Data availability and transnational access to research infrastructures

Easy and free data access is a key issue for enhancing and distributing climate knowledge. The role of national data policies and the limited data provision options of smaller groups as potential barriers to collaboration/coordination on a European level needs to be examined. An open data policy and ICT infrastructures supporting database access need to be promoted for transparency and easy data availability.

In addition to an open data policy, it is also important to maximise the use of national and European research infrastructures. Due to the vast variety of climate-related infrastructures, RI access can be facilitated through the provision of remote scientific services (e.g. reference materials, samples, data) or in person (hands-on), for example by performing sample analyses, specific measurements or experiments. The JPI Climate can support and serve as a strategic platform for enhancing transnational RI access management and also organise database utilisation training and scientific and technical tutorials, particularly for first-time RI users.

Interoperability of observations

The environmental observation data is characterised by vast heterogeneity. This is due to the highly variable and complex data, but also occasionally as a result of the measuring methods and/or data processing used. Such heterogeneity creates immense challenges for the process of interoperability. Barriers to interoperability need to be identified and then recommendations generated that address how these may be overcome. Likewise, standardisation and harmonisation of data formats and observation and data processing methods are important to further joint development at a European level. Advanced analytical and modelling software is required, in addition to sufficient computational capacity to perform demanding workflows on vast data sets. These requirements highlight the importance of establishing integrated e-infrastructure environments that integrate observatories, sensors, data, software, models and computation facilities on an appropriately large scale. The JPI Climate will promote and support European integrated e-infrastructure processes that enable better interoperability of data, databases and data processing and facilitate data utilisation by end-users.

Operational and research infrastructures

Many operational monitoring networks are already well-coordinated through WMO programmes (GCOS) or other networks. There is, however, a lack of sufficient support for full implementation. Transnational collaboration has increased overall, common measuring variables (e.g. list of GCOS Essential Climate variables) and databases have been defined, data processing methods have evolved, and jointly coordinated and run European-level research infrastructures are being established. However, interlinks, interoperability and synergies between operational and research-oriented observation networks and infrastructures remain underdeveloped. The JPI Climate is in a position to promote supporting activities such as joint workshops, training, creation of joint platforms for enhanced sharing of expertise, data trans-access, interoperability, identification of gaps/deficiencies in the European networks and inclusion of new observational parameters in the activities.

Reanalyses of the Earth System

Reanalyses of atmospheric and oceanic observations already play a key role in climate research and provide support for the initialisation and evaluation of models as well as climate change and variability analyses. Reanalyses need to be extended to the land surfaces (e.g. soil moisture) to support decadal prediction. Regular reanalyses will remain necessary to allow a consistent treatment of long observational data series, to improve the treatment of observational biases and to take advantage of progress in data assimilation techniques. Due to the substantial infrastructure needed to perform reanalyses, it is likely that they will be performed by operational centres. The JPI Climate will, however, promote joint projects that involve cooperation between the operational and climate communities and which support the production of “climate quality” reanalyses.

Establishing a network of comprehensive measuring stations

In Europe, there are few internationally leading environmental measurement stations that are specialised in measuring complex interactions between various ecosystems and the atmospheres. This process is important for achieving a comprehensive picture of the matter, energy and momentum budgets, and thus an enhanced understanding of the key processes in the environment and in the Earth system. These stations not only continuously measure energy and material fluxes, but can also provide continuous reference profiling of the atmospheric state and components of the hydrological cycle and thus be used to validate climate models and satellite retrievals. The basis for such a comprehensive station network could include stations such as Cabauw, Hyytiälä, Lindenberg, Payerne, Potenza and Pallas-Sodankylä. By establishing such a network of comprehensive measuring stations, JPI Climate could provide a platform (infrastructure) for research activities described in sub-module 1.3.

Collaboration and data exchange between observational and modelling communities

Enhancement of interactions between climate modellers and observational activities is urgently needed. Enabling joint training, workshops and joint projects and developing common methodologies, standards, metrics, and reanalysis would strongly improve this collaboration.

This would yield development of more useful observation products for modelling purposes and to enable better use of models to complement observations.

Long term research priorities

Securing the European structures for a long-term climate and Earth system

Strategies on securing long-term, integrated observing systems for the Earth system components need to be elaborated and implemented in a sustainable manner. Otherwise many initiatives may become short-lived and may not contribute efficiently to European Earth system monitoring. Moreover, the importance of quantifying patterns and trends of ongoing changes will increase as climate change progresses. The JPI Climate can play a key role by coordinating and optimising efforts on establishing long-term European observing networks that address the key components and key variables of the Earth system. In this way, the JPI Climate can support the European contribution to the international initiatives on observations (e.g. on GEO – Group on Earth Observations - GEOSS).

As observation and monitoring activities develop and additional data become available, appropriate efforts will be required to improve and enhance accessibility of data and interoperability. Data rescue, homogenisation and other activities, e.g. regular reanalyses featuring high-resolution, regional scales and coupled Earth system components, will also remain priorities.

Moving towards a socio-environmental information system

To meet our major environmental challenges, a robust socio-environmental information system that encompasses both natural and social features is needed for the future. This information system should be capable of combining data and knowledge gathered over centuries with new observations and a wide range of model results to support a range of integrated, interdisciplinary datasets, indicators, visualisations, scenarios, and other information products. An information system that ensures broad access to both past and future data, especially with regard to societal dimensions, is a long-term JPI Climate vision.

1.4 LINKS TO OTHER EXISTING INITIATIVES AND NETWORKS/PROJECTS

1.4.1 EC PROJECTS

In the overall Module 1 research domain, collaboration within Europe has been supported by the EC since the First Framework Programme. Several projects are today supported by FP7 under the Environment and Infrastructure programmes.

The European Network for Earth System modelling (ENES) brings together the European network of global climate modelling groups and also some regional modelling groups. Several ENES-related projects are supported by the EC, for example, the ENSEMBLES project (FP6), now concluded, which included global and regional climate modelling, seasonal-to-decadal modelling, climate impact research as well as efforts regarding observation data. Other ongoing programmes are the COMBINE project (FP7) that focuses on the development of ESMs and simulations for AR5 as well as the EUCLIPSE project on the improvement of cloud parameterisation and model evaluation (FP7). IS-ENES is the infrastructure project of ENES (FP7) and concentrates on the objectives of developing a European climate modelling infrastructure. It is complemented by METAFOR (FP7), which is devoted to the development of international standards of metadata for CMIP5.

The COMBINE (FP7) and THOR (FP7) projects more specifically address the issue of decadal prediction and predictability. COMBINE is tasked with investigating initialisation methodologies and its results will support science that will contribute to AR5. THOR (Thermohaline Overturning – at Risk?) will establish an operational system to monitor and forecast the development of the North Atlantic Thermohaline Circulation on decadal time scales and assess its stability and the risk of a breakdown in a changing climate. The ice2sea project (FP7) focuses on projecting the effect of ice sheet mass balance changes on sea-level changes in the 21st Century and, in particular, investigates processes linked to potential ice sheet instability that are relevant on decadal to centennial time scales.

Many EC FP7-funded projects have been contributing and will continue to contribute to process-oriented research activities under JPI Climate Module 1. These include GHG-Europe – Greenhouse gas management in European land use systems; NitroEurope IP on the nitrogen cycle and its influence on the European greenhouse gas balance; EUCAARI IP on aerosol, cloud, climate, air quality interactions; and PEGASOS – the Pan-European Gas-Aerosol-climate interaction study, to name a few.

Several infrastructure projects support long-term observing networks. ESFRI projects - such as ICOS on greenhouse gases monitoring; IAGOS, on trace components in the troposphere; COPAL research aircraft; EURO-ARGO monitoring the oceans through Argo floats; and the integrated Arctic Earth observation system SIOS - are important infrastructures for the objectives of Module 1. They are complemented by many I^3 such as ACTRIS (Aerosols, Clouds and Trace gases Research InfraStructure network) (FP7) and EXPEER (Distributed RI for Experimentation in Ecosystem Research). GEOmon is an EC project contributing to GEOSS by building an integrated atmospheric system for observing greenhouse gases, reactive gases, aerosols, and stratospheric ozone.

The PAST4FUTURE (FP7) project will provide more detailed knowledge on past decadal variability and enable evaluation of models using observations of the past. The FP7 reanalysis project, ERA-CLIM, will provide important information for model evaluation and analyses of climate variability.

1.4.2 INTERNATIONAL PROGRAMMES/PROJECTS

The activities under Module 1 are wholly relevant to the objectives of the ICSU (International Council of Science) and the Five Grand Challenges identified in the Earth System visioning process. The JPI Climate can be regarded as a European-level implementation of the ICSU Grand Challenges, which address climate-change issues. The JPI Climate also relies on valuable work previously carried out over many years and decades by the international global change programmes such as WCRP. Particularly notable programmes include the CLIVAR programme, which centres on present, past and future climate variability; GEWEX, which focuses on global energy and water cycles; SPARC, which addresses stratospheric processes and climate; and IGBP with its many relevant core projects, including PAGES (Past Global Changes) for past climate, iLEAPS, focussing on land-atmosphere interactions, IGAC, concentrating on atmospheric composition, and AIMES - an Earth System synthesis and integration project encompassing integrated modelling activities.

Moreover, WCRP organises major international, coordinated modelling experiments such as CMIP5. It includes coordinated global simulations for past, present and future climate conditions to improve model evaluation and provide the basis for climate change studies. Another international collaboration now underway is CORDEX – the largest ever coordinated regional climate downscaling programme that covers several regions of the world and provides key support for improved assessment of regional impacts. The JPI Climate acknowledges and will benefit greatly from the above-mentioned international activities.

2 RESEARCHING AND ADVANCING CLIMATE SERVICE DEVELOPMENT

2.1 INTRODUCTION

The climate science community finds itself increasingly exposed to various groups of stakeholders asking rather specific questions about consequences, uncertainties, probabilities related to climate and climate change. These stakeholders are decision-makers from industrial and other private enterprises, various policy arenas and planning disciplines as well as highly-trained scientists using the data for impact research and applied research. These various categories of "users" are affected by the physical, ecological, economic or social consequences of climate change in very different ways. This corresponds to a wide variety of "user needs" ranging from information on temperature, humidity, wind speed and solar insolation (relevant to for example, building codes or energy consumption) to information relevant for controlling the risks of hazards caused by extreme weather events, communicate climate sensitive health or disease issues, or enable financial service providers to fulfil their tasks in the assumption of economic risks. Even within an individual sector, information requirements may differ significantly depending on the type of users, the types of risks taken and time horizons considered. Hence, many requests for 'Climate Services' need to be resolved in a problem-oriented approach in direct interaction with the stakeholders involved. As a result, Climate Services will be a two-way exchange: not only will climate information be provided to users. But users will influence the development of Climate Services and the underpinning research by defining their needs and developing specific requests for Climate Services. The wide variety of user needs means that a Climate Service must draw on information from multiple disciplines, not just climate science.

Many member states are developing their own Climate Services capacity, sometimes even with multiple providers per country. Each provider is using its own methods/approaches to provide data and information, even though all services are actually based on the same core information (climate models, climate observations, climate scenarios etc.). Contrary to much of the climate research that generally involves a lot of international cooperation, the work on Climate Services is generally organised on a national level. Hence, we find duplication of efforts and a significant degree of inconsistency. Consistency at a European level would be relevant with regard to data availability, improved tool/methods development and for cross-border issues.

There are different definitions of Climate (change) Services, which is a consequence of the wide variety of stakeholders and their differing needs, as well as of the differing functions of the organisations that deliver Climate Services in each country. In some countries Climate Services are being delivered by meteorological offices, whereas other countries (e.g. German Climate Service Center and the US NOAA) are encouraging a more interdisciplinary approach. In each European country the Climate (change) Services are defined somewhat differently. The definition of Climate Services which has been agreed and adopted for the discussions in this JPI is given in the box below.

Definition of Climate Services:

User driven development and provision of knowledge for understanding the climate, climate change and its impacts, as well as guidance in its use to researchers and decision-makers in policy and business.

To stand up to the challenges of developing and delivering Climate Services "in support of human action and adaptation to regional climate change" (Belmont Challenge) in Europe we need to tackle four issues of scientific research and learning in networks:

2.1.1 IMPROVED DATA AVAILABILITY

The actual value of a Climate Service depends on a number of factors. An important factor is the availability of data. Climate scenarios, essential for Climate Services, describe the likely changes in climate compared to a reference situation. Observational data are essential for the development of climate scenarios and the deployment of Climate Services, yet they are not freely available in each European country, which could provide a barrier to the advancement of Climate Services in Europe.

2.1.2 BETTER TOOLS/METHODS FOR PROVIDING CLIMATE SERVICES

Each method used to estimate future climatic conditions for specific regions and periods has its strengths and weaknesses, for instance due to particular underlying assumptions. These limitations are of great significance, but usually they are neither transparent for the users nor sufficiently communicated and assessed. On the other hand, the climate knowledge required to answer the questions of a user is rather contextual. In many cases the complexity of climate model simulations makes it difficult to link them up to existing risk management and policy instruments. Thus, relevant climate knowledge must not only be made available, but also processed/tailored so that decision-makers and impact researchers are empowered to use and act upon this information.

Climate scientists also find themselves challenged to assist decision-makers and impact researchers in understanding the inherent uncertainty and picking the optimal tool for their needs (which could be climate projections, but also more qualitative decision-making tools) as opposed to merely tailoring climate information to meet customer expectations. Currently, several/some of these tools/methods used for Climate Services are developed at national scales and/or the use of the various tools/methods is strongly influenced by the national setting. Developing joint products, methodologies and standards where appropriate or necessary, would help establish systematic exchange and improve the quality of tools and methods, by "peer review", for example.

2.2 CONSISTENCY IN CROSS-BORDER SETTINGS

Cross-border issues (for instance management of river basins, mountain areas or coastlines) provide a good example of the importance of collaboration and the development of joint products, methodologies and standards. A collaborative approach must be taken to data availability, the development of climate scenarios, an understanding of the strength and nature of the impacts of climate-related events on human activity as well as the nature of the uncertainties involved to arrive at comprehensive and consistent Climate Services in cross-border settings.

2.3 TWO-WAY EXCHANGE ON CLIMATE KNOWLEDGE

A Climate Service will have to encompass more than the delivery of descriptions of climate data, it should also provide guidance related to the information provided (e.g. interpretation of tables, maps, texts, etc.), the uncertainties associated with it (presenting a map of one climate scenario, for example, does not communicate the information about uncertainties), as well as provide decision support tailored to the needs of the user. In some cases, users will not be aware of how their organization could be affected by climate change, what risks they face, and therefore what information is needed from a Climate Service to help them in their decision-making. On the other hand, the demands of users are expected to become more sophisticated. For many users in the UK, descriptions of climate are insufficient and there is already demand for tailored climate knowledge as well as information on uncertainty, vulnerability, extreme events, thresholds, climate impacts and adaptation options. Prospective Climate Services therefore will have much more to draw on multiple disciplines to be able to convey to users the full range of impacts of climate change, including environmental, social and economic impacts. It should also include elements for consumer-driven products and services which are developed to communicate climate change information and its uncertainties in an objective way to non-scientists, with a clear orientation to the questions that are relevant to the users.

A Climate Service will have to be science-based, but it should contain a strong component of user needs-studies, translation of climate and climate impact data for users and decision support. Thus it will be a two-way exchange: not only climate information to users but for users to inform future research and development of Climate Service and products by defining their needs and developing specific requests for Climate Services. We therefore share the basic definition of Climate Services given in the box above.

2.4 COMPONENTS AND KEY OBJECTIVES

In the context of the above issues JPI Climate aims to meet a structural demand across Europe for Climate Services by two following components:

2.4.1 RESEARCH COMPONENT INTO THE DEVELOPMENT AND DEPLOYMENT OF CLIMATE SERVICES

The research will be to help develop Climate Services (in a generalized manner, not to support an operational Climate Service), e.g. in understanding user-needs: What information is required to answer those needs, how best to communicate to users particularly around issues such as uncertainty, and how to systemically include stakeholder needs into the development of Climate Services. It will also include economic and political research into the effects the different degrees of commercialization of Climate Services, accessibility of climate data and quality control (not precluding the right of any countries to choose one policy or another). The priority areas for this research component are explained in the subsequent section 3.

2.4.2 NETWORK OF CLIMATE SERVICE PROVIDERS, WHO CAN EXCHANGE KNOWLEDGE AND SHARE LEARNING

The priority areas for this networking component are explained in section 2.4.

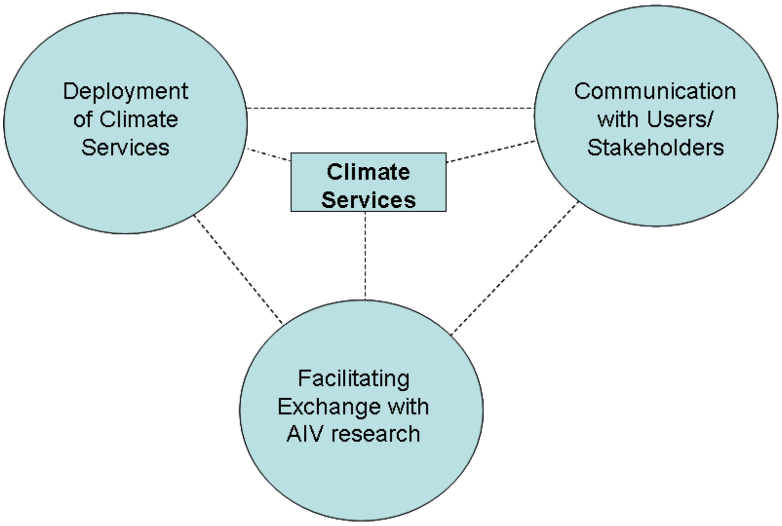
Both components are considered within the expert group to be essential, complementary and urgent to assure the **key objectives** to:

- Improve/enhance the efficiency of the planning and deployment of Climate Services in the individual European countries
- Improve/enhance consistency in the methods/approaches used by the Climate Services in the individual European countries
- Improve/optimise the quality of Climate Services

- Avoid duplication in the development of tools/methods/user inventories
- Improve the communication of climate knowledge to end-users and experts using data for impact research and applied research.

2.5 RESEARCH PRIORITIES

Developing and delivering Climate Services requires a multi-disciplinary approach – bringing together information and expertise from different research communities: fundamental weather/climate research, climate impact, adaptation and vulnerability research ("AIV research"), as well as economics, political sciences, psychology, and communications. There are a number of research issues/challenges that are relevant and need to be addressed in the path toward the development and deployment of Climate Services. Every member state is encountering similar research needs in this respect. The three areas of priority joint research are depicted in the following graph.



2.5.1 DEVELOPMENT AND DEPLOYMENT OF CLIMATE SERVICES

There is a variety of ways how to govern Climate Services that are both, a matter of exchange of experiences within an European network of Climate Services, and a matter of scientific research in social sciences: How do countries structure its Climate Services? What are the strengths/weaknesses of each model? What structure and mechanisms are effective and efficient in delivering Climate Services and enabling a two-way research? Priority areas of research concern the economic effects of different degrees of commercialisation, accessibility of climate data and mechanisms for quality control.

Commercial versus non-commercial approach

A high degree of openness in the sense of institutional experimentation is probably going to be beneficial for an effective public-private partnership in the delivery of Climate Services, with each country making different choices regarding how to handle the economic and social opportunities offered by Climate Services. The alternative between a purely commercial approach by Climate Service Providers or a completely public service will have to be evaluated within the scientifically established tool set of economic and policy analysis based on national circumstances and lessons learnt. The consequences of relying on the private sector and commercialisation of outputs of public-funded climate knowledge will also have to be analysed. In this case, it will also be necessary to analyse the possible incentive-compatible mechanisms for private providers of Climate Services to establish quality standards.

Data accessibility

The activity of the Climate Services is crucially dependent on data, both from observations and numerical climate scenarios. This initiative will have to investigate possible forms of cooperation and sharing that may lead to the successful development of Climate Service products. The approaches will need to protect data authorship and ownership, but at the same it will be necessary to remove barriers that prevent an effective exploitation of climate information. Though every member state will decide their own data policy, it will be important to explore all possibilities to reach a common data policy so that a fair, competitive and innovation-driven level playing-field is established.

Quality control

If multiple agents are going to deliver climate scenarios or other climate information as Climate Services, users require a guidance system so that they are able to judge the relative quality of the service they are getting. If a private Climate Service organisation develops a tool/product, it is important to provide users and the business itself, with some ways of judging the quality. Quality indicators and protocols will have to be developed and standardised across the European Union to provide a uniform measure of skill and capacity. However: how do you define good quality in Climate Services? Is it possible to have a 'European standard' of quality for climate information? Is a certification process desirable and how it could be delivered – would national meteorological offices offer 'training' in using climate projections which confers quality standard? What would certification mean for liability? How could this be used to approach cross-border issues?

2.5.2 COMMUNICATION OF CLIMATE KNOWLEDGE TO END-USERS

Climate Services will have to be delivered by developing a two-way interaction between the service and the users in order to encompass the needs of different user groups with different climate sensitivities and to ensure the Climate Service provides information in a format that is easily understood and facilitates decision making. What methods and tools are most effective at communicating information about future climate change, its impacts and the associated uncertainties? What kind of representation (diagrams, video, animations) can be used to communicate information about climate? Can we develop tools on how best to do risk mapping? How to communicate uncertainty associated with climate projections, whilst enabling decision-making (i.e. not freezing people into inaction)? The three most general needs are: understanding the needs of users, understanding their 'key vulnerabilities' to climate change, the development of tools/methods for communicating climate information and enhancing decision-makers' ability to deal with the inherent uncertainty of climate knowledge.

Understanding user needs

As mentioned earlier, user needs concerning climate/climate impacts data can differ considerably, even within the same sector. User needs can also change in time. Therefore a continuous dialogue between user groups and Climate Service providers is needed to ensure users have appropriate information and to shape climate research in directions which will provide information relevant for users. Where relevant, reasons for failing to develop such sustained, informed engagement between users and providers in the past will have to be investigated, identified and corrected. Users groups in policy, business community and society in general will have to be identified and their specific needs analysed: What information on climate change/climate impacts/ extreme events/ vulnerability /adaptation options do different user-groups require? What format should that information be in to facilitate operational decision-making (e.g. number of days with a temperature exceeding a specific threshold)? What 'quality' of information do users need to make a decision? Reality is that there will be incremental changes in what science can offer but that decision-makers want 'best estimate' information now; how can the gap between needs of decision-makers and what science can offer be narrowed?

Identifying 'climate sensitivities' associated with decision-makers activities

What methodologies can be used to undertake 'climate sensitivities' research with decision-makers? How can we best help organisations to understand their vulnerability to climate change and their 'coping capacity' and which climate data they need for this? What are the 'relative vulnerabilities' of regions and sectors of society/business?

Tools/ methods to communicate climate information

How present climate information in a format that will facilitate decision-making? What methods and tools are most effective at communicating information about future climate change, its impacts and the associated uncertainties? What kind of representation (diagrams, video, animations) and learning models can be used to communicate information about climate to those just learning about climate change and what impact it might have on them? How do Climate Service providers combine information from different disciplines (e.g. climate science and social research) to support decision-making?

Communication of uncertainties

How should a Climate Service communicate probability and uncertainty in climate projections and climate impacts to users? How do users understand the data and information presented in text, tables, maps, etc. How do users interpret probabilistic information, uncertainties, risks? How can we use information about "framing" to improve communication?

2.5.3 IMPROVING THE INTERFACE BETWEEN CLIMATE RESEARCH AND ITS APPLICATION

Climate Services are strongly based on science that is often at the cutting edge of our efforts. Methods and protocols will have to be devised to facilitate the exchange of data and expertise from fundamental weather/climate researchers to applied research in adaptation, impact and vulnerability ("AIV research") and to operational Climate Services.

Improving the interface between climate and climate impacts research

Improving the interfaces with AIV research aims to mobilise, translate and integrate any knowledge from meteorological research, specifically the ones developed in this JPI, for applied research in the fields of AIV. It aims to shorten the time from research to application and to quantify reliability and skill. It will also communicate and integrate research being conducted in JPI water and agriculture for the core purpose to support communities of stakeholders (including the research community) in making better choices in the face of climate change. Research in Module 2, therefore, will by any means be trans-disciplinary and integrative with regard to facilitating exchange of natural sciences, social sciences and local knowledge.

Improving the interface between research and Climate Service providers

What mechanisms to ensure Climate Services is a two-way exchange (i.e. user-needs shape research)? How do we connect multi-disciplinary communities? How do we ensure newest research is available to Climate Service providers?

2.6 EUROPEAN NETWORK OF CLIMATE SERVICES

In order to avoid duplication of efforts and picking on differences in the quality and nature of information being provided from country to country there is a need for a certain degree of consistency of approaches and quality assurance. This is why this Module 2 is also aimed at cooperation between countries within Europe and joint research on and for Climate Services. Encouraging or enhancing permanent cooperation can not be reached by individual short-term collaborative projects, but requires long term commitment. Standardising approaches across Europe for Climate Services would be (at the moment) a step too far, considering the current differences in organisational structures in the various countries and the different scientific opinions on certain approaches, etc. Therefore, it is more appropriate in this early, experimentation phase of the development and deployment of Climate Services that this initiative focuses on the development of a network to share information, tools, case studies, experiences and means to improve Climate Services. The "European Network of Climate Services" (ENCS) would comprise a network of Climate Service providers addressing issues that are going to be more and more relevant as the development and deployment of Climate Services starts everywhere. The purposes of a "European Network of Climate Services" would be to:

- Identify common issues (e.g. urban heat island effect, air quality) or cross-border issues appropriate for joint research projects and initiatives
- Share information on user requirements in various groups of stakeholders and sectors
- Share information and experiences on Climate Services between member states - specifically in geographical regions with similar climate exposure and vulnerabilities
- Establish exchange programmes so that scientists and users can spend time in other Climate Services to experience and learn from others
- Establish a (web-based) forum where the Climate Service providers discuss issues related to the establishment of Climate Services (tools/approaches, communication, essential products, organisation, quality, etc.)
- Ensure that research from other national and international research programmes (e.g. CIRCLE-2 ERA NET) is 'plugged into' Climate Service development

- Initiate collaborative learning processes addressing the needs and limitations on both sides for providers of climate information and users from different sectors
- Set up trans-national cooperation structures for the consolidation and integration of approaches and methodologies for Climate Service provision, with a special focus on cross-border and pan-European issues
- Develop joint products, methodologies and standards where appropriate or necessary
- Establish systematic exchange of good practice
- Improve quality by "peer review" of the tools/methods/etc. by other Climate Services
- Develop links to a shared repository of information (e.g. EU Climate Change Adaptation Clearinghouse) which will guide users to information sources on climate change impacts, vulnerability and adaptation.

2.7 Short-term and long-term activities

The complementary scientific research and networking activities within this module can be decomposed into short-term in the next one or two years (up to 2013) and in the long-term activities in the next five or more years (up to 2016).

Short-term activities are:

User requirements: what is available already (national inventories, from the WMO, EUMETNET, etc.) and what can we learn from it (differences/similarities between countries)?

User requirements: What information do users need on short and long term (e.g. is information on extreme events likely to be short-term priority)? How similar/different are the users from different sectors? [This should lead on to the identification of priorities where information is needed – which should then inform future activities within this module of the JPI].

Mapping national Climate Services, i.e. a cataloguing of current Climate Services providers and their services/products/tools

Exchange of experiences with the help of cross-border case studies

General guidelines for some aspects of Climate Services (e.g. how use climate scenarios in various types of situations, what to do and not to do in communication about uncertainties)

Web portal for access to the Climate Services in various countries

Establish a network of Climate Service providers

Long-term activities are:

How to define and control quality of Climate Services

Defining standard/good practices for several aspects of Climate Services

Research into the effectiveness of Climate Services deployment

3 SUSTAINABLE TRANSFORMATIONS OF SOCIETY IN THE FACE OF CLIMATE CHANGE

3.1 SUMMARY OF THE OBJECTIVES OF MODULE 3

1. Initiating interdisciplinary research to enhance the understanding of the social context (e.g. politics, economics, society, culture) of mitigation and adaptation responses to climate change in Europe and their impact on European social and economic development.

2. Stimulating research on societal barriers and incentives to respond to climate change, including the role of climate knowledge in public and/or private decision-making processes, given that climate change might also open up new opportunities.

3. Enabling integrated analyses of international, national and regional response strategies by identifying and considering socio-ecological and socio-economic limits and opportunities of mitigation and adaptation strategies, while taking into account other global sustainability challenges.

4. Developing and implementing integrated socio-ecological evaluation criteria for sustainable transformation scenarios and processes, both from a European and a global perspective (e.g. social justice, welfare, satisfaction with quality of life).

5. Supporting an integrated view on the societal impacts of climate change, also in relation to other global change trends.

6. Developing governance strategies, involving governments, businesses and NGOs, for sustainable societal transformations on the regional and (supra)national levels.

7. Facilitating transdisciplinary exchange on the objectives, the framework conditions and the realisation of sustainable societal transformations towards “carbon neutral”, adaptive and climate-proof European societies through interaction and joint initiatives with stakeholders as knowledge partners.

3.2 OVERVIEW

The growing body of knowledge on climate change, its causes and consequences is not matched by an equivalent understanding of the societal challenges it poses. This encompasses the societal transformations necessary to confront climate change and develop sustainable and equitable production patterns and lifestyles, while at the same time maintaining or raising the quality of life within Europe and on a global scale.

Given the multiple interrelations between societal responses to climate change, other global change processes as well as other societal and environmental mega-trends, research on sustainable transformations of society is an inherently interdisciplinary[1] endeavour. Given the normative underpinnings of the formulated need for sustainable transformations, understanding, developing and implementing social and economic responses to climate change requires transdisciplinary research and action.

3.3 RESEARCH NEEDS AND DIRECTIONS

If societal complexity is not well understood, even the most rational solutions to climate problems can fail. Socio-cultural realities and decision making are based only to a certain extent on a rational perspective. Socio-cultural realities and decision making mirror different rationalities and are driven by political reasoning and a variety of self-serving interests. Even if a superior goal may be widely accepted, it is not self-evident that individual or collective action will be in agreement with that goal. In fact, climate change is to some degree the outcome of a social dilemma, where individual and collective rationality conflict. In order to develop feasible response strategies, climate change thus needs to be conceptualised in its social dimensions.

For a long time, climate change research has been predominantly conducted in the fields of natural sciences, with increasing interest in technological innovation in the last few years. Only very recently, research has started to address the social science perspective on the challenges of climate change in the fields of economics, environmental policy and planning. This JPI module fosters this recent research strand of conceptualising climate change from a societal perspective, including its economic and cultural dimensions. Moreover, climate change is but one out of a number of other inter-related trends of global change. Sustainable pathways directed to mitigation and adaptation efforts need to take these interrelations into account, such as the risk of coping with one challenge at the costs of others. The JPI module stresses the need to cover such systemic interrelations through integrated, interdisciplinary approaches. In this context, it is relevant to address and elaborate the issue of 'societal transformations' in integrated assessments, model and socio-economic scenario comparisons, where it has been

[1] **Interdisciplinarity** refers to the need for research collaboration among different scientific disciplines. In **transdisciplinary** research collaborations, additionally, non-scientific stakeholders are involved as equals in terms of mutual learning among science and society.

largely excluded in the past. This represents a specific European contribution to these research streams.

Climate change implies a wide range of social, economic and political impacts that call for active and effective transformative responses of stakeholders on different levels of politics, the economy and civil society. The research in this module aims to identify and understand the drivers and obstacles of societal transformations to a carbon neutral, “climate proof” and adaptive Europe[2]. Although the future orientation of European societies and the pathways by which they get there will differ according to specific traditions and characteristics of individual societies, a shared positive vision of such a society and a shared understanding of possible pathways to get there is essential. Research in this field is to be accompanied by considerations as regards the practical implementation of such pathways of sustainable transformations of society. For instance, the notion of an open transformation in contrast to a planned transition from state A to B needs to be explored.

Although this JPI module is conceptualised with a clear focus on Europe, the processes and impacts of climate change appear on a global scale. Climate impacts elsewhere trigger responses in Europe as much as decisions taken in Europe contribute to climate impacts elsewhere. The JPI research aims to take these spatial, as well as temporal, interdependencies into account and thus takes an integrated approach.

Sustainable transformations of societies in the face of climate change challenge research in two respects: In contrast to climate change, being first of all a process defined from a natural science perspective, its impact and the responses necessary to maintain and improve societal well-being extend into the sphere of social sciences. This is the social dimension of climate change. The aspired sustainability of societal transformation reminds us that climate change is just one among several processes of global change influencing the well-being of people and that the outcomes of societal responses to these processes are inter-dependent. This is the systemic dimension of climate change.

3.4 THE SOCIAL DIMENSION OF CLIMATE CHANGE

Climate change impacts depend as much on climate variables as on characteristics inherent to the exposed system. Successful responses to the challenges of climate change require scientific insights on both expected and potential impacts of climate change and their consequences on societies and economies as well as a thorough understanding of conditions and resources for innovative response strategies. In this respect it is important to assess and understand varying perceptions and interests that exist in Europe concerning processes of climate change and differing media representations of the issue of climate change. These differences include

[2] as described in the EU White Paper on adaptation

perceived impacts, coping with uncertainties, risks, benefits and significance of climate change, the appropriate action (now and in future), the willingness to pay and change to avoid risks, and the willingness to accept risk.

In addition to individual perceptions, responding to climate change is also intimately linked to institutional, political and cultural change. This calls for research into the societal preconditions of transformation processes. Learning about climate change is a far-reaching and multifaceted project that involves next to policy-makers all strata of civil societies. In order to facilitate feasible response strategies, climate change is to be conceptualised in its social dimensions. Such research needs to take into account the diversity of societal and individual perspectives and thus allow for stakeholder participation in terms of transdisciplinary social research.

The mere complexity of societies means that a comprehensively managed transformation process is unlikely. This particularly holds true when anticipating controversies, conflicts and rebound effects. In fact, it is highly probable that conflicts will develop when concrete measures are to be adopted to establish pathways of sustainable development. Climate change can add to existing conflicts or trigger new ones. Conflicts arise as climate change and climate policy challenge production and consumption patterns, everyday routines and interests vested in infrastructures, technologies and institutions. These can be related to incoherent objectives between and within social systems, arising from incompatible values, interests and knowledge claims. Conflicts can be expected as a result of differences in perception and interpretation, different views on the fairness of burdens, liabilities and legitimacy. Conflicts may also be related to the implementation and the concrete means of meeting sustainability objectives. Finally, they may be related to power relationships and differing degrees of vulnerability.

In order to govern a process of sustainable societal transformation, it is important to be aware of framework conditions constituted by the cornerstones of working democracies. These involve moral and ethical choices, aspects of equity, social justice, human rights, conflicts of interests, contested knowledge claims, sharing responsibilities and risks. As a consequence, research efforts are required to expand existing insights on the governance of climate change adaptation and mitigation. Implementation deficits in “imperfect future worlds” call for examination. A broad range of possible policies are of interest as boundary conditions for any mitigation and/or adaptation scenario. It is also important to understand what can be learned from history. Social sciences thus constitute an integral part of this JPI module in order

- ...to understand the varying societal perceptions and attitudes to climate risks and opportunities given uncertainty and controversy
- …to identify the social, cultural and economic roots and the conditions (enablers, inhibitors) of societal response to climate change and innovations in terms of sustainable transformation of European societies in the face of climate change.

- ...to analyse and prepare for societal conflicts, possible benefits and governance challenges which are to be induced by both climate change impacts and mitigation policy measures,
- ...to anticipate socio-economic development trends (e.g. population growth, technological developments, effectiveness of government institutions) as a context for climate change response strategies.

Social sciences are also strong in addressing procedural aspects of societal transformations. Investigations into the determinants of societal transformations are required both at the individual and social aggregate level, including the role of private and public organisations and rationalities in decision making and the interaction between both. This raises questions about how to shape responsibilities and understand the distribution of risks as well as potential benefits. It will also highlight problems of policy integration and coherence as well as institutional dimensions of transformation processes.

Finally, climate knowledge is subject to complex societal framing processes that give meaning to this knowledge and shape problem perception. These framing processes need to be studied as part of the policy process in order to help improve communication strategies and means to shape stakeholder interaction.

3.5 THE SYSTEMIC DIMENSION OF CLIMATE CHANGE

Societies are constantly evolving and responding to different challenges of which climate change is but one. Facilitating mitigation and adaptation to climate change need to be an important facet of those transformations – societal transformations in the face of climate change need to be addressed in the context of other transformation drivers and trends.

The regional drivers and impacts of climate change are linked to a complex and global socio-ecological system characterised by feedback processes, delays, uncertainties and indirect effects. Climate impacts elsewhere trigger indirect impacts in Europe while European lifestyles trigger climate impacts in other world regions, now and in the future. For instance, GHG emissions in China relate to European consumption patterns (exported emissions). Research contributions need to consider spatial as well as temporal interdependencies. In this respect potential positive effects and the unequal spatial distribution of climate impacts also need to be taken into account (e.g. global warming is likely to have positive effects on agriculture in temperate Europe over the coming decades, whereas effects are projected to be detrimental in parts of tropical Africa).

Social, economic and environmental sciences will play a key role in exploring the indirect effects of climate change, including interactions with other drivers of global change such as biodiversity loss, human interference with the nitrogen cycle or soil degradation. These interdependencies can also refer to societal phenomena such as migration from so called climate hot spot regions, and their consequences. Sustainable transformation pathways of

Europe in the face of climate change need to consider the multi-facetted, systemic impacts, societal multipliers and mitigating effects and interdependencies between Europe and other regions.

Feasible socio-technological strategies to respond to climate change in terms of sustainable societal transformations require assessments of the capacities of renewable and non-renewable resources, their production dynamics as well as the absorbing and recycling capacity of sinks. To be able to cope with the multi-dimensionality and interrelatedness of climate change, feasible socio-cultural response strategies require assessments of existing environmental management and policy instruments as well as individual factors related to adaptability, such as beliefs, practices, rules and socio-economic demands**.**

3.6 KEY OBJECTIVES

Europe has taken a lead in the global efforts to reach an agreement on climate change mitigation and adaptation and intends to continue to do so. It aims to establish Europe as a best practice example of a sustainable society with a high quality of life. Hence, it is a question of credibility, but also of Europe's future societal and economic stability to demonstrate that high quality of life is achievable in a carbon-neutral society with significantly reduced resource demand and usage. Besides these societal efforts to mitigate human-induced climate change, quality of life will also depend on societal capabilities and improved climate risk management to cope with the inevitable consequences of already ongoing climate change.

The European Research Area (ERA) has the capacity to make important contributions to facilitate sustainable societal transformations in Europe in the face of climate change. Research in this module explores the pathways from carbon intensive, unsustainable lifestyles to a carbon neutral, "climate-proof" and adaptive Europe. It aims to identify and understand the drivers of and obstacles to a sustainable transformation of society. The future face of European societies will follow different pathways to sustainability that will differ according to specific traditions and characteristics of individual societies. However, a joint European effort to develop visions of transition and to understand possible pathways promises to be much more successful than individual attempts. The development and understanding of sustainable pathways needs to be accompanied by considerations on the practical realisation of the pathways, including practical examples of how they might be implemented, in order to contribute to effective societal transformations.

The objective of sustainable transformations in Europe confronted with climate change has implications for both the thematic foci of this module (research objectives) as well as for the modes of knowledge production (research principles).

3.7 RESEARCH OBJECTIVES

- **Understanding the transformation of European societies in a global context:** Although the JPI module is conceptualised with a clear regional focus on European societies, the processes and impacts of climate change appear on a global scale. Climate impacts elsewhere trigger indirect impacts in Europe, while European lifestyles trigger climate impact in other world regions. JPI research takes these spatial and temporal interdependencies into account and contributes to globally sustainable developments in Europe.
- **Understanding the systemic dimensions of climate change**: Climate change is one of the grand challenges of European and global societies. It is, however, only one among other, inter-related drivers of global change. Sustainable pathways directed to mitigation and adaptation efforts need to take these interrelations into account to avoid the risk of coping with one challenge at the costs of others. JPI research enhances the understanding of the complex societal roots, the systemic interrelations and consequences of climate change.
- **Understanding the social dimensions of climate change**: Knowledge on physical-climatological processes and impacts of climate change is a prerequisite for triggering and directing societal response strategies. Nevertheless, this is not sufficient to realise societal transformations. In order to facilitate sustainable response strategies, climate change needs to be conceptualised in its social dimensions. JPI research contributes to integrating the social sciences in the mainstream of climate change research and supports the integration of climate and societal scenarios.

The formulated objectives have implications on the research priorities as well as the research principles.

3.8 RESEARCH PRINCIPLES

- **Integrative and interdisciplinary research**

The JPI module addresses climate change as a complex socio-ecological challenge. Activities within this module reflect the multi-dimensionality and interrelatedness of this challenge and through interdisciplinary research collaborations avoid oversimplification of research frameworks. In this respect the formulated research questions run across disciplines, motivating researchers to come up with integrated insights.

- **Targeting Society**

Societal decision-makers are the ultimate target group of the activities within this module that trigger social learning processes towards a carbon neutral, "climate proof" and adaptive Europe. Thus, suitable modes of knowledge production are needed. The active involvement of stakeholder groups in these activities in terms of transdisciplinary research dialogues assures that the activities meet societal knowledge demands and provide researchers with societal system-, target- and transformation knowledge[3]. Research funding needs to consider new measures to support this kind of research adequately.

- **Reflexivity and transparency on normative propositions**

This JPI module is based on the rationale of a carbon neutral, "climate-proof" and adaptive Europe that is related to two normative settings: (i) there is a need for societal transformations and (ii) societal transformations ought to be sustainable. In order to avoid the danger of top-down social engineering, an active and transparent reflection of these propositions is required within the activities of this module. This links up with the above-formulated principle of knowledge co-production in science and society.

3.9 RESEARCH PRIORITIES

The research priorities of Module 3 are closely linked to the research principles presented above. They are formulated in two complementing directions: **central analytical perspectives** are represented by theoretical concepts and methodological approaches, considered suitable and promising to guide research toward the research objectives of Module 3. Complementary to these perspectives, **key research problems** have been identified in terms of critical bottlenecks of knowledge to societal transformation and concrete sustainability challenges related to societal transformation. Each research priority – opening up to various research questions – can guide the development of specific research activities. The dimensions are interlinked as, for example, a certain process can be looked at from various perspectives.

Research in Module 3 explores new modes of knowledge production and contributes to social learning. Module 3 derives its specific strength from the close connection with the other modules in the JPI. Overall, Module 3 aims at enhancing the connectivity of knowledge between disciplines (interdisciplinarity) and beyond, by bridging between science, society and policy (transdisciplinarity).

3.9.1 SOCIETAL CAPACITY TO RESPOND TO CLIMATE CHANGE – DRIVERS AND INHIBITORS OF ADAPTATION AND MITIGATION

Central analytic perspectives:

- Cultures, values, ethics, risk perceptions
- Behaviour change
- Role of different actors, institutions and networks

[3] CASS / ProClim (1997). Research on Sustainability and Global Change – Visions in Science Policy by Swiss Researchers. ProClim – Forum for Climate and Global Change: Berne.

- Role of human-nature relations
- Role of knowledge and science
- Role of individual and collective capital (e.g. social, financial, symbolic, cultural)
- Trade-offs, synergies, conflicts and co-operation
- Agendas and societal frames, re-framing, assumptions, underlying story-lines, educational paradigms
- Modes and strategies of communication

Key research problems:

- National, regional, local, organisational and individual response capacities (e.g. resources, commitments, responsibilities) in the face of climate change impacts (adaptive capacity) and climate policy measures (mitigative capacity); mechanisms for mobilising these capacities
- Causes for mismatch between public awareness of anthropogenic triggers of climate change and the perpetuation and spread of carbon intensive modes of production and consumption (e.g. priority setting and significance of climate change)
- Causes and consequences of climate-scepticism
- Effects of incoherent societal (e.g. political, economic) objectives and performance indicators (e.g., climate change impacts and GDP)
- Research on the potentials and problems of behaviour change at societal and individual level

3.9.2 Governance of sustainable transformations

Central analytic perspectives:

- Modes of governance: integrated governance and existing governance schemes, multi-level governance, policy coherence, internationalisation of governance and state concepts
- Science-policy interfaces
- Power relations: spheres of influence and decision-making power, conflicting interest groups
- Democratic governance, participation, legitimacy and transparency
- Policy cycle analysis and evaluation (developing adaptive policies under conditions of uncertainty)

Key research problems:

- Coordination of bottom-up initiatives in climate policy in the absence of top-down agreements and connectivity within fragmented governance systems (e.g. role of federalism); allocation of responsibilities to public and/or private actors
- Governing climate change within liberal democracies in a free-market world (e.g. assessment of the effectiveness and transferability of existing instruments)
- The role of the politics-administration interface in policy implementation
- Synergies and trade-offs of climate governance and economic, financial or trade policies
- Research on combinations of mitigation and adaptation policies and practices aimed towards a carbon neutral, "climate proof" and adaptive Europe
- Role of stakeholder's frames and contested knowledge in decision-making processes
- Governing uncertainties

3.9.3 SUSTAINABLE RESPONSES TO CLIMATE CHANGE

Central analytic perspectives:

- Integrated research on socio-ecological, complex problems and on policy formulation and implementation
- Integrated assessments and comparison of climate change adaptation and mitigation pathways and strategies
- Direct and indirect impacts of climate change and rebound effects of mitigation and adaptation.
- Forces and processes leading to mal-adaptation and mal-mitigation

Key research problems:

- Socio-ecological and socio-cultural limits and resilience of climate adaptation and mitigation strategies (e.g. limits of rare earth metals as constraints for energy efficiencies, societal paradigms as constraints for alternative solutions etc.)
- Trade-offs and synergies among climate change policies and other global change policies (e.g. biodiversity and arable land, demographics, digitalisation of society, urbanisation)
- Interdependencies between the causes and impacts of climate change in Europe and impacts in global climate change hot spots
- Definition of system boundaries and their implications for assessing the sustainability of response strategies (e.g. winners and losers of response strategies)

- Links between direct and indirect impacts of climate change (e.g. impacts on ecosystem services) and unforeseen consequences of these (e.g. for the quality of life). Rebound effects of mitigation and adaptation.

3.9.4 TRANSFORMATION STUDIES AND SCENARIOS

Central analytic perspectives:

- Sustainable transitions and transition management
- Path dependencies and path-breaking
- Real-life experiments, case-studies and historical research on societal transformations; multi-level analysis of transformations
- Unintended side-effects (rebound effects) of transformation pathways and processes
- Strategies for managing climate risks and societal innovation processes

Key research problems:

- Developing and exploring socio-economic response scenarios for Europe as contributions to the “new” socio-economic scenarios used by the IPCC
- Lessons learnt from past and ongoing societal transformations on different scales and in different sectors
- Development of positive societal visions, transformation scenarios and pathways towards a carbon neutral, “climate proof” and adaptive Europe
- Examination of the role of values, framings, power differences, economic and political interests
- Research on innovation processes (triggers for innovation and creativity and dissemination in societies)
- Exploration of synergies with research on post-growth economic concepts and integrated approaches towards social justice, prosperity and well-being.
- Identification of key practitioners, pioneers, forerunners and individuals and institutions as change agents.

4 IMPROVING TOOLS FOR DECISION-MAKING UNDER CLIMATE CHANGE

4.1 OVERVIEW

Response to climate change is likely to require structural transformations. Decisions will need to be taken to trade off the climatic consequences of different stabilisation levels of greenhouse gas concentrations with costs, risks and benefits of development pathways consistent with reaching these levels. Also, aspects of equity and effort-sharing will continue to pervade negotiations at a European as well as an international level. Finally, there are still large uncertainties on climate change patterns and risks, making decision-making more complicated, both for mitigation and adaptation.

These processes require analysis of a range of climate response strategies with their implications being communicated in transparent and intelligible ways. Advanced assessment models and scenarios are essentials tools and metrics for provision of both mitigation and adaptation analyses. Scenarios and scenario-based tools have demonstrated their utility for multi-layered analysis of connections between temporally and spatially distant developments and phenomena. They are designed to track complex interrelations between social and natural systems and also to help understand the underlying forces driving systems' dynamics and projecting its trajectories into the future. In this way they are offering tools for communication between and within the scientific and policy communities about appropriate responses.

Science as well as many public and private organisations and sectors have long-standing traditions in using such decision support tools and instruments, in which scenarios, models and other scenario-based tools play a key role. They are employed as learning tools and as support for planning processes to explore alternatives or the long-term and cross-scale consequences of certain developments or strategic decisions.

Considering the uncertainty in future climate change, "optimal" solutions are difficult to design, and it is necessary to select "robust" policies, i.e. policies that yield positive outcome in as many possible scenarios as possible. Decision-making tools can help make "robust" decisions based on a better understanding of risks and uncertainties, trade-offs and feedbacks as well as opportunities and interdependencies. Finally, these tools can assist decision makers on deciding what should be measured to achieve a desired outcome (since it is often what is measured that is managed).

This JPI module will focus on a European coordinated approach to develop a consistent landscape of climate and socio-economic scenarios and scenario-based decision support in Europe reflecting the perspective of global forces shaping regional and local processes and vice versa. For this purpose, it will focus on four areas of research:

(1) Categorising and communicating risks and uncertainties:

There are diverse user needs for scientific, technical and socio-economic climate change analysis. These evolve over time in response to a range of drivers but need to be framed in a manner to enhance and develop communication. The development of integrated climate and socio-economic scenarios - as pursued by this module – needs to be based upon and motivated by a sound common understanding of these user needs, to enable successful uptake of research results.

(2) Integrating global climate change analysis and assessment:

Global models and scenarios for climate change analysis have evolved into powerful tools for integrating knowledge and making it useful for exploring conditions consistent with managed long-run climate outcomes in a policy context. The JPI will support community efforts to increase integration and consistency of modelling and scenario communities while maintaining or increasing variety, innovation and excellence in global model and scenario development.

(3) Nesting scenarios at different levels:

Appropriate reflection of cross-scale dependencies in scenarios at different scales will be a precondition for well-founded and informed decision making in Europe. This requires a system of nested scenarios at different geographic levels. Therefore, this JPI underscores the need for the development of scenarios at the European or regional and country level consistent with global socio-economic and climate scenarios and linked to existing work on the development of emissions inventories and projections.

(4) Linking scenarios and decision tools:

Future decision support tools and instruments should be able to capitalise on a coherent and integrated landscape of climate models and scenarios at different scales. They need to be nested within a shared analytical framework in order to allow comparable assessments of key vulnerabilities, risks and uncertainties for regions and industries, societies and economies as well as globally linked value chains.

Key objective

This module will be catalysing the analysis of robust and sustainable development pathways through (1) bottom-up analysis of user needs in terms of key climate risks and uncertainties, (2) integration of climate scenarios, (3) nesting of scenarios on different scales, and (4) linking scenarios to tools for decision-making.

4.2 OBJECTIVES

4.2.1 CATEGORISING AND COMMUNICATING RISKS AND UNCERTAINTIES

It is obvious that most of the wide range of potential users is not adequately prepared to interpret the complexity of model simulations and to understand the uncertainty attached to various scenario components. On the one hand such understanding needs appropriate categories that help identifying key risks and uncertainties of sectors or organisations to climate change. On the other hand it needs appropriate venues for two-way, cooperative and iterative communication processes that have to be sustained over a long timeframe.

Key objective:

Understanding user needs in terms of potential climate related risks and uncertainties that matter to different user groups and establishing effective and sustained communication processes between scenario communities and stakeholders on these issues.

4.2.2 INTEGRATING GLOBAL CLIMATE CHANGE ANALYSIS AND ASSESSMENT

The provision of scenarios which allow fully integrated assessments of the differential impacts, associated risks, residual damage, and marginal costs and returns of different development pathways remains a challenging goal. A focus within this module will be to support ongoing community initiatives that aim at bringing together modelling teams from different regions and disciplines to enhance integration, consistency and connectivity of various analytical approaches, including assessments of other global dynamics than climate change.

Key Objective

Support development of robust and inclusive global scenarios that are consistent with global assessments of climate change and enhance communication of these via increase interdisciplinary and trans-discipiliniary development within and outside the climate change community.

4.2.3 NESTING SCENARIOS AT DIFFERENT LEVELS

Global models and scenarios are proven value-adding tools for strategic policy-making for mitigation and adaptation. They capture the technical, demographic and economic considerations related to transition strategies consistent with particular climate mitigation or adaptation objectives. However, too few of the other factors that influence the rate of transition, such as institutional and behavioural aspects, are reflected. These are strongly related to regional and local institutional regimes, cultures and value systems. Over the past few years, climate model (statistical and dynamic) downscaling methodologies have become more refined[4]. This needs to be complemented by sets of nested socio-economic scenarios for regions or sectors to support decision-making on mitigation and adaptation.

Key Objective

Stimulate the development of nested models and scenarios to increase linkages between top down scenario analysis to bottom up emissions analyses, independent scientific verification of analysis of emissions and sinks as well as vulnerability, impact and adaptation policy.

4.2.4 LINKING SCENARIOS AND DECISION TOOLS

Decision-making tools should enable users to take account of constraints imposed by the climate system as well as global ecological and societal systems. Just as the scenarios they refer to, they need to consider the dynamics of biophysical, social and economic systems in conjunction. This JPI will aim to make knowledge on best practice co-development of model and scenario based decision-making tools systematically available, in order to analyse the potentials and limits of the development of such tools with active stakeholder participation. It will foster meaningful science-practice interaction with the objective to increase the capacity

[4] This does not mean that research necessarily reduces uncertainties, but the processes underlying the uncertainties may be better understood.

of model and scenario communities to integrate knowledge and deliver results of high practical value.

> **Key objectives**
>
> Forster iterative dialogue between science and practice and provide decision support tools and instruments that are nested in a consistent scenario environment from global to local scales.

4.3 RESEARCH DIRECTIONS

4.3.1 CATEGORISING AND COMMUNICATING RISKS AND UNCERTAINTIES

There are a number of critical factors for the effective uptake of results from climate research: the ability of scientists to understand user needs, the ability of users to specify their needs and interpret related climate information, and the capability of both users and scientists to communicate about needs and limitations on either side. Experience shows that relevant climate knowledge needs to be contextualised and interpreted so that decision-makers are empowered to act upon this information. Climate change needs to be placed in a wider context of decision-making in which factors other than climate often play a dominant role.

For decision-makers, strategic response options are usually expressed in terms of risk governance, framed as one of many factors to be considered and measured in terms of impact and likelihood. The combination of these two factors has distinct implications, due to the inherent uncertainties of climate related risks. For example, a high-impact risk that is believed to have a low likelihood would appear the same as a low-impact risk with high probability in quantitative terms, but appropriate responses would be very different. Also, qualitative or cumulative risks are difficult to assess, while ratings of likelihood tend to be based on the assumption that something that has not happened in the past will never happen. These are standard pitfalls not necessarily specific for the management of climate related risks. But climate change poses new kinds of risks that should trigger a fundamental reassessment of risk management practice and the statistical basis it is predicated on.

Utility of scientific and technical knowledge on climate change depends on close interaction and effective communication between researchers and stakeholders to attain a common understanding of key risks and uncertainties. Integrated climate and socio-economic scenarios need to reflect the concerns of a variety of stakeholders, including politicians and elected representatives, private and public sector leaders, as well as scientific and non-scientific experts. Questions related to the costs and benefits of international greenhouse gas emissions reduction obligations are very much different from questions related to appropriate responses to local climate risks. It is certainly not a straightforward process to establish and maintain a dialogue which would allow the systematic charting of this domain. It will have to be facilitated by a reciprocal, cooperative mode of communication between science and practice. It will also have to include efforts to circumscribe distinct user groups and their decision making processes and contexts, while recognizing potential climate knowledge "value chains". Successful science-practice interaction depends on improved understanding of the 'how' and 'why' of strategic decision-making – the institutional dimension of effective adaptation and mitigation – and the role of scientific knowledge in such processes.

This is a concern cutting across all elements of this Joint Programming Initiative, including Module 2, which will play a key role with respect to the communication of scientific results, and Module 3, framing decision-making on climate change as a process of social learning involving scientific, policy and practitioner communities. Climate models and scenario analyses as addressed in this module are very relevant instruments to integrate knowledge and explore possible outcomes of strategic decisions. Therefore, this Joint Programming Initiative aims to develop a comprehensive understanding of how to clearly communicate robust analysis and information as well as the associated risks and uncertainties. It also aims to identify the key actors in climate change, what kind of issues they currently face, how decisions are taken and how they are linked across scales and through institutions.

Research priorities

In various national research programmes efforts are underway to develop methods, scenarios and other tools in support of specific aspects of climate decision-making under uncertainty. A number of European research projects have analysed the potential climate risks for a number of sectors. However, these efforts are fragmented and not comparable, neither between the national projects, nor between the national efforts and European research.

The JPI will aim to consolidate such knowledge and foster new research on differentiated categories of risks and uncertainties that matter to stakeholders and at the same time provide useful elements for the framing of user-driven scenario development. This can also cover basic categories of spatial and temporal scales that practitioners find relevant for their work.

This initiative will also aim to identify key risk parameters to be quantified in terms of sector sensitivity to specific climate impacts and/or foster systematic and comparable risk exposure mappings on different scales.

This JPI will also endeavour to systematically explore the way companies, civil organisations, groups of citizens or individuals look at the problem of climate change, how they frame it and in which way their attitudes might influence individual or collective decisions. It will foster research into the mechanisms of transmission that allow new information on climate change pervading stakeholder groups, sectors or markets to be taken up in public or corporate decisions. Also, preconditions of traditional institutions need to be understood in terms of developing the interdisciplinary competencies and infrastructures to proactively address these issues.

This research is of cross-cutting relevance for the entire JPI. It will largely be facilitated by the promoters of Climate Services (see description of Module 2), because a deeper understanding of categories of climate-related risks and uncertainties as well as success factors for effective communication on the interface between science and practice is at the very heart of these services. Some of these issues will also be addressed through Module 3 of this JPI.

Module 4 will be complementary in the sense that it concentrates on the consistent relation between sectoral development plans and policies, risk governance schemes and tools, and existing models and scenarios. This includes the development of stakeholder driven, scenario based decision making tools and instruments useful for transforming climate knowledge into decision-relevant information (see 4.4).

Links to other existing initiatives and networks/projects

The understanding and mapping of user needs for climate information builds on and will consolidate and extend earlier work. For example, in the context of climate change impacts and adaptation, the PESETA study of the EU's Joint Research Centre analysed the potential climate risks for a number of sectors, namely river floods, agriculture, tourism, coastal systems study and human health. Follow-up work supported an impact assessment for the development of the EU White Paper on Adaptation, that focused on the role of water and ecosystems. Currently, ongoing work for the EU Commission involves the further development of methods to assess vulnerability and adaptation in water management and identify climate threats to agriculture and forestry, fisheries, regional and territorial cooperations and the physical infrastructure. This is work in support of the adaptation strategy that the Commission has planned for 2013. FP6 projects such as A-TEAM and ADAM led to early insights into possibilities to assess vulnerability to climate change and response options. The FP7 SCENES project developed scenarios for water demand and management, while other FP7 projects such as CLIMSAVE, MEDIATION, CC-TAME, CLIMATECOST and RESPONSES are also developing methods to support climate impact assessment and policy development. The IS-ENES project likewise aims to deliver a climate model service and support the dissemination of model results, which is particularly directed at the impact community as users of model results.

Furthermore, current activities within the ERA-Net "CIRCLE2" will provide a useful starting point and stepping stone for follow-up activities. A series of CIRCLE workshops will aim to frame the discourse on climate-related risks and uncertainties from a sectoral user perspective, starting with the simple observation that, to date, although a great deal of insight is available on a disaggregated level, much can potentially be learned from consolidating experience from different case studies. Hence, CIRCLE will primarily aim to provide an initial assessment of what is already known about climate-related risks and uncertainty in risk governance in different sectors. It will bring together analyses available on various scales in Europe relating to the sector-specific perception of climate related risks, concrete measures taken in terms of risk governance and tools employed.

Finally, this research priority will constitute a natural link to other JPI's, namely the envisioned JPI's on water, agriculture, urban development and the aging society.

4.3.2 INTEGRATING GLOBAL CLIMATE CHANGE ANALYSIS AND ASSESSMENT

Global scenario work can be classified in three types of models and analytic frameworks: climate models (CM), Integrated Assessment Models (IAM), and models and other approaches assessing vulnerability, impacts, adaptation (VIA). Global energy models which are used to analyse international mitigation are assumed to be captured under IAMs.[5]. These global scenario communities are working towards an integrated analytical framework. This process, within the scientific communities, has been catalyzed by the requirements of the IPCC's 5th Assessment Report .

The process draws on a set of "Representative Concentration Pathways (RCPs)" as common assumptions regarding radiative forcing. However, a specific level of radiative forcing can result from different combinations of economic, technological, demographic, policy and institutional futures. This is why the RCPs are envisioned to be complemented by "Shared Socio-Economic Pathways (SSPs)", in order to allow VIA and IAM communities a comprehensive coverage of the range of key assumptions in these fields. These SSPs could be a set of simple narratives consistent with a lean set of quantitative projections for socio-economic boundary conditions structuring the space of plausible socio-economic futures.

[5] Please note that the JPI will not enter into the field of assessing individual technologies for mitigation, though such assessments are supposed to be reflected on an aggregate level by the assumptions underlying socio-economic scenarios.

The scientific infrastructure to carry out the work largely exists (established modelling teams, centres and platforms) including a high level of coordination within the CM and IAM communities. Although coordination is mainly being implemented within these communities, there remains a distinct lack of both interdisciplinary exchange between these communities as well as trans-disciplinary exchange with the various stakeholders that require climate information for policy making, planning or investment decisions. The VIA research is still not very well coordinated, although at the global level UNEP has taken the initiative to change that through PRO-VIA (Programme of Research on Climate Change Vulnerability, Impacts and Adaptation). While JPI Climate does not intend to include actual VIA research, it will play a supportive and catalyzing role in developing a better coordination between national as well as European VIA research[6], because better coordination would be necessary to reach the JPI's objectives in terms of integrated scenarios.

Also, coordination is needed between scenario makers and users, to make scenarios more relevant for actual decision-making and policy design. There is clearly a lack of resources so far to drive and coordinate the process of scenario integration at a pace and level of ambition necessary to deliver timely information to all parts of European society for the highly dynamic field of climate policy and strategic decision making.

This JPI will aim to stimulate further interaction and integration of communities engaged in global climate and socio-economic scenario development, both for the 5th IPCC Assessment Report as well as beyond. And it will encourage interaction of these communities with other global modelling communities analysing questions of e.g. trade, transport and infrastructure development, population, development, health or food.

The value of the controlled comparison of model results and analysis of model differences has been widely recognised especially by the CM and IAM communities, though to a lesser extent in the field of vulnerability, impact and adaptation research. The harmonisation of key assumptions (RCPs, SSPs) and the controlled variation of those assumptions across an ensemble of studies or a set of model comparisons, constitute important initial stepping-stones on the path towards analytical framework integration, in particular when employed to examine single-subject matters of high practical concern.

Such analyses enhance the connectivity of various approaches and modelling communities by harnessing the collective capacities of a variety of experts for the purpose of finding solutions to real problems. Systematic model inter-comparison can provide a scientific apparatus to

[6] A role that might be strengthened in case the ERA Network CIRCLE would not be continued after 2013.

investigate possible transformation trajectories under different (normative) assumptions. It can generate a deeper understanding of the underlying reasons for certain model outcomes and may allow qualified estimations of uncertainties. Furthermore, it enables discussion on the practical consequences of integrated policy integration scenarios, particularly where policy fields overlap, intersect or contradict and strategic planning is not straightforward.

Short-term research priorities

The global SSPs are likely to be finalised by the middle of 2011 and then taken up by researchers working on more specific regional or sectoral impacts and response options. There little time left to derive a more integrated insight from new scenarios to enhance the quality of the 5th IPCC Assessment Report (AR5). The report will be published in 2014. Any literature to be considered formally in the report needs to be published by 2012.

For this purpose and as part of this JPI, the development of a set of model comparison projects in envisaged, fast track activities designed to challenge different modelling teams to generate tangible outcomes from a European perspective for AR5. The results should be instrumental in catalysing low-emission development pathways that are robust in terms of uncertainties in the climate as well as in socio-technological systems. Meaningful subjects for model comparison include:

- Investigation of the possibility of very low stabilisation scenarios consistent with the 2°C or even a 1.5°C limit of global warming, including second best policy solutions
- Improved capacity of standard economic models to generate more realistic policy scenarios (including appropriate representation of the EU regulatory framework);
- Models to enhance the understanding of the dynamics of urban development and infrastructure and their role in shaping future climate change;
- The establishment of a joint analytical framework of assumptions for energy and economic models, that will enable differentiated but consistent model development at all relevant scales (European, national, sub-national).
- Limits of adaptation in different terms, e. g. economic/financial, institutional/political, cultural / social;
- Possibility of reaching thresholds or tipping points in the climate and socio-economic systems and the subsequent consequences, including risks and uncertainties regarding the stability of societies.

- Assessment of the propagation of uncertainties through different types of model, including the question on how to link probabilistic information from global models and scenarios to impact models that are not capable of processing such data.

One element research strategy element will be the extended comparison of IAM of EU provenance with IAM developed by teams from the US, Japan, China and possibly India, in collaboration with the Stanford Energy Modelling Forum. Another element should engage the services of different VIA teams to compare existing representative models or case studies to try and jointly draw general practical conclusions that support, for example, adaptation policy making. Systematic comparison should become a viable investment in enhancing comparability and consistency of VIA analyses and moving towards a theory of adaptation. JPI Climate would provide a sustained platform to facilitate such comparisons.

Comparison of climate modelling experiments is not going to be supported primarily through this module – such comparison is well-organized under a series of inter-comparison exercises, like CMIP5 of the World Climate Research Programme (WCRP), and rather linked to Module 1 of this JPI.

Long-term research priorities

The JPI will endeavour to support CC, IAM and VIA communities in their commitment to a long-term research strategy that aims at developing an integrated framework for climate scenarios. Such scenarios should enable the assessment and quantification of key risks and uncertainties, damages and benefits, as well as include improved and more consistent cost estimates for climate mitigation and adaptation. The scenarios should also encompass non-monetary valuation methods to quantify damages not expressed in changing market values (such as welfare implications from ecosystem change).

In addition, leading modelling teams from both IAM and VIA communities should be challenged to perform policy instrument assessments within their standard models by exposing these to other formalised and non-formalised assessments of the same policy instruments (carbon tax, emission trading schemes, technology subsidies etc.). The outcome should allow conclusions to be drawn regarding the effectiveness and design of policies as well as the strengths and weaknesses of individual modelling approaches. It should also pave the way for improving the integration of policy aspects into scenarios.

Finally, integrated global change scenarios are to be developed that provide a sound understanding of risks and uncertainties related to various possible climate futures and are consistent with plausible trajectories in key areas (e. g. socioeconomic, technological and environmental conditions, greenhouse gas and aerosol emissions and climate).

Links to other existing initiatives and networks/projects

Any ambitions to integrate global climate change analysis and assessment need to be mindful of the fact that there are plenty of scenario development and comparison projects and processes underway. For example, the Energy Modelling Forum is spearheading such community driven efforts and is accumulating valuable knowledge on how to set up a viable dialogue between scientific and non-scientific experts.

The project "Assessment of Mitigation Pathways and Evaluation of the Robustness of Mitigation Cost Estimates (AMPERE)" is funded under the FP7 and will establish a common platform dedicated to climate-economics modelling research activities in Europe. It will addresses uncertainties in the quantification of climate change mitigation costs. Performed by a consortium that includes 17 partners from Europe and 4 from Asia, part of the portfolio will encompass model development, validation, performance assessments and inter-comparisons. The impact expected is akin to some of the objectives of this JPI; namely, a better quantification of the costs of climate change mitigation, increased consistency in cost-related information for policy making and high-quality input for international assessments including the 5th IPCC report.

Generally, community activities designed to develop common ideas and guidelines to foster consistency and integration of climate scenarios across different scales are very relevant reference points for the implementation of this module.

These activities not only include community driven activities set up in support of the 5th IPCC assessment report, but also initiatives such as PRO-VIA (Programme of Research on Climate Change Vulnerability, Impacts and Adaptation), proposed by UNEP in order to redress the lack of organisation and coordination within the VIA community.

These and other activities need to be systematically mapped and regarded as important starting points for this module.

4.3.3 NESTING SCENARIOS AT DIFFERENT LEVELS

Narrative storylines and socio-economic scenarios of development pathways that focus on trends at international system and large region scales need to provide enough flexibility for interpretation at more detailed scales or consistent links to scenarios developed for regions or sectors. It should be acknowledged that scenarios are always developed for specific purposes, and sets of nested, integrated scenarios should explicitly be developed to address specific climate policy questions posed by the stakeholders.

For example, many VIA studies, analysing the robustness or performance of different locally- or sectorally-relevant adaptation strategies, tend to use locally-derived scenarios that reflect development choices on a respective level. These need to capture a sufficiently large range of plausible futures and be embedded in a broader context of plausible socioeconomic or climate futures and consistently represent the global forces shaping local conditions in terms of climate policy objectives as well as climate change impacts, vulnerability and adaptation.

Equally important, key policy decision makers are highly focused on the GHG inventories reported annually to the Commission and UNFCCC. Such reporting requirement have generated highly detailed activity and process models which are applied to key economic sectors and areas such as energy, transport and land use. Information from these systems are the key determinant of achievement of emissions targets and key drivers of sectoral and cross sectoral policy development at national and local levels.

There is a shared objective across Europe to move the GHG inventories, which are effectively coarse national sectoral and systems models, from the use of default information to science based emissions models. This is required to reflect policies and measures which would otherwise be missed in accounting, trading etc.. This work shall be assisted by pan-European research as many issues are similar across Europe. Individual or collective emission targets need to be scientifically robust and where possible independently scientifically validated.

The ongoing scientific development of these systems is essential for improved policy and adequate accounting and verification of these at international levels. Mismatches between top-down scenario analysis and bottom up emissions and emissions projection analysis can be problematic for all levels and in worst cases lead to misguided policy development.

Scale differences, thus, constitute a fundamental challenge for different kinds of models and scenarios and research is required into make scenarios useful and translating relatively coarse information of global scenarios into the relevant geographical scale. In particular, impacts as well as socio-economic and emissions variables specified at relatively large spatial scales need to be translated to values at country or grid level.

Developing nested socio-economic scenarios is not only a prerequisite for informed decision making. It also constitutes a grand methodological challenge. A number of national, regional and local studies have been undertaken based on global scenarios that attempt to translate their assumptions into smaller spatial resolutions. Each approach has revealed its strengths and weaknesses relative to specific fields of application. Obviously, there is no single best technique identifiable as different approaches work better for different needs. Methodology and the choice of methods need to be transparent enough that the communities readily recognise the technique available for their particular need.

For the above reasons, even though it is desirable to advocate for a variety of methodological approaches, European integration calls for a consistent and coordinated way of translating global socio-economic scenarios transparently and reliably for different regions and sectors in Europe and to develop a comparable, overall European picture. This will need to be linked to dynamical and statistical methods for downscaling climate models that are increasingly utilised to produce regional climate information for impact and adaptation studies. It will also support the pursuit of more consistency in terms of facts and figures relating to climate change in the European countries, and also pay due attention to free scientific data exchange within Europe.

Research priorities

All member states will soon be confronted with the challenge to assess the specific regional implications of the new set of scenarios generated as input for the AR5. The JPI will target development of coherent sets of regional, national and European scenarios by the expert community within the participating countries of this JPI. This will be a big step forward compared to the fragmented and uncoordinated approach in the past. But there is clearly a lack of resources and structural support for coordinating this work at a scale necessary to produce coherent and timely output for climate policy and strategic decision making across Europe.

This JPI will provide the means to support, continue and expand the development of nested scenarios. Besides being able to build on experience drawn from a number of FP7 projects, examining the potential of up-scaling successful national approaches to the European level would also be possible (one example might be the so called 'climate effect atlas' developed in the Netherlands). Comparison and assessment of the strengths and weaknesses of different methodological approaches will also be organised to develop a consistent set of climate and socio-economic scenarios. The shared methodological knowledge will be employed to develop a consistent and coordinated set of scenarios at resolutions relevant to meet different regional and sectoral concerns in Europe.

Furthermore, this JPI will serve to enhance research co-operation in movement of bottom-up analysis to higher scientific levels as well as the provision of independent scientific verification of analysis of emissions and sinks. It will provide platforms to increase linkages between top down scenario analysis through nested modelling to bottom up emissions analyses.

Analysis of such issues will also be fostered through module three. The social scientific research can be useful to gain qualitative insights into the validity of general assumptions which are often not explicitly addressed in global scenarios. It may gain policy relevance if linked consistently with the integrated scenario work.

Links to other existing initiatives and networks/projects

European teams are making important contributions to the downscaling of global scenarios. It is a clear advantage in this context that the community working on downscaling issues is already very well organised through the World Climate Research Programme's Task Force on Regional Climate Downscaling (TFRCD). TFRCD has set up a framework called the "COordinated Regional climate Downscaling Experiment (CORDEX)" which endeavours to improve coordination, quality and coverage of international efforts in regional climate downscaling research.

There has also been a small number of national initiatives to develop national or regional socio-economic scenarios within the context of the previously developed sets of global scenarios at the time of IPCC's earlier assessment reports (for example those being pursued in the Netherlands or Finland, the success of which should be followed and evaluated to incorporate lessons learned into other national initiatives). Similar initiatives are currently under preparation with a view towards the new global scenarios.

Nesting of scenarios also holds a number of methodological and conceptual challenges, the resolution of which is of direct practical relevance for e.g. European adaptation strategy implementation and mitigation policies, for example. It will be important to assess the potentials of up-scaling advanced national scenario approaches to a European level and equally important in this respect to review experience drawn from FP7 projects like ADAM and RESPONSES as a starting point for the development of a research portfolio. The PLUREL project funded under FP6, which comprises 31 partner organisations from 14 European countries and China, is another point of reference, particularly with respect to regional adaptation of scenario storylines and modelling data derived from scenario modelling at higher scales. The project started in 2007 and terminated in 2010.

4.3.4 LINKING SCENARIOS AND DECISION TOOLS

A useful set of model-based tools will acknowledge the procedural character of assessment and strategic planning, e. g. through participatory approaches with stakeholders. They will enhance learning about the probability of future effects of current behaviour and at the same time teach us the limits of our ability to predict. This is assuming that any likelihood may simplify decision making and any kind of prediction, even about uncertainty, may help buy time to learn if expressed in terms of probability. It is important to note that the role of scientific climate information differs in different areas of decision-making under uncertainty. While science can provide directly useable information to underpin decision-making for long-term issues, its role would be much more limited with regard to decision-making on shorter term questions

A general observation is that stakeholders are extremely interested in the derived consequences and impacts from changes in climate. The link of climate scenarios and Integrated Assessment Models with VIA research and analysis becomes very relevant in this respect. But equally challenging is the development of tools linking relevant climate related information to other sources of information that need to be taken into account in relation to specific decision making.

Utilisation of such tools depends on improving the customisation of information from climate change analysis through continuous science-practice interaction and dialogue. In addition to the integration and nesting of climate models and scenarios, fostering this kind of interaction will be one of the major undertakings of this JPI and will require incorporation into its design at numerous stages. This module, however, sets out to research priorities related to the methodological progress towards tools and instruments that enhance the capabilities of practitioners and decision-makers to identify and quantify direct and indirect climate change risks to corporate planning, operational processes, public policies or sectoral economies and develop suitable risk governance.

Short-term research priorities

The JPI will contribute to assembling the joint experience in this field of interactive development of model- and scenario-based decision making tools and instruments in the diverse European countries. It will aim to analyse how such tools and instruments can be linked consistently to interpretations of integrated climate scenarios at different levels of scale. It will commence by defining more clearly the possible role of differential stakeholders (change agents) in building scenarios and how they might interact with scientists and it will analyse the potentials, barriers and limits of common learning processes.

Long-term research priorities

The JPI will aim to establish science-practice laboratories as continuous and common learning environments for modellers and stakeholders. They should facilitate interactive development of innovative decision-making tools to improve decision processes in specific sectors under conditions of high uncertainty and complexity.

Depending on social contexts as well as spatial and temporal scales of decision processes, such tools will have to meet different requirements in terms of robustness, error-friendliness, redundancy, diversity, integration, fuzziness and 'decision spaces'.

A major undertaking of these science-practice labs would be the application of various modelling approaches to specific problems of practical concern and the comparison of their explanatory power relative to providing solutions to the problems in question. Such approaches would start by analysing and defining the actual decision-making concern and evaluating the actual capabilities of a model in this respect. It would then compare available models and define what would have to occur to enable them to provide solutions to the decision-making problem.

This process would lead to identifying the methodological and conceptual gaps as well as data requirements that would need to be addressed by the respective communities. It would also facilitate progression towards one - or competing – concept(s) that would frame decision making under climate change in terms of how decisions are taken, what information counts and what methods are best suited to communicate this information.

A practical approach would suggest linking the science-practice labs to different policy fields, including:

a) *Effective management of greenhouse gas emissions* linked to country-level targets consistent with sub-national targets and measures, at sector or city level, for example.

b) *Risk governance and adaptation policy* linked to EU policy objectives and processes, translated consistently into national or sub-national strategies, and linked to other policy fields in terms of mainstreaming, synergies and conflict resolution.

c) *Opportunities and innovation management* with a market-based perspective.

While stewardship of any such lab certainly needs to be with a small number of high profile, lead institutions in Europe, the scope of contributing partners could be very broad, depending on the topic under investigation. The labs should aim to harness the collective capabilities of participating experts from Europe and beyond, coequally including modellers and users of models within the enquiry process. They would also provide a scientific apparatus to investigate sectoral plans and strategies under different sets of assumptions. The results should catalyse low-emission development pathways and adaptation strategies that are resilient in terms of uncertainties in the climate as well as within socio-technological systems.

The implementation of these science-practice labs will require a long-term and strategic funding perspective that allows for failure and iteration. Additionally, it will require continuous strategic support of community-driven processes that target the integration and appropriate scaling of knowledge as well as the differential understanding of user needs for climate information as described previously in this module.

Links to other existing initiatives and networks/projects

The multitude of relevant initiatives and activities make it difficult at this stage to define such long-term activities without more extensive consultation of key players and stakeholders. Such consultation would be in the form of transparent and open processes in collaboration with existing platforms and organisations.

5 INTER-LINKAGES BETWEEN RESEARCH AREAS

Joint Research Area of Module 1 and Module 2:

There are multiple relations between the various areas of investigation outlined in each of the modules.

Results from decadal prediction, as well as from global and regional climate change projections, including abrupt nonlinear responses, provide needful information for a wide range of policies and practitioners. An improved understanding of the processes that govern natural climate variability over the decadal time horizon and the assessment of decadal predictability at regional scale, constitute crucial requirements for the climate services community. Such activities specifically address the space (regional) and time (decadal) scales that are extremely relevant for the design and implementation of the adaptation strategies.

Developing interaction between climate modellers and climate services will help define the data needs for users, from both observations and models, and identify uncertainties of climate predictions and projections. It will identify those climate processes relevant for the climate service community that are not sufficiently resolved by the current models. Such interactions will improve the availability and utility of both model and observational data suitable for the quantification of these processes.

Notwithstanding, research results in Module 2 should be integrated into Module 1 research from the very beginning, with a special focus on those aspects that are of particular relevance for society, for example, physical thresholds based on adaptive capacities.

Joint Research Area of Module 1 and Module 3

Module 1 will document key climate phenomena of relevance to society such as extreme events and possible tipping points, which are then introduced into Module 3, and also provide data needed to understand societal needs in Module 3. Module 1 will also document the range of scenarios which impacts society. The strong regional focus on decadal prediction experiments will help and quantify the climatic drivers that locally impact on societal dynamics. Interactions with Modules 2 and 3 should help better understand how climate change results and uncertainties are perceived by a wide range of agents.

Module 3 will contribute to Module 1 by:

Identifying knowledge requirements from societal/decision-makers' and systemic-scientific perspectives, for instance with respect to socio-ecological impacts of climate change and constraints in mitigation strategies

Identifying societal reactions to climate change impacts and changes in the modes of production and consumption on various spatial scales as a basis for elaborate GHG emission scenarios

Generally dealing with uncertainties inherent to the results being produced by modelling and observation analysis.

Analysing and facilitating interactions between the different scientific communities of modellers and observers. Discussing research results on the natural variability of weather conditions and societal responses in the short- and long-term.

Exploring human climate interactions, such as land use issues and associated feedback.

Conducting research into possible contributions from studies on managing common goods, in terms of what insight can be derived from these studies in relation to dealing with impacts of climate change as global scale common good problems. Generally, it is desirable to have mutual collaborations based on a case study approach, whereby the two following examples are of interest.

Researching the consequences of reaching tipping points: for instance, a possible collapse or weakening of THC is currently widely discussed as one of a number of "low probability – high impact" risks associated with global warming.

Researching the different ways of how shorter-term (e.g. decadal) projections can be interpreted in societal contexts and implemented into actual decisions. A case study would probably have to choose a regional and/or thematic focus.

Researching relations between societal development and climatic conditions based on paleo-climatic analysis and analysis of current climatic development paths.

Researching the information needs of decision-makers, i.e. role of risk aversion, comprehensiveness and uncertainties of knowledge.

Joint Research Area of Module 1 and Module 4

Climate models developed in Module 1 will enable the investigation of possible mitigation strategies important for decision-makers. Interactions between the two modules may also emphasise methodological aspects for different kinds of modelling systems. Model intercomparison tools developed in Module 4 assist in the assessment of uncertainty propagation throughout the prediction system, from initialisation through the prediction models to societal response and the ultimate results. Specific studies on the mutual interaction between climate and anthropogenic drivers, and "laboratory studies" concerning drastic climatic events and the societal response, should be coordinated with Module 4. Expertise from Module 1 can help address policy issues such as geo-engineering technologies for mitigation.

Module 1 will provide access to important community driven initiatives in the CM community, which will need to be accessed and included when developing further integrated climate scenarios. In addition, increased prediction capacities will enhance the explanatory and projective value of scenarios and perhaps at some point become powerful in terms of defining the possibility space of transformation pathways.

Joint Research Areas of Module 2 and Module 3

- Understanding effective science-society communication and interaction. Explore ways of how to make communication and interaction with users more effective (latter priority M2).
- Exploring the role of climate knowledge and other motivators for decision making as input for the development of climate services and identifying the needs of knowledge users.
- Identifying key decision making/stakeholder groups for societal transformation in the face of climate change as potential climate service target groups.
- Exploring their possible roles as change agents and also reflecting on the extent to which scientists act may act as change agents.
- Establishing a learning community across Europe to promote a sustainable and adaptable Europe.
- Study on the potential for involving users in the further development of climate services. Gaining an insight into the use of climate services as a departure point for joint further development.
- Research into the governance of climate services as multi-institutional networks of organisations.
- Enabling of sustainable societal responses to climate change through climate services.
- Investigating optimal ways to create dissemination and outreach in terms of results.
- Development of long-term perspectives for social dynamics in the context of future adaptation strategies (priority M3).

Joint Research Areas of Module 3 and Module 4

- Outcomes of the systemic analysis of responses to climate change as constraints/framework conditions for the exploration of possible scenario and decision-tool ranges.
- Exploring the role of knowledge and other motivators as well as knowledge uncertainty for decision making as input for the development of decision-making tools.
- Integration of the rationales of real-world decision making into socio-economic scenarios
- Assessing and understanding the relevance of uncertainty from a societal perspective.
- Reflecting on the role of public policy.
- Research into the decision making processes and expected outcome of country negotiations at the COP (dynamic decision analysis).
- Integration of socio-economic scenarios and reflection of different models of society.
- Model inter-comparison exercises to systematically confront the basic assumptions, processes and outcomes of model building exercises.
- Advice and reflection on stakeholder participation in developing decision making tools.
- Action research using decision-tool prototypes; user-driven design.

Joint Research Areas of Module 2 and Module 4

Module 4 is driven by improvements in integrated impact modelling, not by the idea of servicing customers. The integration of stakeholder/decision-maker perspectives will therefore be an important element of M2-M4 interaction. For example, in relation to the question of how to deal with uncertainties in impact modelling. Stakeholder decisions are not always driven by research outcomes, but rather how well they meet user needs. We may require 'stakeholder-adaptable tools' for decision making and stakeholder feedback should certainly be included in the development of tools geared towards decision-maker target groups from the very outset. There is a societal need to compare integrated assessment models. Customers will also need an estimation of model quality and, wherever possible, the inclusion of validation procedures. Furthermore, M2 may well inform M4 of sector-specific threshold values or response capacities.

Module 2 is working on a perspective on climate services that will need to be central to any activity related to Module 4. Climate services are a crucial link and interface between actual stakeholder concerns and the scientific modelling and scenario communities. In turn, Module 2 will need to play a moderating and guiding role for the entire JPI in terms of a differential understanding and mapping of actual user needs as well as regards key risks and uncertainties that matter to stakeholders. Besides scientific progress towards the integration of approaches, much of Module 4 should help efforts in climate service development to enhance scientific community capacities to deliver services of high practical value.

Thus, there is clear reference to a number of concerns emanating from the discussion on climate services: for example, the need to downscale from global climate models to regional and then to local impacts; understanding natural variability and uncertainties in climate projections; the need for quality control; and the definition of guidelines for consistent climate scenarios to enable consistent comparison of different results from different models.

Helsinki, May 2011