholders in participating in strategy development. It is essential that all stakeholders are involved, particularly those that will play a major role in implementation.

Prioritizing Adaptation Options

There are many ways to respond to the consequences of climate change, depending on the particular situation of producers and farmers and what would best fit their needs. Therefore, prioritizing adaptation options at the national or regional level can be a challenging task. While methods to quantify factors can be very useful, one interviewee noted that there is a danger of creating a false sense of precision by relying on quantification of particular risks and vulnerabilities that will vary geographically and over time in unpredictable ways.²² To avoid this, those adaptation actions that help to build resilience of systems to change and result in the broadest range of benefits, are generally a more important priority.

In the UK, an initial list of more than one-hundred and twenty possible adaptation measures was narrowed down to about fifty priority adaptation measures. This was done by considering the likely effect of each measure on a range of objectives relating to the services agricultural land should provide for society (encompassing biodiversity; natural resources and ecosystem services; agricultural production; rural communities; and cultural and recreation benefits), and identifying a set of priority measures that address important and/or multiple risks, and would have multiple benefits. An initial cost-benefit analysis was also done, and the feasibility of the priority measures evaluated in consultation with farming stakeholders (Macgregor, unpublished). The current focus is on exploring how to best encourage farmers to apply these measures (eg: through existing practices and programs, improved advice and research, or developing new initiatives) and conducting a further assessment of costs and benefits, including co-benefits, of these measures.

In terms of specific actions, strategies should consider the types of issues that are best addressed at a national-, sectoral-, regional- or farm-level. Interviewees suggested that some priorities could be promoted at the national level, such as water scarcity, pest and disease control, invasive species prevention and management, and linkages to global market dynamics. Specific priorities identified at a national level for Germany so far include: changes to local conditions (ecological impact); adaptation of genotypes; technology, procedures, operating sequences and farm infrastructure; competitiveness

under changed conditions of production and markets (incl. global); forest management; and monitoring. At a more regional level, these general priorities need to be linked with other opportunities. For example, the possibilities for cooperation across farms to account for appropriate ecological scale, to explore benefits of economies of scale and to identify effective ways of managing tradeoffs arising due to external costs and benefits of actions by single farms. In Germany, this perspective was enabled by collaboration in cross-sectoral working groups even at the ministerial level.

Focusing on the farm-level is also important at the phase of ground-testing policies or actions. As well, understanding motivations and constraints at a farm-level is crucial in order to develop appropriate measures, along with accompanying incentives or regulations, and ensure that they can be implemented. All but one respondent felt that farmers in their country or state had the necessary adaptive capacity to respond to climate change, given proper support from other entities (eg: government, industry, researchers). In general, including stakeholders early and often, in all phases of strategy development, is a recommended way to promote buy-in and ensure relevance of proposed measures to those who will ultimately implement them.

In all the analysed countries there was also an awareness of possible opportunities due to a changing climate. Those opportunities listed include longer growing seasons, less frost, increased yields, ability to grow crops further north or grow new crops, better conditions for certain crops. According to interviewees, in the UK many farmers are already taking advantage of such opportunities and the Farming Futures program is an industry-led initiative that provides information to farmers. They have also done some case studies to explore opportunities. In addition, some countries are factoring in potential opportunities arising due to negative impacts of climate change in other areas. For example, changing conditions may enable certain countries to grow new high value crops that will cease being viable in other areas due to decreasing precipitation. Germany and Washington State are specifically exploring changes in the global market and associated export opportunities, given the potential for production to decrease elsewhere in the world.

Integration with other Policy Areas and Sectoral Priorities

There are multiple sources for potential conflicts between agricultural adaptation and actions preferred by other sectors. Adaptation measures often include more complex cross-sectoral measures with diverse trade-offs between sectors. For example, some respondents suggested that at early stages in the adaptation discussion, there may be a tendency to focus on direct impacts and immediate benefits to agriculture, of potential climate changes. While it is easier to recognize the economic implications and threats to livelihoods posed by climate change, it may be harder to see how climate change threats to biodiversity, water quality, or forest fire management, among other things, also have implications for the agricultural sector—both in terms of impacts, and agriculture’s potential role in helping society as a whole to adapt to impacts. Yet these issues are crucial if we are to achieve sustainable adaptation by the agriculture sector. To address this, Macgregor & Cowan (2010) have proposed a framework and method to help provide

a more holistic and sustainable approach to adaptation, which is being applied to the development of the agricultural adaptation work by Defra described above.

There are always conflicting interests around land use, as well as the desired balance between agriculture and environmental goals, urban and rural development and public health. Climate change adds another level of complexity to this discussion, as current land use patterns may not be viable in the future. Areas currently used for agriculture or designated for conservation objectives may not be able to fulfill those functions as the climate changes, requiring a consideration of options from developing new crop varieties, to shifting crops to new areas. As well, the agricultural sector is increasingly involved in the mitigation side of climate change response. Some of these practices may be in conflict with adaptation objectives, and respondents suggested that more effort should go into finding win-win situations accommodating both adaptation and mitigation needs. In California, efforts to incorporate adaptation and mitigation into land use planning decisions are occurring through an advisory group on Climate Change, Land Use and Infrastructure. This group is informing the Strategic Growth Council (a high-level group made up of heads of government agencies) on how to incorporate climate change into mechanisms to incentivize more appropriate development patterns for sustainability.

Despite challenges of cross-sectoral integration, most interviewees noted that the process of developing comprehensive adaptation strategies has helped to improve understanding of adaptation and how to address it. As well, this experience with collaboration has improved the ability and willingness to communicate and cooperate across sectors and agencies. For example, Washington State learned from its efforts to develop white papers on adaptation in 2007, and have crafted a more integrated approach for the second phase to encourage cross-sectoral debate and problem-solving.

Implementation

In the surveyed countries, significant implementation of adaptation actions is planned for the up-coming years. Most countries are working on translating NAS and sectoral strategies into action plans that should be implemented by ministries and stakeholders at a regional or local level. Therefore, initiatives to discuss and collaboratively develop action plans with the regions and states where the actions should be occurring are taking place in many of the countries.

However, many of the recommendations to promote adaptation focused on measures and policies that exist already and would need to be enhanced, transferred, built on, and provided with more funding to encourage effective actions. For example, initiatives in California include:

- The California irrigation monitoring and modelling system
- Mobile irrigation labs that audit on-site water use, and provide recommendations for efficiency
- Incentive programs for water efficiency
- Integrated water management programs regionally to support watershed level conservation strategies

- A statewide task force at governor’s level on pest and disease eradication, detection and prevention
- Farmland conservation
- Development of a “foodshed” model (ie: urban areas would protect areas of agriculture equivalent to what is needed to support their population)

Building on ongoing initiatives, disseminating best practices and providing a range of options to farmers is key to encouraging future adaptations. Many farmers are already aware of changes and are adapting at a farm level. For example, in a survey of farmers in the UK, over half believe that climate change is impacting their farm now, and over a third are already taking action to adapt.²³

Accordingly, much of the emphasis of their adaptation strategy so far, has been on raising awareness so that farmers can take action themselves. In general, a lot of effort should be focused on extension services to help farmers to adopt relevant practices and enhance peer-to-peer support and exchange of experiences.

While most countries are not yet at the stage of developing tools to evaluate the effectiveness of adaptation strategies and actions, most of the countries surveyed anticipate developing indicators later in the process. Some countries are already drawing on case studies or planning pilot projects to find out what types of measures work under which conditions and to understand farm-level triggers that encourage adaptation.

Conclusions

In EU Member states, agricultural policies are set at a national level, but are directed principally through the EU’s Common Agricultural Policy (CAP). The CAP and in particular Pillar II, the Rural Development Regulation (which funds amongst other things agri-environment schemes such as Environmental Stewardship), is well placed to bring about change on climate change issues. It provides a framework of common rules while allowing discretion at member state level to implement actions locally, such as what types of programs and actions will receive subsidies. When the EU issued its guidance documents on adaptation strategies in the context of the CAP, it provided direction for those countries that had not begun developing their own strategies, and an incentive for countries to begin linking adaptation actions to EU funding mechanisms. In the US, individual states have taken the initiative to develop adaptation strategies. These efforts were motivated largely by concerns about the possible negative impacts of climate change on agriculture and were explored by policy-makers and researchers, in conjunction with stakeholder consultation processes.

Agriculture was addressed in all of the analysed NAS documents, and was recognized as a priority area. Most focused on establishing horizontal working groups to address the major challenges that arise across sectors such as agriculture, water resource management, forestry, biodiversity and rural development. Specific activities that are promoted or being implemented include developing consortia of climate modellers and agricultural specialists to link climate information with potential consequences for agriculture; reviewing applied schemes for pest and disease management; reviewing

insurance needs; identifying financial sources needed to support adaptation; and also developing monitoring, research programs and outreach and communication strategies about climate change. At the sectoral level, the focus was on creating working groups or coordinating bodies; reviewing current legislation and policies to ensure that they provide opportunities and flexibility for adaptation and capacity development, including diversification of production; developing specific adaptation measures focused on changes in crops, water-use and irrigation and soil protection; and exploring linkages between agriculture, environment and rural development.

Based on this assessment we propose the following priorities for agencies concerned with adaptation in the agricultural sector:

Policy Development Process and Institutional Involvement

- *Establish advisory bodies and working groups* that include researchers, policy-makers and key stakeholders representing different agencies and sectors so that adaptation policies can be more easily integrated into diverse sectoral priorities and possible trade-offs can be addressed. Particularly, ensure cross-departmental coordination of strategy development within the government.
- *Involve stakeholders in all stages of policy development* to enhance two-way awareness and knowledge development; relevancy of policies and proposed actions; and to improve buy-in by those actors that will be central to implementation. Include a mix of researchers, experts, policy-makers, agricultural organizations, farmers and the public.
- *Explore the question “what is agriculture for?”* It seems to be crucial to identify and develop a shared understanding of objectives and values that will guide development of an agricultural adaptation policy, prior to policy-makers embarking on identifying specific adaptation responses in agriculture. This should include discussion about role of the agriculture in society, preferred land-use types and changes. Naturally, if such a vision for agriculture and land has already been developed, it should serve as a guide to identifying specific adaptations. In this context it is important to allocate time to consider how these values and objectives are linked to sectoral, cross-sectoral and national objectives, including issues such as what role agriculture should play for food security, environmental protection and benefits, climate change mitigation, types of food production and consumer policy.
- *Decide on a vision and/or framework to guide integration of adaptation policy* with existing policy and across sectors and various objectives.

Developing Adaptation Strategies and Policies

- *Conduct vulnerability assessments of agricultural systems* to better understand those areas (both issues and locations) where sensitivity is high and capacity is lacking, and areas where opportunities may exist. Specifically consider how changing global markets may contribute to risk and opportunities locally.
- From this, *identify no-regrets options* (i.e. options that provide benefits even without impacts of climate change) for capacity development.
- *Conduct reviews of current management standards, practices and plans*—especially those dealing with pests and disease control, infrastructure standards

and risk-insurance policies—to incorporate potential impacts of current climate variability and climate change.

- *Look at the implications of longer-term agricultural priorities* (in legislation and policy) for adaptation and capacity development policies, and vice versa.
- *Consider adaptation needs in the agricultural sector concurrently with other priorities* including:
 - Supporting ecosystem services and co-benefits that agriculture provides for society;
 - How agriculture can contribute to or hinder other sectoral adaptation efforts;
 - Other vulnerabilities and opportunities facing the agricultural system;
 - Potential for win-win actions that address both adaptation and mitigation; and
 - Which adaptation options can provide the broadest range of potential benefits to society.
- *Start with existing practices and programs when developing adaptation options.* Many initiatives currently exist that can be enhanced, adjusted or provided with more support or funding.
- *Explore the use of innovative policy tools for incorporating adaptation.* For example, use adaptive policy-making to be able to incorporate outcomes from climate change impact models and forward-looking methodologies to envision preferred future pathways and to help promote flexibility in policy-making.

Towards Implementation

- *Spearhead pilot initiatives to broaden the impact and uptake of adaptation options.* For example, research and implementation of adaptation actions relating to farming techniques, crop varieties and livestock management so that their viability is tested and demonstrated to farmers and agricultural producers.
- *Highlight existing actions by agricultural stakeholders and involve stakeholders in policy development* to enhance relevance of policies and improve buy-in. Include these examples as case studies and/or incorporate them into adaptation options. Producers that are taking initiative on adaptation can play key leadership roles in policy development and facilitating broader implementation in the sector.
- *Develop a suite of adaptation options* that can be adjusted to particular contexts at a farm, ecosystem, community and regional level.
- *Establish extension agencies, communication strategies and dialogue with agricultural producers and farmers* to assist in integrating climate data and possible adaptation actions into their practices.
- *Provide for ongoing research into climate change impacts, adaptation options and implementation issues* (funding, procedures, assessment, etc.) as they relate to the agricultural sector as well as other sectors.

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Appendix

List of Interviewees

Name	Affiliation
Barnett Anna	Agriculture, Soil and Forests Unit, Directorate General for Environment, EU
Bormuth Claus	Coordination of Environmental and Climate Change Affairs, Ministry of Food, Agriculture and Consumer Protection, Federal Government, Germany
Bottomley Nieves	Farming for the Future Programme — Climate Change Adaptation and Agriculture Project, Department for Environment, Food and Rural Affairs (Defra), UK
Cook Kirk	Natural Resources Assessment Section. Agency Lead on Climate Change, Washington Department of Agriculture, USA
Gwynne Bruce	Water Infrastructure Mitigation Specialist, Staff Environmental Scientist, Division of Land Resource Protection, California Department of Conservation, USA
Macgregor Nicholas	Natural England, UK
Nowak Pete	Nelson Institute for Environmental Studies, University of Wisconsin-Madison, USA
Trott Ken	Office of Mine Reclamation, Department of Conservation. Former Manager of Agriculture and Environmental Stewardship, Department of Food and Agriculture and representative of CDFA on the adaptation strategy team, USA
Vainio-Mattila Birgitta	Market Policy Unit, Department of Agriculture, Ministry of Agriculture and Forestry, Finland
Yrjölä Tiia	Climate Change Adaptation Research Program, Ministry of Agriculture and Forestry, Finland

Research Projects on Adaptation in the Agricultural Sector, Completed or in Process

Country	Research Project Title (and partners)	Description	Funding Committed	Project Timeframe
Finland	Climate Change Adaptation and Mitigation Research program (Advisory Board for Government's Sectoral Research)	Open call for research. Must be policy relevant and cross-sectoral.	1 Million €	2010 - 2012
	Impacts of Climate Change on Nordic Primary Industries (NordForsk)	<ol style="list-style-type: none"> 1. Plant and animal health (cross-sector theme) 2. Conservation, adaptation and utilization of genetic resources (cross-sector theme) 3. Adaptation and mitigation in milk, meat and cereal production systems (sector-specific theme) 4. Impacts and adaptation in fish production systems (sector-specific theme) 5. Sustainable biomass production and carbon storage in terrestrial ecosystems (sector-specific theme) 	18 Million €	2009-2014
	Changing Climate and Agriculture Research programme (MTT Agrifood Finland)	Ongoing research programme looking at key projects such as: adaptation of agrifood sector to climate change; adapted field crops; risks and benefits of invasive pest species; sustainability and yield through crop diversity;		

		diversity of weed communities; development of horticultural crops and varieties; sustainable cultivation methods; potential of cultivation technology in agriculture; climatic impact of zero-tillage; GHG balance of reed canary grass cultivations for bioenergy; enhancing adaptive capacity; exploring alternative scenarios of adapting to climate change		
	Role of the insect-transmitted parasite Filarioidea tapeworm "Type 2" in reindeer health and populations, life cycle, transmitters, dynamics and prevention (Finnish Food Safety Authority Evira, Finnish Game and Fisheries Research Institute FGRI, Universities of Helsinki and Oulu and stakeholder groups)	Research project on impacts of climate warming on the health of reindeer.		
	SILMU (Academy of Finland)	Development of mitigation and adaptation strategies for responding to climate change was one of three research	~\$17.5M US over 6 years	1990-1995

		streams in the SILMU project		
	ILMASOPU – Adaptation of agri-sector to climate change (part of ISTO research programme) (MTT Agrifood Research Finland, SYKE, FMI)	Potential increase in crops, changing risks, leaching, economics	989 899 € (337 000 € of that from the Finnish government)	2006–2009
	ELICLIMATE – Food safety and climate change (Technical Research Centre of Finland (VTT), FMI, MTT, Univ. Helsinki, Evira)	Identifying climate change risks for food industry	40 000 €.	2009
	Risk assessment of alien species in plant production (MTT Agrifood Research Finland)	Pest risk assessment (present and potential new pests) based on their ecological and economic impact		2009-2010
	FICCA–Finnish Research Programme on Climate Change (Academy of Finland)	Adaptation is one of four research themes within the FICCA programme. The primary objectives of the research programme are to: generate knowledge of climate change – its effects and governance; promote multidisciplinary expertise and research environments in order to intensify research into climate change and achieve synergy benefits; serve Finnish society by combining the global and local	12M € (for entire project, from 2010 budget)	2011–2014

		perspectives		
United Kingdom	Assessing the risk of climate change for the UK	A national Climate Change Risk Assessment		November 2011 (completion)
	Costing the risks and opportunities from climate change	A national Cost-Benefit analysis of adaptation will be published to complement the Risk Assessment		
	Land-use futures study (Defra, CLG—Foresight study)	Jointly sponsored independent “Foresight” study on land-use futures, including an analysis of how climate change will present challenges and opportunities for the way land is used over the next 50 years and beyond.		
	Food Security Assessment	Assessment of the current state of food security, which will also look at likely trends in the next 5-10 year period		
	Programme of cross-regional research on impacts and adaptation (Defra)	Research themes: (1) planning and the built environment, (2) business, (3) water resources, (4) countryside and the rural economy, (5) quantifying the cost of impacts and adaptation, and (6) linking adaptation research and practice	£400 000	2004 -2006
	Living With Environmental Change (LWEC) programme (at least 20 partners, including Defra)	Its objective is to help people find ways to cope with environmental changes, including climate change that affects their wellbeing and livelihoods	£1 billion over 5 years	Beginning 2008
Germany	New institute established in 2008 for climate research into	Analysis of the impacts of climate change on agriculture and forestry, horticulture, fishery, the		Beginning 2008

	agriculture.	<p>food industry, cultural landscapes, rural areas and aquatic ecosystems, including inventory undesirable emissions (depositions) in agriculture, forestry and fishery.</p> <p>Analysis and development of methods, crop systems, products and services for adapting the agricultural industry to changed climatic conditions, including economic and ecological assessment.</p> <p>Studies on the characterisation, prevention and control of organisms harmful to plants and abiotic causes of damage, natural contaminants, animal epidemics and zoonoses and, if appropriate, their vectors, in cases where their new or intensified occurrence is due to climate change.</p>		
	New key research area “Sustainable Land Management” (Federal Ministry of Education and Research)	<p>Investigating interactions between land use, ecosystem services and climate change. Transdisciplinary and interdisciplinary research approaches will be used to develop strategies, action options and system solutions for sustainable land use management regionally.</p>		
European Union	Seventh Research Framework	Broad research programme on environment, with	1.8 Billion €	2007-2013

	Programme	climate change mitigation, adaptation and interactions with other drivers of environmental change as a focus.		
	CCTAME — Climate Change — Terrestrial Adaption and Mitigation in Europe (EU, IIASA, international partners)	Geographically explicit biophysical models together with an integrated cluster of economic land-use models will be coupled with regional climate models to assess and identify mitigation and adaptation strategies in European agriculture and forestry	4.6 Million €	Beginning 2008
	ADAGIO — Adaptation of agriculture in the European regions at Environmental risk under climate change (EU, University of Natural Resources and Applied Life Sciences— Vienna, Austria, international partners)	To analyse and evaluate potential and actual adaptation measures in agriculture for different climatic and agroecosystem regions under risk in Europe	564 000 €	Beginning 2007
Washington, USA	Comprehensive Assessment of Climate Change Impacts on Washington State, (Climate Impacts Group (CIG))			June 2009
	Chapter 5: Assessment of climate change impact on eastern	An assessment of the potential impact of climate change and the concurrent increase of atmospheric carbon		June 2009

	Washington agriculture - Washington Climate Change Impacts Assessment, (Climate Impacts Group (CIG))	dioxide (CO2) concentration on eastern Washington State agriculture was conducted		
	Impacts of Climate Change on Washington's Economy (Pacific Northwest university scientists and economists)	In 2006 and again in 2009, a team of scientists and economists from Pacific Northwest universities conducted an economic analysis of climate change for the state of Washington. They reached three conclusions about the effects of climate change on the state's economy: Climate change impacts are visible today, and the economic effects are becoming apparent. The costs of climate change will grow as temperatures and sea levels rise. Climate change will also provide economic opportunities.		2006, 2009
California, USA	California Energy Commission: Public Interest Energy Research (PIER) Program	California Perennial Crops in a Changing Climate		Completed 2009
		Climate Extremes in California Agriculture		
		Effect of Climate Change on Field Crop Production in the Central Valley of California		
		Estimating the Economic Impact of Agricultural Yield Related Changes for California		
		Economic Impacts of Climate Change on California Agriculture		

		Potential for Adaptation to Climate Change in an Agricultural Landscape in the Central Valley of California		
		An Assessment of Impacts of Future CO2 and Climate on Agriculture.		
		Analysis of Climate Effects on Agricultural Systems.		
		Climate Change: Challenges and Solutions for California Agricultural Landscape.		
		Climate Change Impacts on Water for Agriculture in California: A Case Study in the Sacramento Valley.		
Wisconsin, USA	WICCI: Wisconsin Initiative on Climate Change Impacts	Assesses and anticipates climate change impacts on specific Wisconsin natural resources, ecosystems and regions; evaluates potential effects on industry, agriculture, tourism and other human activities; and develops and recommends adaptation strategies that can be implemented by businesses, farmers, public health officials, municipalities, resource managers and other stakeholders. WICCI represents a partnership between the University of Wisconsin, the DNR and other state agencies and institutions.	No direct government funding	Initiated in 2007

Sources: Academy of Finland (2009); Defra (2009); Zebisch et al. 2009; Federal Government of Germany (2008); European Commission (2009c); State of California (2010a and b); Washington State Department of Ecology (2008)

Notes

¹ Including state-level adaptation strategies in the case of the United States

² Most of these studies are summarized in the IPCC WG 2, chapter 5 (Easterling et al., 2007)

³ [IPCC](#)

⁴ By this we mean the whole production system, defined as groups of enterprises that integrate agronomic elements (e.g., climate, soils, crops and livestock) with economic elements (e.g., material, labor, and energy inputs; food and services outputs)

⁵ The policy-making process is a complex process in each country and this review captures some of its features. By no means should this be taken as an exhaustive review of strategies and actions in the countries and states covered by this report.

⁶ It is expected that the climatic suitability of crops will generally be moving northwards as a result of these impacts. This movement can be attributed to the changes in temperature, changes in rainfall distribution over time and an increased variability in climate patterns in general (Easterling et al., 2007).

⁷ For example, animals require more water during times of heat stress, and water stress during critical times for plants (e.g. flowering) is especially harmful. The demand for water for irrigation and livestock is expected to rise with increasing temperatures and expansion in these sectors (Sauchyn and Kulshreshtha, 2008).

⁸ This is reflected in the disaster risk concept where Risk = Hazard x Exposure x Vulnerability

⁹ Recently, a generalized capacity called response capacity was introduced that includes both capacities to adapt and to mitigate climate change, or the human ability to respond to vulnerability and impacts of climate change (Burch and Robinson, 2007), including management of the generation of GHGs and the consequences of their production (Tompkins and Adger, 2003).

¹⁰ Bryant et al., (2000) also shows that farmers' responses vary when faced with the same climate stimuli, even within the same geographic area, given different agricultural systems and markets systems in which farmers operate as well as different individual characteristics and contexts such as personal managerial style and entrepreneurial capacity and family circumstances.

¹¹ Uncertainty will remain a component of climate change projection, but it should not be used as an excuse for inaction and inappropriately interpreted as a case of "no knowledge." Scientists need to become better at quantifying and communicating uncertainties, whereas decision makers need to learn how to work with fuzzy knowledge, acknowledging that it is better than no knowledge at all (Nelson et al., 2006 in Howden et al., 2007).

¹² Mostly referring to the Common Agricultural Policy (CAP) and the Rural Development Regulation

¹³ The Government Institute for Economic Research drew up the background study for the NAS.

¹⁴ The first focused attempt to address climate change adaptation in Finland was undertaken in FINADAPT (assessing the adaptive capacity of the Finnish environment and society under a changing climate), a research consortium participating in the Finnish Environmental Cluster Research Programme, coordinated by the Ministry of the Environment (Carter, 2007 in Swart et al., 2009). The objective of FINADAPT was to produce a scoping report based on literature reviews, interactions with stakeholders, seminars and targeted research. It was a major source of information contributing to the development of the NAS (Marttila et al., 2005 and Swart et al., 2009).

¹⁵ [Farming Futures](#)

¹⁶ [DEFRA](#)

¹⁷ For example, in England, existing mechanisms (such as Environmental Stewardship) have the potential to deliver a lot of the necessary adaptation for agriculture (at least in the short-medium term), and one of the priorities should be evaluating the effectiveness of current policy instruments and embedding adaptation into them (Macgregor & Cowan 2010)

¹⁸ For details see: [Nature England](#)

¹⁹ [US Mayor](#)

²⁰ For more details see: [California Climate Change Portal](#)

²¹ Note: financial capacity has decreased since then, due to the economic recession and fiscal challenges

²² This approach also runs the risk of allowing uncertainty to delay action if insufficient quantitative information is available (Howden et al., 2007; Macgregor, unpublished)

²³ [Farming Futures](#)