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Assessing the Implications of Climate Change Adaptation on Employment in the EU

Final Report & Annexes

July 2014

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Abbreviations table

AR	Assessment Report
A&RCC	Adaptation and Resilience for Climate Change
BIS	Department for Business, Innovation & Skills
CBR	Cost Benefit Ratios
CBS	Central Bureau of Statistics
CCA	Climate Change Adaptation
CECIS	Common Emergency Communication and Information System
CEDEFOP	European Centre for the Development of Vocational Training
CGE	Computable General Equilibrium
DDC	Diversified Development Contracts
DG	Directorate-General
DGR	Damage Growth Rate
DKK	Danish Krone
ECN	Energieonderzoek Centrum Nederland
EEA	European Environment Agency
EERC	European Emergency Response Capacity
EGS	Environmental Goods and Services
EIA	Environmental Impact Assessment
ERCC	Emergency Response Coordination Centre
ESPON	European Observation Network, Territorial Development and Cohesion
EU	European Union
GDP	Gross Domestic Product
IEEP	Institute for European Environmental Policy
ILO	International Labour Organisation
IPCC	Intergovernmental Panel on Climate Change
ISCED	International Standard Classification of Education
ISCO	International Standard Classification of Occupations
JRC	Joint Research Centre
LCGES	Low Carbon and Environmental Goods and Services
MS	Member State
NACE	Statistical Classification of Economic Activities in the European Community
NRC	Nuclear Research and Consultancy Group
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organisation for Economic Co-operation and Development
PPP	Purchasing Power Parity
RCP	Rotterdam Climate Proof
R&D	Research and Development
SBS	Structural Business Statistics
SRES	Special Report on Emissions Scenarios
STEM	Science Technology Engineering and Mathematics
SWD	Staff Working Document
WITCH	World Induced Technical Change Hybrid
WHO	World Health Organisation

Summary for policy-makers

Climate change is increasingly recognised as a major threat to the stability and prosperity of society. No matter what the climate change mitigation efforts are, unavoidable climate impacts will take place together with the economic, social and environmental costs coming along. In April 2013, the EU Strategy on Adaptation to Climate Change was adopted by the European Commission.[1] The aim of this Strategy is to contribute to a more climate-resilient Europe. This will ensure that all territories and regions of the EU, including those which are currently 'lagging', can make appropriate preparations to adapt. The overall purpose of this study is to understand and fill in knowledge gaps with respect to the implications of climate change adaptation on EU employment and skills. As part of the mainstreaming of climate change adaptation in EU policies, the results of this study also identify EU employment and social policies, which could promote the transition to a climate resilient EU economy, including the provision of adequate skills.

Climate change adaptation

Climate change adaptation (CCA) is defined as 'anticipating the adverse effects of climate change and taking appropriate action to prevent or minimise the damage these effects can cause, or taking advantage of opportunities that may arise'.[2] Climate change affects different sectors of the economy, as a response to which adaptation-related economic activities might arise. Economic activities related to adaptation include financial, physical, technical and capacity building activities and they could cover nearly all sectors of the economy. However, some sectors and activities are at greater risk than others. In this study, the 11 most affected sectors are taken into account and split up in the above mentioned four types of adaptation activities.

Adaptation jobs and skills

Adaptation jobs – definition
Adaptation jobs are all jobs created, sustained or redefined in the process towards building resilience to the existing and projected impacts of climate change. This means jobs related to climate risk management solutions and measures to cover short-, medium- and longer-term climate change risks. These jobs are a result of economic activities related to adaptation, including financial, physical, technical and capacity building activities."

Adaptation skills – definition
"Adaptation skills" are defined as 'specific and generic skills related to adaptation activities and adaptation jobs, which can be new or topped-up existing skills.' The analysis differentiates between different types of skills, such as main occupation types and disciplines; levels of skills: high, medium, low education level; new or existing skills.

Economic framework for adaptation activities

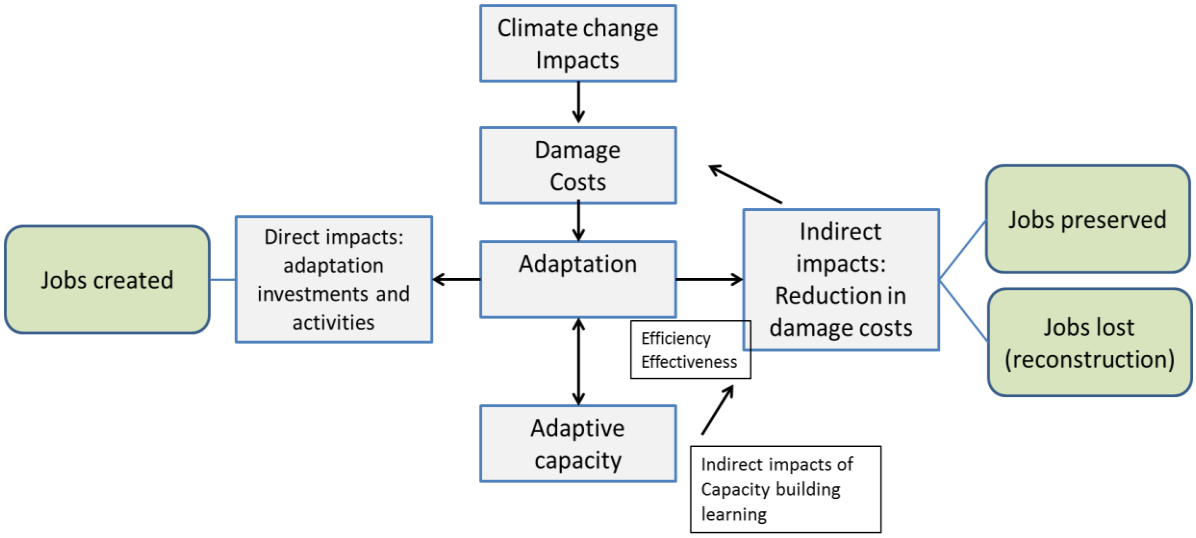
Adaptation measures may involve investments that in the short-term boost spending and create demand for goods and services that also have an impact on employment. Adaptation expenditures can include operational expenditures (Opex), such as costs of running training programmes, and capital expenditures (Capex), such as investment in flood walls. Effective adaptation measures contribute to the economy and

[1] COM (2013) 216 final
[2] http://ec.europa.eu/clima/policies/adaptation

employment as they reduce or prevent the social, environmental and economic costs of climate change. The reduction in the expected damage costs is the indirect impact of climate change adaptation on employment. Adaptation can for example preserve jobs in agriculture despite the temperature increases and their negative impacts on crop productivity. Therefore, adaptation activities are important in sustaining economic activities and jobs against climate changes.

Many investments have impacts beyond the sector of origin, benefitting the economy as a whole (Figure 1). For example, adapting the transport and energy infrastructure to climate change and climate extremes enables the economy to operate by minimising any disruptions. On the other hand, climate change adaptation may lead to job losses as demand for reconstruction activities decreases. This study provides estimates on the employment impacts of adaptation that are highlighted in green.

Figure 1 Economic implications of climate change adaptation



Source: own analysis

Adaptation strategies and action plans

In order to explore evidence on how adaptation policies can be used to preserve jobs despite the adverse impacts of climate change, and to establish the known implications of adaptation measures on employment in the EU, national adaptation strategies available at the Climate-Adapt website and six local/regional strategies were reviewed.

Sectors that are most often included in adaptation strategies/action plans, either at local, national or regional level are:

- infrastructure (including energy infrastructure);
- water (including flood measures);
- agriculture (including forestry, fisheries and husbandry);
- biodiversity (including natural environment and desertification); and
- human health.

A large share of the measures presented in these strategies is cross-cutting in nature, i.e. addressing education, awareness-raising and evidence gaps that could be classified as capacity building or soft measures. These are important in supporting decision-making by building a solid evidence base for further actions. By 2014, very

few strategies and action plans have explicitly considered the employment impact of adaptation actions.

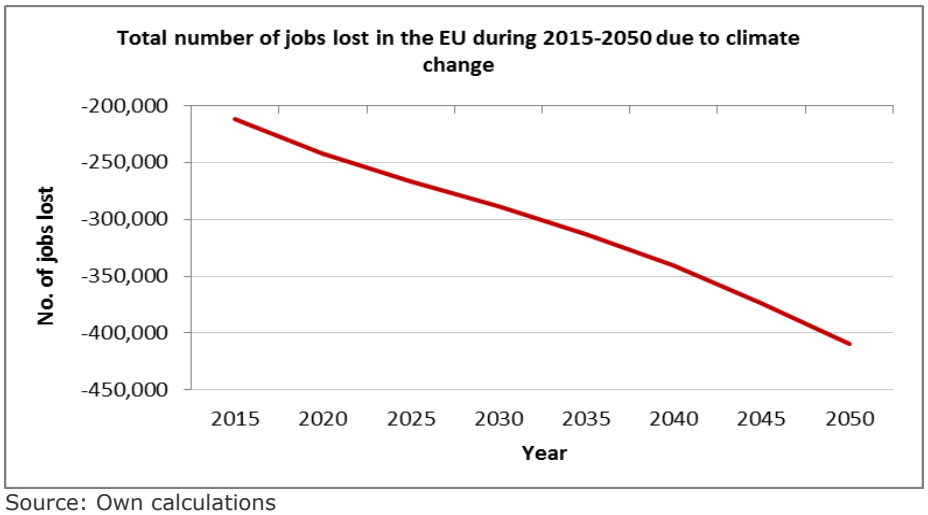
Scenarios

For the purpose of quantifying the impacts of climate change adaptation on employment, two baseline scenarios (4 degrees and 2 degrees temperature change by 2100 relative to pre-industrial levels) were developed as well as a reference and an ambitious scenario. Findings are reported only for the 4 degree baseline scenario. The **baseline scenarios** assumed no new (from 2011 onwards) adaptation activities are taking place. In the **reference scenario**, new adaptation activities (needed to meet the EU Adaptation Strategy objectives) were considered. It includes both, planned (government triggered) and autonomous adaptation (private sector triggered) activities. The **ambitious scenario** assumed that much more adaptation is taking place compared to the reference scenario in order to reflect the adaptation potential of European cities and the scale of the challenge.

The impacts of climate change on employment

In case no new adaptation is taking place (the baseline scenario), climate change will affect employment at EU, sectoral and MS levels. At the **EU level**, the results of modelling climate change impacts on employment show that climate change damages (or benefits) will have an effect on the productivity of various economic sectors and their production and employment. This will result in loss (or gain) in employment. Figure 2 presents the findings on the number of lost jobs due to climate change in the EU up to 2050.

Figure 2 The total number of jobs lost due to climate change in the EU for 2015 – 2050



Source: Own calculations

According to these estimates, approximately 410 thousand jobs will be lost by 2050 due to climate change if no further adaptation is taking place. In the short-run, up to 2020, the total number of lost jobs would be around 240 thousand. This implies that in addition to the expected 12 million of structurally unemployed people in the EU, around 240,000 additional people will become unemployed (temporally or structural, in function of the recovery path related to the type of natural hazard). If such jobs were structurally lost, the number of structurally unemployed individuals would increase by about two percent due to climate change.

At **the sectoral level,** sectors with the largest negative climate change impacts include manufacturing, public utilities, retail and tourism. Climate change has only a

minor overall impact on the primary sector, consisting of agriculture and fisheries. However, there are large distributional impacts in the latter sector with positive effects in Scandinavia (Sweden, Finland and Denmark) and other parts of Western Europe (Great Britain, the Netherlands, Ireland and Belgium), and negative effects in Bulgaria, Slovenia, Estonia, Slovakia, Czech Republic and Croatia. Moreover, extreme events lead to additional demand for construction sector services as well as other capital goods such as machinery, equipment, etc. These negative or positive effects on the sectors directly affected by climate change also affect the sectors that are not directly influenced by climate change. These effects are due to up-stream and down-stream linkages between the economic sectors.

Regarding the impact on employment, the largest number of jobs is lost in the sector 'Manufacturing and Public Utilities' (this sector includes manufacturing, electricity, gas and water supply). The negative effect of climate change on this sector is due to the loss of labour productivity and the indirect effects from other economic sectors such as 'primary industry' and 'retail and leisure'. However, other economic sectors are also negatively affected by climate change. This negative effect is primarily due to the loss of labour productivity caused by heat and increases in the number of illnesses. Moreover, the negative effects of climate change on the primary industries lead to strong negative spillover-effects on manufacturing.

The total number of jobs lost due to climate change depends not only on the total economic damages as percentage of GDP (can amount to almost 4% of GDP) but also on the labour productivity (i.e. the number of employed people per unit of output) in different EU countries. The **MS level** analysis showed that countries with the largest number of employed people per unit of output will lose the highest number of jobs. This is the case for example for Bulgaria, Croatia, Greece, Romania and Baltic states (Estonia, Latvia and Lithuania). These countries experience negative effects of climate change on their agriculture and tourism sectors with high number of employed people per unit of output.

This shows that climate change will affect labour markets in the European regions differently depending on their core economic sectors and climatic conditions. The bottom up research conducted (via interviews and case studies of local adaptation initiatives and projects across the EU countries) also showed that there are currently large differences in the development of local climate change adaptation initiatives between Member States, which positions the countries at a different stage of implementation of their adaptation strategies and plans in 2014.

The impacts of adaptation activity on employment

To quantitatively assess the impacts of adaptation action on employment in the EU, a reference and an ambitious scenario estimated the relative changes in employment due to climate change adaptation expenditures compared to the baseline. The difference between these two scenarios is related to the size of the assumed climate change adaptation expenditures (and thus the willingness in the ambitious scenario to invest more in climate adaptation).

There are two channels that cause changes in employment due to climate change adaptation expenditures. In the short-run, additional investments are translated into an increase in the demand for certain goods and services, which are related to specific climate change adaptation activities. This results in positive effects on employment in these sectors and in addition, it leads to positive spillover effects in other sectors. In the long-run, investments in climate change adaptation measures lead to a reduction of climate change damages and will save jobs in sectors that would be otherwise

negatively affected by climate change. On the other hand, adaptation activities will also reduce the demand for some services, such as reconstruction services and therefore, adversely affect the employment in these sectors.

Results of the reference scenario
The predicted climate change adaptation expenditures in the reference scenario (i.e. in total 0.5% of GDP in 2050 in the EU) are largely related to the transport sector (26% of expenditures in 2050, i.e. €29 billion), built environment (21%, i.e. €24 billion), health sector (17%, i.e. €19 billion), agriculture (12%%, i.e. €13 billion), and insurance and financial services (10%, i.e. €12 billion). The expenditures related to both, the transport sector and built environment, such as new roads or improved buildings, are associated with an increased demand for goods and services from the construction sector. Bottom up research also confirmed that currently most of the projects within the advanced local adaptation plans are related to build environment/infrastructure (e.g. local plans in Rotterdam, Copenhagen and Stuttgart).

In terms of the employment impact, just over 50,000 additional jobs are created in the EU in 2020 (compared to the baseline) due to the increased adaptation-related expenditures. These jobs are a combination of directly and indirectly created jobs.[3] In the long run, with increasing climate change adaptation expenditures, the total number of additionally created jobs (direct and indirect) increases to almost 500,000 by 2050, which is approximately 0.2% of the working population.

The number of created jobs should be seen as potential maximum as, even with high levels of unemployment, not every created job vacancy will be immediately filled due to labour market frictions. Most jobs are created in business activities, public services and the construction sector. There will also be saved jobs, which are the result of the mitigating effect of climate change adaptation expenditures on climate change damages. The largest number of saved jobs will take place in the manufacturing industry, public utilities and public services.

The countries in Central and Eastern Europe (Latvia, Lithuania, Poland, Czech Republic, Slovakia, Croatia, Hungary, Romania, Slovenia and Croatia) have the largest increase in the number of jobs. This is in line with the projected climate change adaptation expenditures. Similarly, countries with relatively lower predicted expenditures, such as Sweden, Denmark, Norway, Finland, the United Kingdom and Ireland, also show a lower number of created jobs.

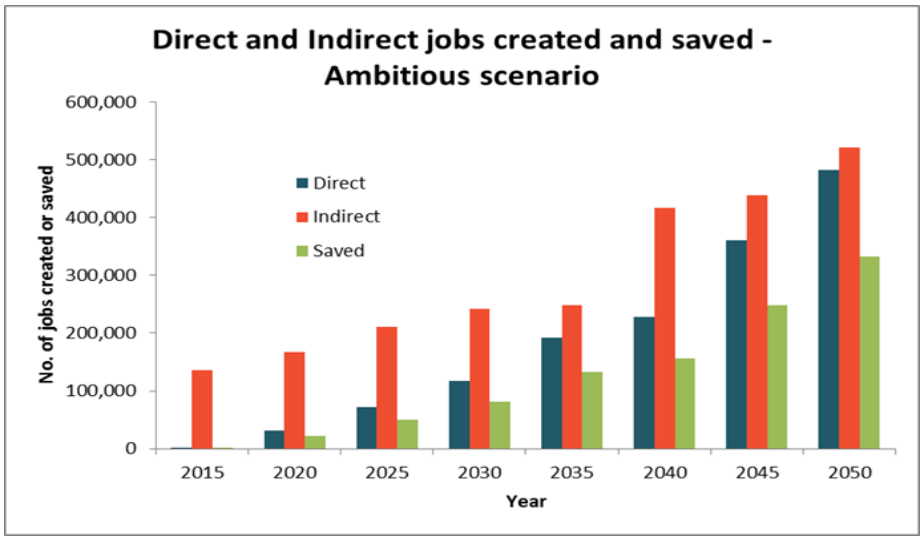
Results of the ambitious scenario
In the ambitious scenario, the amount of projected climate change adaptation expenditures increases to 1% of GDP in the EU by 2050. This results in almost a fourfold of the number of created jobs in the ambitious scenario in 2020 (200 thousand) compared to the reference scenario. Figure 3 shows the number of direct and indirect jobs created in the ambitious scenario as well as the number of saved jobs (around 1 million direct and indirect created jobs and around 330 thousand saved jobs by 2050).

The changes in employment in the ambitious scenario show largely the same picture as the changes in employment in the reference scenario. Most jobs are created in business activities, public services and the construction sector. When looking at the

[3] Directly generated/ lost jobs are jobs linked to the changes in economic activity in that particular sector, i.e. sector employment effects triggered by activities in that sector. Indirectly generated/ lost jobs are the result of backward inter-industry (supply) linkages.

more detailed sector classification, most of the jobs are created in public administration, health, education and research and development. Relatively more jobs are created in the retail and tourism sectors (when compared to the reference scenario). This is largely related to a proportionately large increase in the number of jobs in the wholesale sector.

Figure 3 - Total jobs created (direct and indirect) and saved for the EU from 2015 to 2050 in 5 year periods in ambitious scenario compared to the baseline



Source: own calculations

The geographical pattern is also similar to the reference scenario - with relatively many jobs generated in Estonia, Latvia, Lithuania, Czech Republic, Slovakia, Croatia, Hungary, Romania, Slovenia and Croatia and relatively fewer jobs generated in the rest of Europe.

In terms of the relation between adaptation expenditures and jobs created, the largest number of jobs created per billion EUR spent on adaptation in the ambitious scenario is in Bulgaria – over 22 thousand jobs, followed by Romania and Croatia – both with over 14 thousand jobs created, and Hungary and Lithuania. These are also the five countries where the cost per climate change adaptation job created is the lowest. Inversely, the smallest number of jobs per billion EUR spent on adaptation is created in Ireland – around 2 thousand jobs, followed by Belgium, Sweden, France and Spain. These are the countries in which the cost per adaptation job created is the highest. Another explanation is the differences in the composition of adaptation expenditures. Expenditures in building new infrastructure create relatively more jobs as compared to the financial services. The latter requires hiring people with high education who are more expensive, which leads to the creation of fewer jobs with the same amount of monetary expenditures.

Skills needs, mismatches and shortages for adaptation activities

Besides providing estimates on the number of jobs created and lost due to climate adaptation, the study also mapped the necessary skills for undertaking adaptation activities and assessed the skills gaps and shortages. The results show that occupations that will benefit the most from climate change adaptation investments, and hence will be needed in the future include:

- '*other associate professionals*' - e.g. statisticians, mathematicians, insurers, real estate agents, technical and commercial sales people, as well as

environment and conservation professionals, researchers, planning engineers, building and civil engineering technicians and related professionals;
- '*personal and protective services workers*' – e.g. medical assistants and fire-fighters;
- '*office clerks*' – e.g. production (planning, materials), accounting, statistical and finance clerks; and
- '*sales and services elementary occupations*' – e.g. building workers (simple repairs, maintenance), meter readers in buildings and cleaners.

This shows that a variety of occupations will benefit particularly in the construction and consulting/ engineering sector. The benefits on these occupations are minor in the short-term but increase significantly in the long-run and as more adaptation activities are taking place.

Furthermore, the education level is divided into three skill levels: *low, medium* and *high* skills. The highest number of adaptation jobs is created for people with average education level. This is because they represent the largest working population group and are employed in all sectors of the economy. In relative terms, (as percentage of working people) the largest number of jobs is created for the high-skilled people. In addition, climate change adaptation will favour jobs which are traditionally done by the male population. This is because the larger part of climate change adaptation investments is spend on economic activities such as construction, machinery and engineering where males have a certain dominance in most EU countries.

To calculate the mismatches between the supply of skills available on the labour market and the new adaptation jobs, it was assumed that the people available to fill in new vacancies related to created jobs will come from the pool of unemployed. The results show that due to high unemployment rates, there will be no shortage of skills in the short-to-medium-term by occupation and education level and also no disproportionate effect on gender. However, in the long-run, potential manpower bottlenecks may occur due to increased adaptation investments and decreasing unemployment rate.

The largest long-run mismatches are associated with occupation types which are the most affected by adaptation investments. These are the aforementioned 'other associate professionals', 'personal and protective service workers', and 'other business services'. Climate change adaptation activities are expected to have a disproportionate impact on low-skilled people since these activities will favour medium- and high-skilled people (secondary/tertiary education) and therefore, the majority of adaptation jobs will be created for this education level. The workers with average level of education are the largest group of employed and hence the mismatches for them will be the largest. On the other hand, these investments are not expected to have a large disproportionate impact on gender (even if jobs done by males are in a greater demand). Both male and female jobs will be in oversupply in the short-to-medium term and there are some shortages expected in the long run.

The qualitative analysis based on the information collected from five case studies and multiple interviews with public authorities, research institutions, consultancies and sectoral organisations also indicate that there will be a need for a mixture of different levels of skills. The focus of interviewees was predominantly on 'proactive' or anticipating adaptation, which will require attracting and developing high-level Science, Technology, Engineering and Mathematics (STEM) skills (which are expected to be key across all technologies). Monitoring and network management skills will also be affected by this trend, depending on the extent to which consumers adopt and use these new technologies. In most cases, the focus will be on topping existing skills

rather than creating new competences. This is because good generic skills can be used for other occupations as well, including adaptation-related jobs.[4]

Policy recommendations

Best practices
The review of the national adaptation strategies available at Climate-Adapt and six local/regional strategies suggested that very few strategies have considered employment implications of climate change adaptation. The available evidence discussed opportunities for the private sector, the importance of vulnerable sectors, such as fishing, for employment in coastal communities and the need to engage relevant stakeholders (e.g. employee and employee representatives and local councils). Artificial snowmaking is an example of mal-adaptation as it is water and energy intensive thus potentially increasing the risk to climate stimuli. On the other hand, diversifying tourism base is a win-win strategy because irrespective of the future climate change, the economy will benefit from summer tourism as well.

Priority issues to be addressed
The analysis carried out in this study suggests that climate change will have a negative employment effect and therefore many jobs will be lost in the EU by 2050. The most negatively affected sectors are 'manufacturing and public utilities' including manufacturing, electricity, gas and water supply. A similar amount of jobs will also be lost in the 'retail and leisure' sector. In some sectors, for example in agriculture, the impacts are relatively small but there are distributional impacts with positive effects in some countries and negative in others. Most affected countries, i.e. countries that will lose most jobs are Bulgaria, Croatia Greece, Romania and the Baltic (Estonia, Latvia and Lithuania). These countries do not only have high climate change damage costs but also a relatively high share of people employed by unit of output. These countries experience negative effects on climate change on their agriculture and tourism sectors with high number of employed per unit of output.

None of the sectors are expected to experience major restructuring due to adaptation as only a small share of jobs in the corresponding sector will be affected. However, the demand for different level of skills or occupation will be affected. For example, the demand for high skilled labour will increase due to CCA activities as a large share of adaptation investments will be spent on consultancy, engineering and R&D related services where people with highest level of education are working. Therefore, the most important focus is to promote intra-sectorial mobility to address such skills needs.

Policy options
The European Commission and Member States can promote job creation and the provision of adequate skills in the transition to a climate resilient economy through two main channels.

1. *Integrating employment and skills considerations in adaptation policies*

LIFE+ Programme
This programme has a Climate-Action sub-programme including adaptation starting from the funding period 2014. The first call for proposals under the new LIFE Regulation (2014-2020) was published in June 2014. Even if climate change adaptation projects are only one fraction of LIFE projects, there is a great potential for developing training and educational activities:

[4] Interview with UK Energy & Utility skills

- Identify and apply best practices of LIFE projects that consider skills and employment aspects – there have been already several best practices related to employment identified for green employment, which could be applied to adaptation projects.[5] This includes having a knowledge transfer mechanism in place, design and implementation of a tailored training/ course, developing a cooperation model between academia, industry and local government, or cooperation with employment services.
- Adapting the application guidelines to better consider the skills and employment aspects – application guidelines will be amended on a yearly basis to take account of changing EU policy priorities or in view of identified weaknesses in activities proposed under existing projects. Hence, suggestions can be made on the type of project with high value added from an adaptation and employment perspective and additional indicators can be included that would stir project beneficiaries towards adaptation activities promoting adaptation jobs and skills.

Horizon 2020

Under the Horizon 2020 flagship research programme, new research initiatives could support the assessment of climate adaptation on employment going forward. First, this study acknowledges a knowledge gap in skills required for climate change adaptation. There is very little comprehensive data and information on skills, by sector or adaptation activity type (even at local level) therefore, research to *Improve understanding of skills requirements for climate change adaptation* is needed to address this gap and help assess whether the EU labour force possesses both, the level and types of skills adequate to deliver EU adaptation strategy objectives. Primary research questions may be developed for key economic sectors, for example:

- Will planned adaptation investments in the construction sector require the same skills and occupations as currently represented in the sector?
- What are the distributional effects across EU of any changes in skills and occupations in the construction sector due to increased investments in adaptation?

The second research project could *Improve representation of labour markets relevant to climate change adaptation* by developing further the available labour market models in Europe or developing a new model that would allow a consistent assessment of employment impacts of climate adaptation, both in the short and long term.

Local level

At local level, *Guidance on integrating employment and skills considerations into local adaptation plans* is proposed. Local adaptation plans are the appropriate place to start moving from high level capacity building and assessment to local options that have direct assumptions about activities and concrete adaptation investments. These have implications for local jobs and skills, although these implications are not necessarily made explicit in current practice. Considering employment implications at different stages of the process will help ensure that planners are aware of, and preparing for, the implications of their proposed adaptation activities for creating new jobs, preserving existing jobs, or requiring the workforce to develop new skills.

[5] Camarsa, G. et al. (2013), "LIFE creating green jobs and skills", European Commission, Luxembourg: Publication Office of the European Union

Climate-KIC Programme

Climate-KIC is another venue through which supply of adaptation-related skills and knowledge can be enhanced. Climate-KIC operates through three pillars (education, entrepreneurship and innovation) and eight themes, two of which are directly related to CCA. There are many opportunities for the European Commission to play an active role in this initiative by for example:

- Supporting the creation of a vocational professionals track by providing CCA expertise and identifying policy priorities to be tackled;
- Opportunity to cooperate with the regional centres of Climate-KIC;
- Circulating and disseminating knowledge about Climate-KICs activities;
- Refocusing the priorities of Climate-KICs activities.

2. *Integrating adaptation considerations in employment and skills policies.*

Lifelong learning strategies

Lifelong learning is a key overarching concept of the EU's strategic approach to education and training. It is a response to the need to adapt to change, including technological changes and climate change. There are eight key competences for lifelong learning out of which climate adaptation "hooks" could be shown in two, "learning to learn" and "science and technology" competences. However, so far, the education and training field has not taken a sufficiently coherent approach to the consequences of climate change, including the opportunities in relation to jobs and skills. The European Commission can encourage MS to reflect on how curricula, pedagogy and assessment should be adapted to better prepare learners in light of climate adaptation. This integration of adaptation into MS lifelong learning strategies is also consonant with the emphasis in Rethinking Education on the development of transversal skills - such as the ability to think critically, take initiative, problem solve and work collaboratively – that young people need to be able to adapt to the increasingly inevitable labour market changes.

Promoting mobility and training to advance adaptation

Climate change will impact European labour market, and adaptation is an opportunity to alleviate the negative impacts on employment and also to exploit new job opportunities. Hence, it is important in policy and planning to take into account the sectors that will be most affected both, by climate change and CCA. The support for adaptation through mobility and training could focus on strategies that support skills matching, up-skilling and the vision of adaptation as a strategic opportunity to develop technical and policy innovations. The main routes to be considered are:

- Skills matching through improved mobility.
- Training and support for upskilling.
- Improved skills and mobility are expected to ease potential bottlenecks in labour markets and skills mismatches.

European conference on climate change adaptation, employment and skills

The aim of this option would be to start the process of cooperation across policy fields so as to enable the issue of climate change adaptation to be linked in to employment and skills policies, and potentially other fields as well, e.g. research and innovation and regional policy. A model of such cooperation already exists in the form of cooperation on the subject of entrepreneurship education. The first step of such cooperation would be to organise a conference to bring together stakeholders to develop a catalogue of initiatives and best policy practices. This initiative would raise awareness and stimulate thinking around the employment and skills policies that need to be developed to cope with climate adaptation.

Mutual learning programme

The mutual learning programme is part of the open method of coordination in the employment field and aims to help Member States to progress towards the goals of the European Employment Strategy. It provides an opportunity to raise the issue of climate change adaptation in the employment field through the following channels:

- Peer reviews hosted by MS who wish to present an effective policy or practice to a group of up to 10 similar countries.
- Learning exchanges which offer rapid, targeted support to EU countries in addressing specific policy challenges and issues.
- Thematic events.

A two-stage approach is suggested, focusing first on peer reviews and secondly, on learning exchanges. The small scale of such events would suit better the profile of current activity in climate adaptation.

1. Introduction

1.1 Background context

Climate change is increasingly recognised as a major threat to the stability and prosperity of society. No matter what the climate change mitigation efforts are, unavoidable climate impacts will take place together with the economic, social and environmental costs coming along. As the 2012 EEA report 'Climate change, impacts and vulnerability in Europe' confirmed, climate change will increase the frequency and magnitude of extreme events (e.g. floods, droughts, windstorms and heat waves) and may trigger other hazards (e.g. snow avalanches, landslides and forest fires). Climate change will test the EU's vulnerability, putting additional pressure to both human and natural systems.

In April 2013, the EU Strategy on Adaptation to Climate Change was adopted by the European Commission.[6] The aim of the EU Adaptation Strategy is to contribute to a more climate-resilient Europe, and this will involve ensuring that all territories and regions of the EU, including those which are currently lagging, can make appropriate preparations to adapt. Following this new adopted strategy, it is the European Commission, EU Member States as well as other EU institutions that have a role to play to ensure that the effects of climate change are adequately understood at the European level, that it is appropriately presented in all EU policies and facilitates appropriate adaptation measures that will reduce the European Union's vulnerability to climate change impacts.

A supporting study to the development of the EU Adaptation Strategy by McCallum et al. (2013) revealed that only a few studies are available that address the long term, economy-wide effects of climate change adaptation policies on labour market. The little evidence available demonstrates that depending on the sector, adaptation to climate change can bring with it positive and/or negative effects on employment. For example, the warmer climate and longer growing periods are expected to extend opportunities for agriculture in Northern Europe. At the same time, greater damages and thus losses are expected from increasing frequency of climate extremes, such as heat waves and droughts or winter storms. Currently, most studies focus on climate change mitigation policies and employment impacts; only a rather few, and only qualitatively, examine the employment impacts of climate change adaptation policies. Additional research is needed to fill these gaps. In particular, there is a need for quantitative evidence on job creation, job destruction, job preservation and related skills due to climate change impacts and adaptation action. Moreover, further evidence is needed with respect to the re-/up-skilling and restructuring of the workforce that might be observed as a result of such actions.

1.2 Objectives of the study

The overall purpose of this project is to understand and fill in knowledge gaps with respect to the implications of climate change adaptation (CCA) on EU employment and skills. As part of the future mainstreaming of climate change adaptation in EU policies, the results of this study also identified EU employment and social policies which could promote the transition to a climate resilient EU economy, including the provision of adequate skills.

This project should complete the following five specific objectives:

[6] COM (2013) 216 final

1. To define the *interactions between climate change adaptation and employment and skills*, and to clarify linkages between climate change adaptation and mitigation activities;
2. To assess how adaptation action can preserve employment in the EU and how this can be supported by EU policy – this includes the potential of climate change adaptation to provide new skills;
3. To assess any potential losers from climate change adaptation action in the EU in the different economic sectors and why this might be the case – this includes assessing how this can be addressed by EU policy;
4. To identify the sectors in which adaptation-related jobs are being created and quantitatively estimate the number of these jobs in the EU – this includes looking at job creation in green economy as well as beyond; and
5. To provide a *detailed and disaggregated review* of the necessary skills to pursue adaptation activities in the EU – this includes identifying the needed skills in the sector and assess to what extent there are manpower bottlenecks with respect to these skills, and what strategies would help to address them.

1.3 Structure of the report

The remaining Chapters of this report are organized as follows:

- Chapter 2 defines adaptation-related jobs and skills and reviews the relevant literature.
- Chapter 3 provides findings from the review of adaptation strategies and action plans.
- Chapter 4 explains the data gathering, the modelling approach and the scenarios.
- Chapter 5 presents findings of the assessment of the impacts of climate change on employment and unemployment in the EU.
- Chapter 6 presents findings of the assessment of the impacts of climate change *adaptation* on employment and unemployment in the EU.
- Chapter 7 discusses the results of the mapping of skills needed for adaptation activities in the EU and the potential skills mismatches and shortages in the EU.
- Chapter 8 presents eight concrete policy recommendations and their assessment.
- Chapter 9 summarises the main results and suggestions for further research and follow up activities.

The annexes are structured as follows:

- Annex A: Data Collection & Modelling Approach
- Annex B: Case studies
- Annex C: Adaptation plans and strategies reviewed
- References

2. Adaptation, jobs and skills: definitions & literature

2.1 Definitions

2.1.1 Climate change adaptation

Climate change adaptation is defined as anticipating the adverse effects of climate change and taking appropriate action to prevent or minimise the damage they can cause, or taking advantage of opportunities that may arise.[7]

Climate change affects different sectors of the economy, as a response to which adaptation-related economic activities might arise. Adaptation-related economic activities are driven by inter-linkages between physical impacts of climate change, the policy response to prevent or cope with them and the economic implications on the sectors that are affected by and respond to climate change impacts. Economic activities arise when climate change impacts, such as greater frequency of extreme weather events drives the market for climate risk management solutions and measures to cover short-, medium- and longer-term risks. A more detailed typology of economic activities related to adaptation would include the following:

- ***Financial*** (e.g. reinsurance products to reduce insurance companies risks against both more frequent and increased levels of claims);
- ***Physical*** (e.g. flood protection for electricity sub-stations following 2007 floods);
- ***Technical*** (e.g. infrastructure specifications such as peak load assumptions for drainage systems, the scale of flood defences, power station locations, etc.);
- ***Capacity building*** (e.g. embedding management practices in organisations such as railway operators to ensure that climate risks are factored into maintenance regimes).

Adaptation activities could cover nearly all sectors of the economy. However, some sectors and activities are at greater risk from climate impacts than other. As such, 11 sectors are taken into account and split up in the above mentioned four types of economic activities (see also Table 2-1).

2.1.2 Green jobs and skills

According to the Commission Staff Working Document (SWD) on "Exploiting the employment potential of green growth", green jobs are defined as: "*… covering all jobs that depend on the environment or are created, substituted or redefined (in terms of skills sets, work methods, profiles greened, etc.) in the transition process towards a greener economy (SWD(2012) 92 final)*." This is the definition that will be used in this report.

There is a discussion at a policy level whether green jobs lead to new job creation or only to changes in existing jobs. CEDEFOP (2010a) has found that 'green' policies and programmes will probably not give rise to completely new occupations with a novel set of competences, but rather add to and change competence profiles. This is what will differentiate an occupation as new or existing.

Green skills literature and documentation indicate that similar to green jobs, ***"green skills" are not easy to define*** mainly due to the overlap with skills and

[7] http://ec.europa.eu/clima/policies/adaptation

competencies in traditional sectoral activities (CEDEFOP 2010a[8]; ILO 2009). Green skills evolve as green jobs (new and up-skilled) are created. In addition, the boundaries between what is and is not green work are becoming blurred as much of the skills base relevant for green jobs can be found in existing occupations.

Current discussions on green skills at EU level distinguish between different types of skills. CEDEFOP (2010a; 2010b) distinguishes between four types of green skills: generic skills (autonomy and communication), generic green skills (e.g. reducing waste and improving energy and resource efficiency), "top up" existing skills and specialised green skills.

It is argued that ***strategic skills responses should focus more on topping up current competences rather than creating new competences***. This topping-up is most likely to be characterised by additional training to familiarise workers with new concepts and practices that will enable them to operate in green industries but also improving generic skills (leadership, commercial understanding or management) required in almost any occupation, (CEDEFOP 2010a).

2.1.3 Adaptation jobs and skills

Adaptation-related jobs are to some extent included in the discussion on "green" jobs. For example, "green" jobs according to the SWD (2012) definition mentioned above include aspects such as climate change adaptation, resource efficiency, energy efficiency, eco-industries and renewable energy. However, unlike the definition of "green" jobs, where the main focus is on decreasing the environmental impact of economic activities in order to make a transition to a greener economy, *the main focus of adaptation jobs is responding to climate change impacts, which does not necessarily need to lead to better environmental quality*. Hence, it can be concluded that certain adaptation jobs overlap with jobs protecting the environment, including mitigation, while other adaptation-related jobs do not fall under the current definitions of green jobs. This is also evident from the recent OECD report on 'Greener Skills and Jobs' (2014), which calls for the expansion of the definition of green jobs to climate change adaptation.

Following the SWD definition of green jobs, **adaptation jobs in this report are defined as**:

> **Adaptation jobs - definition**
> "Covering all jobs created, sustained or redefined in the process towards building resilience to the existing and projected impacts of climate change. This means jobs related to climate risk management solutions and measures to cover short-, medium- and longer-term climate change risks. These jobs are a result of economic activities related to adaptation, including financial, physical, technical and capacity building activities."

Similarly as has been the case for green and adaptation jobs***, adaptation-related skills overlap to some extent with green skills***. BIS (2010a) identifies that some skills requirements for adaptation may overlap with mitigation activities (e.g. transport infrastructure, energy efficiency of buildings, efficient use of water) whereas others are more unique, such as safeguarding against extreme weather events.

[8] This literature focuses in large part on "low-carbon" economy, rather than on the wider definition of green economy.

However, existing sources do not assess adaptation related skills requirement in great detail. For example, BIS (2010b) in their consultation on green skills specifically asked about the skills needs for adapting to climate change, i.e. to build adaptive capacity and to take adaptive action. However, it became apparent that further awareness of the importance of adaptation across the private and public sectors needs to be raised, as well as a need to address barriers to adaptive action within organisations. Some activities to undertake research on adaptation skills has been started for example in the UK, but have been recently stopped.[9] Sectoral business associations doing research on skills for different industries and sectors, e.g. Energy & Utility Skills in the UK, do include climate change adaptation in their analysis as one of the drivers for businesses in the future. However, their analysis does not disaggregate between mitigation, adaptation or other green skills areas.[10] On the other hand, some local initiatives, e.g. the city of Copenhagen (see Annex B1, section 2.1 for further detail) did start research on adaptation jobs and skills as they find it important to analyse such impacts since the implementation of their Adaptation Plan to make Copenhagen climate resilient will cost considerable amount of money in the next 30 years.[11]

In this report adaptation skills are defined as 'specific and generic skills related to adaptation activities and adaptation jobs, which can be new or topped-up existing skills.' The analysis also differentiates between different types of skills, such as:

- ***Main occupation types and disciplines*** - jobs within each sector fall under different occupations or disciplines along the value chain. For example in the building sector, you need engineers, designers, architects, operations and maintenance, marketing and sales, project managers, etc.
- ***Levels of skills: high, medium, low education level*** – the study relies on three broad levels of qualifications connected to different ISCED (International Standard Classification of Education) groups[12]: low (primary and secondary), medium (upper and post-secondary) and high (tertiary).
- ***New or existing skills*** - when mapping skills the study also looks at whether the skill is new and hence needs to be developed or whether up-skilling/ re-skilling or topping up skills is enough. This will have consequences on the need and scope of education and training (and hence relevant for policy recommendations).

2.1.4 Green and adaptation jobs and skills: overlaps & differences

A typology table of adaptation-related activities was developed as part of this study based on literature review. This table also matches the definition of adaptation jobs in this report. In order to determine the overlaps and differences between adaptation jobs/ skills and green jobs/ skills, this typology table was used. To link the different adaptation activities to green or non-green jobs, literature review was conducted to identify which activities fall under the activities related to green jobs and which fall beyond what is currently defined as an activity related to green jobs. This is a simple approach to provide a scope for adaptation jobs and how they relate to the green jobs discussion. In the approach used in this study (discussed in Chapter 4), the link between adaptation activities and adaptation jobs is created by identifying adaptation-related investments for these activities, which are translated into jobs using the model

[9] For example research started in the Commission for Architecture and the Built Environment (CABE) which was stopped in 2011 due to cut funding.
[10] Interview with Head of Research of Energy & Utility Skills in the UK, based on their (2013) Skills Foresight reports for water, waste management, gas and power industry
[11] Interview with Head of strategy and authority of Municipality of Copenhagen
[12] CEDEFOP qualifications table http://www.cedefop.europa.eu/en/files/Table_III_Qualifications.pdf

used in this study, EXIOMOD (for more details on this model see the methodology chapter of this report and Annex A section 1.4). The table below shows the identified adaptation activities and whether they fall under the activities related to green jobs or those going beyond what is currently defined as a 'green' activity. 'Green' colour presents the overlaps between adaptation and green activities (hence overlap of adaptation jobs with green jobs) and 'red' colour shows adaptation activities outside the current scope of green activities (hence outside of green jobs).

Table 2-1: Typology table of adaptation-related activities and how they are related to green jobs

Sectors	Activity category*	Description/Activities ('green' = activity within green jobs, 'red' = activity outside green jobs)
Built environment	**Physical**	• Reinforcing buildings and infrastructures mainly against heat • Green infrastructure such as green roofs to reduce heat and stormwater run off, and parks (use of trees and plants to cool urban temperatures, reducing energy needs for cooling) • Energy-efficient adaptation of buildings against heat (e.g. vertical green) • Smart meters, which are part of smart grids – can also serve as adaptation as in heat-wave conditions they contribute to climate resilience
	Capacity building	• Upgrading of qualifications/training • Reinforce comfortable summer temperature requirements in heating regulations
Water management	**Physical**	• Water & sewer systems construction and/ or rehabilitation • Pump & pumping equipment manufacturing
	Technical	• The development and manufacture of advanced water management technologies (drinking water purification and desalination, water filtration and reuse technologies) – these fall under eco-industries (Sustainlabour 2013), which are in turn classified under green job
	Capacity building	• Demand management • Support efficient water management actions in urban areas
Agriculture	**Physical**	• Rainwater harvesting, flood meadow, buffer strips • Manufacture, installation, and operation of irrigation and water supply systems
		• Organic farming
	Technical	• Development, distribution and cultivation of drought-resistant seeds • Crop and soil management that mitigate soil erosion (such as plant winter cover) • Enhance floodplain management • Adapting and management of the farm equipment • Cultivation of new crops enabled by the changing climate
Services (consulting)	**Capacity building**	• Strategic training services and programmes • Introduction of new professional services related to adaptation.
Forestry	**Physical**	• Rehabilitation forest fires
	Technical	• Identification of protected areas and establishment of migration corridors • Improved forest fire early warning systems
	Capacity building	• Dissemination of improved forest management practises • Climate change may introduce new opportunities in commercial forestry

Sectors	Activity category*	Description/Activities ('green' = activity within green jobs, 'red' = activity outside green jobs)
Disaster preparedness and response	**Technical**	• Advanced modelling to identify risks • Sustainable urban drainage systems • Coastal defences • Development of early warning systems • Improvement and implementation of emergency relief services
	Physical	• Protection of coastal zones (Hard and soft measures)
	Capacity building	• Landscape design that accounts for climate risk
Insurance and financial services	**Financial**	• Reinsurance products to reduce companies risks against the increase of claims • Financing models for climate change adaptation • Provision of finance to SMEs providing relevant services. • New products such as weather indexed crop insurance
Health	**Technical**	• Energy efficient cooling of hospitals
	Capacity building	• Health education services • Monitoring of disease outbreaks and development of a national response plan
Energy generation, transmission and distribution	**Physical**	• Building a cooling tower • Flood protection for power stations and other energy generation facilities • Hydropower reservoir stations: increase in dam height • Installing underground cables to the extent possible
	Technical	• Manufacture and distribution of small scale energy technologies • Energy-efficient ventilation systems • Solar cooling (PV powered) to cope with demand peaks • Increase the intake capacity to accommodate larger supply of biomass
		• Increase robustness of transmission grids to storm
Transport	**Physical**	• Improve fundaments of roads and bridges • Make asphalt of roads and airports heat resilient
	Technical	• Adequate design and maintenance of bridges and tunnels • New transport routes due to climate change (e.g. arctic shipping route)
Tourism	**Physical**	• Construction of new services (accommodation, water etc.) to account for increased capacity needed
	Technical	• Design of sustainable services and better access • Infrastructure planning following the new trends in tourism
	Capacity building	• Water conservation education for employees and guests • New tourism destinations due to climate change.

Source: own analysis

2.2 Adaptation jobs and skills in the literature

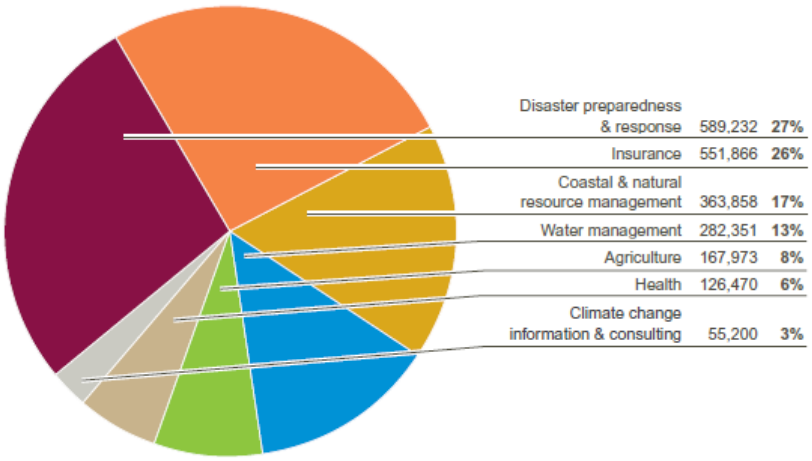
2.2.1 Quantitative evidence from the literature

The review confirmed earlier findings that **there is very limited quantitative information on the impact of climate change adaptation on employment and skills**. Quantification of green jobs is already challenging due to a lack of a clear definition of green jobs and what constitutes to a green economy. The issue with quantifying adaptation jobs is the fact that some overlap with green jobs estimates, while another part lies outside green jobs. Moreover, these jobs are also mixed with local economic development activities cutting across many sectors (OECD 2014).

The UK Department for Business, Innovations and Skills (BIS) estimated the jobs supported by adaptation activities in the UK (BIS 2013). However, they do not account for all adaptation-related sectors (see chapter 4). According to tis BIS study, the total number of jobs in climate change adaptation activities is 19,900 in the fiscal year 2011/2012. The most significant sectors for jobs are construction and retrofit (33%), transport infrastructure (23%), architecture (10%) and finance and insurance (10%). Employment figures are based on estimated job numbers across the supply chain of adaptation activities.

Oxfam (2010) has estimated US jobs in the adaptation marketplace. It identified approximately two million US jobs in seven economic sectors (excluding the energy supply due to data issues) that contribute to climate resilience (see figure 2-1). However, they did not disentangle climate resilient jobs from other jobs in these sectors; hence, not all the jobs in these sectors are directly relevant to climate change adaptation. Moreover, engineering services and remodelling construction of homes and buildings are not included in these estimates as it was difficult to identify the subset of adaptation related jobs within those sectors (Oxfam 2010).

Figure 2-1 Employment in sectors that contribute to building climate resilience



Source: Oxfam (2010)

2.2.2 Assessing the number of adaptation jobs per level of investment

Another way of assessing the potential number of adaptation jobs is to compute the **number of jobs that could be created for a given investment**.

For example, in Canada it is estimated that CAN$1 billion (EUR 656 million)[13] invested in addressing the water infrastructure deficit would create between 11,500 and 47,000 jobs (17,530 to 71,646 jobs per EUR 1 billion invested) and investments in water efficiency can be quickly deployed to yield 15,000 to 22,000 new jobs for each $1.2 billion spent (17,530 to 71,646 jobs per EUR 1 billion invested) with broad-based economic benefits (Flow 2008).

A few EU figures can be found back in two case studies in McCallum et al. study (2013). The first case, on agriculture, is referring to the irrigation investment plan up to 2011 in the major regions of the Po river basin in Italy. In total, the direct and indirect employment potential of public investments in structural measures amounts to 12,000 to 16,000 jobs per EUR 1 billion public investments. The second case is related

[13] 1 CAN = 0.656 EUR

to water supply and sanitation. The total employment potential ranges from 12,805 to 27,000 jobs per billion USD invested (17,760 to 37,448 jobs per EUR 1 billion invested).[14]

When comparing these figures with available assessments for renewable energy and energy efficiency investments, the results show that energy efficiency investments create similar scale of employment: the research by the Energy Efficiency Industry Forum estimates that on average EUR 1 million invested in upgrading the energy efficiency of the building stock will create 19 new direct jobs (i.e. 19,000 per EUR 1 billion invested) (Janssen and Staniaszek 2012). On the other hand, the potential employment effect of investing EUR 1 billion in renewable energy is much higher, resulting to around 52,000 jobs (if funded under the Multiannual Financial Framework 2014-2020) (Daly, Pieterse, Medhurst 2011). The same study estimates 7,800 jobs in organic farming, 25,900 in energy efficiency and 21,500 in sustainable transport per EUR 1 billion invested (Daly, Pieterse, Medhurst 2011). Job creation potential of fossil fuels is much lower, generating only 5.3 jobs per USD 1 million in spending 7,351 jobs per EUR 1 billion invested) according to a US source (Pollin, Heintz and Garrett-Peltier 2008). The results of similar calculations based on this study are presented in section 6.2.1.

Table 2-2 Summary table comparing the number of jobs created per billion EURO invested across different sectors

Sector	Jobs created per billion EUR invested
Water infrastructure	17,530 – 71,646
Water efficiency	22,866 – 33,536
Agriculture (public investment in structural measures)	12,000 – 16,000
Water supply and sanitation	17,760 – 37,448
Energy efficiency (buildings)	19,000
Energy efficiency	25,900
Renewable energy (if funded under the Multiannual Financial Framework)	52,000
Organic farming	7,800
Sustainable transport	21,500
Fossil fuel	7,351

Source: Flow (2008); McCallum et al. (2013); Janssen and Staniaszek 2012; Daly, Pieterse, Medhurst 2011; Pollin, Heintz and Garrett-Peltier 2008

The aforementioned sources show the difficulty of quantitatively estimating adaptation-related jobs. To fill the gaps a bottom-up database was developed as part of this project to account for the main adaptation-related activities. This is discussed in a greater detail in chapter 4.

[14] 1 USD = 0.721 EUR

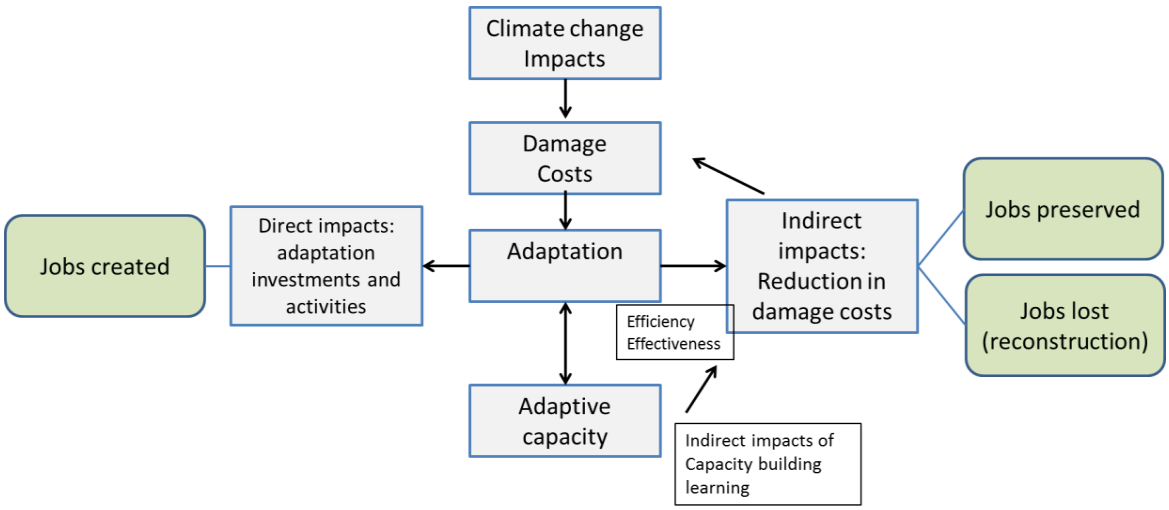
3. Employment considerations in adaptation strategies and action plans

3.1 The transmission channels of adaptation policies on employment

European national and transnational region adaptation strategies and action plans are available in the European Commission's Climate-ADAPT web site.[15] The objective of reviewing these strategies and action plans was to explore evidence for how adaptation policies can be used to preserve jobs, despite the adverse impacts of climate change, and to establish the known implications of adaptation measures on employment in the EU. The evidence from strategies at Member State level forms a common ground for a more general intervention at the EU level.

The way in which adaptation can impact the economy and employment is complex. The main channels and mechanisms are illustrated in Figure 3-1 and discussed below.

Figure 3-1 Economic implications of climate change adaptation.



Source: own analysis

First of all, adaptation measures may involve investments that in the short term boost spending and create demand for goods and services that also have an impact on employment. Expenditure in adaptation can include operational expenditure (Opex), such as costs of running training programmes, maintaining internet platforms etc, as well as capital expenditure (Capex), such as investment in flood walls. Effective adaptation measures contribute to the economy and employment by reducing the damage costs of climate change and extreme weather events by, for example, preventing business disruptions, helping farming to remain profitable when conventional methods would prove unprofitable, or monitoring and controlling new diseases that could have adverse impact on health. The reduction in the expected damage costs is the indirect impact of CCA that could have important implications for employment through preserving jobs. On the other hand, climate change adaptation may lead to job losses as demand for reconstruction activities decreases, as an example, see Figure 3-1 above. Estimates on the employment impacts of adaptation that are highlighted in green will be provided, see chapter 6 for further details.

[15] http://climate-adapt.eea.europa.eu

In addition, the objective of many adaptation measures found in the national adaptation strategies and plans (i.e. capacity building/soft measures) is to increase the adaptive capacity[16] that could be correlated with both the level of adaptation and/or effectiveness of adaptation measures. Capacity building measures can be correlated with an increase in adaptation activities by addressing market failures such as the provision of public goods (mostly publicly financed climate change research programmes produce information on the potential impacts of climate change including country, regional and local impacts including dissemination of the findings). EEA (2013) recognizes a positive feedback loop: sectors that are highly important in terms of climate change adaptation and for which there is relatively more information on the potential impacts are more likely to be developing adaptation policies and actions. Capacity building activities can also increase the effectiveness of adaptation investments by providing information on sectors most affected by climate change as well as on the costs and benefits of different measures. Therefore capacity building can facilitate channelling the resources to activities that provide good value for money. The national, transnational regional and local, city level strategies reviewed are presented in Annex C (for more detail on Rotterdam and Ancona, see Annex B2 and B3 respectively). The review shows that there is a great variation in the depth and structure of the national strategies and action plans. For example, some strategies are short frameworks on countries' approach to adaptation whereas others are lengthy documents presenting hundreds of adaptation measures (see next section). In addition some strategies focus more on the priority sectors i.e. the main sectors affected by climate change whereas others discuss all sectors potentially affected without a clear prioritization.

3.2 Findings

3.2.1 From adaptation strategies

The analysis suggests that Member States are considering adaptation in a wide range of sectors, such as built environment, infrastructure, water management and flooding, biodiversity, agriculture and forestry, energy, health, transport and spatial planning including urban planning, see Table 3-1. Sectors that are most often included in adaptation strategies/action plans are[17]:

- infrastructure (including energy infrastructure),
- water (including flood measures),
- agriculture (including forestry, fisheries and husbandry),
- biodiversity (including natural environment and desertification), and
- human health.

Many of the measures are cross-cutting in nature, i.e. addressing education, awareness-rising and evidence gaps that could be classified as capacity building or soft measures. They are important in supporting decision making by building a solid evidence base for further actions. However, the economic impact of these measures is very difficult, if not impossible, to measure, based on the available information.

[16] Adaptive capacity refers to "the ability of a (human) system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences"

[17] This confirms the earlier finding of EEA (2013) that water management, forestry, agriculture, biodiversity and ecosystems as well as human health are the most commonly mentioned sectors and that the business, economy and regional development gain less attention in adaptation strategies . However, Table 3-1 is not completely identical to EEA (2013) classification. First of all, EEA (2013) has used additional material for those countries that have not yet completed adaptation strategies. In addition, current analysis has dropped some sectors such as mountain areas that were only identified by 1 member state. EEA (2013) has also included sub-sectors (such as rescue services) whereas this report presents the main sectors only.

Table 3-1 Sectors covered in national strategies/action plans.

Country	Built Env	Infrastructure	Water	Agriculture	Biodiversity	Coastal areas	Spatial Planning	Health	Transport	Tourism	DDR/ Natural Hazards	Cities/ Urban planning	Communities	Business /Industry
Finland	✓	✓	✓	✓	✓		✓	✓	✓	✓			✓	✓
Denmark			✓	✓				✓	✓			✓		
UK	✓	✓		✓	✓								✓	
Ireland		✓	✓	✓	✓	✓		✓	✓					✓
Germany	✓	✓		✓		✓	✓							
Netherlands	✓		✓	✓	✓	✓	✓	✓	✓	✓				
Belgium	✓	✓		✓	✓			✓		✓				✓
France	✓	✓	✓	✓	✓						✓	✓		
Spain			✓	✓	✓	✓								
Portugal		✓	✓	✓	✓	✓		✓						
Austria	✓	✓	✓	✓	✓		✓	✓		✓	✓			✓
Hungary			✓	✓				✓						
Malta			✓	✓				✓		✓				
Poland		✓	✓	✓	✓	✓	✓	✓	✓					
Lithuania			✓	✓	✓	✓		✓						
Baltic		✓		✓	✓					✓				
London			✓		✓			✓						✓
Rotterdam		✓	✓				✓							
Ancona	✓				✓	✓		✓	✓	✓	✓			
Alps			✓	✓	✓			✓		✓				
TOTAL	9	12	15	17	17	7	5	15	7	9	3	2	3	6

Notes: Infrastructure includes energy

Water includes flooding

Agriculture includes forestry and fisheries

Biodiversity includes natural environment and desertification

Many strategies also includes cross-cutting sectors such as education, governance and communications.

Source: own analysis

The analysis suggests that very few strategies include detailed or quantified information on investment plans and/or needs. Some research activities and budgets have cost estimates but very few other types of activities include cost estimates. Importantly, as none of the action plans indicated overall costs, the cost estimates found were scattered across sectors and countries.

Very few strategies and action plans have explicitly considered the employment impact of adaptation actions. Building resilient economies through CCA is itself contributing to preserving jobs and economic activities, but strategies have not considered the employment impacts of individual actions. There are a few illustrative exceptions. The *Danish Action Plan* has a separate section on Green transition - growth and employment. The *Hungarian* programme acknowledges that afforestation can boost employment in rural areas whereas *French* investment in research will contribute to employment in higher education and research centres. The *Swedish* climate change vulnerability assessment does not assess the direct implications of climate change adaptation but does acknowledge the importance of vulnerable sectors, such as fishing, for employment in coastal communities. The *Maltese strategy* has a particular focus on communications and the Maltese Resource Authority[18] shall form a partnership with relevant stakeholders such as employee representatives, employer representatives and local councils. In addition, the Maltese strategy addresses the skills aspect by forming communications partnership between the Resource Authority, Directorate of Education Services and University of Malta to address how climate change can be incorporated in the national curriculum and higher education (for more details see the example in the box below). Finally, the *Austrian adaptation strategy* acknowledges that more research on the employment impacts of CCA is needed.

In this respect, the review of national adaptation strategies suggest that Member States are currently monitoring the impacts, building the evidence base and opting for capacity building and soft measures as explained earlier. For example, the Austrian adaptation strategy includes 132 measures of which 101 are soft measures covering spatial planning as well as knowledge transfer and other measures to increase adaptive capacity. The economic implications of capacity building and soft measures are not easy to assess; it is therefore important to discuss the expected benefits of these strategies particularly from the point of view of employment.

Maltese Adaptation Strategy
The Maltese authorities have pioneered an initiative on communication partnership with relevant stakeholders such as employee and employer representatives and local councils. The initial experience of Maltese authorities suggests that the partnerships may need to change the focus from communications to more focused education and knowledge transfer in order to introduce lasting changes. For example, local councils and both employee and employer representatives need a better understanding of climate change impacts and how these are translated into economic impacts at local level to facilitate the assessment on employment impacts. An important part of the education and knowledge transfer is to translate the technical information and data to a format that is meaningful for the relevant stakeholders.

[18] Responsible authority for climate change

3.2.2 Cross-sectoral implications

As already explained is section 3.1 the direct economic implications of adaptation investments realise through increases in the demand for goods and services. Technical and physical measures provide employment opportunities mainly through capital expenditure whereas employment opportunities from capacity building activities arise mainly through operational expenditure, such as communications, including awareness raising, research and education activities.

The indirect impacts of adaptation measures are realised through avoided damage costs and decreases in climate change risks. Capacity building measures across sectors can lead to more effective adaptation measures or increase the level of adaptation by addressing market failures and by providing information to base adaptation decision such as on the benefits and costs of different adaptation activities. The potential indirect impacts of physical and technical measures on employment including cross-sectoral linkages are presented in Table 3-2 below. The analysis suggests that adaptation activities are central to ensure the sustainability of economic activities and jobs in the face of climate hazards. In the same way that many investments have knock-on impacts beyond their sector of origin - benefitting the economy as a whole - adaptation activities that enhance the resilience or sustainability of an investment can also have cross-sectoral benefits for the economy and employment. For example, adapting the transport and energy infrastructure to cope more reliably with more frequent or severe extreme weather brings benefits to all sectors of the economy which are dependent on this infrastructure by minimising potential disruptions, avoiding increased costs and delays to business, and stabilising employment.

Table 3-2 Indirect impacts of adaptation activities on employment

	Built Env	Infrastructure (including energy and telecoms)	Water	Agriculture	Health	Transport	Tourism
Examples of adaptation activities	- Revision of building standards and norms to take into account climate change -Training and further education on issues of adaptation to the consequences of climate change in the area of construction and housing	-Climate-proofing energy infrastructure (optimization of network infrastructure; increased research on the potential for energy storage; diversification of energy sources; financial and regulatory incentive for adaptation in the power sector)	-Flood protection -Improved water efficiency -Storm water management - Regulation and demand side measures	-New seed varieties (heat-tolerant and water-saving crops and grasses and species with low susceptibility to pests shall be favoured) -Improved irrigation -Soil management (sustainable protection of soil fertility, structure and stability)	-(Establishment and monitoring of early-warning systems) -Awareness raising (Preparing for extreme events and/or outbreaks of infectious diseases) -Monitoring the outbreak of new diseases - Training and further education of doctors and personnel	Climate-proofing transport infrastructure -Safeguarding thermal comfort through the reduction of thermal loads - Cooling systems in public transport during heat waves	-Diversification of tourism base ((Aim at a better complementarity between summer and winter tourist seasons by favouring interseasonal tourism) -Water conservation education

	Built Env	Infrastructure (including energy and telecoms)	Water	Agriculture	Health	Transport	Tourism
Indirect implications on employment	-Preserving jobs and economic activities by minimising disruptions	Preserving jobs and economic activities across sectors by minimising disruptions Maintaining communications system and service delivery	- Viability of energy and telecoms infrastructure due to reduction in flood-related disruptions - Improved competitiveness in other (water-intensive) sectors such as agriculture, industry and tourism	- Maintaining the competiveness of agriculture improving food security and preserving jobs - Also links with tourism (agri-tourism)	-Preserving jobs by maintaining the productivity of the labour force (for example during heat waves)	Preserving jobs and economic activities across sectors by maintaining the logistics (distribution of goods and people) Reduction in adverse health impacts from heat waves	Maintaining the competitiveness of the tourism industry and the provision of tourism-related jobs

Source: own analysis.

The sectorial linkages and co-benefits are also demonstrated at local level as demonstrated in an example for the municipality of Bullas, Spain below.

Bullas: a local example[19]

The production of wine is a particular feature of Bullas in Spain and is important to both the agriculture and tourism sectors. As a result of a prolonged dry spell in the region, the adaptation needs for the wine industry are already apparent. Bullas has been active in increasing the resilience of the wine industry and local agriculture to climate change and climate extremes for example by participating in local and international research activities aiming to produce new heat-resistant varieties of grapes and fruits. In addition to agriculture, adaptation in the tourism sector is also closely linked to health. For example, the municipality is taking steps to ensure the comfort of tourists visiting the region during summer months: by building a canopy over the main market of the city during summer time, revising the opening hours of the wine-museum, sharing information on the best time to visit Bullas and by providing health advice for tourists.

The transmission channels for the impact of adaptation on employment and the evidence from adaptation strategies provide a foundation for the scenarios and subsequent modelling in this report. The methodology used is briefly explained in the next chapter and more details are provided in Annex A, in particular section 1.5.2.

[19] http://www.actlife.eu/medias/262-lap-bullas-final-version.pdf

4. Modelling and scenarios

4.1 Data collection & modelling approach

4.1.1 Data collection

To build the scenarios, extensive top-down and bottom-up data collection was done. Top-down data refer to estimates on adaptation activities that are constructed at an aggregated level (sectorial, national). Bottom-up data mean collecting local, project level data which can then be scaled up for a more aggregated estimate. Several datasets including EGS and SBS data from Eurostat were explored, but none of the standard environmental datasets or datasets on economic activities includes sufficient level of information on climate change adaptation for the purpose of this study.

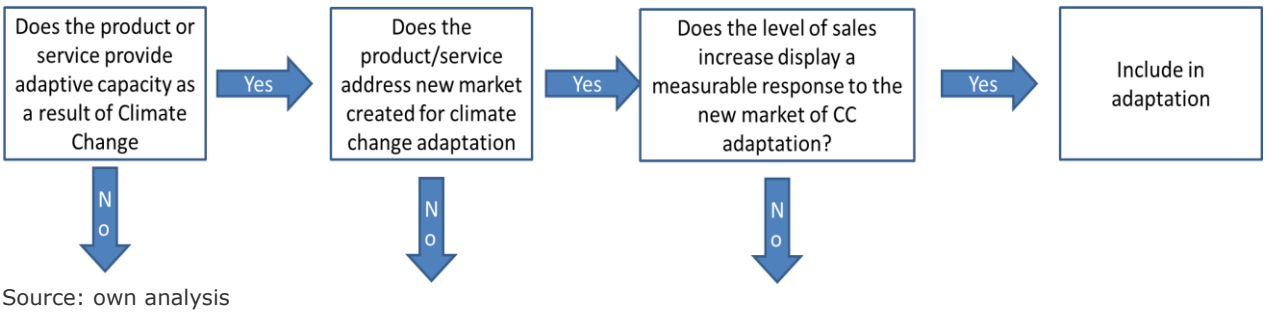
Top-down data

The main data source used for top-down data is the Adaptation and Resilience for Climate Change (A&RCC) dataset. For the UK, the data has been commissioned by the UK Government but the developer, K-Matrix, has completed the data for all EU 28 countries. A&RCC follows a similar methodology and uses similar data sources as the Low Carbon and Environmental Goods and Services, LCEGS data.[20] The sectors covered in the A&RCC[21] data are:

- Construction & retrofit;
- Finance, investment & insurance;
- Risk management & business continuity;
- Urban environment redesign & re-engineering ;
- Sustainable drainage & water management;
- Transport infrastructure & logistics resilience;
- Water irrigation & foot printing.

The methodology for creating the dataset involves a triple-gate approach where the decision whether or not to include a product/service to the dataset is determined by answering three questions:

Figure 4-1 Triple-gate approach to creating the A&RCC dataset



Source: own analysis

In this context, adaptive capacity covers sector specific products and services required to respond to the different outcomes (or anticipated different outcomes) of climate change across countries.

[20] For further information see: https://www.gov.uk/government/publications/low-carbon-and-environmental-goods-and-services-2011-to-2012

[21] The A&RCC data used in this study consists of company sales data. It is constructed from various sources including trade, company, industry, academic, public and market research data and national statistics. For further information regarding A&RCC data please see the annual reports.

Bottom-up data
During the bottom-up research, data on local/ project level were collected (more than 63 cases across the EU were reviewed) to fill in the gaps of the top-down data by scaling them up to national level and extrapolating them to Member States and to create the "ambitious" scenario (see supra). Based on this bottom-up research, three best practices in terms of adaptation plans and strategies in European cities - Rotterdam (Annex B2), Ancona (Annex B3) and Copenhagen (Annex B1) and two adaptation-related sectors - tourism in the Alps region (Annex B5) and energy (Annex B4) were selected as case studies to provide further bottom-up information on the adaptation activities, and their impact on employment and skills. These case studies were also the major source for data on the investments needed for specific adaptation activities used to create the ambitious scenario.

4.1.2 Modelling approach

The modelling approach used in this study consists of the use of a general equilibrium model EXIOMOD[22] that uses climate change adaptation expenditures and translates these into number of jobs by type of skill including education level and occupation for each of the selected scenarios. More in-depth information on the modelling approach can be found in Annex A, section 1.4.

Step 1: Input data on current and projected impacts of climate change
To estimate current and projected impacts of climate change on employment, data on climate change damages were incorporated into EXIOMOD. In order to have consistency of damage estimates across the different countries, the results of the Climate Vulnerability Monitor of DARA was used.[23] The monitor provides an internationally comparable and global picture of the current and future impacts of climate change and the carbon economy based on the current state-of-the-art science and research.

The Climate Vulnerability Monitor estimates damages for the time horizon 2010-2030 which means that these damages had to be extrapolated to 2050. The relative changes in climate change damages have been used to do such extrapolation.

The above calculated damages were then translated into sector-specific climate change damages in order to be used in EXIOMOD. This was done by estimating for each of the damages a reduction in the sector-specific productivity parameter (which implies a reduction in the sector-specific natural resource or its productivity). Most of the climate change effects are sector specific and have a direct impact on, for example, agriculture, transport, tourism and forestry. Other effects are related to climate extreme events and these have a broader impact upon various sectors of the economy. These broad effects are represented either as a loss of total physical capital endowment in the economy or via a reduction in the supply of labour or its productivity.

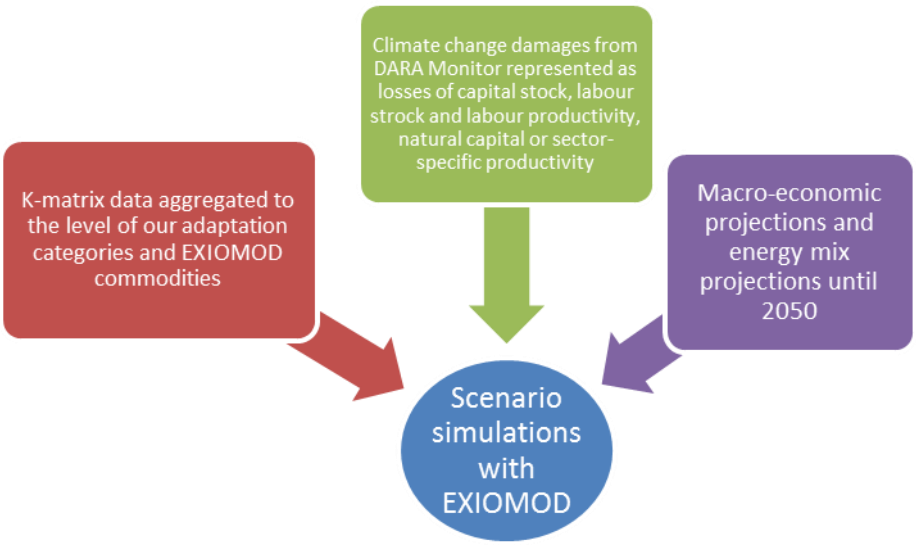
[22] EXIOMOD is a large scale and highly detailed world model built on the detailed Input-output database EXIOBASE. It is a macro-economic 'computable general equilibrium' (CGE) model that divides the global economy in 44 countries and a Rest of World, and 163 industry sectors per country. The model includes 5 types of households, a representation of 29 types GHG and non-GHG emissions, different types of waste, land use and use of material resources (80 types). Moreover, it includes a physical (in addition to the monetary) representation for each material and resource use per sector and country.
[23] DARA is an independent non-profit organisation committed to improving the quality and effectiveness of humanitarian action for vulnerable populations affected by armed conflict and natural disasters; see http://daraint.org/climate-vulnerability-monitor/climate-vulnerability-monitor-2012/

Step 2: Input data on current climate change adaptation activities
In order to estimate the effects of the climate change adaptation expenditures on the number of jobs by sector and type, first a database was created that describes the current spending on adaptation activities for the year 2011 by type of adaptation activity. This dataset is the starting point for creating the two baseline scenarios, reference and ambitious scenarios. As such, the starting point for the estimation of adaptation expenditures of the European Union countries for the period 2015-2050 is the A&RCC dataset provided by K-matrix that includes information on the volume of sales of goods and services related to climate change adaptation in 2010 and 2011.

The next step maps the A&RCC data with the developed typology table (cf. Table 2-1), which presents the most important economic sectors (11) in terms of adaptation activities along with main climate hazards and main economic impact of climate hazards, including direct and indirect impacts. As the A&RCC dataset does not cover all the adaptation activities, other studies and bottom-up data were used to fill in the gaps between the A&RCC data and the typology table.

Macro-economic and energy projections (from Primes) that provide figures about the future investments in the European energy sector were also added as they were missing in the K-matrix dataset. Steps 1 and 2 are summarized in Figure 4-2.

Figure 4-2 Inputs to the simulations' setup with EXIOMOD



Source: own analysis

Step 3: Incorporating effects of future CCA activities into EXIOMOD
Climate adaptation activities have both short and long run effects on the employment and jobs. In the short run, additional expenditures on climate adaptation are translated into additional demand for goods and services (for example: machinery, construction, insurance and consulting services). These goods and services are necessary for the performance of climate adaptation measures and are associated with certain investment costs to the private and public sector. The period of initial investments differs between the types of climate adaptation activities with infrastructure investments having the longest initial investment period. In the long run, after the initial investment period is over, climate adaptation measures have positive effects on various economic sectors by reducing the possible future damages

on the climate change associated with higher temperature. The later effect is captured by reduction in specific types of climate change damages.

Step 4: Calculating the affected jobs
In order to calculate the total number of direct and indirect jobs, two separate approaches were used:

- Partial equilibrium approach – to calculate **direct jobs** without any indirect effects – this is calculated outside of the CGE framework (to exclude all indirect effects) using some of the equations of the EXIOMOD;
- General equilibrium approach – to calculate the **total number** of affected jobs with the full EXIOMOD model.

To generate the direct effects, the climate change damages were translated into the loss of sector specific productivity and physical capital losses into the changes in the employment using the sector-specific nested Constant Elasticity of Substitution (CES) production functions of EXIOMOD. The same methodology was used to calculate the direct effects of climate adaptation expenditures.

The total number of jobs (both directly and indirectly affected) that are associated with climate change and climate adaptation expenditures was further calculated using the CGE model EXIOMOD for each EU28 country separately. To derive the total number of jobs that have been indirectly affected by the climate change, the total number of directly affected jobs was subtracted from the total number of affected jobs.

A qualitative approach was relied on (through case studies, see Annex B1-B5), to take into account potentially transformed jobs. The number of direct and indirect jobs (created and lost) - calculated through EXIOMOD – do include the transformation of labour force between sectors/jobs. Moreover, through EXIOMOD, the number of jobs and skills mismatches per education level (high/ medium/ low), occupation type and gender and per MS, were calculated.

4.2 Scenarios

For the purpose of this study two baseline scenarios were developed, a reference scenario and an ambitious scenario. The **baseline scenarios** are the A1B[24] IPCC scenario (4 degrees) scenario and the E1 ENSEMBLES scenario (2 degrees scenario). The results are presented for the A1B scenario only; information on the E1 scenario can be found in section 6.2.4. In the baseline scenario it was assumed that no new (from 2011 onwards) adaptation activities are taking place. In the **reference scenario** new adaptation activities were added – compared to the baseline scenario - in line with what is needed to meet the EU Adaptation Strategy objectives. It includes both planned (government triggered) and autonomous adaptation (private sector triggered) activities. In the ambitious scenario it was assumed that much more adaptation is taking place compared to the reference scenario. Below the three scenarios are described shortly. More information can be found in the Annex in section 1.5.

[24] The Special Report on Emission Scenarios (SRES) A1B is closest to the Representative Concentration Pathway (RCP) 6. The main difference is that RCPs start with atmospheric concentrations of GHGs rather than socioeconomic processes. The RCP6 was not used because damages for this scenario on the level of detail used in this report are not available (yet).

4.2.1 Baseline scenario

The so-called 'emission SRES A1B scenario' of IPCC was taken as a baseline scenario. This scenario assumes a future world of rapid economic growth, new and more efficient technologies, and convergence between regions. In this scenario, a balance across all energy sources (fossil and renewable) is adopted for the technological change in the energy system. This scenario reflects a medium-to-high emission trajectory and leads to mid-range estimates of global average temperature change of around 3.4°C by 2100.

The baseline scenario takes into account the effect of technological progress on the productivity of capital and labour. In addition, it is considered how the use of energy per unit of output will develop in the future based on the PRIMES runs done for 'Energy Roadmap 2050'. It should be noted that the macro-economic model such as EXIOMOD cannot take full account of future changes in detailed technologies for all its economic sectors. It would be very time consuming and does not fit within the timeline and budget restrictions of the present study.

4.2.2 Reference scenario

The reference scenario is a policy-driven scenario where adaptation activities are expected to increase in line with objectives of current adaptation policies but taking into account the economic prospects and realities of the Member States. The main assumption used is that investment in adaptation is determined by Member Sates' potential to invest in adaptation activities, expected damage costs and current level of adaptation[25].

The starting dataset for the reference scenario is the same as for the baseline scenarios. The flow of reference scenario expenditures on climate adaptation is created by applying country and climate adaptation type specific annual growth rates to the dataset compiled for 2011. In order to model the employment impacts of adaptation activities and investments Member States were grouped. The concept 'potential to invest in adaptation' was used, which reflects the ability of a Member State to invest in effective and sustainable adaptation measures.

4.2.3 Ambitious scenario

To develop the ambitious scenario, it was assumed that current best local adaptation practices in Europe are applied across all EU MS. As part of this scenario, 25 adaptation measures were defined (see separate spreadsheets submitted with this report) which are assumed to be fully implemented by 2050 in addition to the activities in the reference scenario). To populate the scenario with data, micro-level data collected from the bottom-up approach were used (mainly based on information collected on adaptation-related investments in Copenhagen, Rotterdam and the energy sector, see Annex B1, B2 and B4 respectively). These data were used to calculate the future adaptation expenditures assuming an increasing trend over time. To be able to use bottom-up information in the analysis, the local data were scaled up to the national level. The up-scaling was based on the assumption that all regions in a given MS will adopt a local adaptation strategy/plan and as such a similar investment pattern. Detailed bottom-up data on investments related to adaptation measures for some cities were collected from local strategies/ plans (Rotterdam – Annex B2, Copenhagen – Annex B1, Stuttgart) and from specific sector studies (cf. literature list and Annex B4 for the energy sector and B5 for tourism sector). This information was

[25] Some of the adaptation activities form investment stock that depends on the new investments and investment in the previous period (Adaptation White paper Background report, Annex 4).

up-scaled to national level by using country, city and regional (NUTS3) level data on population, km of roads, number of buildings, land use type and area, and the price information coming from the bottom-up research (which was corrected for purchasing power parity).

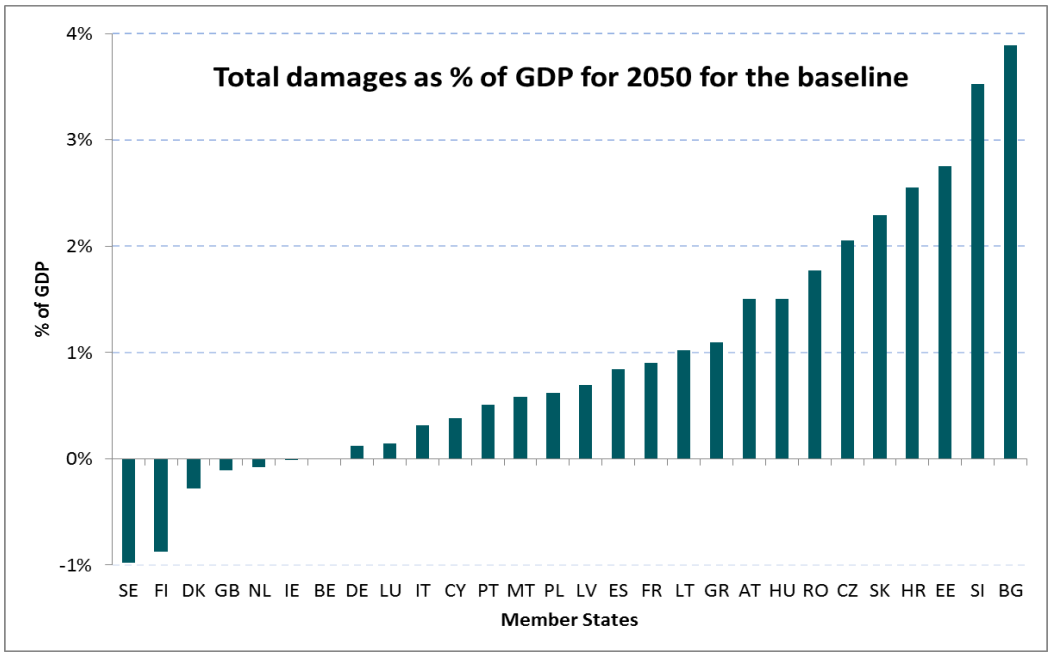
5. The impacts of climate change on (un)employment

5.1 Projected damages from climate change on economic activity

To estimate damages from climate change on economic activity, the DARA Climate Vulnerability Monitor, discussed in the previous chapter, was used.

Figure 5-1 presents the total climate change damages (in monetary value as percentage of GDP for the year 2050). Climate damages have a negative impact on most European member states for the year 2050. Total damages can go up to almost 4% of GDP in sectors such as agriculture, forestry, fishery, tourism and overall health effects. Bulgaria, Slovenia, Estonia, Croatia, Slovakia and Czech Republic (from high to low) will bear the largest costs that can amount from 2 percent to almost 4 percent of GDP. Sweden, Finland, Denmark, Great Britain and the Netherlands have (small) negative total damages. This is due to the increase in temperature by 2050 which has a (small) positive impact on certain economic areas such as agriculture and/or tourism. These countries will probably also benefit from lower heating costs due to this temperature increase. However, water use and labour productivity in these countries are negatively affected by climate change. Note that the damages presented in this study are based on the Climate Vulnerability Monitor of DARA where not all effects of climate change were quantified, which represents data limitations for this study.

Figure 5-1 Total damages as % of GDP for IPCC climate scenario A1B in 2050



Source: Own calculations

5.2 Quantitative results

The results of modelling the impact of climate change on employment in the EU (thus based on the A1B baseline scenario) show that climate change damages (or benefits) will have an effect on the productivity of various economic sectors and reduce (or increase) their production and employment. This results in loss (or gain) in employment. Sectors with the largest climate change impacts on their productivity include agriculture, forestry, fishery, hydro energy and hospitality and gastronomy industry/tourism. Moreover, extreme events lead to destruction of infrastructure and

buildings that have to be repaired after the extreme event. This leads to additional demand for construction sector services as well as other capital goods such as machinery, equipment etc.

These direct effects give rise to the indirect effects on sectors linked with most affected economic activities via up-stream and down-stream linkages. These include for example the manufacturing sectors that use products of agriculture forestry and fishery. Negative impacts on tourism lead to negative impacts on the hospitality and gastronomy sectors and on the manufacturing sectors that produce products used in tourism industry such as food and textiles.

To have an easier interpretation of the results from the EXIOMOD model, its 163 economic sectors have been aggregated to seven major sectors of the economy presented in Table 5-1.

Table 5-1 Mapping of NACE rev 1.1 sectors into seven aggregated sectors

Aggregated sectors	NACE rev 1.1 code	NACE Sectors
Primary Industry	A, B and C	Agriculture, hunting, forestry, Fishing, Mining and quarrying
Manufacturing and Public Utilities	D and E	Manufacturing, Electricity, gas and water supply
Construction	F	Construction
Retail and Leisure	G and H	Wholesale and retail trade; repair of motor vehicles, motorcycles, personal and household goods, Hotels and restaurants
Transport and Finance	I and J	Transport, storage, communication and Financial intermediation
Business and Public Services	K, L and M	Real estate, renting, business activities, Public administration and defense; compulsory social security and Education
Other Services	N, O, P and Q	Health and social work; Other community, social and personal service activities; Activities of households; Extra-territorial organizations and bodies

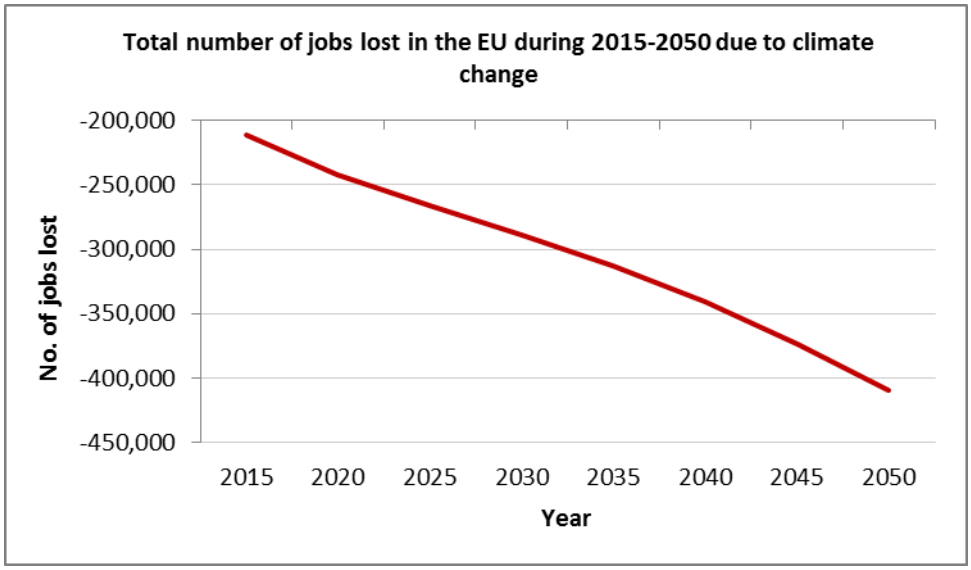
Source: own analysis

5.2.1 Impacts on employment in the short, medium and long term

To assess the effects of climate change on employment in the short, medium and long term, first the total number of lost jobs is estimated, which is shown in Figure 5-2. The effects of climate change over time are non-linear (slightly concave-convex functional), where the total number of lost jobs increases more rapidly towards the end of the simluation period.

The total number of jobs that are lost due to climate change amount to 409.5 thousand in 2050. To put this number in perspective, it can be compared to the total number of working people. The total number of working people in 2050 is predicted to be around 220 million. This means that the percentage of the lost jobs due to climate change is about 0.2% of the working population.

Figure 5-2 The total number of jobs lost due to climate change in the EU for 2015 – 2050



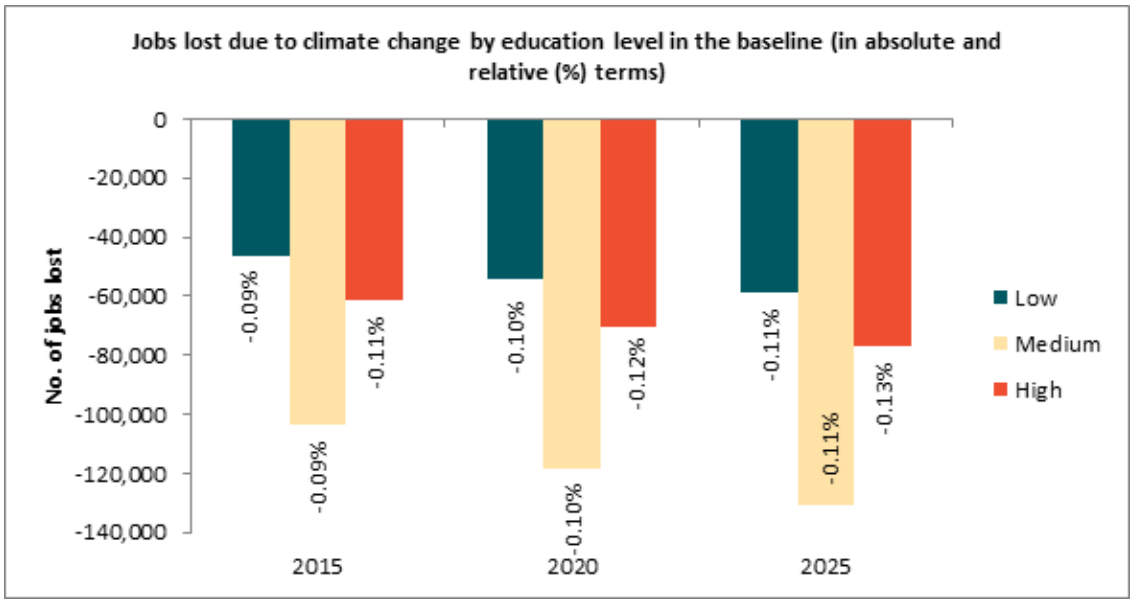
Source: Own calculations

5.2.2 Impacts on unemployment in the short-term

In the short run, up to 2020, the total number of jobs lost due to climate change is around 240,000. This is the number of jobs that are lost, when there is only limited CCA. The total number of unemployed persons in the EU28 was just over 26 million in 2013. More than 12 million of those unemployed persons have been unemployed for more than 12 months. This can be seen as the level of structural unemployment. To put the number of lost jobs in perspective, it is assumed that the jobs lost due to climate change will be mainly structurally lost, i.e. these jobs will not be replaced by other jobs. That would imply that in addition to the 12 million of structurally unemployed persons in the EU, around 240,000 more persons will become long-term unemployed. In other words, in the short run the number of structurally unemployed individuals increases by about two percent due to climate change.

Figure 5-3 shows the distribution of lost jobs between different education levels. The education levels have been grouped into low, medium and high level of education. As can be seen from the figure, the largest number of jobs are lost for the medium education category. This is also the most common education classification in the population. The variation in the magnitude of the absolute effect reflects the size of the particular population group with a certain education level. From Figure 5-3 one can conclude that changes in relative terms have a different pattern. Percentage of lost jobs for each education level is calculated compared to the total number of employed people with this particular education level. Highly educated people are affected in relative terms more than low and medium educated ones. This is because climate change has a negative effect on the industrial and service sector with relatively high share of highly educated people. Please note that the differences in relative effects are quite small.

Figure 5-3 Number of jobs lost (in absolute and relative (%) terms) due to climate change by education level in 2015, 2020 and 2025 in the baseline



Source: own calculations. Relative terms (%) show the percentage of lost jobs due to climate change out of the total employment in the corresponding education level.

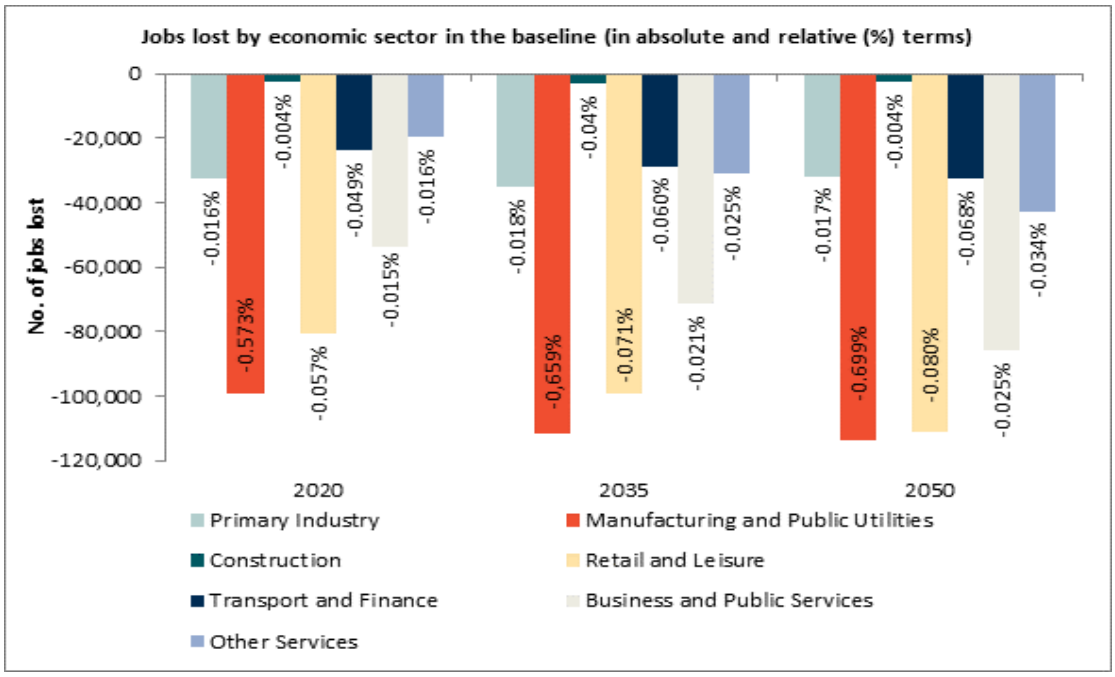
5.2.3 Sectoral and geographical results

Figure 5-4 shows the total number of jobs lost due to climate change by economic sector in the EU. The largest number of jobs is lost in the sector that is the largest in the EU economy 'Manufacturing and Public Utilities' that includes Manufacturing, Electricity, gas and water supply. The negative effect of climate change on this sector is due to the loss of labour productivity and the indirect effects from other economic sectors such as 'Primary Industry' and 'Retail and Leisure'. Sector 'retail and Leisure' is also affected negatively which is due to negative effects of climate change on tourism in EU. The effects of climate change on the 'Primary Industry' that includes agriculture and fisheries is relatively low which is due to the positive effects of climate change on agriculture in a number of EU countries including Denmark, Belgium and Hungary. Other economic sectors are also negatively affected by climate change. This negative effect is primarily due to the loss of labour productivity due to heat and increases in the number of illnesses. The negative effects of climate change on the primary industries will lead to strong negative spillover-effects on manufacturing via down-stream inter-sectoral linkages. For example, negative impacts of climate change on the forestry sector lead to relatively small number of directly lost jobs due to low labour intensity of the forestry sector. However, the reduction in production of wood has wider economic effects on in particular wood products manufacture sector, publishing and media sector, pulp and paper producing sector as well as reprocessing of wood products sector. All these sectors have much higher labour intensity as compared to the forestry sector and will lose more jobs per one Euro of lost output. The difference in labour intensity of primary and manufacturing industries is the main factor that explains strong negative spillover effects of climate change on employment in these sectors.

Also in relative terms, sector 'Manufacturing and Public Utilities' loses the highest number of jobs. The relative changes are calculated compared to the total number of employed in each sector. The relative negative effect on 'Transport and Finance' sector is larger than the effect on 'Business and Public Services'. In absolute terms it is the other way around. Transportation sector is closely linked with other sectors of the

economy via down-stream and up-stream linkages and hence will suffer more from negative effects of climate change on other sectors.

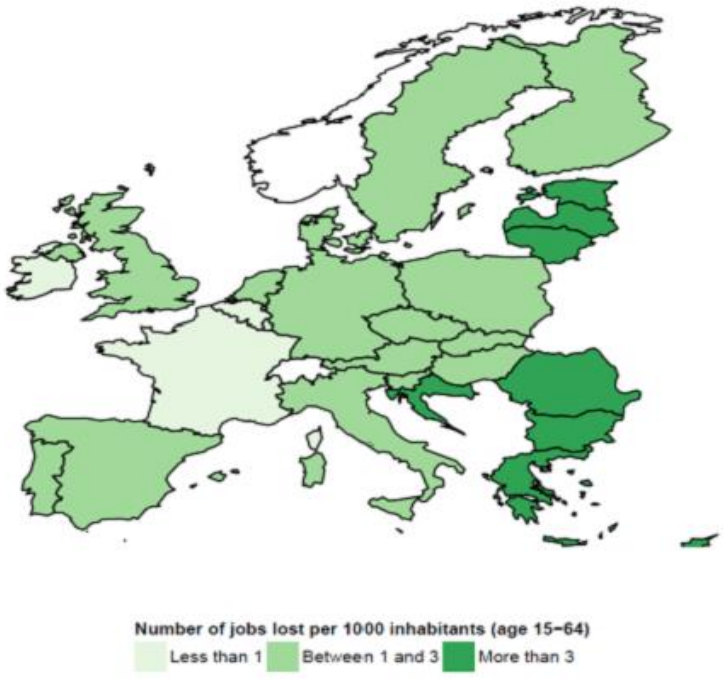
Figure 5-4 Number of jobs lost (in absolute and relative (%) terms) for 7 aggregated economic sectors for 2020, 2035 and 2050 in the baseline



Source: own calculations

Figure 5-5 shows the total number of jobs lost due to climate change in 2050 per 1000 inhabitants of the working age.

Figure 5-5 Map of EU - the number of total jobs lost per 1000 individuals (age 15-64) due to climate change for 2050



Source: own calculations

The number of lost jobs is closely related to the overall damages from climate change, which is the highest in Bulgaria, Croatia, Cyprus, Estonia, Greece, Latvia, Lithuania and Romania. These countries have a relatively large agricultural sector which is negatively affected by climate change. Belgium, Ireland, France and Luxemburg have much lower negative climate change effects and hence a lower number of lost jobs compared to the rest of Europe. Scandinavian countries and Great Britain have positive climate change effects on a number of their economic sectors including agriculture, forestry and tourism.

This shows that climate change will affect labour markets in the European regions differently depending on their core economic sectors and climatic conditions.

5.3 Qualitative results as identified in case studies

The case studies (Annex B1-B5) showed that climate change can have significant economic impacts. The **Copenhagen** adaptation plan (see case study in Annex B1, section 2.1) estimates the costs of flooding from sea-water and rain-water to be DKK 350 million in 2010 annually (EUR 46.9 million[26]), a number that rises to DKK 570 million (EUR 76.3 million) in 2060 and DKK 1050 million (EUR 140.6 million) in 2100. Besides these financial costs, there are additional social and environmental problems that follow with the floods which are deemed unacceptable.

Moreover, as the case of **Ancona** (see Annex B3, section 4.1) shows, nearly the whole of Italy is at risk of landslide and flooding. Four out of five towns in Italy (82% of total) have areas at hydrogeological risk (as identified in local hydrogeological plans) affecting over six million people. A report by Legambiente[27] suggests that 21% of towns in Marche region have whole districts in high risk areas, and 82% of districts have at least some houses at risk. The risk of landslides is also very relevant for the local industry, with 66% of factories located in high risk areas. In 1982 a massive landslide destroyed a large area in Ancona, the principal city of the Marche region. The landslide resulted in:

- 3661 homeless people;
- 280 total buildings destroyed, including large hospital facilities;
- Destruction of 31 farms, 3 industrial plants and 42 shops;
- Severe damage to transport and utilities infrastructure (railway, roads, gas and water pipelines);
- 500 people jobless.

The investment required to completely reclaim the area at risk is estimated to be over €60 million. In addition to the expense, total stabilisation of the landslide would also have serious environmental impacts due to the extensive stabilisation measures.

Winter tourism that provides many jobs in the Alps region is also under a threat of climate change (see case study on tourism, Annex B5 section 6.1). According to the OECD (Agrawala 2007), the effects of climate change in the Alps are three times higher than the world average[28]. Currently, over 90% of skiing areas in the main six countries (Austria, France, Germany Italy, Slovenia Switzerland) rely on natural snow (609 out of 666). A simulation exercise suggests that an increase of 1 °C in

[26] 1 EUR = 7.46 DKK
[27] Legambiente, Ecosistema Rischio 2013; Available from: http://www.legambiente.it/sites/default/files/docs/ecosistema_rischio_2013_def.pdf
[28] For example temperatures in the Swiss Alps are projected to increase by about 1-5 °C in the summer and about 1-3 °C in the winter by 2050, relative to 1990.

temperature would reduce the areas that can survive on natural snow to 500; an increase of 2 °C would reduce the number to 404, while a 4°C increase would lead to only 200 areas operating on natural snow. Without adequate adaptation policies, the loss of natural snow will also have an impact on the jobs supported by the winter tourism.

In the **energy sector** (see case study in Annex B4, section 5.1), the power plants in Europe face the following severe risks to climate change:

- A decrease in precipitation will require preventive investments for hydro power plants in the Mediterranean region;
- An increase in the sea level will require preventive investments for offshore wind power plants in all European Seas;
- An increase in the occurrence of floods will require preventive investments for thermal generation technologies all over Europe, except for the North Sea region;
- An increase in the occurrence of storms will require preventive investments for networks all over Europe, except for the North Sea region.

Investments to minimise these risks are estimated to be between EUR 15-19 billion per year (from now until 2080). The increased incidence of flood impacts on thermal power plants (nuclear, biomass, and fossil-fuel based) amount to EUR 3-6 billion (Rademaekers et al. 2010).

Based on the interviews for the energy sector case study (Annex B4), no major changes are expected on employment in the coming ten years, however, this will depend on the priorities of the government and the ability to ensure the private sector a return on investment.[29]

[29] Interview with Head of Research at the UK Energy & Utility Skills

6. The impacts of adaptation activity on (un) employment

This chapter presents the results of the quantitative assessment of the impacts of adaptation action on employment in the EU compared to the baseline, i.e. the relative change of employment due to CCA. The results of the reference and ambitious scenarios are compared. The difference between these scenarios is mostly in the size of the total CCA expenditures in the EU:

- Reference scenario adaptation expenditures total 0.5% of GDP in 2050,
- Ambitious scenario: adaptation expenditures total 1% of GDP in 2050.

The adaptation expenditures will have a direct effect on the damages due to climate change. The adaptation expenditures decrease damages depending on the relative effectiveness of each measure. In the annex, section 1.5.3, cost-benefit ratios are provided that describe how the different adaptation measures affect damages in different sectors. There are two channels that cause changes in employment due to CCA expenditures. In the short-run, additional investments are translated into an increase in the demand for certain goods and services. The type of goods and services with increased demand are related to the type of CCA activities. This results in positive effects on employment in these sectors and in addition leads to positive spillover effects in other sectors.

In the long-run, investments in CCA measures lead to a reduction of climate change damages. This leads to saved jobs in sectors that are otherwise negatively affected by climate change.

The negative effects of CCA activities depend upon the assumptions about their financing. For this modelling exercise it is assumed that half of the expenditures of adaptation are covered by the private sector and half of them by the public sector. This assumption does not affect the number of created jobs in the economy, but only the distribution of the created jobs between sectors, since government invests in a slightly different way in different industries and sectors compared to the private sector. As CCA expenditures represent a small fraction of total expenditures by government and the private sector, this difference in distribution does not change the overall results. The total pool of savings in the economy stays the same as without the adaptation activities. At the same time the larger part of savings is going to investments related to climate change adaptation (compared to the baseline). There is less money spent on other types of investments, such as for example purchasing computers, furniture and software, economic consulting, trainings not related to climate adaptation, machinery and equipment for plants, motor vehicles etc. This has a negative influence on the employment in the corresponding economic sectors.

6.1 Reference scenario

The predicted climate change adaptation expenditures in the reference scenario (0.5% of GDP in 2050 in the EU) are largely related to the transport sector (26% of expenditures in 2050, €28.7 billion), the built environment (21%, €23.7 billion), the health sector (17%, €18.8), agriculture (12%, €13.3 billion), and insurance and financial services (10%, €11.6 billion). Energy efficiency measures in buildings are covered by expenditures in the built environment sector. This amount is much higher

than estimates by the World Bank (2010)[30]. On the other hand, Stern (2007) estimates that additional costs of making new infrastructure and buildings resilient in OECD countries could range from $ 15-150 billion annually (0.05 – 0.5% of GDP). OECD estimates total weighted adaptation costs at 0.64% of GDP for Europe and 0.14% for Eastern Europe against a 2.5 °C temperature rise.[31] Importantly, EEA (2010) suggested that scaling up national estimates of adaptation costs to European level produces higher estimates compared to aggregated sectorial studies or integrated assessment models.

The different cost estimates are a result of different methodologies used but some key drivers of the differences are likely:

- Different climate model: World Bank study uses the 2°C threshold whereas in this study the 4 degrees baseline scenario - A1B IPCC has been used.
- In the World Bank study adaptation costs increase over time but their respective share in GDP fall over time. This is based on an assumption that countries become less vulnerable to climate change as their economies grow. This is in line with increased adaptive capacity to respond. On the other hand, IPCC (2007) in Perry et al. (2009) suggest that damage costs may increase rapidly after 2030.
- World Bank estimate only takes into account adaptation costs related to adverse impacts and not any investments that may be necessary to exploit the benefits.
- The World Bank study presents country case studies of developing countries. It is not clear whether the adaptation measures included in the global study (i.e. including the developed world) are adjusted to the context.
- Recent evidence recognises the limits of adaptation (see for example IPCC AR5). Therefore in this context the World Bank estimate seems very low in order to bring the welfare back to the level without climate change.

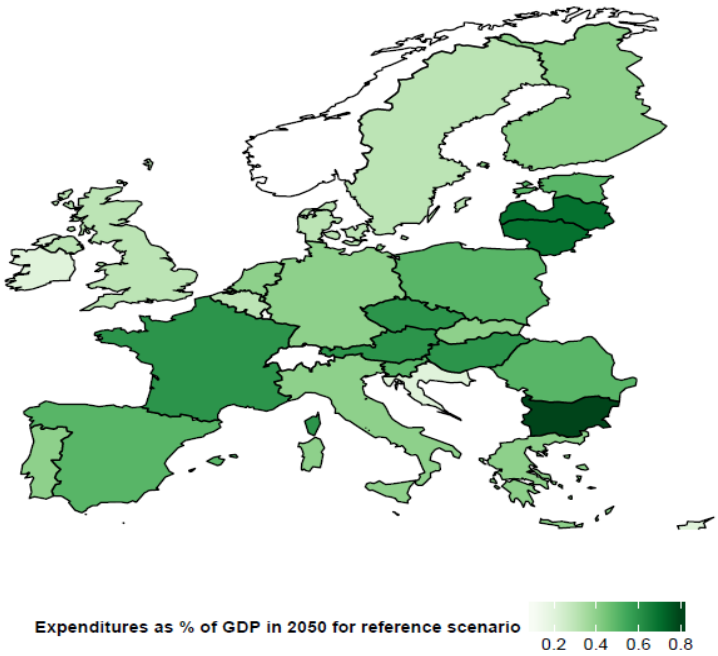
The expenditures related to both the transport sector and the built environment, such as new roads or improved buildings, are associated with an increased demand for goods and services from the construction sector. As the combined expenditures related to these sectors make up almost 50% of the total expenditures in 2050 related to climate change adaptation, large effects in the construction sector are expected.

Figure 6-1 shows the climate change adaptation expenditures in 2050 as a percentage of GDP for the individual countries in the EU. These are closely related to the growth of climate change damages. The higher the growth of these damages, the higher is the share of adaptation activities. However, they do not have a one-to-one relationship with them as CCA expenditures consider also the adaptive capacity, baseline expenditures, etc. (see Annex A, section 1.5). These expenditures are largest in Bulgaria, Latvia and Lithuania and smallest in Sweden, the UK and Ireland. The reason behind it is the effects of temperature raise on the agricultural, forestry and fishery sectors in different countries in combination with the increase or decrease in demand for heating and cooling. In several countries an increase in temperature will be beneficial for the agricultural and forestry sectors. In general, Eastern European countries have relatively low levels of GDP compared to the Western European countries which means that with the same level of climate adaptation expenditures the share of these expenditures to GDP will be higher for these countries.

[30] The World Bank study estimates the total annual cost of adaptation action in Europe and Central Asia (for all sectors for the period 2010-50) as $ 13 billion (in 2005 prices, only including adaptation against damage costs).

[31] De Bruin et al. (2009). Economic Aspects of Adaptation to Climate Change: Integrated Assessment Modelling of Adaptation Costs and Benefits. OECD Environment Working Paper No. 6.

Figure 6-1 Climate change adaptation expenditures as % of GDP in 2050 for the reference scenario



Source: own calculations

6.1.1 Impacts on employment in the short, medium and long term

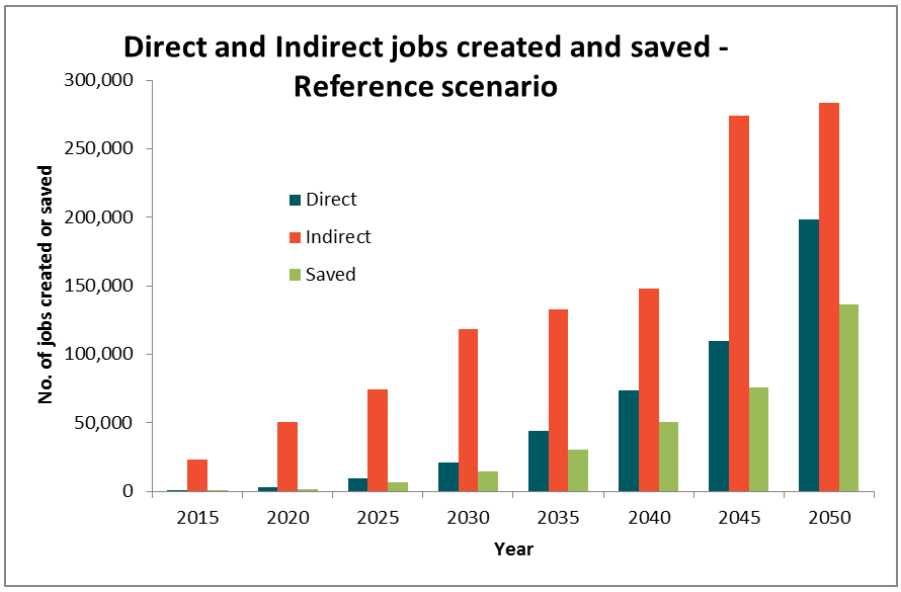
The additional expenditures related to CCA lead to additional jobs. The total number of additionally created jobs is a combination of directly and indirectly created jobs.[32] Jobs are created directly if the economic activity in a sector increases, because climate change adaptation expenditures directly lead to an increased demand for the goods and services from that sector. In addition to creation of these jobs, an increase in the direct demand for goods and services in a sector leads to indirectly created jobs in other sectors due to backward inter-industry (supply) linkages.

Figure 6-2 shows the number of directly and indirectly created jobs and saved jobs in the EU between 2015 and 2050. In the short run, the combined effect of directly and indirectly created jobs is small. Compared to the baseline, just over 50,000 additional jobs are created in the EU in 2020 due to the increased expenditures related to climate change adaptation. Moreover, the number of saved jobs in 2020 due to climate change adaptation is also negligible (less than 2,000).

In the long run, with increasing climate change adaptation expenditures, the total number of additionally created jobs (direct and indirect) increases to almost 500,000 by 2050, which is 0.2% of the working population. There will also be around 136 thousand saved job by 2050 as an effect of climate change adaptation in sectors affected negatively by climate change.

[32] Directly generated/ lost jobs are jobs linked to the changes in economic activity in that particular sector, i.e. sector employment effects triggered by activities in that sector. Indirectly generated/ lost jobs are the result of backward inter-industry (supply) linkages.

Figure 6-2 Directly and indirectly created and saved jobs over time in the EU in the reference scenario, compared to the baseline



Source: Own calculations

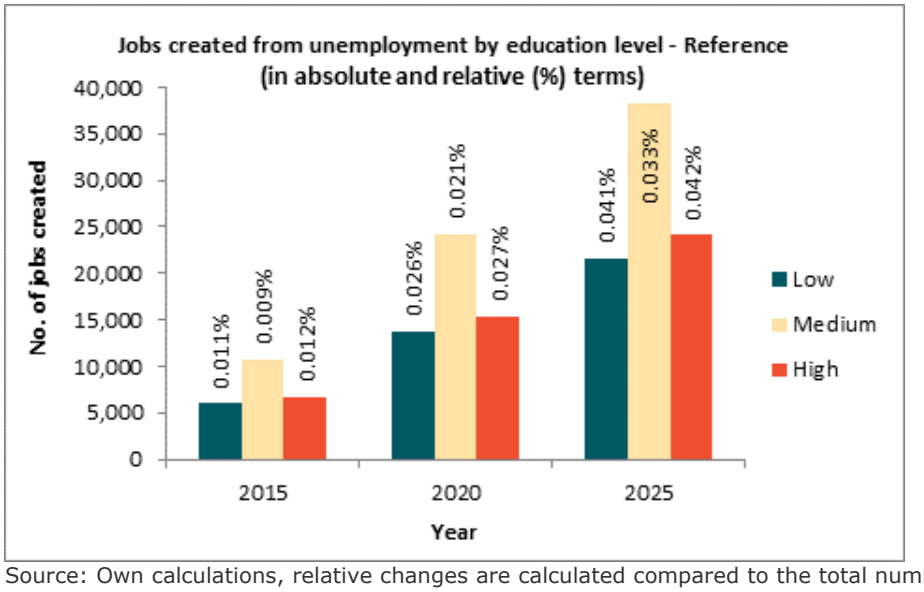
The share of the indirectly generated jobs is decreasing over time with an increase in the amount of investments into CCA activities. This is due to the fact that the total number of employed people in all scenarios is equal to the projections of the Europe Aging Report 2012 and is not influenced by scenarios. Given that the supply of labour (number of employed) is fixed, increase in the demand for labour results in an increase in the price of labour. What changes in scenarios is the distribution of employed between different economic sectors and types of jobs. The higher is the amount of directly generated jobs, the larger is the increase in the price of labour and the smaller is the room to create additional jobs indirectly through inter-industry linkages given that the total number of employed in EU is fixed.

This mechanism can be illustrated with a simple example where an economy is assumed to have 100 people employed in three economic sectors. In the initial situation 50 people are employed in sector X, 20 people are employed in sector Y and 30 in sector Z. Due to investments in CCA, the demand for output of sector X has increased by 10% which resulted in an increase in employment in this sector and leads to positive spillover effects on sector Y. The distribution of total number of employed (100 persons) between these sectors is determined by demand for labour from these sectors. It is further assumed that this initial change in demand did not affect the prices of labour and has resulted in 5 directly generated jobs in sector X and 5*multiplier of 2 = 10 indirectly generated jobs. The number of employed in sector Z goes down by 5 + 10 = 15 jobs. If a new situation is considered with an increase in demand for output of sector X by 20% due to CCA investments, this change in demand is large and will lead to increase in the price of labour by 10%. This means that the number of directly generated jobs will not be 10 (as it would be with constant labour prices) but 9 jobs instead. The number of indirectly generated jobs will be in this case equal to 9*multiplier of 2*(1 -0.1) = 16.2 jobs. In the first case, the ratio between indirectly and directly generated jobs is 2, whereas in the second case, it is equal to 1.62, hence the relative share of directly generated jobs becomes higher the larger is the increase in the price of labour. This explains a catching up effect of direct with indirect jobs over time.

6.1.2 Impacts on unemployment in the short-term

To assess the impacts of CCA on unemployment in the short-run, the number of jobs created from unemployment in the short-run by education level is estimated. Education levels are grouped in three categories: low, medium and high level.

Figure 6-3 – Number of new jobs created from unemployment (in absolute and relative (%) terms) by education level for 2015, 2020 and 2025, compared to the baseline



Source: Own calculations, relative changes are calculated compared to the total number of employed people by education level.

The total number of jobs created is around 23,000 in 2015, over 53,000 in 2020 and over 83,000 in 2025. This corresponds to the reduction of the total number of unemployed by 0.11% in 2015, 0.28% in 2020 and 0.45% in 2030, where the total number of unemployed is calculated according to the projections of Europe Aging Report 2012. The number of created jobs has been calculated as the number of new vacancies that appear during one year due to CCA investments. The number of vacancies in the short run is always smaller than the number of unemployed. Even with high levels of unemployment, not every vacancy that is created will be immediately filled, because of labour market frictions, such as search frictions or mismatches in the supply and demand for skills. The number of created jobs should therefore be seen as an upper bound to the number of individuals that find a job. The number of individuals that find a job as a result of increased CCA expenditures will most likely be a bit lower than the numbers presented above.

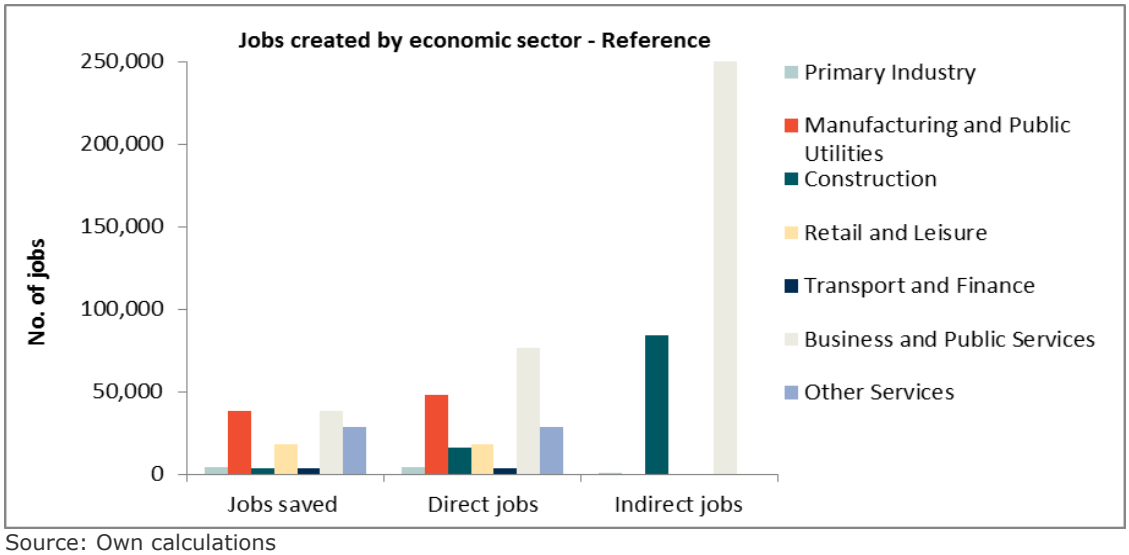
In absolute numbers, the most jobs are created for the individuals with medium education level. They are also the largest population group in the EU. In relative terms, the most jobs are created for highly educated people. This is due to the nature of climate change adaptation activities that involve consultancy, research and engineering activities. Almost the same relative amount of jobs is created for low educated people. This is due to high expenditures on construction of new infrastructure and modernisation of the old one. The relative changes are calculated compared to the total number of employed people by education level.

6.1.3 Sectoral and geographical results

Figure 6-4 shows the changes in employment in 2050 by seven aggregated sectors. Most jobs are created in business and public services sectors and the construction sector. The more detailed sector classification, not presented here, shows that most of

the jobs are created in public administration, health, education and research and development (this is in line with the expenditures). The large number of jobs created in the construction sector for example is also consistent with the share of expenditures that are related to this sector. In addition, expenditures directed towards the construction of buildings and roads translate in the purchase of both physical materials and labour. Expenditures directed towards sectors providing services have a larger effect on jobs, as labour costs are a higher share of the total costs for these sectors.

Figure 6-4 Jobs created by economic sector in 2050 in the EU in the reference scenario, compared to the baseline



Source: Own calculations

Saved jobs are the result of the mitigating effect of CCA expenditures on climate change damages. The largest number of jobs saved is in the 'Manufacturing and Public Utilities' sector. This sector has been affected the most by climate change, as was shown in the baseline scenario. Addressing the damages from climate change therefore benefits it the most. Business and public services and other services are also important reflecting the importance of climate change in preserving jobs across the economy (see also Chapter 3 for further discussion).[33]

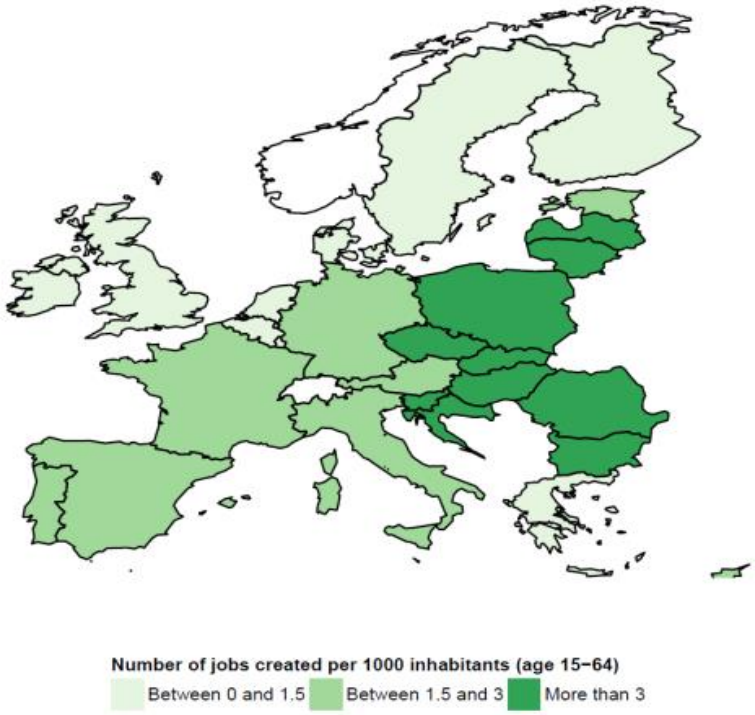
Figure 6-5 shows the total number of jobs created in 2050 due to CCA expenditures for different countries in the EU. To be able to compare the numbers between the different countries, the number of created jobs is scaled by the number of individuals in the working age population in the country. This figure shows that the countries in Central and Eastern Europe (Bulgaria, Croatia, Czech Republic, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia) have the largest increase in the number of jobs per 1000 inhabitants (age 15-64). This is in line with Figure 6-1, which shows that projected CCA expenditures as a share of GDP is relatively larger for these countries. Similarly, countries with relatively lower predicted expenditures, such Sweden, Norway, Finland, the United Kingdom and Ireland, also show a lower number of created jobs in Figure 6-5.

The total number of jobs created per 1000 individuals depends on the following main factors: (1) the share of CCA expenditures in GDP, (2) labour efficiency of the economy and (3) the composition of types of CCA activities. By comparing the spatial

[33] The percentage of saved jobs due to climate change adaptation per industry has been calculated as well. However, since these industries are highly aggregated where only a minor part corresponds to the sectors related to CCA, the percentage of jobs saved is very small (max 0.63% in the ambitious scenario).

distribution of CCA expenditures with the distribution of created jobs, it can be seen that Spain and France become less dark on the map with the created jobs as compared to the expenditure as % of GDP. This can be explained by the fact that these countries have relatively high labour productivity and hence fewer jobs are created per 1000 individuals as compared to Bulgaria, Latvia and Lithuania.

Figure 6-5 - Total created jobs (per 1000 individuals) for 2050 in the reference scenario, compared to the baseline



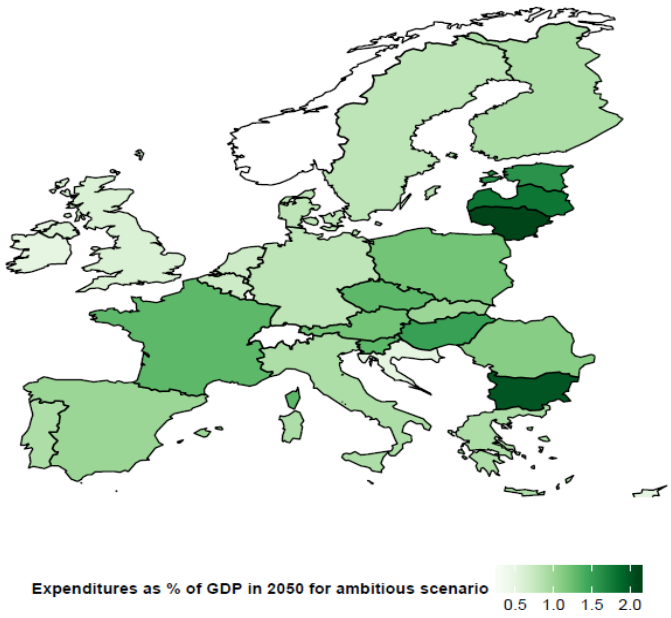
Source: own calculations

6.2 Ambitious scenario

Compared to the reference scenario, the amount of CCA expenditures is higher in the ambitious scenario. The projected expenditures in 2050 amount to 1% of GDP for all the EU countries combined. This is twice as high as the 0.5% for the reference scenario. In terms of geographical distribution the picture is very similar to the reference scenario, as can be seen in Figure 6-6.The ambitious scenario shows larger variation between countries, with expenditures as a share of GDP being as low as 0.2% in Luxembourg and ranging up to 3% for Bulgaria, reflecting the high expected costs of climate change for the latter. Compared to the reference scenario, the share of climate change adaptation expenditures related to the built environment is higher; 30% (€69.1 billion) in 2050 in the ambitious scenario versus 21% (€23.7 billion) in the reference scenario.

The ambitious scenario has been created by adding the bottom-up information on various CCA measures to the reference scenario, as described in Annex A section1.5.3. The case studies on Copenhagen (Annex B1), Rotterdam (Annex B2) and energy sector (Annex B4) were a major source of data on unit costs of adaptation-related investments. A large share of considered measures had to do with climate-proofing of infrastructure and energy sector. This leads to an increase in the share of expenditures related to the built environment and increases the share of adaptation expenditures to GDP in the countries with large public and energy infrastructure.

Figure 6-6 - Climate change adaptation expenditures as % of GDP in 2050 for the ambitious scenario

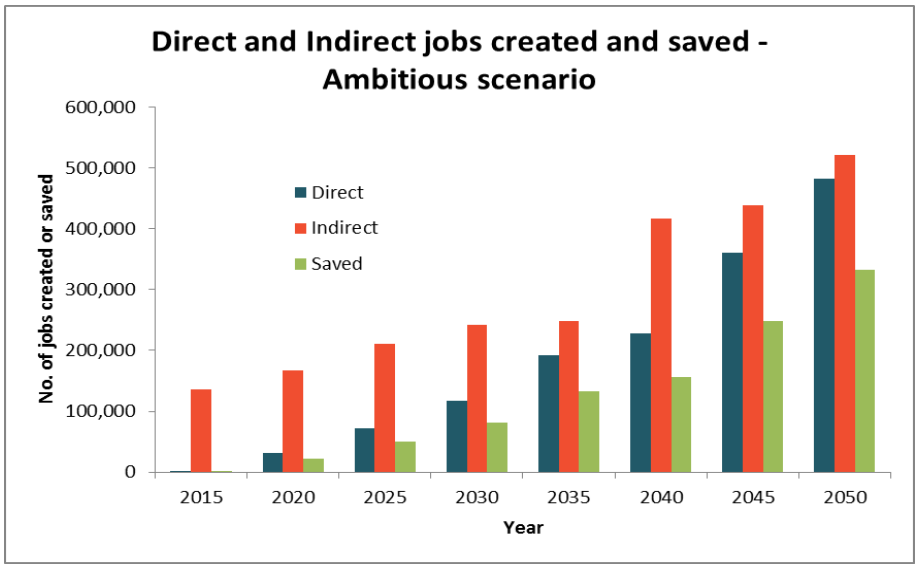


Source: own calculations

6.2.1 Impacts on employment in the short, medium and long term

Error! Reference source not found. shows the number of directly and indirectly created jobs and saved jobs in the ambitious scenario in the EU. At almost 200,000, the number of created jobs in the ambitious scenario in 2020 is almost four times as high as the number of created jobs in the reference scenario in 2020. The number of saved jobs is also considerably higher in this scenario than in the reference scenario (21 thousand by 2020 compared to less than 2 thousand).

Figure 6-7 - Total jobs created (direct and indirect) and saved for the EU from 2015 to 2050 in 5 year periods, compared to the baseline



Source: Own calculations

In 2050 the projected number of created jobs is larger than 1 million. This is more than twice the amount of jobs that are created in the reference scenario in 2050. This

is in line with the increase in CCA expenditures in terms of GDP, which is also a factor two higher in the ambitious scenario. Similarly, the number of saved jobs is more than twice higher than in the reference scenario in 2050.

Examples of some adaptation investments that create jobs based on case studies:

- **The Copenhagen Adaptation Plan** allocated in total about € 1 billion to adaptation measures over the next 30 years. This will create work in particular together with the publicly owned Copenhagen Utility (today called Greater Copenhagen Utility) in designing innovative projects, setting up innovation platforms and stakeholder forums to assess the potentials and enable a creative environment. Planning of such projects will require highly educated people in the fields of economics and engineering, but the majority of the jobs will be blue-collar sector jobs related to water management such as surveyors, road-maintenance workers and other construction workers. Moreover the maintenance is expected to also have a positive impact on employment.[34] For more details see Annex B1.
- **In Rotterdam** investments into outside dike area, dike reinforcement and urban water system will create an economic spin-off during 2012 and 2025 between EUR 2,317 million - approximately 28,400 man–years to generate – and EUR 5,023 million (generating 46,000 man-years). The measures will create jobs related to applied research, permitting and financing and project development as well as construction.[35] For more details see Annex B2.
- **In Ancona**, the early warning system setup required a total investment of € 1.5 million, which was spent on the purchase of instruments, their installation on the landslide area, and the computerised system in the monitoring centre (hardware and software). The operating costs amount to €250,000 per year, mostly used to pay the staff employed. The total investment required to prevent hydrogeological risk have been estimated at €45 billion, but less than 10% of it has been allocated to local basin authorities to carry out these works since 1990. The monitoring systems effectively support additional jobs in related traditional activities, and avoid the displacement of jobs for companies located in areas at risk.[36] For more details see Annex B3.

6.2.2 Impacts on unemployment in the short term

The number of jobs that are created in the short-run in the ambitious scenario by education level is shown in the figure below. The projected total number of jobs created is 137,000 in 2015, rising to over 280,000 in 2025. Compared to the reference scenario, the number of jobs created is higher in the ambitious scenario. However, relatively more jobs are created in 2015 where almost six times (5.9 times) as many jobs are created in the ambitious scenario than in the reference scenario. By 2025, the difference is only 3.4 times as many jobs in the ambitious scenario than in the reference scenario. This is due to the catch-up effect for some of the EU countries. They will spend relatively more on CCA activities in the beginning of the period.

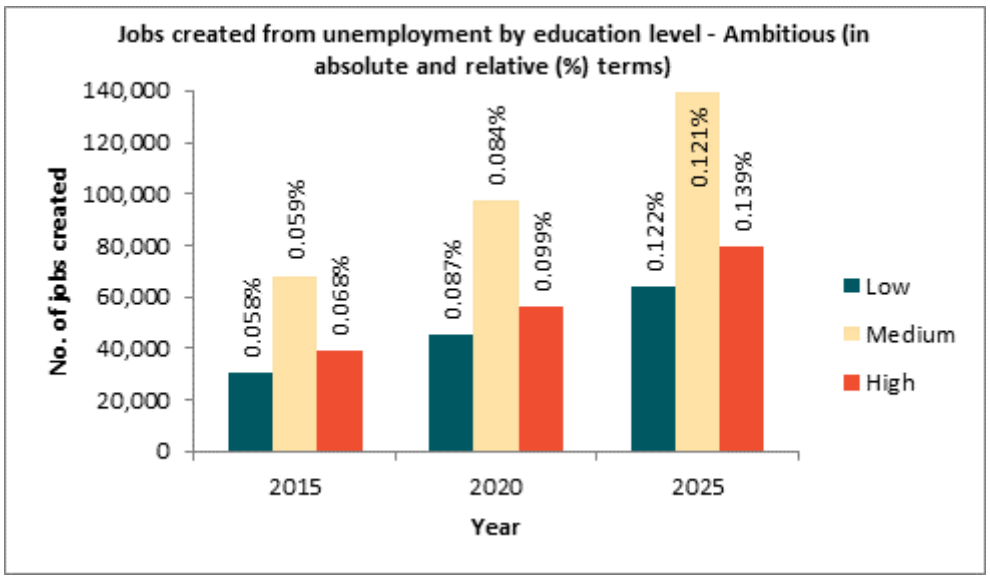
The demand for the different education levels is very similar to the distribution that was projected in the reference scenario.

Under the ambitious scenario, a shift of created jobs towards the highly educated people can be seen. They will get a higher relative advantage in terms of created jobs as compared to the reference scenario. This is because of the changes in the portfolio

[34] Interview with the municipality of Copenhagen, Copenhagen 2025 Climate Plan, 2011
[35] Rotterdam Climate Initiative (2010), Study on Economic Spin-off Effects of the Rotterdam Climate Proof programme
[36] Interview with the geologist on the local administration and responsible of the early warning system

of CCA investments under the ambitious scenario where more engineering and consulting work is required. The relative number of created low and medium education jobs is lower and there is very little difference between the two of them.

Figure 6-8 – Number of new jobs created from unemployment (in absolute and relative (%) terms) by education level for 2015, 2020 and 2025, for the ambitious scenario compared to baseline



Source: Own calculations, relative changes are calculated compared to the total number of employed people by education level.

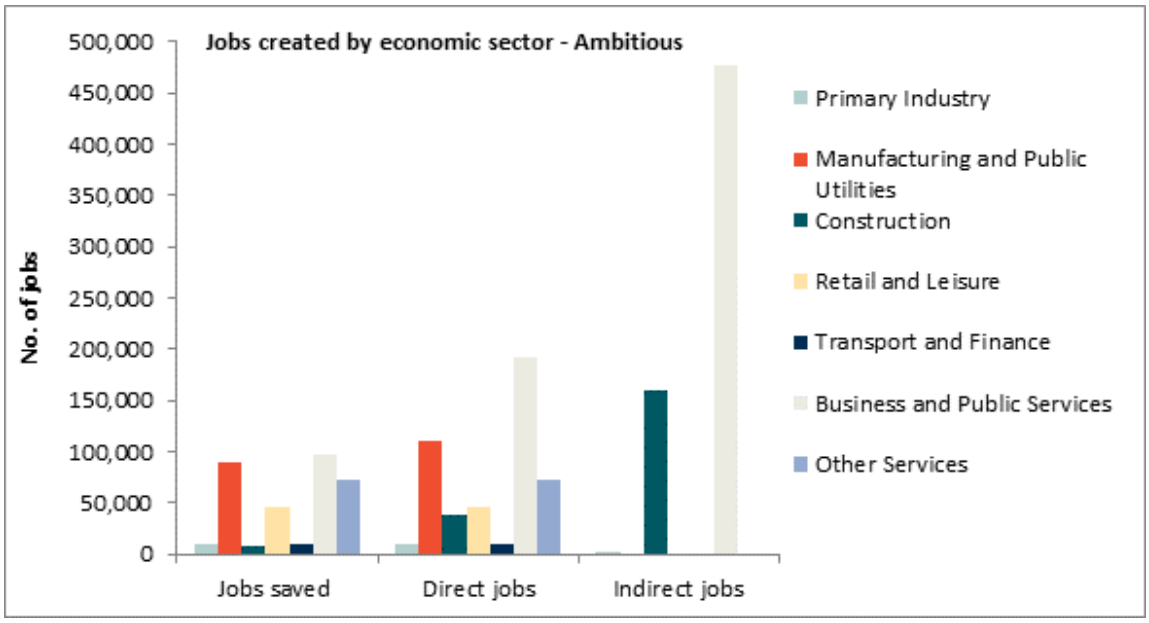
6.2.3 Sectoral and geographical results

The changes in employment for different sectors in the ambitious scenario (cf. Figure 6-9) show largely the same picture as the changes in employment for different sectors in the reference scenario. Most jobs are created in the business and public services sector and the construction sector. When looking at the more detailed sector classification, again, most of the jobs are created in public administration, health, education and research and development. The large number of jobs created in the construction sector for example is also consistent with the share of expenditures that are related to this sector. In addition, large expenditures directed towards the construction of buildings and roads translate into the purchase of both, physical materials and labour. Expenditures directed towards sectors providing services have a larger effect on jobs, as labour costs represent a larger share of the total costs for these sectors. Even though the same trends can be observed in the ambitious scenario, the number of jobs created is approximately double the one in the reference scenarios. This is consistent with the higher expenditure dedicated to adaptation in the ambitious scenario.

Saved jobs are the result of the mitigating effect of CCA expenditures on climate change damages. The largest number of jobs saved is in the 'Manufacturing and Public Utilities' and 'Business and Public Services' sector.

Furthermore, a large amount of direct jobs is created in the 'Business and Public Services' sector and 'Manufacturing and Public Utilities' that includes engineering, consultancy and financial services. These types of services are purchased as an important part of investments into Climate Change Adaptation. Relatively more jobs are created in these sectors in the ambitious scenario compared to the reference scenario. This is largely related to a proportionately large increase in investments related to improvement of infrastructure.

Figure 6-9 - Changes in employment for seven aggregated economic sectors decomposed into saved jobs, and directly and indirectly created jobs in 2050, compared to the baseline.



Source: Own calculations

***Energy and tourism sectors*:**

- Case study on the **energy sector** (Annex B4 section 4.1 and 4.2) shows that approximately EUR 15-19 billion per year are necessary (from now until 2080) to adapt EU's electricity sector to climate change. For example, the largest investments will be needed for electricity generation from offshore wind to adapt to sea-level rise (over EUR 4 billion), followed by investments in electricity grids to adapt to more intense storms and higher temperatures (EUR 2-4 billion). The increased incidence of flood impacts on thermal power plants (nuclear, biomass, and fossil-fuel based) amounts to EUR 3-6 billion (Rademaekers et al. 2010). Regarding job creation, adaptation measures tend to follow the direction of the main risks associated to the implementation site and government priorities to invest in the sector. For the UK, one of the main concerns is floods, hence it is expected that adaptation measures to decrease this risk will be adopted also in the energy sector. In addition, the timeline of implementation will depend on the adaptation measure and how politically important it is, although these new activities in 10 years are expected to streamline and become more established in the so-called "business as usual".[37] It is expected that jobs will be created for traditional engineers (civil mainly) to implement the projects, research and development activities and advanced technicians. For more details see Annex B4.

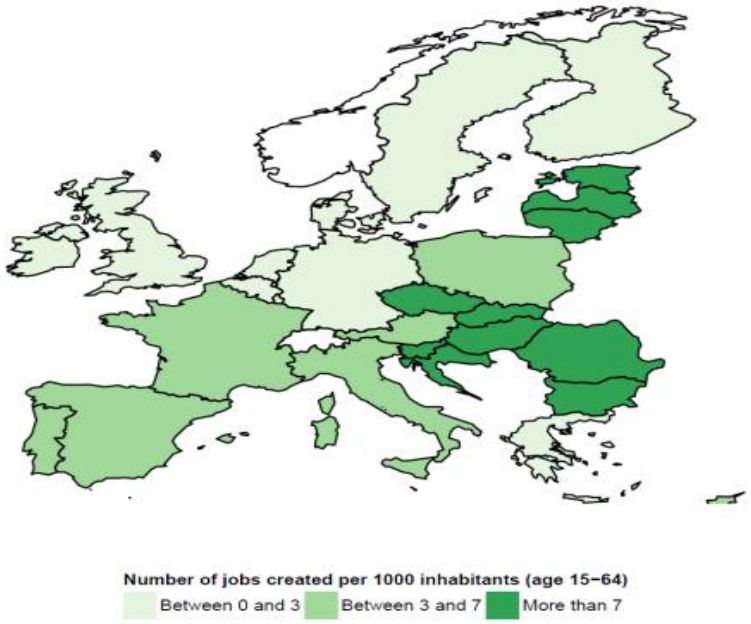
- Regarding **winter tourism** (case study in Annex B3), some adaptation strategies in the tourism sector may actually pose new problems and could therefore be considered as mal-adaptation. For example, snow-making is water and energy intensive; the grooming of ski slopes can reduce slope stability, while moving ski operations to higher altitudes can have adverse impacts on fragile environments (Agrawala 2007). An alternative is to de-seasonalise the offer and convert skiing facilities to summer tourism. However, none of these strategies is pursued exclusively in relation to climate change adaptation. Implementation of adaptation strategies overlaps with the strategy for diversification of

[37] Interview with Head of Research at the UK Energy & Utility Skills

the tourism offer. These strategies are implemented and financed mainly through diversified development contracts. In Rhone Alps, one such contract had an overall budget of EUR 800,000. This creates jobs mainly related to the diversification and de-seasonalisation, which have already been identified and do not appear to be difficult to source. Hence, in this case jobs related to these activities are not exclusively adaptation jobs.

Figure 6-10 shows the projected total number of jobs created in 2050 per 1000 individuals in the working age population for different countries in the EU. This map is virtually the same as the map shown in Figure 6-5, except that the number of jobs created is twice as high. The same geographical pattern can be seen, with relatively more jobs generated in Central and Eastern Europe (Slovakia, Czech Republic, Hungary, Slovenia, Croatia, Bulgaria, Romania and the Baltic states and relatively fewer jobs generated in Sweden, Finland, Denmark, etc.). The differences are mostly due to the variations in labour productivity between the countries.

Figure 6-10 – Total created per 1000 individualsfor 2050 in the ambitious scenario, compared to the baseline



Source: own calculations

6.3 Number of jobs per billion of adaptation expenditures

Table 6-1 shows the number of created jobs per billion EUR of expenditures related to the composite portfolio of adaptation measures by economic sector. In the reference scenario, a total of almost 63 thousand jobs will be created per EUR 1 billion of CCA expenditures, while in the ambitious scenario a total of 69 thousand jobs. These expenditures represent the combination of different types of climate change adaptation measures including mainly infrastructure, engineering and consultancy related expenditures. The direct expenditure of climate change adaptation activities give raise to indirect employment effects in primary industry, manufacturing, transport, retail and wholesale and services sectors. Both direct and indirect effects of climate change adaptation on jobs are captured by the figures in Table 6-1. This is why for example, primary industry has a relatively small number of jobs created while business and public services has a substantial amount.

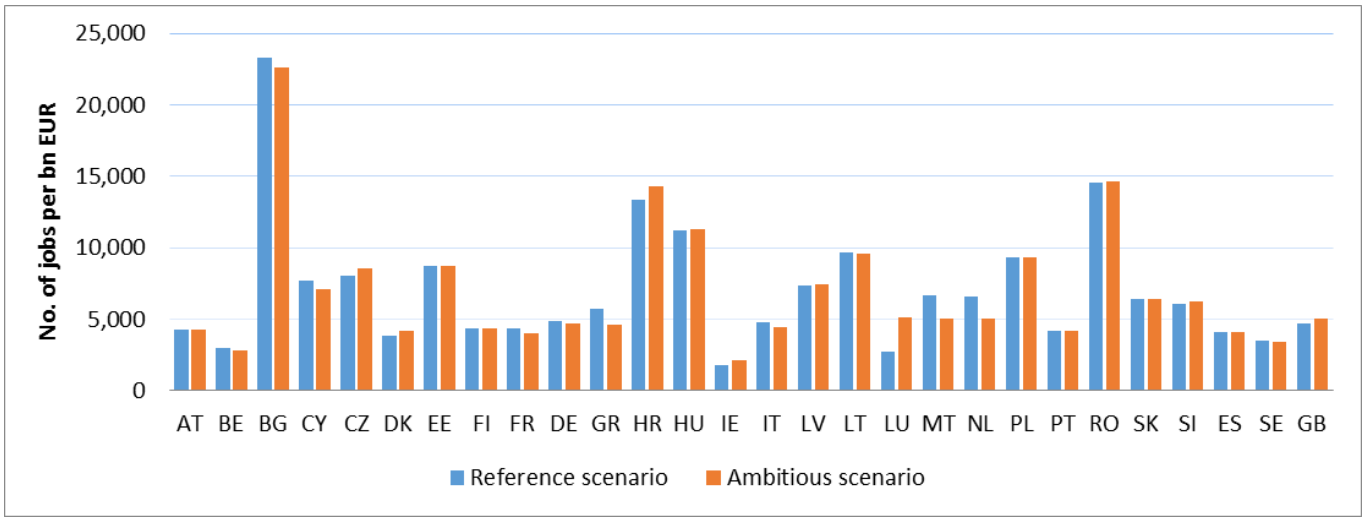
Table 6-1 Number of created jobs per billion EUR of adaptation measures per aggregated economic sector in 2050

	Reference scenario	Ambitious scenario
	Number of jobs created per billion EUR	
Primary Industry	464	638
Manufacturing and Public Utilities	16,220	16,119
Construction	6,142	3,737
Retail and leisure	587	886
Transport and Finance	112	181
Business and Public Services	39,365	47,768
Other Services	48	52
Total number of jobs	**62,938**	**69,381**

Source: own calculations

Figure 6-11 shows the variation among the EU MS on the number of jobs created per billion EUR in 2050.

Figure 6-11 – Number of created jobs per billion EUR of adaptation measures in 2050 for different EU countries



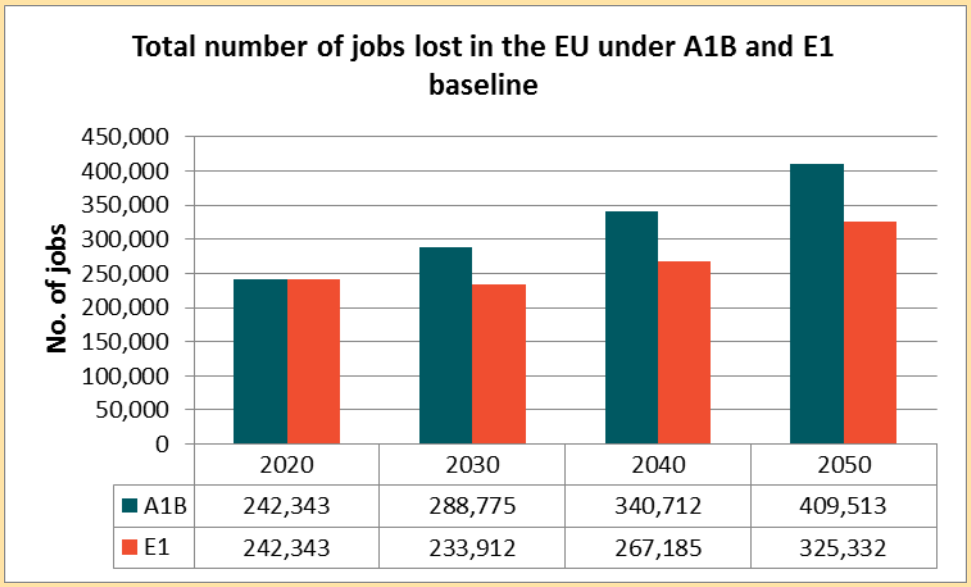
Source: own calculations

The highest number of jobs is created in Bulgaria, Croatia, Hungary and Romania. The lowest number of jobs is created in Belgium, Ireland and Sweden. This variation is explained firstly, by the difference in labour costs (hence labour productivity) between the countries. It is easier to create additional jobs in the countries with relatively low wages such as Bulgaria and Romania. Another explanation is the differences in the compositions of the CCA expenditures. Expenditures in building new infrastructure will create relatively more jobs as compared to financial services. The latter requires hiring people with high education that are more expensive and hence one can create less jobs with the same amount of monetary expenditures. More details for all Member States and the Reference scenario can be found in the Annex, section 1.6.

Comparing the results of two baselines

For the analysis of both, effects of climate change on jobs and the effects of CCA investments two baselines were used: (1) A1B IPCC scenario that corresponds to an increase in average temperature by 4 degrees by 2100 and (2) E1 ENSEMBLES scenario that includes climate mitigation component and corresponds to an increase in average temperature by 2 degrees by 2100. A1B scenario has much higher climate change damages in the long-run and hence results in higher loss of jobs as compared to the E1 baseline scenario. The Figure below represents the total number of lost jobs for the two baseline scenarios. The difference between them becomes larger in the medium and long-run.

Figure 1: The total number of lost jobs under A1B and E1 baseline scenarios



	2020	2030	2040	2050
A1B	242,343	288,775	340,712	409,513
E1	242,343	233,912	267,185	325,332

Source: Own estimations

The figure above only addresses the effect of climate change on employment and does not include adaptation measures. The effects of the CCA investments on jobs have been calculated for both E1 and A1B scenarios but the difference in relative effects proved to be very small. This means that the alternative E1 baseline scenario was dropped from the detailed analysis presented in the report and focus has been on the main A1B scenario of IPCC. The effects of CCA investments on jobs were a bit larger under the A1B scenario due to the long-term reductions in the total damage costs. They have allowed for saving more jobs in the long-run compared to the E1 baseline scenario.

7. Mapping skills, mismatches and shortages for adaptation activities in the EU

This chapter provides the mapping of the necessary skills for undertaking adaptation activities in Europe and their potential mismatches and shortages in the EU. It is based on both, qualitative and quantitative analysis, which assesses occupation types, skills as well as gender balance for jobs in the most important adaptation sectors.

Skills needs is understood here as the change in skills that is needed to adequately fulfil a certain job function in the future. Anticipation and management of skills needs is necessary to avoid skills shortages and/ or skills gaps in the future.

Skills gaps are understood as "situations in which the level of skills of the currently employed is less than that required to perform the job adequately or the type of skill does not match the requirements of the job" (CEDEFOP 2010c).

Skill shortages are defined as "a situation in which the demand for a particular type of skill exceeds the supply of available people with that skill" (CEDEFOP 2010c). This is marked by the absence of sufficient appropriately qualified and experienced people to undertake particular roles when employers seek them.

7.1 Skills assessment: what the quantitative results tell

7.1.1 Skills needed

Which occupations will be affected in the EU?
Occupations that will benefit the most from the climate change adaptation investments, and hence will be needed in the future include:

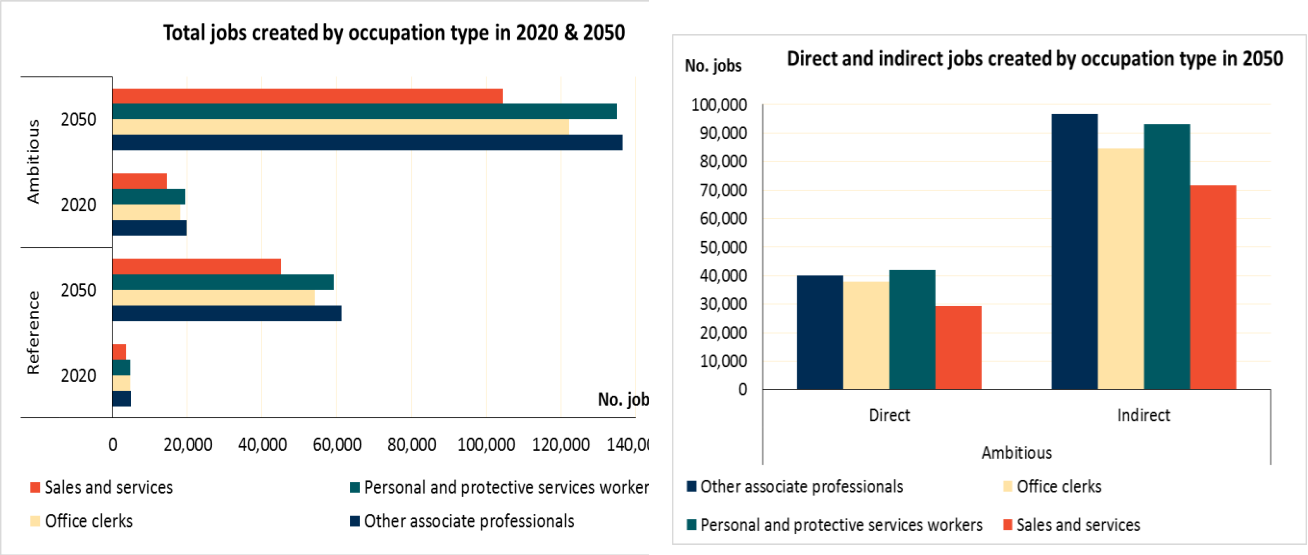
- '*other associate professionals*' and '*personal and protective services workers*' - these two types of professions are employed by the construction sector and 'other business services' sector that includes among others consulting services and engineering services. They represent 8% and 7% of the total employment of the construction sector and 9% and 9.5% of the total employment of the sector 'other business services'. Jobs falling under 'other associate professionals' include statisticians mathematicians, finance and sales associate professionals – insurers, real estate agents, technical and commercial sales people,[38] as well as environment and conservation professionals, researchers, planning engineers, building and civil engineering technicians and related professionals.[39] 'Personal and protective service workers' include medical assistants and fire-fighters.[40]
- Occupation '*office clerks*' is also affected relatively high which is explained by the fact that this occupation is widely used in various economic sectors and in particular in services. Jobs include production (planning, materials), accounting, statistical and finance clerks.[41]
- '*sales and services elementary occupations*' are also positively affected by climate change adaptation because the whole sale and retail trade is one of

[38] ILO classification http://www.ilo.org/public/english/bureau/stat/isco/isco88/34.htm
[39] HECSU's type of work categories
http://www.hecsu.ac.uk/assets/assets/documents/Wdgd_supporting_docs_TOW.pdf
[40] ILO classification http://www.ilo.org/public/english/bureau/stat/isco/isco88/51.htm
[41] ILO classification http://www.ilo.org/public/english/bureau/stat/isco/isco88/41.htm

the sectors that is directly affected (climate change adaptation investments go directly to this sector). Jobs include building workers (simple repairs, maintenance), meter readers in buildings and cleaners.[42] These are the low skilled jobs necessary for CCA repairs and maintenance.

This shows that **a variety of more generalist occupations will benefit particularly in the construction and consulting/ engineering sector**. Figure 7-1 below shows how this benefit evolves over time in the EU and how the level of adaptation affects this.

Figure 7-1 Jobs created by occupation type in the EU in 2020 and 2050 (total jobs) and directly and indirectly in 2050



Source: own calculations

It can be seen that **the benefits on these occupations are minor in the short-term but increase significantly in the long-run and as more adaptation activities are taking place**. It is also evident that these more 'general' occupations benefit to a large extent from jobs created indirectly due to climate change adaptation investments in other sectors. Thus, climate change adaptation has positive spill-over effects on occupations in sectors not directly affected by climate change adaptation.

France
France is the most affected MS, directly and indirectly for all the main occupations, comprising of around 20% of the total jobs created for each occupation in the EU. This can be explained by the fact that France is a large country and its share of CCA investments to GDP was also relatively large, hence many jobs are created. For example, France will have 15% of EU working population in 2050 and CCA expenditures will be higher than 1% of its GDP in the ambitious scenario. This is the highest combination in the group of EU countries.

Will there be disproportionate impacts on low/high skilled workers?
The education level is divided into three skill levels:

- *'low skills'* - People with low education represent a decreasing share of the working population of the EU. They are responsible for 25% of employment of

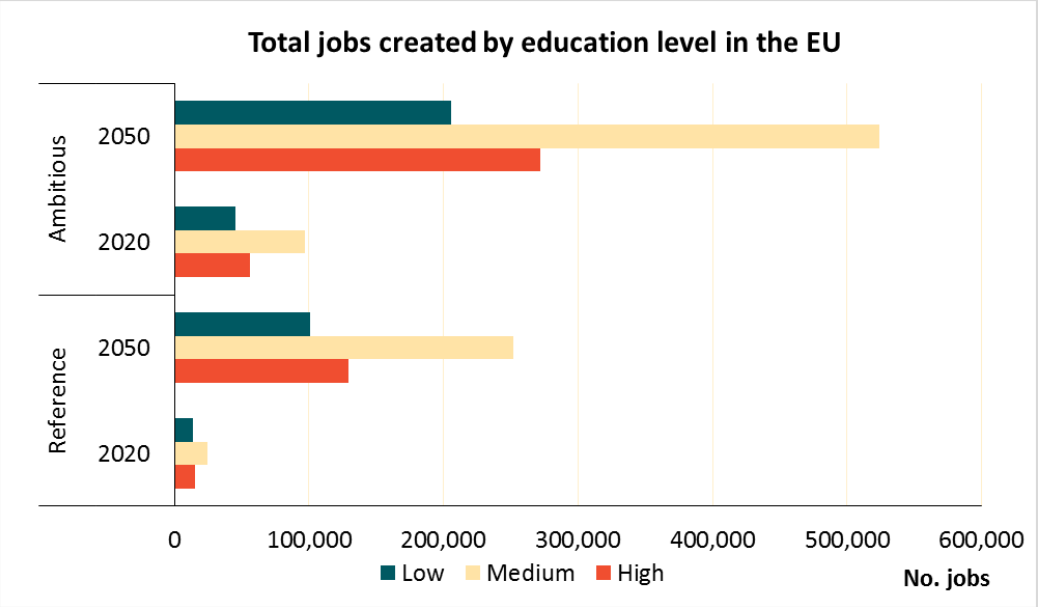
[42] ILO classification http://www.ilo.org/public/english/bureau/stat/isco/isco88/91.htm

the construction sector and 22% of the industry producing machinery and equipment.

- '*medium skills*' - The share of employment related for the people with the average education level is the highest in the majority of economic sectors.
- '*high skills*' – The high skilled workers have a great significance across several sectors. Even in the construction sector the highly-educated workers are responsible for 28% of the total employment of that economic sector.

The figure below shows how the education level is affected over time in the EU by the adaptation activities.

Figure 7-2 Total jobs created by education level in 2020 and 2050 in the EU



Source: Own calculations

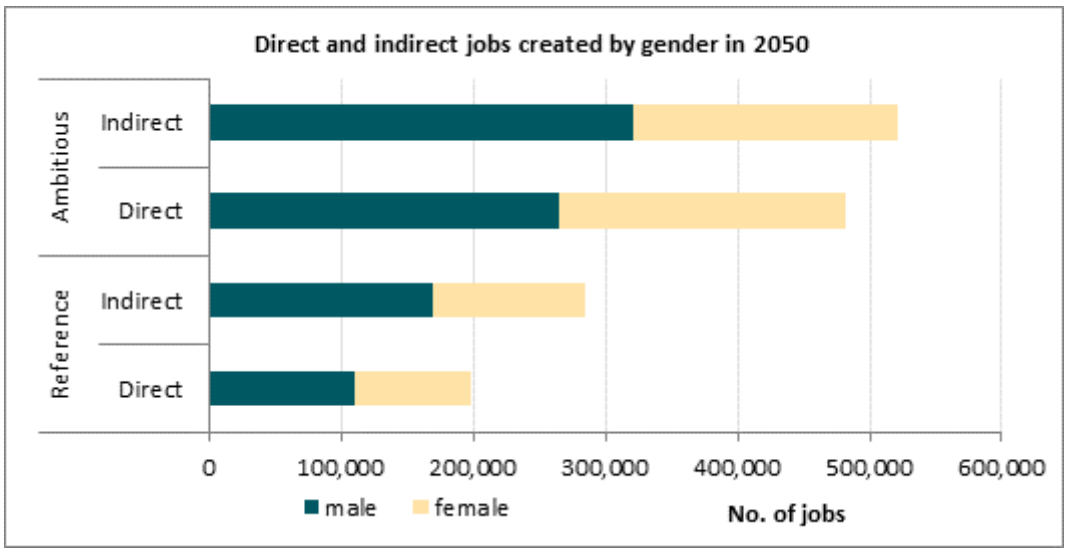
The highest number of jobs is created for the people with the average education level. They represent the largest working population group and are employed in all sectors of the economy. The number of jobs created for people with average level of education is almost two times higher than the number of jobs created for the highly educated people. This can be related to the main occupations affected by CCA investments, such as office clerks and protective service workers. The increasing number of high skilled workers can be explained by the fact that a large share of CCA investments is spend on consultancy, engineering and R&D related services where people with highest level of education are working. The overall employment share related to low skilled workers is relatively low compared to other education types and hence they have the lowest number of created jobs.

Regarding geographical differences, around 42-45% of high skilled jobs related to CCA investments will be created in France, Germany and Poland, where France covers more than 20% of the total. These three countries also account for around 40% of medium level jobs created due to CCA, where France alone covers 15% of the total. More than 50% of low level jobs created due to CCA are expected in Italy, France and Spain.

7.1.2 Results by gender

Climate change adaptation will favour jobs which are traditionally done by the male population. This is because the larger part of climate change adaptation investments is spend on economic activities such as construction, machinery and engineering where males have a certain dominance in most EU countries. The figure below shows the direct and indirect jobs created in 2050 by gender in the EU. The trend shows that the total number of created jobs increases gradually over time with the volume of CCA expenditures and is almost double as high under the Ambitious scenario as compared to the Reference one.

Figure 7-3 Total jobs created by gender directly and indirectly created in the EU in 2050



Source: own calculations

The number of indirectly created jobs is higher than that of directly created jobs. The main sources of indirect jobs include first of all positive forward and backward inter-sectoral linkages. For example, CCA expenditures lead to higher demand for construction services as well as machinery and equipment. This will be translated into an increase in the demand for the intermediate inputs of these sectors such as minerals and metals, services and industrial goods. This indirect effect will create additional jobs in the corresponding economic sectors. The figure above shows that the directly created jobs have a higher share of female jobs as compared to that share in the indirectly created jobs. This is explained by the indirect effects related to sectors such as construction services, machinery and equipment, which typically employ more males than females.

7.1.3 Skills mismatches and shortages

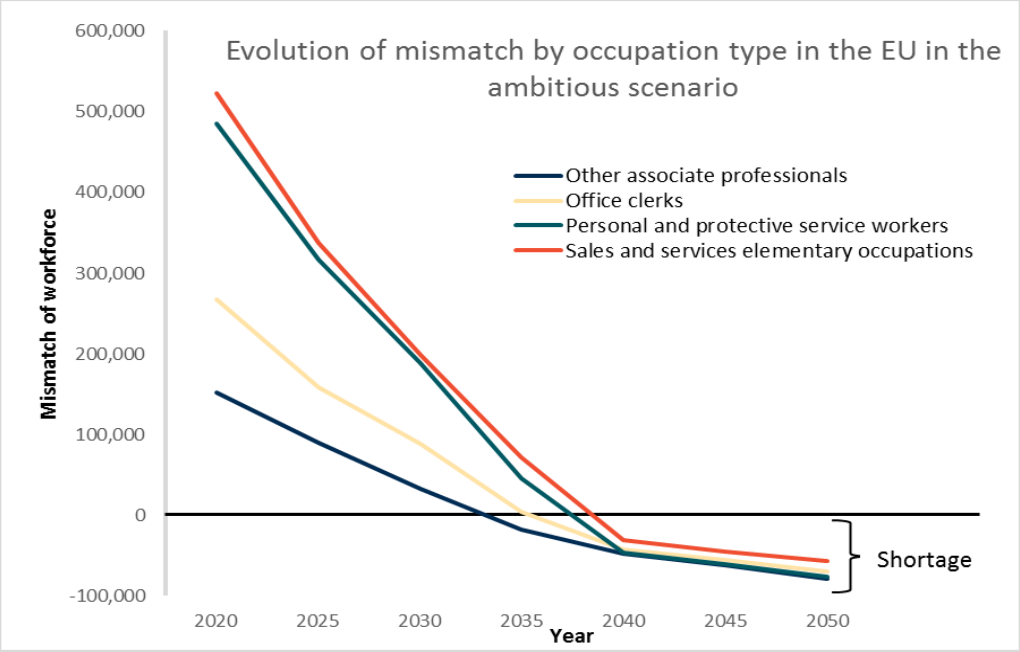
In order to calculate the mismatches between the skills of people available on the labour market and the new jobs created due to the CCA investments it was assumed that the people available to fill in new vacancies related to created jobs will come from the pool of unemployed. This assumption is justified since it is very difficult to assess the number of the employed people who would be willing to change their current job for another associated with CCA investments. There are no reliable statistics about on-the-job-search that could be used for this type of quantitatve analysis. In order to estimate the available pool of unemployed a linear projection of the unemployment rates by education and gender was made from the relatively high (for some countries) level to the level of structural unemployment in 2050 that is consistent with the forecast of the Europe Aging Report 2012. This means that the pool of available

unemployed will decrease over time together with the unemployment rates. In order to calculate the number of new vacancies related to CCA investments that have to be filled in, the total number of created jobs over all sectors of the economy was summed up. The mismatch is further calculated as the difference between the total number of available unemployed and the total number of new vacancies.

The results show that due to high unemployment rates, there will be no shortage of skills in the short-to-medium-term by occupation and education level and also no disproportionate effect on gender. However, in the long-run, potential manpower bottlenecks may occur due to increased CCA investments and decreasing unemployment rate.

The largest long-run mismatches are associated with occupation types which are the most affected by CCA investments. These are the aforementioned 'other associate professionals', 'personal and protective service workers', and 'other business services'. In the short-run there is oversupply of people available to fill these positions, which might be explained by the fact that these occupations are of rather general character and cut across a large variety of economic sectors and range across different education levels. A similar trend can be seen in the reference scenario.

Figure 7-4 Evolution of mismatch of workforce by occupation type in the EU in the ambitious scenario



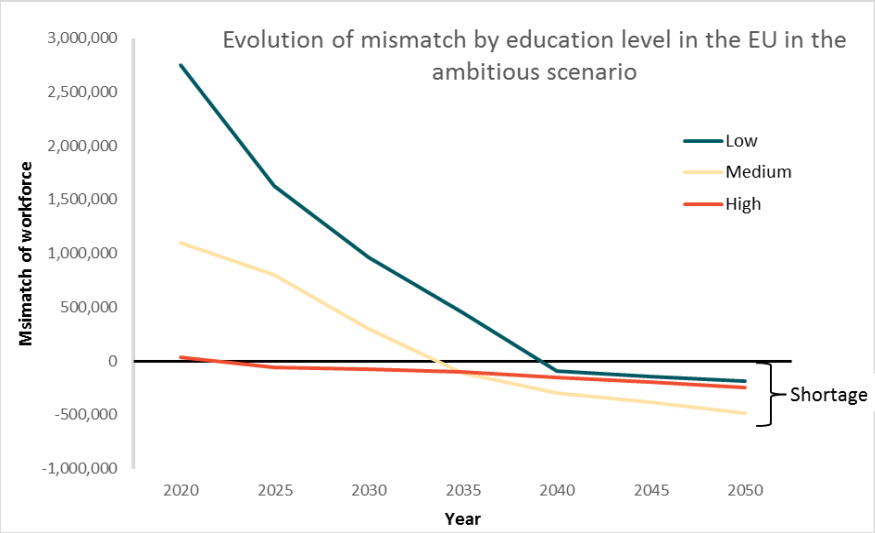
Source: Own calculations

The figure above shows that in the long-run manpower bottleneck may occur for these four types of occupations, the highest being in consulting and engineering services (other associate professionals) and construction workers (personal and protective service workers).

Climate change adaptation activities are expected to have a disproportionate impact on low skilled people since the CCA activities will favour medium and high skilled people (secondary/tertiary education) since the majority of adaptation jobs will be created for this education level. The workers with average level of education are the largest group of employed and hence the mismatches for them will be the largest. What can be observed is that shortages for high skilled people are expected to occur

much earlier than for low and medium skilled people. The reason is that the highly educated people are employed with a relatively high employment share of 25-30% in the economic sectors directly affected by CCA investments. These sectors include construction, machinery and equipment, other business services, R&D and education.

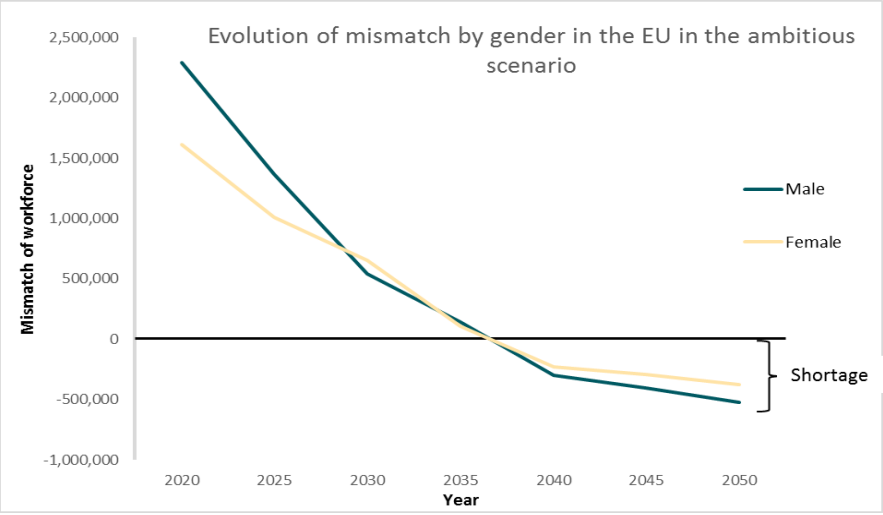
Figure 7-5 Evolution of mismatch of workforce by education level in the EU in the ambitious scenario



Source: Own calculations

On the other hand, CCA investments are not expected to have large disproportionate impact on gender (even if jobs done by males are in a greater demand). Both male and female jobs will be in oversupply in the short-to-medium term and there are some shortages expected in the long run.

Figure 7-6 Evolution of mismatch of workforce by gender in the EU in the ambitious scenario



Source: Own calculations

7.2 Skills assessment: a more qualitative approach

This section relies primarily on qualitative analysis through case studies (found in Annex B1-B5) and stakeholder interviews. It looks at the most important adaptation

sectors and gives concrete examples of skills needed and potential skills shortages for adaptation related activities.

7.2.1 Skills needed

Impact on high/ medium/ low skilled people
Qualitative analysis showed similarly as the quantitative analysis that there will be a need for the mixture of different levels of skills. The Oxfam (2010) report shows that adaptation related jobs require all skills type and levels. This ranges from farmworkers to civil engineers, planners, construction workers and environmental managers. The application of the skills can range from manufacturing plants to national forests and include private as well as public entities. Case studies of Copenhagen (Annex B1, section 2.3), Rotterdam (Annex B2, section 3.3) and Ancona (Annex B3, section 4.3) also showed that high skilled people will be needed for the more technical and R&D jobs, while low skilled people are needed for the construction works and repair of damages.

The focus of interviewees has been predominantly on 'proactive' or anticipating adaptation, which will require attracting and developing high-level Science Technology Engineering and Mathematics (STEM) skills which are expected to be key across all technologies. Monitoring and network management skills will also be affected by this trend, depending on the extent to which consumers adopt and use these new technologies. Moreover, BIS (2011) identifies some key skills supporting climate resilience: technical skills such as modelling and interpreting climate change projections; risk management such as assessment of future resource availability; skills to design and adopt technologies, products and processes to improve resilience; operator level actions such as retrofitting water efficient technologies in household and business premises) (BIS 2011).

Impact on new and existing skills
Similarly to the green skills discussion, it seems that in most cases the focus will be on topping existing skills rather than creating new competences. This is because good generic skills can be used for other occupations as well, including green or adaptation related jobs.[43] This will be characterised by additional training to familiarise workers with new adaptation-related concepts and practices. However, even up-skilling may require significant investment in skills in some sectors due to the scale of up-skilling required (CEDEFOP briefing note 2010). For example, making buildings climate resilient might require a huge amount of workers to be up-skilled, which creates a concern on meeting this skills demand even if up-skilling is not that complicated.

There is also demand expected for new skills (BIS 2010b), hence to some extent new skills will also be relevant for adaptation-related jobs, e.g. designing new energy utility solutions.[44]

UK is already taking a step forward to identify the anticipated demand for new skills. The Energy & Utility Skills Group have developed reports on the skill needs for gas, power industry and water management. In these reports (EU Skills 2013) they identify some specific new skills needed, which are related to climate change adaptation:

- *Water managemen*t

[43] Interview with UK Energy & Utility skills
[44] Interview for Copenhagen case study (Annex B1)

  - Need for multi skilled network and process technicians, i.e. "mix and match" qualifications for optimum role flexibility, trend towards modularisation
  - Need for staff better equipped to work with new 'cutting-edge' technologies and systems, mainly for network and process technicians working with wastewater.
  - Raising awareness of water efficiency technologies among plumbers.
- *Power and gas sector*
  - In terms of supply and demand balancing, smart networks will create a need for knowledge and understanding around 'big data analytics'
  - More specialist process engineers to develop knowledge in most efficient technologies
  - Engineering skills in different operation systems, such as transmission networks
  - More commercial awareness skills to engineer in order to better inform customers, particularly for smart meter installations to advise them how to have the better use it;
  - Provide to installers additional modular qualifications, particularly regarding smart meter installations
  - Specialist scientific knowledge to process engineers to lead research studies in order to reduce error rates;
  - Up-skilled analysts, network operatives and planners due to the more complexity of the systems.

Impact on occupation types

Construction sector
The case studies (primarily the Copenhagen case study, Annex B1) and desk research showed that in the *construction sector*, skills required to make buildings more climate resilient overlap with mitigation skills to design and construct energy-efficient buildings. They require primarily familiar skills from the construction sector, but they also require incremental training to understand how those skills can be applied in the construction of energy-efficient structures (OECD 2012).

Specific skills and occupations needed in the construction sector related to making buildings climate resilient (which overlaps with energy efficiency) include (see Copenhagen case study, Annex B1, section 2.3):

- architects,
- environmental engineers, digital technological skills
- auditors,
- craftsmen, repair & maintenance
- technicians and
- technical sales and marketing to customers and insurers and financiers.

In general, jobs created in energy efficiency tend to be skilled, stable and not subject to delocalisation (COM (2011) 109 final). Moreover, energy efficient building solutions are often technically demanding and as such require high skilled labour force.

Water management
Based on the information from case studies on Copenhagen (Annex B1, section 2.3) and Rotterdam (Annex B2, section 3,.3), adaptation skills needed in the water management are expected to cut across different skill levels, ranging from high to low skilled labour force. Measures related to coastal defences and protection of coastal zones or any other city flood protection measures require high skilled people to do integrated modelling and climate risk assessment, project management, consulting

and engineering. However, a lot of blue-collar manpower is needed to implement infrastructure projects. Many projects currently exist across Portugal, Spain, Germany, Italy, Denmark, Greece, United Kingdom, Romania and Netherlands related to the protection of coastal zone, as could be seen from the bottom-up research (see Additional Documentation submitted separately from the report for further reference). These projects involve measures such as beach nourishment, "hard" coastal structures, creation of plans for coastal management and measures to avoid coastal erosion. Hence, the need for these types of skills is expected to be high in the short-run at least.

The Box below shows an example of skills needed for adaptation in the water management sector based on the Copenhagen (Annex B1, section 2.3) and Rotterdam case study (Annex B2, section 3.3).

Water management employment and skills in Copenhagen and Rotterdam

The mapping of employment and skills needs in the **Copenhagen** case study (see Annex B1) indicates that while planning will require highly educated people in the fields of economics and engineering, the majority of the jobs will be blue-collar sector jobs related to water management such as surveyors, road-maintenance workers and other construction workers. Not only the construction of new infrastructure will create jobs but also the maintenance is expected to have a positive impact on employment.

In the **Rotterdam** case (Annex B2), a floating building has been designed that is protected against flooding. The preparatory phase involved higher educated people (science, technology, engineering and mathematics skills set) and senior officials. At this stage, all activities are related to applied research, permitting and financing and project development. Labour forces are dominantly construction workers managed by high skilled professionals.

Another adaptation activity to protect the city from flooding is the adaptation of quays and banks. The distribution of labour is related to project development and planning on one hand and the construction on the other. As this process is less innovative than for example the floating building project, the proportion of the budget going to the pre-construction phase (thus R&D, project development/ planning, permitting, financial closure) is much lower (circa 10-20%). As such, 70-80% of the labour is related to blue-collar construction workers.

Energy generation, transmission and distribution

In the energy sector, it is expected that jobs will be created for traditional engineers (civil mainly) to implement the projects, research and development activities and advanced technicians. In the implementation phase the highest share of job creation (man power) will be related to construction workers.[45]

The main adaptation activities in the sector were linked to the main occupation types and disciplines (see case study on the energy sector, Annex B4 section 5.2 and 5.3). The following occupation types were taken into account: manufacture and installation; engineering; monitoring; operation and maintenance; research and development (R&D); management; consulting services; and administrative. The main occupation throughout all the adaptation activities in the energy sector is manufacture & installation, mainly related to the installation of additional capacity of plants, as well as for the implementation of devices or means to increase the efficiency and resilience. Engineering services have also a great share of the occupation types in the energy sector due to the design of upgraded plants or the need to identify techniques to adjust construction or to improve the operation systems. For more details see the

[45] Interview with Head of Research of the UK Energy & Utility Skills Group

case study on the energy sector (Annex B4, section 5.3). There will also be a continued need for more generic, cross-sector skills, including first line management, engineering skills and project management.

Disaster risk management and preparedness sector
In the disaster preparedness sector it is expected that skills at all levels will be needed (see cases study on Ancona, Annex B3 section 4.3). Over the years, EU cooperation in civil protection has evolved significantly, shifting the focus from response to preparedness, prevention and risk management measures. The Community Civil Protection Mechanism created in 2001 (Council Decision 2007/779/EC, Euratom[46]) aims to improve the coordination of civil protection response in major emergencies by defining the obligations of the EU28.

The new civil protection legislation, the 2013 Union Civil Protection Mechanism[47], incorporates a number of activities to strengthen risk prevention: expand knowledge base on disaster risk; increase monitoring and mapping of natural and man-made disaster risks; increase prevention activities and awareness-raising; report to the Commission on risks and risks management planning. In particular, paragraph (C) article 6 requires Member Country to assess their risk management capability, including at national and relevant subnational level. In terms of response preparedness, the Union Mechanism requires the Commission to manage the Emergency Response Coordination Centre (ERCC), the Common Emergency Communication and Information System (CECIS) and to facilitate coordination and interchanges among countries. Member States are required to regularly update the Commission on disaster risk assessments and on their risk management capabilities to deal with the identified risks. In practice, Member States have to assess whether they have a sufficient number of experts and processes in place to ensure the identified risks are correctly managed. Experts involved at various stages of the risk management process represent highly skilled labour. High level skills will also be required for the administrative support of these operations and in the private sector organisations contracted to supply equipment and supporting expertise.

The European Emergency Response Capacity (EERC) is a pool of capabilities and modules[48] that Member States make available for response within and outside the EU. The Union Decision addresses capacity gaps with the provisions at article 13, *Training, exercises, lessons learnt and knowledge dissemination.* Article 13 puts emphasis on the development of complementary capabilities across Member States with the facilitation of mutual learning and the development of experts' competences.[49] Initiatives such as the European Civil Protection Training Programme[50] are already in place to provide specific preparation to practitioners at different levels. These curricula incorporate climate-related risks and response strategies, including the identification of appropriate monitoring tools (see preparedness policy[51]).

Risk prevention approaches in the European Adaptation Strategy promote measures such as Early Warning Systems. They require a mix of high level skills to cover the operational phase of the monitoring system and a very high level set of skills in the

[46] Link to the council decision: http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32007D0779(01)
[47]http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1401964135427&uri=CELEX:32013D1313
[48] self-sufficient and autonomous predefined task- and needs-driven arrangement of Member States' capabilities or a mobile operational team of the Member States, representing a combination of human and material means that can be described in terms of its capacity for intervention or by the task(s) it is able to undertake
[49] Source: http://ec.europa.eu/echo/policies/disaster_response/mechanism_en.htm
[50] http://ec.europa.eu/echo/civil_protection/civil/prote/pdfdocs/Training%20brochure.pdf
[51] http://ec.europa.eu/echo/policies/prevention_preparedness/preparedness_en.htm#ews

supply chain. The following skills/job roles have been required at various stages (see case study on Ancona, Annex B3 section 4.3):

- *Supply chain:* electronic and software engineers, geologists and geotechnicians, supported by laboratory and testing engineers.
- *During installation, maintenance and operation of the system*: geologists and geotechnicians, surveyors, telecommunication and GPS engineers, hardware for geological monitoring engineers, software and systems integration.
- *Supporting roles*: the system's main role is to alarm the local population on time if a major landslide event is due to happen. The success of this system relies on
    - Public safety services
    - Health emergency sector
    - Local disaster planning
    - Information and sensitisation campaigners
- *Related risk reduction actions***:** geologists and civil engineers (studies and assessments, prioritisation of actions), town, transport and country planners, engineers, earthworks workers and mobile-plant operators (risk reduction operation on the field)

Moreover, highly skilled workers will be needed for consulting services, development and distribution of mobile information technology, and improvement of strategic training services and programmes. Blue-collar manpower would be important for implementation of ad hoc response measures. Reconstruction activities will require the traditional set of professions and skills, from construction workers planners, engineers and architects.

Currently, the revised Environmental Impact Assessment Directive already requires a consideration of the vulnerability of projects to disaster risks[52]. Some Member States have already included hydrogeological risk into national planning regulations (Italy for example requires building standards to be related to the earthquake risk of the area[53]). The demand for skills in disaster risk management and preparedness from the private sector is instead highly correlated with economic activity, as investment in monitoring and prevention systems are usually suspended during economic downturns.

7.2.2 Skills mismatches and shortages

According to the interviews with several stakeholders (see Additional Documentation on bottom up research submitted separately from the report for further information), potential skills mismatches and shortages are expected to be related to the STEM group of competences ***– science, technology, engineering and mathematics*** – in which Europe continues to suffer deficiencies. STEM skills will need to be improved at secondary and tertiary levels as they provide the basis for high-level adaptation skills.

Energy generation, distribution & transmission sector
Skills shortages might be expected due to the technological change within the energy sector (see case study on energy, Annex B4), and will depend on the countries' capacity to promote measures across the entire sector.[54] Currently stakeholders are aware of the existing gaps and shortages, as well as the associated trends and are willing to fill the gaps.

[52] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0052&from=EN
[53] P.C.M. n. 3274 20 March 2003, updated on 16/01/2006
[54] Interview with Head of Research of the UK Energy & Utility Skills Group

Disaster risk preparedness and response
To assess skills mismatches and gaps in this sector, the early warning system in Ancona was analysed (see Annex B3, section 5.1). The main skill gap identified concerns the specific combination of technical and organizational skills. Gaps in technical skills are due to the extremely innovative nature and complexity of the system. According to Stefano Cardellini[55], only a handful of firms in Italy were able to support the delivery of this system at the commissioning phase (starting in 2006), while experts in the operation of this type of systems were virtually non-existent. The current team received basic training from the hardware suppliers; afterwards they have been teaching themselves how to run and maintain the equipment and are involved in planning for its extension to other areas of the region. Recent international exchange (with Sweden and the UK), involving the local administration and suppliers, suggests that this type of skills shortage is not unique to Italy.

It is also very difficult to identify people able to design, develop and deliver the type of technology needed for the early warning system. The reasons behind the skill gap are clearly identifiable:

- Developing these systems requires technical workers expert both in geology and engineering.
- It is a niche sector, still very new and which has a limited number of applications.
- It is a sector largely dependent on public investment in monitoring technologies. However, often the public budget is used in remediation actions (post disaster) which are much more expensive. The result is that there is very little investment in monitoring.

The supply chain companies often have to further invest on the training of new recruits. According to one source within the industry estimates that training activities require up to two years. The supply chain is often connected with universities, but most of the exchange and research projects rely on EU and national funding.

The skills gap is mostly related to the monitoring system, while there is no evident gap to deliver the supporting activities (supporting roles and risk reduction interventions). The main issue related to the supporting activities is the availability of funding to regularly carry out these actions.

Not everyone expects skills bottlenecks
The case study of Copenhagen (Annex B1, section 2.1) showed that not everyone expects skills shortages for adaptation activities. The availability of people in large technical consultancies, the university and construction companies, both in Copenhagen and in Denmark in general, are expected to be adequate to meet the demand for different positions. Only in occurrences when the timing of several infrastructure projects coincides could hamper the availability of construction workers; however this is expected to be an ad hoc problem rather than a structural challenge.[56]

Some training and the collaboration between the city, companies and stakeholders will help employers to meet skills challenges related to adaptation.

[55] Geologist on the local administration and responsible of the early warning system.
[56] Interview with the municipality of Copenhagen

8. Policy recommendations

8.1 Best practices

The review of the national adaptation strategies available at Climate-Adapt as well as of 6 (local/regional strategies) suggested some good and bad practises in adaptation policies with implications on employment. As discussed in chapter 3, the evidence on employment considerations are limited but there are some good examples. The *Danish Action Plan* has a separate section on Green transition - growth and employment which describes opportunities for Danish companies in terms of global opportunities, innovation on the domestic market, and public-private collaboration. In addition, *Copenhagen* has started research on adaptation jobs and skills given the large programme on adaptation (see Annex B1, section 2.1). The *Swedish* climate change vulnerability assessment does not assess the direct implications of climate change adaptation but does acknowledge the importance of vulnerable sectors, such as fishing, for employment in coastal communities. The *Maltese strategy* has a particular focus on communications and the Maltese Resource Authority[57] shall form a partnership with relevant stakeholders such as employee representatives, employer representatives and local councils.

The Intergovernmental Panel on Climate Change (IPCC) defines maladaptation as actions that inadvertently increase vulnerability to climate stimuli.[58] An example of maladaptation is artificial snowmaking (water and energy intensive). Measures to protect skiing tourism, such as grooming of slopes and moving resorts to higher altitudes can also have other adverse impacts on the environment. Therefore, adaptation policies should assess the options of adapting current activities to climate change vs. diversifying activities (for more detail on winter tourism, see Annex B4). Policies should not only consider "climate-proofing" current activities but to explore new opportunities. Isere in the French Alps has started to diversify tourism base to cover summer tourism as well.[59] The origin of the strategy was not climate change but to offer better employment opportunities for the local workforce. Diversifying tourism base is a low-risk strategy because irrespective of the future climate change the economy will benefit from summer tourism as well.

8.2 Priority issues to be addressed

The analysis carried out in this study suggests that climate change will have an adverse effect on employment and therefore many jobs will be lost in the EU by 2050. The most negatively affected sectors are 'manufacturing and public utilities' including manufacturing, electricity, gas and water supply. Similar amount of jobs will also be lost in 'retail and leisure' sector although in relative terms (comparing the number of jobs lost to the number of people employed by the sector) manufacturing and public utilities is much worse off due to the smaller size of the sector. The number of lost jobs in the primary industry including agriculture is relatively small although there are large distributional effects: agriculture sector Hungary, Denmark and Belgium are expected to benefit from climate change but on the other hand losses are expected for example in France, Austria, Germany, Italy, Austria and Estonia. Looking at the overall employment impact of climate change, Latvia, Lithuania Bulgaria, Croatia, Cyprus, Estonia, Greece and Romania are most adversely affected. This is why climate change adaptation will be important and needs to be considered also with respect to employment policies.

[57] Responsible authority for climate change
[58] http://www.ipcc.ch/pdf/glossary/tar-ipcc-terms-en.pdf
[59] Also the Alps regional adaptation strategy promotes inter-seasonal tourism.

Member States and regions/localities, in general, seem not to be prepared in terms of understanding the employment and skills effects of climate change and climate change adaptation. The review of national and local adaptation strategies suggested that employment implications of CCA are not present in the strategies.

8.2.1 Addressing employment considerations in vulnerability hotspots

Climate change adaptation will have both positive and negative employment effects. There will be job growth in some sectors whilst the effect on skills will be fairly widespread.

Most affected countries, i.e. countries that will lose most jobs are Bulgaria, Croatia Greece, Romania and the Baltic States (Estonia, Latvia and Lithuania). These countries not only have high climate change damage costs but also a relatively high share a people employed by unit of output. These countries experience negative effects on climate change on their agriculture and tourism sectors with high number of employed per unit of output.

8.2.2 Promoting intra-sectoral mobility

The analysis also showed that the number of jobs created due to climate change adaptation expenditures also varies between MS and EU regions. For example, Eastern Europe (in particular Bulgaria, Croatia, and Romania) as well as Greece and the Baltic face largest risk from climate change including economic and employment impacts on the most vulnerable sectors. On the other hand, Central and Eastern European countries[60] also have the largest increase in the number of jobs (as a share of the working population in the country) due to climate change adaptation activities. As none of the sectors are expected to experience major reconstructing due to CCA, it is important to focus on promotion of intra-sectorial mobility to address such skills needs.

8.2.3 Bridging the skills gaps & shortages

In the long run, skills shortages are also expected in certain occupations and education levels. For example, in relative terms the high skilled labour will benefit the most. A large share of CCA investments is spend on consultancy, engineering and R&D related services where people with highest level of education are working. Other affected occupations are personal and protective service workers such as medical assistants and fire-fighters. Moreover, it is expected that both men but also women will be needed to meet these shortages.

8.3 Policy options

There are several ways in which the European Commission and Member States can promote the transition to a climate resilient EU economy, focusing on job creation and the provision of adequate skills. Such policy instruments and supporting measures can be categorised into two groups:

1. Mainstreaming employment and skills aspects into adaptation policies, and
2. Mainstreaming adaptation aspects into employment and skills policies.

Several options identifying the entry points into EU adaptation and employment policies to optimise the employment opportunities associated with climate change adaptation have been assessed. The top eight recommendations are presented below.

[60] Latvia, Lithuania, Poland, Czech Republic, Slovakia, Hungary, Croatia, Romania and Bulgaria

8.3.1 Integrating employment and skills considerations in adaptation policies

Employment and skills considerations can be integrated into adaptation policies at EU level, national and local level. The focus is on EU and local level.

EU level

1. ***LIFE+ Programme***

Short description of the programme

LIFE Programme is an EU financial instrument for the environment. The new LIFE Regulation for funding period 2014-2020 establishes Climate-Action sub-programme, with Climate change adaptation as one of its three priority areas. The first call for proposals under this new regulation (LIFE 2014 call) took place in the second half of June 2014.

However, there have been some adaptation projects already in the previous funding periods. Moreover, even though the aim of the programme is not to create jobs and develop skills, the programme has played an important role in this.[61] For example, the output indicators reported by the project beneficiaries, which measure performance of LIFE+ projects, include training (e.g. number of training provided, number of sessions, number of people, total cost, etc.) and educational activities (i.e. number of students involved in different educational levels). These output indicators are collected for all LIFE+ projects. They show that for example as part of LIFE projects during the period 2007-2010, there have been in total more than 4,000 training sessions organised involving more than 85,000 people and educational activities involving more than 1.2 million students.[62] Even if climate change adaptation projects are only one fraction of LIFE projects, there is a great potential for developing training and educational activities.

Concrete policy recommendations

a) Identify and apply best practices of LIFE projects that consider skills and employment aspects

Several best practices related to 'green' employment have been identified in past funded projects. New adaptation projects to be funded could build on these good practices and apply them to the adaptation context.

Projects (best practices related to employment)[63]:

- *Usa e Riusa* (Italy) – in the project, the company made sure all managers acquired the necessary green skills and they employed a dedicated person to oversee environmental affairs, security and quality control. He made sure all employees are familiar with the new procedures and implementing them. Moreover, regular training was "essential" to keep the skills updated.
- *Forest Cities (Greece)* – the project helped develop know-how in modern technologies on forest fire prevention planning and trained local civil protection officers how to implement it. The project was cooperation between academics who developed the know-how together with stakeholders and then trained two

[61] Camarsa, G. et al. (2013), "LIFE creating green jobs and skills", European Commission, Luxembourg: Publication Office of the European Union

[62] Rob Williams et al. (2012), "Final evaluation of the implementation of the LIFE+ Regulation", DG Environment, European Commission

[63] Camarsa, G. et al. (2013), "LIFE creating green jobs and skills", European Commission, Luxembourg: Publication Office of the European Union

local authorities to develop complete local action plans to provide an example to others. The result was a template with detailed guidelines that could be used to develop a local forest fire action plan in any area of Greece.

- *LEADFREE* project (Germany) – set-up of a non-profit training centre. Some 700 companies received training in the form of workshops and trials.
- *RCYCL* – working with employment services to train unemployed and disadvantaged groups. This project shows the benefits of governments working with employment services to address the needs of employers and the labour market. This approach could be applied to adaptation projects needing low/ medium-level skills for example.
- *RENEW BUILDING* (Austria) – providing architects and builders with training in sustainable construction techniques. The project developed nine sustainable concepts that could be taught and explained to architects and craftsmen.
- *SUN EAGLE* project (Italy) – the project involved design, organisation and launching of green skills training to top up the skills of the existing workforce.

Lessons learned:

- Training courses – lesson from agriculture sector is that training needs to be structured and sustained rather than on a "one-off" basis, with support at regional/ national level and the involvement of agronomists.
- Practical guidelines need to be developed with stakeholders and public authorities on local climate change adaptation plans and strategies.
- Public authorities need the support of external experts (consultants/ academics).
- Support of tertiary education – universities and other institutions have an important role to play in transferring CCA skills to public authorities and the private sector. They also play a role in 'teaching the teachers' and in providing vocational training to top up the skills of the existing workforce.
- Consultant is important to help the private sector on an ongoing basis.
- Need for national, regional and local authorities to create programmes and structures to identify skills shortages and to work with higher education institutions to fill these gaps.
- A specific job creation/ training plan disseminated as a standard project output would have a significant impact. Projects should develop business plans not only with market-related analysis but also with an analysis of the impact in terms of jobs. The beneficiary could include information about job creation and skills within the required report on the socio-economic impact of the project. This would make the beneficiaries to consider it in their proposals already.

Potential example of a climate change adaptation and employment & skills project

Creating jobs through support to the local authority on the implementation of its local adaptation plan/ strategy

Several EU cities have developed or are in the process of developing their local adaptation plans and strategies. Implementation of these plans is where the bottleneck is. LIFE+ projects would help tremendously with implementation in this area while spurring job creation at the same time. The projects would involve a cooperation between project developers (e.g. an engineering company with a consulting branch), municipalities (involved in the implementation of the local strategy/ plan) and for example a utility company.

The goal of the projects would be to develop specific joint projects – identifying measures/ solutions, how and where they should be implemented and their cost – that would help implement the local CCA strategy/ plan. In addition, impact on employment from such LIFE project would form part of the deliverables.

Projects could involve:

- Joint projects with public water utilities and municipalities to develop innovative solutions for water and sewer system construction
- Infrastructure projects to design and test a pilot floating pavilion/ building
- Design and testing of a cooling system in public transport during heat waves
- Capacity building projects teaching adapting and management of the farm equipment

To trigger activities that consider adaptation jobs and skills, the beneficiaries of adaptation and employment projects should report on a selection of the following indicators:

- Number of jobs (permanent and temporary) created per unit value (e.g. EUR 100,000) invested in CCA – this would trigger activities related to the creation of low and high skilled adaptation jobs and would provide data on the investment needed for such jobs. Moreover, reporting on the unit value would make the data comparable across projects, i.e. project A generates X amount of jobs per EUR 100,000 while project B only Y.
- Number of people trained per unit value – this would trigger activities involving training and up-skilling of workforce in adaptation-related knowledge. This should contribute to decreasing the knowledge gaps in adaptation and shortage of adaptation-related skills. Reporting on unit value (e.g. per EUR 100,000 of project cost) will again provide the possibility to compare across projects.
- Transfer of knowledge channels – number of such channels – this would trigger activities designing a system of adaptation knowledge transfer. Knowledge of adaptation needs to be transferred to different levels within an organisation (e.g. from management to employees). By reporting on this indicator the project beneficiary will have to think of the different channels/ venues how adaptation knowledge can be transferred to different employees.
- Availability of apprenticeships – number of apprenticeships offered per unit value – this would trigger activities related to cooperation with universities and knowledge transfer. It is important for adaptation that already master level students gain knowledge about this topic and are interested and prepared for such jobs. The project beneficiaries should be incentivised to offer apprenticeships related to adaptation jobs to help develop the needed skills. Reporting per unit value would again allow for the comparison between projects.
- Sustainability of the project and future prospects in terms of growth – are these jobs available in 2-/5- years time after project completion? – this would trigger activities where adaptation jobs are created to be longer-term and not only project related. This is important for adaptation as many CCA investments are longer term.

b) Adapting the guidelines to better consider the skills and employment aspects

Application guidelines have been issued for the LIFE 2014 call. These guidelines are produced on a yearly basis and differ per strand (environment & climate) and per type of projects ("traditional", preparatory, integrated, technical assistance and capacity building).

The application package contains several lists of priorities that could be amended on a yearly basis to take into account employment and skills aspects:

- a list of EU policy priorities for 2014
- a list of indicators that could be used to measure the output and impact of the project.

In the coming years, the guidelines for applicants will be amended, on a yearly basis, to take account of changing EU policy priorities, or in view of identified weaknesses in activities proposed under existing projects. Therefore, there are opportunities to make additional suggestions on the type of projects with high value added, from an adaptation and employment perspectives. Additional suggested indicators could be included, to steer applicants towards the right adaptation activities. For instance:

- *mainstreaming of employment and social considerations in all LIFE adaptation projects*
    - Support given to projects that have the potential to develop adaptation related skills through training – transfer of knowledge would be one important component in all LIFE adaptation projects. This could be measured by the number of trained people per unit project cost (e.g. per EUR 100,000), the number of apprenticeships offered.
    - Importance of job-creation (temporary and permanent) potential of the project – all projects would have to take into account the number of jobs created and their sustainability/ potential growth in the future. Monitoring indicators could include the number of permanent/ temporary jobs created per unit project cost, the number of permanent/ temporary jobs expected to be created by the end of the project/ 2 years after completion.
    - Mapping of needed skills/ jobs per adaptation activity and identification of any overlaps with non-adaptation activities – this would improve the knowledge base on the share of adaptation-related jobs in a particular economic activity. Indicators would include % of FTE related to adaptation per business activity.

- *promotion of best-practice on adaptation and employment*
    - addressing most vulnerable economic sectors and their loss of labour productivity and indirect effects due to climate change – list of indicators could include an estimate on the number of jobs lost due to climate change per 100 employees in that sector.
    - Capacity building projects for public authorities to develop local and national adaptation plans and strategies – indicators could be: number of workshops/ seminars offered, number of civil servants reached per 100 civil servants.
    - projects improving intra-sectorial mobility – such projects would develop skills that can be applied across different positions within a sector.
    - Development of best practise examples in engaging relevant stakeholders such as education institutions, trade unions and employee representatives – indicators would include the number of institutions reached.

Assessment of policy recommendations

The benefits of including more employment and skills aspects into adaptation projects under LIFE would mean that greater consideration is given to creation of adaptation related jobs and skills. This would also help the programme to evaluate better its social impacts. On the other hand, there is a trade-off with funding other projects which might be beneficial to economic growth and/or adaptation action but which do not consider greatly employment and skills aspects. Implementing these recommendations will also require some additional resources to prepare and implement the best practices and application guidelines.

2. Horizon 2020

Horizon 2020 is the financial instrument implementing the EU's Innovation Union strategy[64], a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness. It is the biggest EU Research and Innovation programme ever, with nearly €80 billion of funding available over 7 years (2014 to 2020), in addition to the private investment that this money will attract. Given Horizon 2020's focus on

[64] http://ec.europa.eu/research/innovation-union/index_en.cfm

investing in smart, sustainable growth and jobs in Europe and tackling societal challenges, there is scope for a project within this programme which would aim to reduce the knowledge gap in employment and adaptation.

The suggestions made below are based on knowledge gaps identified in the context of the implementation of this project.

Suggestion 1 for addressing a research gap – Improve understanding of skills requirements for climate change adaptation

The challenge: addressing knowledge gaps for skills required in climate change adaptation.
This report has used both a top-down and bottom-up approach to understand the impact of climate change adaptation on employment in the EU. However, very little comprehensive data and information on skills, by sector or adaptation activity type (even at local level) were found. The necessity to improve the knowledge on skills is important for efficient employment policies as highlighted in the 2008 Communication New Skills for New Jobs - Anticipating and matching labour market and skills needs[65] :

Improving the monitoring and anticipation of labour market and skills requirements is necessary to […] orientate skill development in order to improve long-term job prospects. A substantial improvement in the Member States' and the Union's capacity to forecast, anticipate and match future skills and labour market needs is a precondition for the design of efficient employment, education and training policies and individual career choices.

The overall objective is to help assess whether the EU labour force possesses both the level and types of skills adequate to deliver EU adaptation strategy objectives.

Scope: expand primary evidence base on the skills required in climate change adaptation
Develop a line of funding within the work programme Climate action, environment, resource efficiency and raw materials/Fighting and adapting to climate change to improve understanding of skills needed and used in climate change adaptation. The aim is to undertake primary research to develop the evidence base of micro-level data on the skills (type, level, and distribution) required to support CCA, by adaptation activity and sectors. Primary research questions may be developed for key economic sectors, for example,

- Will planned adaptation investments in (say) the construction sector require the same skills and occupations as currently represented in the sector?
- What are the distributional effects across EU of any changes in skills and occupations in (say) the construction sector due to increased investments in CCA?

Research methods. The studies should use surveys and in-depth case studies, among others to strike the right balance between the representativeness of the data and information gathered and accounting for specific characteristics of adaptation jobs.

65
https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCUQFjAA&url=http%3A%2F%2Fec.europa.eu%2Fsocial%2FBlobServlet%3FdocId%3D1496%26langId%3Den&ei=swibU7WSF8nuOsCJgLAJ&usg=AFQjCNH6uISc_aBMTaPhHCFqXs9Oj1rE3g&bvm=bv.68911936,d.ZWU&cad=rja

It is also necessary not only to understand which skills are required, in which quantity, and where in the EU, but also to investigate the options for developing these skills, such as at which stage of the education/career development, and associated funding implications. For some sector specific skills it could be more convenient and effective to provide 'on the job training', while other skills may be best developed at an earlier stage (e.g. during final years of academic training). Studies should address this question to the extent possible.

Requirements for a proposal
The applicants/partners are expected to demonstrate a variety of knowledge and skills such a climate change impact assessment, technical expertise, sectorial expertise, regional expertise and economic analysis including Cost-Benefit Analysis (CBA) of adaptation activities.

Suggestion 2 for addressing a research gap– Improve representation of labour markets relevant to climate change adaptation

The challenge: Current labour market models for Europe do not support impact assessment of climate change adaptation policies on employment
To assess the employment implications of CCA a combination of short run and long run models is needed. Current labour market models are either short run or long run models but they are difficult to combine in a consistent manner. Therefore, there is poor understanding of how labour markets function in the short, medium and long term. Adaptation investments have both short-term impacts on employment (through increased demand for adaptation goods and services) and long-term (through job preservation as a result of reduced damage costs but also because of less demand on certain services like reconstruction services). Therefore, the modelling of employment impacts of CCA needs to account for both short run and long run impacts in a consistent manner.

Scope: Develop a labour market model that would account for short and long run impacts of CCA in a consistent manner
Create a line of funding within the work programme to develop further the available labour market models in Europe or developing a new model that would allow a consistent assessment of employment impacts of climate change policies including CCA both in the short and long term.

Assessment of policy recommendations

Expected impact
The studies funded on skills are expected to increase the understanding of skills needed in climate change adaptation and therefore facilitate an effective employment policy response to support the implementation of the EU Adaptation Strategy. The labour market models developed in this research call could also be used in assessing the impacts of climate change on employment both in the short and long run.

Costs
This policy option would not require additional resources from the Commission but the cost would be the opportunity cost of funding within the Horizon 2020 programme. Resources would be needed to monitor the research output and in future to act upon it.

Local level

3. Guidance on integrating employment and skills considerations into local adaptation plans

Short description of the option

This option considers how the Commission can influence and support the development of local adaptation plans so that these local plans will better integrate employment and skills considerations. The primary route to achieve this is by integrating employment and skills aspects into guidance on developing adaptation strategies. This has been explored through specific consideration of where and how such additions and improvements could be incorporated into the guidelines on developing adaptation strategies (published with the EU Adaptation Strategy)[66]. However, it is also important to recognise that the Adaptation Support Tool (AST) and associated guidance for city-level adaptation planning on Climate-ADAPT is probably the key place in which to integrate a consideration of jobs and skills since this has the potential to be continuously updated and made interactive. The assessment below is transferable to the context of guidance on Climate-ADAPT[67].

Local adaptation plans are the appropriate place to start moving from high level capacity building and assessment to local options that have direct assumptions about activities and concrete adaptation investments. These have implications for local jobs and skills, although these implications are not necessarily made explicit in current practice.

This is in contrast to national level strategies where the emphasis is on establishing an appropriate policy framework so that the most locally effective adaptation options and activities can then be identified in lower level planning and policies.

In many cases, sectors and services that are important at a local level are directly linked with a specific kind of employment or a specific set of skills. Local adaptation plans can, for example, address the key services that they are responsible for (such as health, education, security). Assessing how climate change may potentially affect the provision of these services ties in logically with an assessment of the required skills and resources needed to maintain the services.

Concrete policy recommendation

The ways in which employment and skills considerations could be incorporated into the EC document[68] Guidelines on developing adaptation strategies (SWD(2013) 134) are explored below, aligned with the stages specified in the document:

- Step 1: Preparing the ground for adaptation
- **Step 2: Assessing risks and vulnerabilities to climate change**
- Step 3: Identifying adaptation options
- **Step 4: Assessing adaptation options**
- Step 5: Implementation
- Step 6: Monitoring and evaluation (M&E)

[66] http://ec.europa.eu/clima/policies/adaptation/what/documentation_en.htm

[67] We understand that Climate-ADAPT is a dynamic platform and the content available under the Adaptation Support Tool will continue to be enhanced and revised, including in response to outcomes from ongoing projects, such as the Mayors-Adapt programme.

[68] Available from: http://ec.europa.eu/clima/policies/adaptation/what/docs/swd_2013_134_en.pdf

The key steps to expand to include specific consideration of employment and skills are Steps 2 and 4. Both could include questions or criteria which encourage local planners to consider the following three aspects of employment:

- Employment creation
- Employment preservation
- Skills

Considering these aspects at different stages of the process will help ensure that planners are aware of, and preparing for, the implications of their proposed adaptation activities for creating new jobs, preserving existing jobs, or requiring the workforce to develop new skills.

Step 2: Assessing risks and vulnerabilities to climate change

Step 2b: Undertake a climate change risks and vulnerability assessment

Step 2b focuses on analysing information on a region's future threats and opportunities. This section could be expanded to include consideration of threats and opportunities that relate to employment as well.

Step 2b provides a list of information that should be included in the risk assessment. It is suggested that the following questions could be included within the assessment of the "expected (direct and indirect) impacts (threats and opportunities)." This step will identify whether particular economic activities are most at risk of climate change. Within this assessment, the following points should be included:

- Are there specific economic activities at risk of climate change? If so, what are the employment implications within those sectors? Do these implications for employment make the risk more significant?

For example, if employment in a mountainous region is highly dependent on winter tourism, a reduction in snowfall could pose a risk to the tourism sector in general, and to employment in that region in particular (see case study on winter tourism, Annex B). Considering both the impact of reduced snowfall on the sector and on employment provides a better understanding of the overall risk. At simplest, such a consideration would identify the number or proportion of jobs in each sector included in the risk / vulnerability assessment to show the potential for employment impacts. More detailed assessment might look in more detail at the identified risks to identify which subsets of local employment are more or less vulnerable.

- Are there certain economic activities where climate change presents a particular opportunity? If so, what additional skills would be needed in order to take advantage of that opportunity?

For example, a reduction in summer rainfall and an increase in summer temperatures may make a particular region more attractive as a summer tourist destination. Would new skills be needed in order to take advantage of this opportunity in the tourism sector in that region? Skills in this context need to be understood very broadly including strategic planning, market analysis, marketing, outreach etc.

Step 4: Assessing adaptation options

Step 4.a: Assess possible options in terms of time, cost, benefits, and efforts.

Step 4a currently provides guidance on how to assess appropriate responses to potential impacts from climate change. It suggests that the assessment should address "direct and indirect effects of the option in economic, environmental, and social terms … with an emphasis on potential benefits."

This section could be expanded to include the potential creation or destruction of jobs as a factor to be considered when assessing adaptation options. In particular, three questions could be included to encourage planners to assess the options specifically in relation to employment:

- Will the adaptation option help protect jobs in a specific sector or service?
- Will the adaptation option help create jobs in a new area?
- Are new skills required in order to fully develop this adaptation option?

These questions can be addressed to differing levels of detail, and through a range of approaches, and the effort made to quantify the job potential should be proportionate to the scale and ambition of the local adaptation planning effort. Indeed, as with all adaptation management, this can be an iterative process, perhaps starting from a qualitative judgment from sectoral stakeholders and experts, followed by more in-depth assessment in those areas or activities which are a local priority. Some examples are given below.

Example 1: Assessing employment implications of adaptation options in Ancona
Ancona, Italy is located on the coastal area of Marche, a region which experiences frequent landslides and is at high hydrogeological risk. In 2002 Ancona's local administration decided to implement an early warning system to provide a real time monitoring of the landslide area.

Considering the employment implications of innovative adaptation options such as the Ancona early monitoring system illustrates the benefit of early take-up of such options. The monitoring system is a new function and does not cause any relevant job displacement. The monitoring system does have several positive implications for employment in the region:

- It supports jobs in traditional activities by protecting companies located in areas at risk of landslide (e.g. 500 people lost their jobs following the 1982 land slide).
- It directly employs 10 technicians (surveyors, engineers and geologist), and a coordinator.
- It has encouraged the development of a number of new skills in order to develop and maintain this bespoke system.

For further details on the Ancona early warning system, see the case study on Ancona (Annex B3).

Example 2: Local research on the adaptation economy in London
In some local administrations, specifically large cities, there may be an appetite for undertaking own local research, such as to define local understanding of adaptation jobs or the potential adaptation market. Such studies would provide additional information for Step 4 in the adaptation strategy process.

As cited by OECD[69], in relation to green jobs more broadly, London undertook research to refine understanding of the labour market potential of moving to greener growth, by defining

[69] OECD (2012) Enabling local green growth: addressing climate change effects on employment and local development, available at http://www.oecd.org/regional/leed/49387595.pdf

and developing a working definition of the low-carbon economy and the number, type and skills levels of low-carbon jobs in the London labour market. The research used an alternative and experimental approach to mapping green jobs and skills in the local economy

Similar local level work would be possible to explore the adaptation economy, and indeed, currently, London is undertaking a study to quantify the kinds of jobs involved in adaptation activities in London, so that the city is in a better position to address employment implications of adaptation in the future.

Step 4.c. Prioritise adaptation options and select preferred ones

Similarly, this issue could be incorporated into the criteria used for ranking and selecting the preferred adaptation options. We suggest that the criteria could include:

- Positive or negative effect on employment in the region

Including specific mention of employment in this way throughout the guidance document would act as reminders to consider how particular adaptation options may have an effect on employment and skills. It could also potentially strengthen the case for particular adaptation options by offering a win-win opportunity to preserve jobs in the region or create new jobs, while also strengthening the region's ability to adapt to climate change.

Assessment of the policy recommendation

Benefits of the recommendation

Including specific prompts and questions on employment in guidance documents such as this could provide a number of positive outcomes:

- It will improve local level understanding of climate risks by encouraging planners to consider the implications for employment as well as the impact on a particular sector.
- It could provide some win-win opportunities – identifying adaptation options which also have a positive impact on employment in the region could encourage planners to take action.
- It could help develop new skills in a region if a gap is identified early.

Potential costs

- It would be relatively low cost to DG CLIMA to incorporate high-level guidance and potential development of simple tool to support appraisal of jobs and skills aspects of adaptation options at local level
- The additional burden at local level of a further element of appraisal within the development of adaptation strategies should not be overlooked. However, local planners, particularly in developing local economic plans and strategies, are often required s to include assessments of jobs and skills within other policy areas, and so this policy recommendation could be seen as bringing adaptation planning in line with many other policy areas, in this respect. There is no commonly agreed methodology how to assess the jobs created from investment activities but there exists some general guidance in the literature.[70]

[70] See for example:
"Evaluating Local Economic and Employment Development. How to assess what works among programmes and policies' OECD, 2004. Available at: http://www.paca-online.org/cop/docs/OECD_Evaluating_local_economic_and_employment_development.pdf. This includes a reference to a commercial tool in the UK context.
"Forecasting the number of jobs created through construction", Forbes, D., et al, 2012. Available at: http://www.arcom.ac.uk/-docs/proceedings/ar2012-0317-0326_Forbes_El-Haram_Horner_Lilley.pdf

- A potential challenge is that updating the guidance document that was published alongside the EU Adaptation Strategy is not necessarily appropriate or feasible at this point in time.

Opportunities
The guidance on developing adaptation strategies at city level is currently under development on Climate-ADAPT and in response to recent/current DG CLIMA projects; so there is an available opportunity right now to ensure that the right words/prompts about employment and skills are incorporated alongside other changes to this guidance.

Given the high priority on the urban dimension on adaptation, and the relatively low cost of introducing additional aspects into existing guidance, this option is recommended. For example, ongoing work with the Covenant of Mayors (Mayors-Adapt) could be used to develop further the case studies and examples of good practice in relation to consideration of employment and skills in developing adaptation strategies. The Mayors-Adapt initiative will enable sharing and exchange of approaches undertaken in cities, but may also develop specific guidance (based on city-level experience) on some priority topics (which could include employment and social considerations in strategies). Depending on the implementation programme for the initiative, and the needs expressed by participating cities, a webinar or workshop on this topic could be arranged. Ultimately, outputs from Mayors-Adapt would be incorporated in ClimateADAPT.

4. Use of Climate-KIC[71]

Short description of the initiative
Climate-KIC is a European Commission's initiative rooted in DG EAC and in the creation of the European Institute of Innovation & Technology (EIT). EIT channels the funds given to it by the EC to the different Knowledge & Innovation Communities (KICs), which are then responsible to distribute these funds to beneficiaries (for activities involved in education for example). Beneficiaries include students, entrepreneurs, academia, research organisations, or businesses. Not all of them are engaged by funding.

Climate-KIC is one of such KICs that supports activities in the field of climate change mitigation and adaptation in Europe. Climate-KIC aims for the continuous development of innovative tools and services to increase the adaptation capacity and resilience of societies, infrastructure, and cities to the anticipated climate change impacts. These adaptation services address different economic sectors, reliable climate information and time to be reduced to act and implement adaptation strategies. The adaptation tools and services developed by Climate-KIC are intended to identify the lack of expertise predicted and incorporate in investment decisions the general knowledge of the potential importance of climate impacts for operations. The main goal is to overcome widely dispersed information or limited understanding of uncertainties.

It has three pillars:
1. Education – focus is on supporting and creating innovators of the future, and to ensure supply of skills/ personnel to carry out identified innovative activities;

'Measuring Structural Fund Employment Effects'. Available at:
http://ec.europa.eu/regional_policy/sources/docgener/evaluation/pdf/empleffect06.pdf

[71] Information collected from Climate KIC website (http://www.climate-kic.org/) but primarily from interviews

2. Entrepreneurship – focus is on SME's and start-ups (e.g. if they have ideas for innovative solutions for adaptation); and
3. Innovation – focus is on innovative projects.

Eight themes run across these three pillars, out of which adaptation services and land & water themes link most closely to climate change adaptation. However, some adaptation activities could also be found bundled in other themes, hence the division 'mitigation vs. adaptation' is not crystal clear.

In order to address skills gaps and shortages related to adaptation within this initiative, the aforementioned two adaptation themes and the education pillar have the most direct relevance. However, entrepreneurship and innovation are also relevant as several projects relate to adaptation.

Existing work programme:
Climate-KIC is already active in many ways to ensure adequate supply of skills for adaptation activities. Their activities in the education pillar include:

- Organisation of PhD summers related to the eight themes. These are currently two-week summer schools organised for PhD students.
- Master label for master students - adaptation activities should be directed at master levels as this is the most influential stage for students, when they choose a direction to go afterwards. Climate-KIC offers a master label attached to the general master programme.
- Journey programme – master students can work together with municipalities on real life case studies at city level. These case studies aim at achieving certain skills among students that cannot be found in schools' curriculum.
- Thematic Green House events - this is for students to practice their ideas related to a specific theme, including adaptation.

The education pillar does not explicitly differentiate according to the eight themes. The activities are multidisciplinary. However, in the innovation pillar, the share of adaptation vs. mitigation activities is relatively low. For example, out of 72 approved Innovation and Pathfinder projects to date, (innovation projects represent the vast majority of the Climate-KICs turnover), only 17 are related to adaptation and there might be some additional projects due to overlaps in other themes. With respect to the 2013 budget, this represents approximately 10-15% of total project spends.

Regarding the number of students and PhDs, there are in total around 120 PhDs and 130 master students to date (2014), but the numbers are increasing substantially every year. In terms of expertise, many partner universities and research centres have adaptation relevant knowledge and participate in adaptation projects. Due to overlaps with mitigation expertise or latent possibilities it is not possible to quantify precisely how many students/ partnerships/ business are related to adaptation only.

Moreover, the alumni network is growing considerably. In 2014, there are more than 1000 alumni of Climate-KIC who have done a PhD summer school or a master label. This shows that even though the impact of this initiative seems small (in absolute numbers), the network is growing over the years successfully.

Regarding geographical impact, the initiative operates across 13 EU centres with six national centres in France, the Netherlands, Germany, Switzerland, UK and Nordic and six regional centres covering western, eastern and southern Europe (Central Hungary, Emilia-Romagna in Italy, Hessen in Germany, Lower Silesia in Poland, Valencia in Spain and the West Midlands in the UK). There are comparably more Dutch initiatives and partners active in adaptation related projects (especially land and water

management). It is difficult to pin point what is classified as adaptation hence making statistics becomes challenging. The geographical scope has been recently expanded by the addition of the Danish/Nordic colocation centre. There is no notion to expand the number of the Regional centres or refocus in any way in the coming future.

Future expectations:
In the innovation pillar, there is a notion to enhance their adaptation efforts with new strategic partnerships and more focused community engagement to generate new activities in this area. They will develop an adaptation metrics framework by 2015 to be better able to assess the adaptation impact of their activities, particularly in their innovation pillar.

Adaptation metrics is still a quite experimental, not very well researched area as compared to mitigation in their view. They will set out to create a simple framework that would:

- Designate at least one reliable index that could serve as the basis of measuring adaptation – such as capital/wealth saved, lives saved etc.
- Help projects to forecast and estimate their expected adaptation impact at the outset
- Help them judge the robustness of the adaptation claims of projects
- Help them to monitor and account the adaptation impact of funded projects.

The initiative is at its very early stages and they aim to organize some workshops with experts to formulate it. It may be possible for DG CLIMA representatives to take part in these workshops.

In the education pillar, since there is no mechanism in the innovation and entrepreneurship pillars to capture knowledge and skills, there is an ambition to develop a vocational certified professionals track to do so. There is a pilot running (now in the design phase), called Climate-KIC executive leadership programme ("mini MBA") which brings together company executives and municipalities. It has a high profile executive board in place and the first course should start in October 2014. The focus of this programme is not only on climate change topics but it also provides a leadership perspective.

Concrete policy recommendation
According to the interviews with Climate-KIC, there are many opportunities for the European Commission, particularly DG CLIMA to play an active role in this initiative:

- Opportunity to play a pro-active role in the creation of the vocational professionals track → the European Commission could bring in expertise in adaptation policies priorities (what the track should focus on); host events, organise conferences. Once the track is up and running, it could cooperate closely and support this community. The value added of the European Commission would be the emphasis on climate change adaptation. Climate-KIC is also open for discussion for the European Commission to sit on the advisory board of this programme.
- Opportunity to cooperate with the regional centres as they are responsible for the deployment of knowledge.
- European Commission could also play a role in terms of circulating and disseminating knowledge regarding the Journey programme for master students. The pilot course for this focuses on cities and brings in entrepreneurship skills.
- Influence climate change adaptation policy at MS level by for example disseminating findings.

Based on the information received, it may be further suggested that European Commission through close cooperation with Climate-KIC stresses the importance to:

Education pillar:

- Increase the number of PhD summer schools related to the two main adaptation themes.
- Offer more specialised adaptation modules for students as part of their master label based on the needs of the European Commission.
- Work together with municipalities to create real life case studies at city level related to adaptation and the specific challenges thereof.
- Prepare thematic Green House events related to adaptation.

Entrepreneurship pillar:

- Increase the number of professional training related to CCA. Every Climate-KIC centre has training courses in entrepreneurship pillar.

Innovation pillar:

- Better integrate sectors that are most affected in terms of skills needs and shortages due to adaptation into the eight themes. Current themes are present and stable since late 2012 and there are no expectations to change them. However, there is the possibility to merge or refocus existing ones, or create new ones.

In general, each pillar (education, entrepreneurship and innovation) have their internal processes of decision making which activities to support/ fund. These processes may involve internal and external experts and are based on sets of comprehensive quality and eligibility criteria. Their focus is driven and set by the eight Themes, the strategies of which being developed and updated by a team of experts in each field and steered/facilitated from a central level. However, there is an opportunity for the European Commission to steer the activities towards CCA, and with a pro-active role it can significantly influence Climate-KICs activities. This could be done first, through developing pilots of activities, which can be developed further.

Assessment of the policy recommendation

The main impact to note is that most of the activities of Climate-KIC are focused on developing high-level academic skills, rather than medium-to-low level skills. This initiative hence affects skills shortages identified in this report only partly.

Moreover, the impact of this initiative related to adaptation is small in absolute numbers as the number of students and projects is only in hundreds. The current turnover of the initiative is only EUR 80 million per annum (a small budget compared to other EC funding programmes) but they are doing well and the initiative has a direct and tangible impact (it is not only funding research activities). Hence, the overall impact of including more CCA into this initiative might be small (in absolute terms – number of students, PhDs, training, etc.) but effective, i.e. directly translated into increased supply of adaptation skills in Europe.

Regarding focus areas, it cannot be expected that the initiative will refocus only towards adaptation activities. Mitigation will still stay one of the two focus areas.

The main benefits of the recommendation include:

- Growing alumni network related to adaptation
- Increased number of students/ courses involved in CCA
- Increased number of partnerships related to CCA
- Increased supply of adaptation professionals and employee skills

- Increased number of training related to adaptation.

It is expected that the increase will be gradual. For example, in 2014 there were six summer schools organised, while five years ago only one.

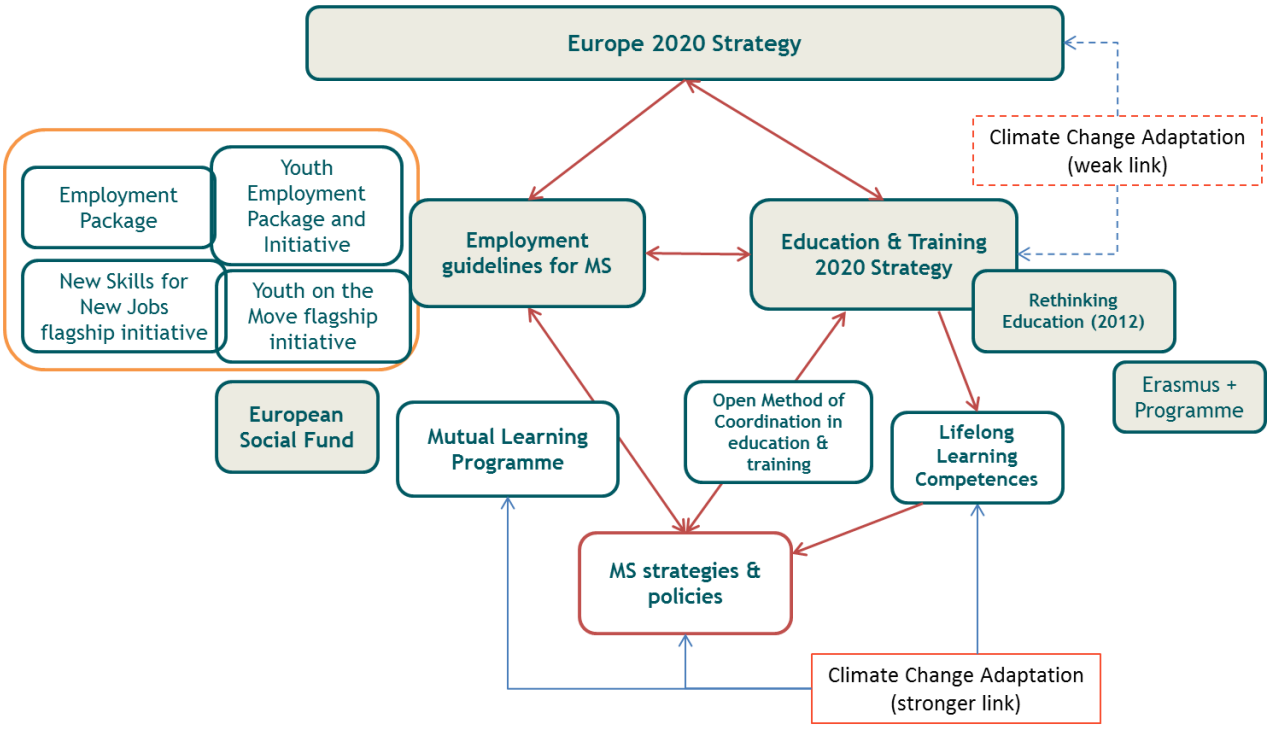
8.3.2 Integrating adaptation considerations in employment and skills policies

Overview of EU Employment and Skills Policy
EU employment and skills policies sit under the umbrella of Europe 2020 and are expressed through, on the one hand, employment guidelines for MS and a range of more specific measures (employment packages and flagship initiatives which bring together and focus existing measures), and, on the other hand, the strategic framework for Education and Training 2020 (ET 2020) and related policy documents such as Rethinking Education.

In these policy fields the Commission cannot direct Member States, it relies on Member State cooperation (through the open method of coordination) and upon Member States incorporating the employment guidelines and the priorities of ET 2020 into their strategies – i.e. their National Reform Programmes - on the employment side (linked to the ESF), and lifelong learning strategies on the education side. There is overlap between these two documents. European Social Funds are used by Member States for major policy reforms and actions in employment as well as education and training. There are no similar funds available on the education and training side, with Erasmus+ being designed mainly for smaller scale innovative work, although the link to policy reforms has been strengthened.

Member States cooperate to exchange and develop policy and practice through the mutual learning programme (MLP) in the employment field and similar activities in education and training. The open method of coordination in education and training is subject to evaluation and review at the present time to improve its functioning. The figure below presents an overview of all the main elements of EU employment policies, and shows through which channels adaptation could be possibly integrated.

Figure 8-1 Overview of EU employment policies and potential mainstreaming of adaptation into these policies



Source: Triple E Consulting analysis

A review was conducted of the potential 'entry points' for climate change adaptation into this framework of policies, Member State learning mechanisms and funds. Overall, the employment field appears to be more fertile than education and training since the relationship to employment is a direct one and very little attention has been given to the issue of green skills at a policy level in education and training[72]. In addition, the Education and Training 2020 strategy is currently undergoing a mid-term stocktake and the open method of coordination is also in a development phase, factors which inhibit the potential to prioritise climate change adaptation. At the same time, there is a potential entry point through the key competences for lifelong learning which have been an important element of policy. On the employment side, the opportunity to influence mainstream policy directly has passed. However, there are two key opportunities to start the process of integrating climate change adaptation and employment policy and practice by organising a European level conference and making use of the mutual learning programme.

5. Integrate adaptation into Member State lifelong learning strategies via key and transversal competences

Short description of the policy option

Lifelong learning has been a key overarching concept of the EU's strategic approach to education and training since the very beginning. The concept is a response to economic and social changes which have seen the disappearance of employment certainty in the labour market ushered in by new technology and work processes and

[72] A notable, and rare, reference is in Rethinking Education which identifies the need for vocational training to better address shortages of 'green skills' and the needs of growing industries including 'green sectors'. EC (2012) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Rethinking Education: Investing in skills for better socio-economic outcomes. Strasbourg, 20.11.2012 COM(2012) 669 final

the corresponding need for people to be able to update their competences and obtain new ones throughout their lives. These developments mean that people need to have the flexibility to adapt to change.

The need to adapt to climate change leads to the same point – and is arguably now just as significant a driver - but has not featured to any significant degree in education and training policy at EU level. This is not true at Member State levels and below. In some countries schools now routinely have climate change as part of the curriculum, although it is unlikely that mitigation and adaptation are differentiated. In higher education, the idea that 'sustainability' should be part of the core curriculum is spreading rapidly. Vocational education and training tends to respond on a piecemeal basis, occupation by occupation according to specific needs, and whilst some transversal topics have been dealt with in some countries through nationally set curricula and qualifications, (e.g. entrepreneurship) climate change adaptation has not received the same treatment. The EU increasingly lags behind therefore.

The Education and Training 2010 Work Programme contained a target for "lifelong learning participation" and also for Member States to develop lifelong learning strategies. The key competences for lifelong learning were adopted in 2006 as a European reference framework[73], defining the competences necessary for personal fulfilment, active citizenship, social cohesion and employability in a knowledge society which all European citizens should be able to develop. They were intended to be a key focus for Member State lifelong learning strategies.

There are 8 competences in the key competence framework:

- Communication in the mother tongue
- Communication in foreign languages
- Mathematical competence and basic competences in science and technology
- Digital competence
- Learning to learn
- Social and civic competences
- Sense of initiative and entrepreneurship
- Cultural awareness and expression.

Competences with an affinity with CCA are as follows:

1) the definition of "learning to learn" which currently states (our emphasis to show potential 'hooks'):

A positive attitude includes the motivation and confidence to pursue and succeed at learning throughout one's life. ***A problem-solving attitude supports both the learning process itself and an individual's ability to handle obstacles and change****. The desire to apply prior learning and life experiences and the curiosity to look for opportunities to learn and apply learning in a variety of life contexts are essential elements of a positive attitude.*

2) the text relating to science and technology which currently is as follows (our emphasis to show potential "hooks'):

For science and technology, essential knowledge comprises the basic principles of the natural world, fundamental scientific concepts, principles and methods, technology

[73] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32006H0962

and technological products and processes, as well as ***an understanding of the impact of science and technology on the natural world. These competences should enable individuals to better understand the advances, limitations and risks of scientific theories, applications and technology in societies at large (in relation to decision-making, values, moral questions, culture, etc)***

[…]

Competence includes an attitude of critical appreciation and curiosity, an interest in ethical issues and respect for both safety and sustainability, in particular as regards ***scientific and technological progress in relation to oneself, family, community and global issues****.*

Whilst lifelong learning strategies were in place by 2008, implementation has often proceeded at a slow pace. Education and Training 2020, the current strategic framework in the field, has "making lifelong learning a reality" as one of its four strategic objectives. But most Member States still lack education and training systems which fully enable lifelong learning[74] and there have been calls for action to improve the teaching and learning of transversal key competences.

Concrete policy recommendation
It is a strong argument that so far the education and training field has not taken a coherent approach to the consequences of climate change, including the opportunities in relation to jobs and skills and the corresponding need for a response to ensure those opportunities can be realized. At the same time, CCA adds to the imperative for lifelong learning rather than changing anything about lifelong learning at the systems level, e.g. opening up opportunities for adults to learn. However, CCA should have consequences for the competences being taught and there is a strong argument that the key competences for lifelong learning are not 'fit for purpose' in this regard. In addition, there is a valid role the EU ought to take in encouraging MS to reflect on how curricula, pedagogy and assessment should be adapted to better prepare learners in light of CCA.

There is no legal basis for a review of the key competences, so this is not a viable route for integrating CCA. However, Member State lifelong learning strategies need to demonstrate how policy and practice is equipping people with the lifelong learning competences they need, and this provides an opportunity for integration. The lines of argument are that, in general, citizens need to be better prepared to adapt to change, and that in specific occupations there will be changes to skills profiles and new jobs which citizens will need to be equipped for if they are to benefit from some of the opportunities arising from CCA. This argumentation is also consonant with the emphasis in Rethinking Education on the development of transversal skills - such as the ability to think critically, take initiative, problem solve and work collaboratively – that young people need to be able to "adapt to the increasingly inevitable changes in the labour market during their career".

Assessment of the policy recommendation
As noted, Member States have been encouraged to step up their activities to ensure populations are equipped with the lifelong learning competences and transversal skills they need to cope with economic change. CCA offers both an incentive and a means to respond to this challenge. Implementing this option calls for a coordinated approach

[74] Council and EC (2012) 2012 Joint Report of the Council and the Commission on the implementation of the Strategic Framework for European cooperation in education and training (ET2020)

by the EC to encourage MS to reflect on CCA in their lifelong learning strategies. Success will depend in part on the extent to which such coordination can be achieved. At the same time, even if CCA were to be integrated into MS strategies, the effects will necessarily take some time to filter through education systems and into the labour market by impacting on the skills of individuals. This is not an option with a quick 'return'; benefits will take many years to accrue.

6. Promoting mobility and training to advance adaptation

Short description of the option
Climate change will impact European labour market (see chapter 5 of this study) and climate change adaptation is an opportunity to alleviate the negative impacts on employment and also to exploit new job opportunities. Hence, it is important in policy and planning to take into account the sectors that will be most affected by climate change and climate change adaptation (see also section 1.2.1).

Sectors at a risk of restructuring:
- Climate change will have negative impacts on manufacturing and public utilities (including knock-on effects from other sectors such as primary industry), retail and leisure (including negative impacts on tourism) sectors. Climate change has only a minor aggregate impact on the primary sector including agriculture, tourism and fisheries but there are large distributional impacts with positive effects in Sweden, Finland, Denmark, The United Kingdom, The Netherlands and Belgium, and (large) negative effects in Bulgaria, Croatia, Greece, Romania, Estonia, Latvia and Lithuania.
- By 2050 it is expected that 0.2% of total working population in the EU will lose jobs due to climate change impacts on these sectors.

Impact of climate change adaptation on employment
- Most of the new jobs will be created in public administration, health, education, research and development and construction sector.
- It will also save jobs lost due to climate change in the manufacturing and public utilities sectors.
- There will be large differences in impacts across EU member states, with the largest number of created jobs in the Central and Eastern European countries. More than 3 jobs per 1000 inhabitants (age 15-64) are expected to be created by 2050 if the objectives of the EU Adaptation Strategy are implemented (reference scenario).

Current Strategies
The Employment Strategy[75] aims to coordinate the efforts of Member States and to achieve employment rate of 75% of the working-age population (20-64 years) in work, focusing on improving jobs markets' flexibility and the ability to match skills and jobs requirements. **The EU adaptation Strategy**[76] has already identified several policies aimed at employment and skills: funding for capacity building, the need to bridge the knowledge gap and the further development of the main knowledge sharing platform (Climate-ADAPT). Other priorities concern sectoral actions aimed at agriculture, fisheries and infrastructure. The 2012 Green Jobs communication included a reference to climate change adaptation: "advancement and implementation of

[75] http://ec.europa.eu/social/main.jsp?catId=101
[76] http://ec.europa.eu/clima/policies/adaptation/what/documentation_en.htm

climate adaptation measures will spur demand for both high- and low-skilled labour" (SWD (2012) 92 final).

Concrete policy recommendation
The support for adaptation through mobility and training could focus on **strategies that support skills matching, upskilling** and the **vision of adaptation as a strategic opportunity** to develop technical and policy innovations. It should also pay particular attention to addressing training and upskilling initiatives to workers in sectors at risk (negative employment impacts expected in primary sectors in Bulgaria, Croatia, Greece, Romania, Estonia, Latvia and Lithuania in particular). There are two main routes available to achieve these objectives:

Skill matching through improved mobility:
Supporting the movement and relocation of workers across sectors and countries will be the key policy able to provide skills and workforce to adaptation activities. The analysis suggests that there will be no shortage of skills in the medium term due to high unemployment rate (at EU-level). However, in the long run these shortages may rise for professions most affected by adaptation investments. The free movement of people can also help to address unemployment in the countries adversely affected by climate change.

- Sectoral mobility
    - Occupations positively affected due to CCA include more generalist occupations particularly in the construction and consulting/ engineering sector, whose skills can be applied across a variety of sectors. Professional coaches/ trainers can help in the process of equipping workers with the skills sought by employers in adaptation sectors. Regarding built environment, water management and organic farming for example, synergies between green and adaptation jobs and skills exist that could be explored.
    - In the long term limitations to adapt to climate change impacts within sectors may also imply restructuring the economy. For example, viability of agricultural sectors in Bulgaria, Croatia, Greece, Romania, Estonia, Latvia and Lithuania countries may significantly deteriorate in which case the adaptation strategy would be to shift away from agriculture. Sectorial mobility would be a key to success.

- Intra-EU mobility. Demand for adaptation skills will be highest in countries with largest adverse impacts of climate change and therefore largest investments in adaptation. Therefore intra-EU mobility to fill employment gaps due to adaptation in some regions, e.g. from Finland, Sweden, Denmark the UK, Ireland, Netherland and Belgium (low increase in jobs created from CCA compared to the baseline) to Lithuania, Latvia, Poland, Czech Republic, Slovakia, Slovenia, Romania and Bulgaria (countries where there is high expected increase in jobs from CCA compared to the baseline). Initiatives/ instruments promoting intra-EU migration are not necessarily linked to adaptation and to be successful they do not need to be but there are some options that could be promoted.

- Extra EU mobility (out of scope)
    - Climate change will have impacts on human mobility therefore and promoting and facilitating migration could be seen as an adaptation

strategy. However, most migration is likely to occur within the Global South, not Europe (SWD 2013, 138 final).[77]

Quantitative analysis carried out in this report suggests that there is no need for increased mobility across MS to address skills shortages in climate change adaptation, at least in the short term. Therefore, the most effective tool would be to promote sectoral and intra-sectoral mobility through training and upskilling.

Training and support for upskilling

Most of the skills required for implementing adaptation measures are already available in the market, and due to the economic crisis there is currently a surplus of workers with relevant skills. However, with the economic recovery, adaptation jobs may need to compete with other roles.

EU adaptation policy supports mainstreaming adaptation into sectorial policies and therefore mainstreaming and integrating the skills and training requirements into sectorial policies would be a logical step forward. The analysis carried out in this study suggests that adaptation related jobs are mostly associated with middle and higher education levels. Therefore CCA offers the opportunity to upskill workers in sectors where job losses are expected due to climate change. It is also important not to restrict CCA to specific roles/professions only, but to include it in more general training programmes such as including adaptation in the Civil Protection Training programme. For example, the impact of climate change on natural disasters has been a recent topic in the refresher courses for Operational Management and High Level Coordination.[78] In general adaptation skills could be incorporated in the flagship initiative "New skills for new jobs" see figure 8-1.

- Available training programmes in the renewables sector[79] suggest that workers are interested in training if funding and a long term demand for the skills are available. Therefore in addition to the funding, awareness raising and a clear signal from the Governments with regards to adaptation investments are important to raise the profile of adaptation jobs within the labour force.
- Promoting the inclusion of adaptation skills in training and skills development programmes for professional for which there is high demand from CCA (consulting and engineering services, building and civil engineering technicians, medical assistants and fire rescue service etc).
- Adjusting sectoral training and academic curricula to reflect the change in skills required (the jobs lost due to climate change are in primary sectors but most jobs related to CCA are related to medium and higher skilled jobs).

Assessment of the policy recommendation

Benefits of the recommendation

- Some adaptation skills will be very transferable to other situations and can also be used for exporting expertise (e.g. the sale of water management technologies outside Europe) where as other will be more specific to European context, such as planning.
- Improved skills and mobility are expected ease potential bottlenecks in labour markets and skills mismatches.

[77] SWD (2013) 138 final
[78] http://ec.europa.eu/echo/civil_protection/civil/prote/pdfdocs/Training_Civil_Protection.pdf
[79] See for example http://www.euenergycentre.org/our-activities/courses

Potential costs
There are costs involved in supporting training programmes and research and development. Impacts assessments of previous programmes can be used to guide the allocation of funding.

7. European conference on climate change adaptation, employment and skills

Short description of the option
The aim of this option would be to start the process of cooperation across policy fields so as to enable the issue of climate change adaptation to be linked in to employment and skills policies, and potentially other fields as well, e.g. research and innovation, and regional policy. A model for such cooperation already exists in the form of cooperation on the subject of entrepreneurship education. Although the context is different, it demonstrates the types of cooperation and outputs possible.

Inter-DG Cooperation in entrepreneurship education across the EC started in 2009 but was preceded by an accumulation of policy documents and attempts to stimulate Member State action in both the entrepreneurship and education fields. The broad policy framework was set initially by the Lisbon strategy and subsequently by Europe 2020 in which the need to develop entrepreneurship features prominently. More specifically, on the entrepreneurship side there was the European Charter for Small Enterprises in 2000, a Green Paper of 2003, and an Action Plan the following year whose Strategic Policy Area 1 was on "Fuelling Entrepreneurial Mindsets". In 2005 entrepreneurship featured as one of the key competences for lifelong learning. In 2006 reporting on the Charter for Small Enterprises was incorporated into the reporting of the Lisbon strategy and the European Commission issued a Communication on "fostering entrepreneurial mindsets through education and training". In 2008 the Small Business Act for Europe of 2008 (SBA) found that education systems were still not focusing enough on entrepreneurship, and Council Conclusions in 2007 and 2009 emphasised the need to improve teacher education systems so as to produce teachers who are reflective, creative and innovative, complementing the EU entrepreneurship policy agenda. In 2009 Education and Training 2020 was launched and included entrepreneurship amongst its objectives.

In order to help Member States to develop more systematic approaches to entrepreneurship education as a whole, DG ENTR and DG EAC began to cooperate more closely.[80]

The first step was in 2006 when the Oslo Conference brought together stakeholders to develop a catalogue of initiatives (the Oslo Agenda for Entrepreneurship Education). Then in 2009/09 the two DGs launched a pilot action consisting of a series of High Level Reflection Panels which brought together policymakers and practitioners in four regionally-based workshops. These aimed to develop greater cooperation between ministries responsible for entrepreneurship education and to develop more systematic approaches to the development and delivery of policy and practice. A report with good practices was published.[81]

[80] http://ec.europa.eu/enterprise/policies/sme/promoting-entrepreneurship/education-training-entrepreneurship/
[81] http://ec.europa.eu/enterprise/policies/sme/promoting-entrepreneurship/education-training-entrepreneurship/reflection-panels/files/entr_education_panel_en.pdf

Subsequently more specific cooperative actions have been undertaken, picking up on the report's recommendations: in 2011 the two DGs undertook a pilot action to explore how teachers should deliver effective entrepreneurship education - the Budapest Symposium and accompanying "Budapest Agenda" for policy-makers and practitioners; and in 2012 they ran workshops or in 2012 in Dublin and Brdo on the same topic for practitioners.[82]

Concrete policy recommendation

It is evident from this study that amongst officials responsible for employment and skills there is, in general, a lack of awareness of the detailed employment consequences of climate change and in particular of the differences between mitigation and adaptation activities. There is a need to raise awareness and also stimulate thinking around the employment and skills policies that need to be developed to cope with climate change adaptation.

In order to provide opportunities for this to happen, DG CLIMA could take the lead on the development of a range of activities to enable Member States and authorities and organisations at other levels to come together to hear from experts in the field and to share experiences. It is proposed that, in the first instance, the aim should be to explore the links between climate change adaptation and employment and skills policies. Employment and skills policy is preferable at this point as the link with the climate change domain is clear and links could also be made to potential funding sources, e.g. ESF which can be used in volume for training purposes, and Erasmus+ which can fund innovative education and training developments. In organisational terms, this would require cooperation and coordination across the EC. DG CLIMA would need to involve DG EMPL and DG EAC, and potentially also RTD, REGIO and ECHO.

It is recommended that DG CLIMA takes the lead role to coordinate EC action to organise a European conference on climate change adaptation, employment and skills. Participants would include policymakers from national ministries and also authorities and other stakeholders at local and regional levels since, as demonstrated in this study, most relevant strategic and practical work has been taking place at this level. Scale is important in order to give the conference credibility in terms of having participants from a wide range of Member States and a wide range of stakeholders backgrounds. In order to encourage collaboration between policy fields, senior policymakers with backgrounds in both employment and climate change adaptation should be invited from each Member State. Representation from relevant employer bodies in key sectors linked to climate change adaptation should be ensured. The conference should aim to have approximately 75 to 100 participants to obtain critical mass and give credibility to the outputs.

DG CLIMA and DG EMPL would use their formal communication channels to relevant Member State ministries to invite participants. This report could provide a key 'state of the art' input to the conference whilst expert inputs would be provided by academics, consultants and relevant EU agencies, e.g. Cedefop. There would also be presentations of good practices from across Member States.

The aim would not simply be to exchange expertise and experiences but to produce a concrete output similar to the Oslo Agenda for Entrepreneurship Education. This output would systematically set out a comprehensive range of actions in terms of

[82] http://ec.europa.eu/enterprise/policies/sme/promoting-entrepreneurship/education-training-entrepreneurship/teacher-education-entrepreneurship/index_en.htm

policy and practice that can be taken by stakeholders, along with recommended follow-up actions for the EC and Member States.

The Agenda would be structured around the themes of the conference which could be taken from this report.

This initial conference would provide a platform for further cooperation. Accordingly, opportunities for cooperative actions at European level would be identified and prioritised as part of the conference (e.g. in workshop format) and subsequently developed into concrete actions. For example, there might be a follow-up workshop on developing employment research to better support climate change adaptation. At this stage, such opportunities are difficult to foresee.

Assessment of the policy recommendation
In light of the crosscutting nature of the employment effects of climate change adaptation, the need for some form of coordination across the EC and amongst Member State stakeholders seems to be self-evident. Indeed, it would be an important part of the foundation on which other activities could be built. It would also start to build a community of interest around the topic amongst a broad group of stakeholders.

This option has the advantage that the action can be initiated by DG CLIMA and can begin on an informal basis to some degree.

A European conference of this type is a logical first step, especially in view of the lack of a well-developed policy framework on the employment side. This parallels the situation in entrepreneurship education at the time of the Oslo Conference when most policy development had been on the enterprise side.

The option also benefits from being a 'low risk' activity – simply running the conference has some awareness-raising effects. At the same time, it has strong potential for initiating sustainable cooperation at a variety of levels, European (across the EC), Member State and local/regional, and of stimulating concrete follow-up actions.

The costs of this option involve time to organise the conference plus costs associated with venue, and accommodation and travel for participants. The venue costs incurred depend on whether Brussels is selected as the location and then on whether EC premises can be used. Accommodation costs are normally covered by the EC. Travel costs to attend EC-organised meetings sometimes fall on the participants, but in this case it is recommended that these are also covered by the EC, if possible, to encourage participation, given the relative novelty of the subject and the lack of policy imperatives to stimulate participation. Outside contractors might be used to organise the conference. This was the approach used for the Budapest Agenda conference, and the total contract value was EURO 130,000, which included a conference report**.**

With regards to challenges, it may not be an easy task for the Commission to stimulate cooperation. The topic is not easily conveyed (as found in this study) and the policy anchors for Member States are not strong. Even with solid policy anchors, the experience in entrepreneurship education was of major variation in interest from Member States. It was also often difficult to find the "right" individuals within ministries who would be able to contribute well/fully to the activities.

8. Mutual learning programme of the European Employment Strategy

Short description of the option

The mutual learning programme is part of the open method of coordination in the employment field and aims to help Member States to progress towards the goals of the European Employment Strategy (which is based, inter alia, on the employment guidelines, part of Europe 2020). It consists of a range of activities designed to stimulate mutual learning amongst Member States, and to disseminate the results to wider audiences. It provides an opportunity to raise the issue of CCA in the employment field.

The EU civil protection training programme

One example of mutual learning is the EU civil protection training programme. So far, the programme has mainly targeted response and recovery experts. However, it is planned to provide training courses to DRM practitioners from all over Europe, targeting experts with high level skills to cover a wider series of issues. Enhancing knowledge on adaptation to climate change among this community is already one of the main priorities.

While this is a fairly focused programme, it provides an example of how improvement of skills in adaptation could be mainstreamed into EU-wide mutual learning and training schemes in related areas of policy and practice. It also offers an alternative model for consideration in the development of a peer review or learning programme on the subject of employment and skills in adaptation, specifically.

http://ec.europa.eu/echo/civil_protection/civil/prote/pdfdocs/Training%20brochure.pdf

The activities are as follows:

- Peer reviews which are hosted by Member States who wish to present an effective policy or practice to a group of up to 10 similar countries. Each peer review is hosted by one Member State, takes place over 1.5 days, involves 25-35 people and is supported by the European Commission. A mix of presentations, round tables and working groups is used. Independent academic experts contribute Thematic Discussion Papers. Study visits can also be part of peer reviews.
- Learning exchanges which offer rapid, targeted support to EU countries in addressing specific policy challenges and issues. They bring together small groups of government representatives and associated stakeholders. Each exchange involves a 'facilitated dialogue' between 2-4 countries and is hosted by one of the countries. National, regional and local authorities and social partners may participate[83].
- Thematic events - large events that bring together stakeholders to debate the most important areas of the European Employment Strategy. They are open to a wide range of stakeholders.

Concrete policy recommendation

Under this option, a two-stage approach would be adopted, focusing first on peer reviews, which would then help to identify the possibility for 'second stage' learning exchanges (in line with current general relationship between these two types of activities). These two activities are the preferred once since thematic events are large scale. Learning exchanges and peer reviews involve small groups of countries and

[83] http://ec.europa.eu/social/main.jsp?catId=1073&langId=en

stakeholders which suits better the profile of current activity in climate change adaptation.

A peer review on the employment and skills effects of climate change adaptation would appear to be the optimum activity at this point. An event could be proposed for a peer review on employment and skills linked to the climate change adaptation strategy. The topic is higher on the agenda in some countries/regions than others so a targeted approach to inviting participants would be appropriate.

The peer review would require the identification of one Member State to host and showcase a good practice, plus up to 10 participating 'peer countries'. The good practice might be at the national level (for example in relation to the implementation of a sectoral infrastructure investment), at the local level (such as local training or apprenticeship schemes), or even at the level of an individual company or organisation. Potential candidates for hosting peer reviews are therefore many and varied, and could include government ministries, local administrations, municipalities, regional partnerships, sector or trade associations, research institutes, etc. A starting point could be to revisit some of the case studies or local strategies reviewed within this study to identify their appropriateness or appetite as potential hosts.

Peer exchange and mutual learning at the local level is envisaged as a key pillar within the Mayors-Adapt initiative. Depending on the strategy and future implementation programme for Mayors-Adapt (which is still in development and open to being shaped according to needs of signatory cities), one of the priority topics for sharing and exchange of approaches at city level could be employment implications of adaptation and approaches for the inclusion of jobs, skills and wider social considerations in city-level adaptation strategies).

Experience from adaptation capacity building and peer exchange activities in the past (including, for example, the EU Cities Adapt project, and INTERREG programmes such as Future Cities and others within the SICAdapt! Cluster) shows that in order for participants to draw the most value from the scheme, content should be tailored and participants will have ownership of the exchange programme. Discussion points may vary quite widely, depending on the nature and level of the good practices that are showcased, and the make-up of the peer exchange group (e.g. national or local officials, sectoral experts, economists, planners, etc). Evidence from this study could help in this process and also provide material for the Thematic Discussion Paper that would need to be prepared[84]. It can be expected that some or all of the following components will be included:

- Presentations of good practice projects, approaches, outcomes
- Expert input to set local examples in EU-wide policy contexts (e.g. building on content from this study)
- Optional training modules on topics or tools related to adaptation and employment/skills (e.g. building on content from this study)
- Exercises to establish transferable and context-specific learning
- Discussion of barriers and enablers to replication of good practices elsewhere
- "Site visit" (practical project, view methods in action, observe meetings, etc.)
- Collation of learning points and recommendations for local and EU
- PR / press opportunities.

[84] These papers are allowed to draw on experiences beyond participants in the peer review according to the current guidelines.

As stated, one of the aims of the peer review should be to identify opportunities for subsequent learning exchanges, including how these might be integrated into other exchange opportunities in related policy areas to contribute to mainstreaming and open up contributory funding.

Assessment of the policy recommendation

An important factor in implementing this option will be current priorities within the employment field at EU and Member State level, and the related issue of space within the current timetable of activities.[85] An important concern at this point - in the new programming round for ESIF - are activities and policies that are new on Member States' agendas (e.g. the Youth Guarantee and counterfactual impact evaluation, both topics of forthcoming peer reviews). At the same time, the climate change adaptation strategy provides a strong policy lever and also raises new issues for Member States – the argument that there is a need to share practice is strong. Equally, it is clear that learning exchanges are open to broad topics – the next one is on the employment effects of foreign investment and will be held in Turkey.

Peer reviews presuppose the existence of a group of Member States with sufficient experience to reflect on one another's policy and practice and offer constructive advice. It is a moot point whether sufficient interest amongst countries can be generated to stimulate enough participants, especially in light of other priorities they may face.

A potential impediment of a peer review is the demands placed on the host to, inter alia, be actively involved in the preparation including the agenda, to chair the meeting and make presentations, and to provide the venue. This means an enthusiastic host needs to be found who is willing to commit time and effort, although on the plus side support is available for the host to be able to play their role effectively through the consultancy support provided by the EC to support peer reviews. Peer review logistical costs for visiting participants are also paid for by the EC. For learning exchanges the host country needs to cover the transport and accommodation costs of participating countries, which constitutes a potential obstacle to follow-up activities resulting from the peer review.

Impacts would be on direct participants in terms of raised awareness of the topic and the need for action, as well as learning in terms of which policies and practices work in which contexts and why, and the development of on-going contacts and networking opportunities. It is intended that peer reviews provide participants with lessons to put into practice in their own countries. The spread of effects beyond participants would depend on the extent to which the activities lead to changes in policy and practice within Member States.

[85] http://ec.europa.eu/social/main.jsp?catId=1047&langId=en

9. Conclusions

9.1 Main results

Defining adaptation jobs and skills

- Adaptation jobs and skills are not clearly defined – it is an evolving concept.
- For the purpose of this study, adaptation jobs were defined as 'all jobs created, sustained or redefined in the process towards building resilience to the existing and projected impacts of climate change.'
- Adaptation skills were defined as 'specific and generic skills related to adaptation activities and adaptation jobs, which can be new or topped-up existing skills.'
- Some adaptation jobs fall under the category of green jobs, while others go beyond; green jobs are those that focus on transition to a greener economy.

Employment considerations in adaptation strategies and action plans

- Most of the measures presented in national/local adaptation plans are capacity building/soft measures.
- In order to increase the adaptive capacity of a country, measures should be correlated with both the level of adaptation and/or effectiveness of adaptation measures.
- Strategies do not consider employment dimension of adaptation except of Danish, Hungarian, Swedish, French and Maltese strategies.

Impacts of climate change on (un)employment

- Most of the Member States will be adversely affected by climate change - Bulgaria, Slovenia, Estonia, Croatia, Slovakia and Czech Republic will bear the largest climate change damages that can amount to almost 4 percent of GDP.
- It is estimated that climate change will result in 410 thousands lost jobs by 2050 in the EU. Under the assumption that these jobs are structurally lost, the number of structurally unemployed individuals increases by about two percent due to climate change.
- Sectors that are most affected by climate change (in terms of damages and lost jobs) include manufacturing and public utilities, and retail and tourism. The primary sector (agricultural and fisheries will have a minor overall impact but large negative and positive distributional impacts across MS.

Impacts of adaptation on (un)employment

- To assess impacts of climate change adaptation on employment and skills, two adaptation scenarios were developed, a reference and an ambitious scenario.
- In the reference scenario, adaptation expenditures total 0.5% of GDP in 2050, while in the ambitious scenario, 1% of GDP in 2050. These expenditures are largely related to the transport, built environment, insurance and financial services, agriculture and health sectors.
- In the long run, the total number of additionally created jobs (direct and indirect) due to adaptation increases to almost 500,000 by 2050 in the reference scenario (approximately 0.2% of the working population) and to more than 1 million by 2050 in the ambitious scenario (around 0.5% working population).
- Most jobs are created in business, public services and the construction sector. There will also be saved jobs, which are the result of the mitigating effect of CCA expenditures on climate change damages. The largest number of jobs saved will be in the manufacturing and public utilities sector and business and

public services sector. These sectors have been affected the most by climate change.

Mapping skills needs and gaps and shortages

- Occupations that will benefit the most from adaptation activities are in the construction sector and other business services sector, including consulting, engineering services and researchers. Office clerks and sales occupations will also benefit from adaptation jobs.
- Most jobs are created for people with medium education level (in absolute numbers) and high education level (in relative terms).
- It was also found out that adaptation investments will favour jobs which are traditionally done by males.
- The analysis suggests that there will be no shortage of skills in the short-to-medium term due to high unemployment rate (looking at the EU level). However, in the long run these shortages may rise for professions most affected by adaptation investments.

Policy recommendations

In order to promote the transition to a climate resilient EU economy, focusing on job creation and the provision of adequate skills, the European Commission could make use of the following policy instruments and supporting measures:

1. Integrating employment and skills aspects into adaptation policies
    - LIFE+
    - Horizon 2020
    - Guidance for local adaptation strategies and plans
    - Climate-KIC
2. Integrating adaptation aspects into employment and skills policies
    - Lifelong learning strategies
    - Promoting mobility and training
    - European Conference on CCA, employment and skills
    - Mutual learning programme

9.2 Follow-up initiatives

There have been several follow-up initiatives identified in this study.

Research needs

1. Primary research on adaptation skills (Horizon 2020).
2. New/improved labour market models (Horizon 2020).
3. Further research to disaggregate employment impacts by the type of adaptation.
4. Understanding the implications of CCA across different sectors/regions in terms of employment. As an example, the implications for most vulnerable sectors and/or regions should be further investigated.
5. Looking at the employment effects of each climate change adaptation measure individually.
6. Understanding which climate adaptation measures lead to the largest direct and indirect effects (that is measures with the highest spillover effects).
7. Understanding which of the climate adaptation measure help the most to reduce or prevent unemployment.
8. Assess the income inequality effect of climate adaptation as it seems to give advantage to highly educated people.

Other - policy

9. Strategic cooperation with Climate-KIC.
10. Conference on climate change adaptation, employment and skills.
11. Discussion with MS to share the findings of the report but also to provide MS an opportunity to share any best practises – particularly of those countries that did consider employment and skills aspects in their adaptation strategies and plans.
12. Dissemination of the findings to relevant stakeholders and opportunities for them to provide feedback how to take the topic forward (Mayors Adapt, private sector, academia etc.).

ANNEXES

1 Annex A: Data Collection & Modelling Approach

1.1 Linking typology of adaptation activities to A&RCC data

At the start of the study, an adaptation typology table was developed presenting the most important economic sectors in terms of adaptation activities along with main climate hazards and their main economic impacts, including direct and indirect impacts. The typology table also included the most relevant adaptation activities for each sector further disaggregated into financial, technical, physical and capacity building. The typology table was continuously updated and revised during the course of the study. The A&RCC data was then mapped with the typology table to determine the extent to which the data match with the study typology and identify any gaps. The mapping is presented in the typology table in additional spreadsheets.

The typology table suggests that there is a relatively good match in built environment, water management, professional services, disaster preparedness and response, insurance and financial services, and transport with the A&RCC data. Generally, these are the sectors where adaptation activities are most advanced and quantitative information exists, at least to some extent. Some gaps in the matching relate to the overlaps between low carbon and adaptation activities. For example, due to accounting issues, some energy efficiency and waste water treatment measures have been accounted for in the LCEGS data and not in the A&RCC data. Further, the transport sector is partially incomplete as the A&RCC data only covers adaptation in the most common travel methods, road and rail and therefore, excludes the aviation sector. However, arguably the biggest investments are needed in roads and rails. In agriculture, only irrigation-related activities are included in the A&RCC data.

On the other hand, the matching suggests that forestry, health, tourism and energy generation and distribution are not covered at all in the A&RCC data. In the section below, some of these sectors are discussed. In the typology table (in spreadsheets), the data which was used to fill in these gaps is indicated.

1.2 Additional data to fill in the gaps

To fill in the gaps for tourism and energy sectors in the typology table, additional information and data was collected.

Energy sector: The main source for the energy sector is the study by Rademaekers et al. (2010), which assesses the sectorial climate change costs and investment needs. In this study, eight climate change indicators were identified, namely water and air temperature, precipitation, average wind speed, sea level and extreme events like floods, heat waves and storms. In order to cover impacts on Member State (MS) level, the Primes 2010 energy baseline (up to 2050) was used. Information on the loss of generation capacity, the threshold and the investment needs per kW is taken from Rademaekers et al (2010). Implications of climate change adaptation (CCA) on the energy sector, including impacts on employment and skills are portrayed in a greater detail in a case study (see Annex B4).

Tourism: For tourism, projected changes in the tourism flows within the EU due to climate change have been used.[86] The core assumption is that Member States have the capacity to adapt and take advantage of the increase in tourism flows if needed and that there are no institutional barriers (such as school holidays etc.) diminishing

[86] http://www.pnas.org/content/early/2011/01/27/1011612108.full.pdf+html

the seasonal adjustments.[87] The projected changes in annual tourism (bed night change % in 2080 compared to 2005) for each Member State were used and the results were scaled to 2050 using tourism specific climate change damage functions from GRACE ADAPT model of CICERO. Using the EXIOMOD data on consumption of goods and services by non-residents in each Member State, the employment impacts of climate change impacts in the tourism sector could be calculated. Further details on tourism sector can be found in the case study on tourism (Annex B5).

1.3 Bottom-up Data

1.3.1 Overview of cases investigated

In order to gather insights from the local level, climate change adaptation local plans and projects across Europe were analysed. They have been chosen not only to demonstrate sector specific issues related to adaptation but also to examine interactions regarding the policies and undergoing activities across the different Member States.

A total of 63 cases were investigated, across 17 countries within the European Union (Portugal, Spain, France, Germany, Netherlands, Belgium, Italy, Sweden, Denmark, United Kingdom, Finland, Czech Republic, Slovakia, Estonia, Romania, Switzerland and Cyprus). From these 63 cases, 49 people were contacted, either from private companies/ initiatives or municipalities, of which 11 provided relevant information on ongoing projects or expected local developments. It is clear that most of the investigated cases are still either in a study phase or an implementation phase regarding the CCA measures proposed in their local strategy plans. Cases which were in an early stage of development were dropped since they could not provide relevant information related to investment needs for adaptation measures. These cases were still scoping their adaptation measures and/or trying to find sufficient financing to fund their activities, or had a different focus. In addition to the strategy plans, adaptation projects related to specific sectors in different locations were also investigated. An overview of all cases can be found in Additional Documentation report.

1.3.2 Bottom-up information on a sectoral level

The bottom-up information on the adaptation related sector/activities varies depending on the extent the local plan is developed, the location (risks, impacts) or on the access to funding (budget, policies). The findings are presented across the report and more detailed information on Copenhagen, Rotterdam, Ancona, energy and tourism sectors can be found in case studies (Annex B).

1.4 Modelling Approach

1.4.1 Incorporating climate change effects into EXIOMOD simulation setup

Each type of the climate and carbon related effects and damages were estimated by DARA for A1B scenario of IPCC. In order to create the corresponding detailed damages for the alternative baseline scenario E1, the results of ICES CGE model for the background report to the IA of climate change adaptation strategy were used. The model runs have produced country and sector-specific demand and supply side effects of climate change for both A1B and E1 scenarios. The relative differences between the two scenarios were used in order to scale up or down the detailed damages of the A1B scenario. In particular, following the data of ICES runs was used to create the second E1 baseline scenario:

[87] For example school holidays or other institutional arrangements do not affect the opportunity to take holidays in autumn instead of summer.

Table 1-1 Mapping between climate damages from DARA Monitor and the results of ICES CGE model runs

Results of ICES CGE model runs	Corresponding updated DARA Monitor Damages
Supply side impacts for agriculture	Drought, Agriculture stress, Desertification, carbon effects on water
Supply side impacts flooding	Floods and landslides
Supply side impacts SLR	Storms, Labour productivity, Permafrost, Sea-level rise, Water, Transport stress, Corrosion
Supply side impact for ecosystems	Wildfires, Forestry stress
Demand side impacts for electricity	Heating and cooling
Supply side impacts for health	Diarrheal infections, heat and cold illnesses, hunger, malaria and vector-borne and meningitis, air pollution, indoor smoke, occupational hazards and skin cancer
Supply side impacts for fishery	Fishery stress
Demand side impacts for tourism	Tourism stress

The table below gives an overview of the model channels through which the sector-specific climate change damages have been included into the EXIOMOD simulation setup for the two baseline scenarios. Most of the climate change effects have been represented as a reduction in the sector-specific productivity parameter that is also equivalent to the reduction in the sector-specific natural resource or its productivity. Most of the climate change effects are sector specific and have a direct impact on agriculture, transport, tourism, and forestry and agriculture sectors. Other effects that are related to climate extreme events and health have a broad impact upon various sectors of the economy. These broad effects are represented either as a loss of total physical capital endowment in the economy or via reduction in supply of efficient labour units that is labour supply corrected to labour productivity changes.

Table 1-2 The use of DARA Monitor data for the baseline simulation setup

Climate change effects	Overview of impacts[88]	Implementation in EXIOMOD
TEMPERATURE RELATED ENVIRONMENTAL DISASTERS		
DROUGHT	Excess damage costs relative to GDP (GDP USD %) due to climate change for drought and soil subsidence (%)	Reduction in productivity of agricultural sector.
FLOODS AND LANDSLIDES	Excess deaths per capita and excess damage costs relative to GDP (GDP USD %) due to climate change for floods and landslides (%)	Loss of capital stock of the affected economic sectors.
STORMS	Excess deaths per capita and excess damage costs relative to GDP (GDP USD %) due to climate change for storms (%)	Loss of capital stock of the all economic sectors.
WILDFIRES	Excess deaths per capita and excess damage costs relative to GDP due to wildfires (GDP USD %) due to climate change for wildfires (%)	Reduction in productivity of forestry and tourism sectors.
TEMPERATURE RELATED HABITAT CHANGE		

[88] The descriptions of the impacts are taken from DARA (2012), "METHODOLOGICAL DOCUMENTATION FOR THE CLIMATE VULNERABILITY MONITOR 2nd Edition" available at www.daraint.org/cvm2/method

Climate change effects	Overview of impacts[88]	Implementation in EXIOMOD
BIODIVERSITY	Zones of biodiversity are examined through the many world biomes.	Not taken into account as it is difficult to link to economic activities.
DESERTIFICATION	Future vegetation distribution due to climate change	Reduction in productivity of agriculture and forestry sectors.
HEATING AND COOLING	Future change Heating Degree Days (HDDs) and Cooling Degree Days (CDD) due to global warming	Increase/decrease in demand for heating and cooling translated into changes in demand for electricity.
LABOUR PRODUCTIVITY	Marginal costs of productivity change relative to GDP (USD) (%)	Change in labour productivity of all economic sectors.
PERMAFROST	Change in frozen ground under projected climate forcing and resulting accelerate depreciation of infrastructure	Extra costs for maintenance of infrastructure for electricity and transport sectors and housing stock for households.
SEA-LEVEL RISE	Costs due to climate change-induced sea-level rise for coastal zones (Change in tidal basin nourishment costs, beach nourishment costs, land loss costs, migration costs, river flood costs, salinity intrusion costs, sea dike costs, sea flood costs and wetland nourishment costs due to climate change).	Loss of capital stock by all economic sectors.
WATER	Marginal (adaptation) costs for replacing water losses due to climate change adjusted for local market conditions/scarcity	Reduction in productivity of "Collection, purification and distribution of water" sector.
TEMPERATURE RELATED HEALTH IMPACT		
DIARRHEAL INFECTIONS	Excess deaths per capita due to climate change for diarrhea (%)	Decrease in supply of labour.
HEAT AND COLD ILLNESSES	Excess deaths per capita due to climate change for respiratory diseases, including cardiovascular diseases and skin cancer (%)	Decrease in supply of labour.
HUNGER	Excess deaths per capita due to climate change for hunger, including malnutrition and associated risk factor diseases/illnesses (%)	Decrease in supply of labour.
MALARIA AND VECTOR-BORNE	Excess deaths per capita due to climate change for malaria & other vector borne – yellow fever and dengue fever (%)	Decrease in supply of labour.
MENINGITIS	Excess deaths per capita due to climate change for Meningitis (%)	Decrease in supply of labour.
TEMPERATURE RELATED INDUSTRY STRESS		
AGRICULTURE	Percentage change of agricultural output due to climate change	Change in productivity of agricultural sector.
FISHERIES	Decrease in fish catch yield due to climate change	Reduction in productivity of fishery sector.
FORESTRY	Change in forestry under projected climate change.	Reduction in productivity of forestry sector.
HYDRO ENERGY	Change in developed hydropower potential due to impact of climate change on river discharge	Change in productivity of hydro electricity sector.
TOURISM	Decrease in winter tourism revenue due to climate change	Change in productivity of tourism sector.

Climate change effects	Overview of impacts[88]	Implementation in EXIOMOD
	Decrease in reef tourism revenue due to climate change	
TRANSPORT	Marginal costs of riverine discharge decline linked to climate change for river-borne transportation in the transport sector	Reduction in productivity of transport sector.
CARBON RELATED ENVIRONMENTAL DISASTERS		
OIL SANDS		Has not been translated into the model due to difficulty to link their environmental costs to the economic activity.
OIL SPILLS		Has not been translated into the model due to difficulty to link their environmental costs to the economic activity.
CARBON RELATED HABITAT CHANGE		
BIODIVERSITY		Has not been translated into the model due to difficulty to link to the economic activity.
CORROSION		Loss of capital stock by transportation sectors.
WATER		Reduction in productivity of agricultural sector.
CARBON RELATED HEALTH IMPACT		
AIR POLLUTION	The indicator (for Indoor Smoke) on the health impact of Air Pollution linked to emissions of greenhouse gases which are a principal cause of climate change is broken down from its composite form into two sub-indicators, one covering Urban Air Pollution as defined by the WHO, and a second expanding the problematic to Asthma with similar root causes (notably tropospheric ozone toxicity).	Decrease in supply of labour.
INDOOR SMOKE	Indoor smoke, a form of indoor air pollution, examines the impact on human health of incomplete combustion of different fuels – coal, wood, and other forms of biomass – which generate toxic smoke, black carbon and other emissions and GHG	Decrease in supply of labour.
OCCUPATIONAL HAZARDS	Indicator for occupation hazards aggregates three distinct sub-indicators related to hazards stemming from workplaces closely related to high greenhouse gas emissions, as follows: 1) Asthma, from industry specific exposures; 2) COPD, for similar reasons; 3) Coal Workers Pneumoconiosis (CWP) and coal accidents that only concerns coal extraction professionals; and, 4) Stomach Cancer, which again is linked to industry specific exposures.	Decrease in supply of labour.

Climate change effects	Overview of impacts[88]	Implementation in EXIOMOD
SKIN CANCER	impact of UV exposure, caused by the ozone depletion by CFCs and halocarbons, on skin cancer incidence in the period 2000-2030	Decrease in supply of labour.
CARBON RELATED INDUSTRY STRESS		
AGRICULTURE	Agriculture is comprised of four sub-indicators: 1) acid rain, 2) ozone toxicity, 3) global dimming, and, 4) carbon fertilization	Change in productivity of agricultural sector.
FISHERIES	Fisheries is comprised of two sub-indicators: 1) marine fisheries (ocean acidification), and, 2) in-land fisheries (acidification/acid rain).	Reduction in productivity of fishery sector.
FORESTRY	Forestry comprises two sub-indicators, as follows: 1) ozone toxicity, and, 2) acid rain.	Reduction in productivity of forestry sector.

1.4.2 Incorporating climate change adaptation activities into EXIOMOD

Adaptation and damages

The effectiveness of each type of climate change adaptation measure to reduce the damages was based on the existing Cost Benefit Analysis studies in combination with (where other data is not available) the formulation rest damages from AD-WITCH model that are a function of accumulated expenditures on climate change.

The results of the 'methodologies for climate proofing investments and measures under cohesion and regional policy and the common agricultural policy' (Hjerp et al. 2012) report were used to derive cost benefits ratios (CBRs) for the different activities/categories and sectors. In this study, a detailed cost benefit assessments were undertaken for several adaptation options. The efficiency or cost benefit ratio of each adaptation option was linked to the activities/categories in each sector. Moreover, the CBRs were used but the maximum total effects were restricted to be 50% of climate cost damages in 2050. The main reason for doing this is to restrict the effect of adaptation measures caused by high CBRs for certain activities/categories. Sensitivity analysis was used to check whether this is a correct approach and no significant differences were seen.

The annual benefits of adaptation measures were calculated assuming geometric progression, i.e. the total benefits of adaptation over the whole time period (until 2050) was calculated and these benefits were distributed over all years in such a way that the value of benefits in a year could be found by multiplying the benefits of the previous year by a non-zero, and where the value of benefits in 2050 is maximally 50% of the damages in 2050. In this way the benefits were nonlinear distributed and increasing over time. But the total (discounted) cost and benefits were fixed and based on the cost benefit ratios found in the literature. The cost benefit ratios for each sector and activity/category could be found back in the dataset.

Implementation of climate change adaptation measures was then translated into the following types of effects in EXIOMOD simulation setup:

- Short-run effects: increase in demand for goods and services during the investment stage of climate adaptation measures;
- Short-run effects: additional investments from private and governmental sector;
- Long-run effects: reduction of climate change damages.

The data of K-matrix allows one to estimate the share of expenditures that are allocated to particular type of service or commodity. Table below presents the average shares of spending on services and commodities that correspond to each of the adaptation activity categories. The information on these shares forms a part of the simulation setup and gives information about the short-term employment effects of CCA measures. These short-run effects were modelled as an increase in demand for particular services and commodities by private and public sector.

Table 1-3 Mapping between the activity types and types of commodities and sectors in EXIOMOD

Activity category	Additional demand for EXIOMOD commodities and services	Demand shares are estimated on the basis of
Financial	Insurance and pension funding services, except compulsory social security services (C_FINS) 59%; Other business services (C_OBUS) 41%	K-Matrix data
Physical	Wood and products of wood and cork (except furniture); articles of straw and plaiting materials (C_WOOD) 4%; Chemicals n.e.c. (C_CHEM) 2%; Fabricated metal products, except machinery and equipment (C_FABM) 6%; Machinery and equipment n.e.c. (C_MACH) 19%; Construction work (C_CONS) 34%; Wholesale trade and commission trade services, except of motor vehicles and motorcycles (C_TDWH) 17%; Other business services (C_OBUS) 17%	K-Matrix data
Technical	Fabricated metal products, except machinery and equipment (C_FABM) 6%; Construction work (C_CONS) 6%; Other business services (C_OBUS) 88%	K-Matrix data
Capacity building	Research and development services (73) C_RESD 5% ; Other business services (74) C_OBUS 20%; Education services (80) C_EDUC 70%; Public administration and defence services; compulsory social security services (75) C_PADF 5%	Own assumptions

In order to create the shares presented in the table above, these steps were followed:

1. Create the mapping between the Level 4 classification of K-matrix dataset and the classification of CCA activities in this study. K-matrix Level 4 classification includes 32 types of activities that are relatively detailed and include for example 'Enviro Finance Planning' and 'Retro Fit Buildings Services'.
2. The most detailed level of K-matrix dataset is Level 5. This level of detailed includes 138 types of services and commodities that were mapped towards the EXIOMOD classification. The EXIOMOD classification is much less detailed especially for the part of services and hence, most of the important services such as engineering, design and consulting services have been mapped to the 'Other Business Services'.
3. The two types of mappings described above were used in order to create (1) CCA expenditures by the types of categories for the year 2011 and the matrix of CCA expenditures that includes on the one hand, the categorisation of CCA expenditures in this study, and on the other hand, the EXIOMOD classification of services and commodities.

The constructed matrix was used to derive the expenditure shares presented in the table above and used for modelling of the short-term effects of climate change adaptation activities.

Table below provides the mapping between the classification of CCA activities and the climate damages that are affected or reduced as a result of their implementation. This mapping was used for the representation of long-run effects of CCA measures.

Table 1-4 Mapping between the climate adaptation activities and the type of climate damages estimated by DARA Monitor that can be affected by them

Type of climate adaptation	Corresponding climate damages from DARA Monitor
Built environment	DROUGHT FLOODS AND LANDSLIDES STORMS WILDFIRES PERMAFROST SEA-LEVEL RISE
Water management	DESERTIFICATION SEA-LEVEL RISE WATER STORMS
Agriculture	DROUGHT DESERTIFICATION AGRICULTURE
Professional services (consulting)	ALL
Forestry	FORESTRY WILDFIRES
Disaster preparedness and response	DROUGHT FLOODS AND LANDSLIDES STORMS WILDFIRES
Insurance and financial services	ALL
Health	DIARRHEAL INFECTIONS HEAT AND COLD ILLNESSES HUNGER MALARIA AND VECTOR-BORNE MENINGITIS
Energy generation, transmission and distribution	HEATING AND COOLING HYDRO ENERGY
Transport	TRANSPORT PERMAFROST FLOODS AND LANDSLIDES STORMS
Tourism	TOURISM WILDFIRES

1.4.3 Calculating the affected jobs

Partial Equilibrium approach for the calculation of directly affected jobs

The number of jobs directly lost and generated as a consequence of climate change and CCA measures was calculated outside of the CGE framework in order to exclude all indirect effects. In order to calculate the number of directly affected jobs, a partial equilibrium model was constructed by using some of the equations of the EXIOMOD, namely equations related to the representation of sector-specific production functions and fixing prices sectoral outputs exogenously. This excluded the general equilibrium and hence, all indirect effects of climate change.

In order to generate the direct effects of climate change on employment, the climate change damages to the loss of sector specific productivity and the physical capital losses were translated into the changes in employment using the sector-specific nested Constant Elasticity of Substitution (CES) production functions of EXIOMOD. The direct employment effects depend upon the share of labour in the capital-labour nest of the production function, substitution possibilities between capital and labour as well as the level of the total factor productivity changes due to climate change. For example, in sector with higher share of labour inputs decrease in their productivity will lead to higher negative effects on employment.

The same methodology was used to calculate the direct effects of CCA expenditures. Short run effects of CCA (expressed as additional demand for goods and services during the investment period) were translated into additional output of the sectors. The assumptions used to calculate the employment effects were (1) the shares of domestically produced and imported goods and services stay constant and (2) sector-specific demand for labour is determined on the basis of inverse production function that is a labour demand function.

The long-run effects of the CCA measures consist of a reduction in the negative effects from climate change and hence lead to the reduction of various types of climate change damages. The changes in the climate change damages were translated into changes in sector-specific productivity and changes in stocks of physical capital and labour. Their direct effects of jobs were calculated in the same way as in case of the calculation of the direct effects of climate change.

General Equilibrium approach for the calculation of total affected jobs

The total number of jobs (both directly and indirectly affected) that are associated with climate change and CCA expenditures was further calculated using the CGE model EXIOMOD for EU28 country separately.

Calculation of indirectly affected jobs

In order to derive the total number of jobs that have been indirectly affected by the climate change, the total number of directly affected jobs (calculated with partial equilibrium approach) was subtracted from the total number of affected jobs that had been calculated using EXIOMOD (general equilibrium approach). The difference between directly and indirectly affected jobs is explained by various types of general equilibrium effects and depends on, for example, substitution possibilities between domestic and foreign goods.

Jobs that are directly linked with Climate Change Adaptation (CCA) expenditures are jobs in the sectors that produce goods and services that constitute a major part of the CCA investment expenditures. These sectors include for example, machinery and equipment sector, construction sector, research and development sector, education sector, whole sale and retail sector and other business services sector that produces various consultancy services. An example of how the effects of CCA expenditures propagate through the economy and how this gives rise to directly and indirectly affected jobs is the following:

A large share of the CCA expenditures (about 35%) goes to purchasing additional construction services. This additional demand is almost fully translated into demand for domestic construction services and results in an increase in directly affected jobs in the construction sector. This is due to the fact that the import share of construction services is quite low for most of EU member states. Increase in demand for construction services over some period of time results in an increase of the construction sector and contraction of some other less competitive sectors of the

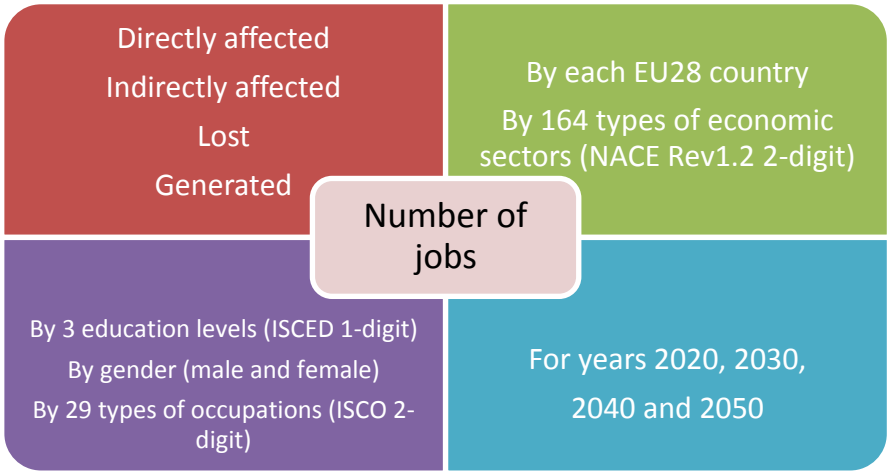
economy. Contraction of economic activities in other sectors of the economy results in loss of jobs in those sectors and hence gives rise to the loss of indirectly affected jobs. The magnitude of these effects depends, among other factors, upon how easy it is to replace domestically produced goods with the imported ones. If it is relatively easy, the sector will contract faster and stronger than if otherwise.

For the construction sector, some intermediate goods and services for its production were used. An increase in the output of the construction sector will lead to positive economic effects on the sectors that provide it with the intermediate inputs. This gives rise to positively affected indirect jobs.

Construction activity can be used to reduce the effects of climate change on for example, forestry. This results in positive effects on the productivity of the sector and hence leads to positive indirect effects of jobs related to forestry.

Directly and indirectly affected jobs are further grouped for representation purposes into the following four categories presented in the figure below:

Figure 1-1 Grouping of jobs directly and indirectly affected by climate change in the Excel files with the modelling results



The list below specifies the type of education and the type of occupation for which the number of jobs directly/indirectly lost and generated were calculated.

In case of the International Standard Classification of Education (ISCED), three categories were used, with the following explanations:

Table 1-5 Classification of skill levels according to the ISCED used in the model

ISCED_02 is a combination of	ISCED_34 is a combination of	ISCED_56 is a combination of
Level 0: Pre-primary education.	Level 3: Upper secondary education	Level 5A: First stage of tertiary education: largely theoretically based programmes intended to provide qualifications for gaining entry into more advanced research programmes and professions with higher skills requirements.
Level 1: Primary education or first stage of basic education.	Level 4: Post-secondary non-tertiary education	Level 5B: First stage of tertiary education: typically shorter, more practical/technical/occupationally specific programmes leading to professional

ISCED_02 is a combination of	ISCED_34 is a combination of	ISCED_56 is a combination of
		qualifications.
Level 2: Lower secondary education or second stage of basic education		Level 6: Second stage of tertiary education (leading to an advanced research qualification).

1.4.4 Methodology for forecasting supply of labour by education and occupation for the period 2015 until 2050

The labour supply projections to 2050 used in this study include the indicators of labour supply detailed by educational level, gender and occupation for each of the 28 EU Member States. Data-wise, the Cedefop[89] database and the Eurostat population and labour force projections till 2050 were used. The Cedefop dataset contains actual data (from 2000 - 2010) and projections (from 2010 - 2025) for employment detailed by education level, occupation and sector as well as population and labour force by gender and education level. The projections of labour force by education level and employment by occupation from 2010 - 2025 were interpreted as labour supply by the category of labour.

For the period from 2025 - 2050, the labour supply by category was projected based on the Eurostat population projections for each Member State. More specifically, the trend regressions for the share of each of the three education groups in the working age population were estimated on the base period from 2000 - 2025. To ensure that the three shares add up to one, the following logistic form was used:

$$s_{ckgt} = \frac{e^{-a_{ckg}-b_{ckg}t}}{\sum_j e^{-a_{cjg}-b_{cjg}t}}, \quad (1)$$

where s_{ckgt} is the share of the labour force of education level k in the total working age population, for country c, gender g, and at time t. As not everyone in the working age population is employed, other estimations used were: the share of people that are participating for each country, education level, and gender as a function of time, using a similar formula. For the period from 2025 to 2050, Eurostat population projections for each Member State were used. For these years, the estimates which were obtained above for the distribution of education levels were then applied to the population projections for individuals between age 15 and 64. This provided a projection for individuals in the working age population by education level. Subsequently, the predictions for the participation rates were used to obtain projections for the labour supply by country, gender, and education level. In summary, the size of the labour force by education and gender for each country was projected, by extrapolating the trends for the education shares and participation share onto the years 2025 – 2050 and projecting these shares on the population projections from Eurostat.

In order to split the projections by education and gender into various occupation types, the labour force survey data that provides the link for the current situation between education, gender and occupation was used. The shares of particular occupation type in the total amount of people with particular education level and gender were assumed to stay the same until 2050. This assumption is a bit crude but there are no readily available sources that could be used to make this assumption more realistic.

[89] European Center for the Development of Vocational Training.

1.5 Scenarios

1.5.1 Baseline scenarios

To create the two baseline scenarios, the emission scenarios as described in the European ClimateCost project were used.[90]

Baseline scenario (E1 ENSEMBLES scenario) (2°C)
The first baseline scenario is the so-called 'mitigation scenario', which stabilizes global temperature change at about 2°C above pre-industrial levels. This scenario is the ENSEMBLES E1 scenario in the ClimateCost project, which was constructed using the methodology of the fifth assessment report of IPCC, i.e. starting at concentrations, running forward calculations for climate projections, and reverse calculations for emissions and socio-economic parameters. This scenario includes only mitigation activities.

Baseline scenario (A1B IPCC scenario) (3.4°C)
The second baseline scenario does not include any mitigation or adaptation activities, and is the so-called 'medium-high non-mitigation baseline scenario'. This is the emission SRES A1B scenario. This scenario assumes a future world of rapid economic growth, new and more efficient technologies, and convergence between regions. In this scenario, a balance across all energy sources (fossil and renewable) is adopted for the technological change in the energy system. This scenario reflects a medium-to-high emission trajectory and leads to mid-range estimates of global average temperature change of around 3.4°C by 2100.

Comparing GDP growth rates for the A1B scenario (see http://sres.ciesin.org/final_data.html) to GDP growth rates used in the "The 2012 Ageing Report Economic and budgetary projections for the 27 EU Member States (2010-2060)", it can be concluded that in the long run (2030-2050) they do not differ a lot (for A1B scenario annual average growth rate of 1.7-1.8% for EU28 compared to a 1.6% projection in the Ageing report). However, in the short run (2013-2030), the growth rates for the A1B scenario are significantly higher (2% compared to 1-1.5%). The same growth rates for both scenarios were assumed, however, due to the different damages, the macro economic impact turned out different.

Climate adaptation expenditures in the baseline
In order to create the flow of CCA expenditures, the expenditures on climate adaptation for the year 2011 (the last available year of K-Matrix A&R CC dataset) were used as a starting point. Expenditures on hard measures, such as investments into infrastructure are based on the K-Matrix dataset that is further supplemented with other calculations to come up with the full coverage of the climate change adaptation activities. The table below summarizes the data sources for the preliminary compilation of CCA expenditures in the year 2011.

Table 1-6 Mapping between available data source on climate adaptation expenditure and the climate adaptation categories (percentages in brackets are for the ambitious scenario)

Sector	Technical	Physical	Financial	Capacity building
Agriculture	K-matrix	1% of investments in the sector in 2030	-	0.5% (1%) of total CCA expenditures in sector

[90] For more information see http://www.climatecost.cc/

Sector	Technical	Physical	Financial	Capacity building
Built environment	K-matrix	K-matrix	1% (2%) of other adaptation activities in sector	0.5% (1%) of total CCA expenditures in sector
Disaster preparedness and response	K-matrix	2% (4%) of damages to the sector in 2030	1% (2%) of other adaptation activities in sector	0.5% (1%) of total CCA expenditures in sector
Forestry	1% of investments in the sector in 2030	K-matrix	-	0.5% (1%) of total CCA expenditures in sector
Insurance and financial services	-	-	K-matrix	0.5% (1%) of total CCA expenditures in sector
Tourism	K-matrix	2% (4%) of damages to the sector in 2030	-	0.5% (1%) of total CCA expenditures in sector
Transport	K-matrix	2% (4%) of damages to the sector in 2030	1% (2%) of other adaptation activities in sector	0.5% (1%) of total CCA expenditures in sector
Water management	K-matrix	1% of investments in the sector in 2030	1% (2%) of other adaptation activities in sector	0.5% (1%) of total CCA expenditures in sector
Professional services	-	-	-	0.5% (1%) of total CCA expenditures in economy
Health	0.125% of total output in the sector	0.125% of total output in the sector	-	0.25% of total output in the sector
Energy	30% of energy costs in 2010	70% of energy costs in 2010	-	0.5% (1%) of total CCA expenditures in sector

The volume of CCA expenditures was assumed to stay the same until 2050 and hence would not react to changes in GDP or climate damages. This means that the CCA expenditures are included into the predicted sectoral and GDP growth of the countries and *do not have any effects on the sectoral structure of the economies or have an effect on the level of climate change damages*. Another element of the baseline scenarios is the costs associated with the recovery from the climate extreme events. These expenditures cannot be avoided and consist of repairing and/or replacing the lost infrastructure, housing and physical capital stock. The damages from climate extreme events vary between the two baseline scenarios (A1B and E1) and are associated with additional annual flow of investments into capital goods, infrastructure and housing.

1.5.2 Reference scenario

The reference scenario is a policy-driven scenario where adaptation activities are expected to increase in line with objectives of current adaptation policies but taking into account the economic prospects of the Member State. The main assumption is that investment in adaptation is determined by Member Sates' potential to invest in adaptation activities, expected damage costs and current level of adaptation[91].

[91] Some of the adaptation activities form investment stock that depends on the new investments and investment in the previous period (Adaptation White paper Background report, Annex 4).

The starting dataset for the reference scenario is the same as for the baseline scenarios. The flow of reference scenario expenditures on CCA are created by applying country and CCA type specific annual growth rates to the dataset compiled for 2011. In order to model the employment impacts of CCA activities and investments, simple and transparent grouping of Member States based on the three dimensions listed above was necessary. The concept *potential to invest in adaptation*, which reflects the ability of a Member State to invest in effective and sustainable adaptation measures, was used. This study does not have the scope to go deep into the literature of and different opinions surrounding the topic of adaptive capacity. Therefore, this is not an attempt to develop a robust indicator of adaptive capacity of Member States but rather an indicator on the potential to invest for the purpose of this study. A distinction between the Member States on the basis of their potential or ability to make investments was needed. As it would be too difficult to make individual assumptions for each Member States on their adaptation investment projections, the grouping based on expected damage costs and potential to invest in adaptation was used.

As a minimum, the potential to adapt could be considered on the basis of financial capital, e.g. presented by GDP per capita. However, the adaptive capacity itself is considered to depend on a wider angle of capitals and research suggests that also other factors are important in preparing Member States to make investments in adaptation and thereby grow the economy or impact on jobs. Some existing indicators of adaptive capacity for Europe (such as IEEP, 2012 or Espon Climate) can also be used but not enough information on Member States' adaptation strategies and planning procedures could be gathered to judge the long term investment potential in adaptation. Also a single criterion whether the Member States has a National Adaptation Strategy in place (alongside with GDP per capita) could have been used to make the grouping. However, the carried analysis suggests that these strategies are all very different and high level and not necessarily commit to investment in adaptation. Therefore, differences in adaptive capacity remain between countries that do have an adaptation strategy.

Instead, the potential for Member States to invest in adaptation is presented based on the following key factors which emerged from literature:

- Weighted average of Cities' self-assessment of cities capability to adapt (acknowledging that cities are important actors in implementing climate change adaptation (Ballard et al. 2013b);
- Analysis of Member States' current capability to conduct climate change related research based on existing summary of adaptation research activities[92] (see the criteria for ranking in box below);
- Analysis of Member State's current capability in adaptation planning focusing on the existence and scope of the national adaptation strategy (see the criteria for ranking in box below);
- GDP per capita.

Criteria for Ranking MS Potential to Invest in Adaptation

Research

Countries were categorised using the following criteria:

Good

- Extensive in-country research on climate impact, vulnerability and adaptation
- Research addresses all key sectors
- Research undertaken at a national level and also extensively at a regional level

[92] Regional Adaptation Report, Appendix 1

Some

- In-country research but less extensive
- More reliance on projects that span a number of countries
- Research on climate impact and/or vulnerability and/or adaptation provides partial coverage of sectors and/or regions

Limited

- Research predominantly relates to projects that span a number of countries
- Research focused on impacts only and provides partial coverage of sectors and/or regions.

Planning (based on the existence and scope of the national adaptation strategy)

Countries were categorised using the following criteria:

Good

- National adaptation strategy/plan
- National and regional action plans address all key sectors and identify adaptation actions
- National adaptation indicators operational or in development

Some

- May or may not have a national adaptation strategy/plan
- If there is a national adaptation strategy/plan then coverage of sectors and/or regional plans is partial
- If there is no national adaptation strategy/plan then there is extensive coverage of sectors and regions

Limited

- No national adaptation strategy/plan
- If there are regional adaptation plans coverage of sectors and/or regions is partial.

Based on the above four indicators, an indicator whether a MS belongs to first (low), second or third tercile was constructed and then a weighted average to indicate the potential to invest in adaptation was developed. Finally, a low potential was given to Member States who were in bottom 14 in capacity rank and high capacity was given to Member States that were in top 14 in the ranking. A separate indicator on whether a country has an adaptation strategy or not was not used since this was reflected in the indicator planning & action. The table below shows the ranking. It is important to note that the only purpose of the ranking is to distinguish "high" and "low" in terms of Member States' potential to invest in adaptation; the scores are relative and therefore cannot be used as an absolute measure describing the potential to adapt. However, the categorisation is viewed as having a sound basis and being fit for the purpose of defining groups in the reference scenario.

Second, the data from the DARA Monitor on the total climate related damages in combination with the country-specific GDP prediction for 2015-2050 was used in order to calculate the climate damages to GDP ratios for MS countries in 2050. These ratios were used in order to decide whether the country was in the group of countries with low or high climate change damages. The countries were ranked according to their damage-share of GDP and the high cost category includes the top 15 countries whereas low cost countries are the bottom 13 countries. The cut-off point is approximately 0.6% GDP. The results mostly agree with PESETA II results; the main difference is that in the analysis the Baltic countries belong to high damage category.

Long term Investment in adaptation is a function of the potential to invest in adaptation and expected damaged costs. In order to group countries with different growth paths it is assumed that greater potential will have a greater influence on long term investments. There is greater uncertainty with damage costs. Hence, the potential to adapt would play a greater role relative to damage costs in planning documents and strategies to allocate funding for adaptation activities.

As a result, the countries were divided into the following 4 groups:

1. High costs, high potential to invest in adaptation;
2. Low costs, high potential to invest in adaptation;
3. High costs, low potential to invest in adaptation
4. Low costs, low potential to invest in adaptation.

Based on the above explained analysis, the four groups consist of the following countries:

Table 1-7 Proposed grouping of countries according to their potential to invest in adaptation and expected damages from climate change

Group 1	Group 2	Group 3	Group 4
Austria	Finland	Bulgaria	Cyprus
France	Belgium	Croatia	Malta
Spain	Denmark	Czech Republic	Luxembourg
	Italy	Estonia	
	Ireland	Greece	
	Netherlands	Hungary	
	Germany	Latvia	
	Sweden	Lithuania	
	United Kingdom	Poland	
	Portugal	Romania	
		Slovakia	
		Slovenia	

The groups have the following characteristics:

1st group: High damage cost and high potential to invest in adaptation

- Implementation of adaptation strategy by 2020
  - Continued investment in capacity building;
  - Towards 2020 starting to invest in priority sectors (determined by damage costs) over and above current levels.
- After 2020 steady increase in investments in priority sectors (determined by growth in damage costs). But there are still residual damage costs (i.e. damage costs after adaptation) due to budget constraints and other realities etc.[93]
- Capacity to take advantage of opportunities brought by climate change: Countries will also invest in sectors that are expected to benefit from climate change in order to maximise the benefits. However, these sectors receive less investment than adversely affected sectors.[94]

2nd Group: Low expected damage costs and potential to invest in adaptation

- Implementation of adaptation strategy by 2020

[93] Investments are prioritised by damage costs: the higher the damage growth rates the larger the investments in the particular sector. We have used 75% of the damage growth rate.
[94] We have assumed that investments equal 50% of the benefit growth rate (i.e. the rate that the benefits are growing.

  - Continued investment in capacity building. Towards 2020 starting to invest in priority sectors (determined by damage costs).
- After 2020 some investments in priority sectors, determined by growth in damage costs(less investments compared to group 1 because damages are smaller).[95]
- Capacity to take advantage of opportunities brought by climate change (see group 1).

3rd Group: High damage costs and low potential to invest in adaptation and 4th Group: Low damage costs, low adaptive capacity

- Adaptation strategy completed by 2020.
- Towards 2020 mainly investing in capacity and investment in capacity building will continue throughout the period
- After 2020 starting to invest in priority sectors. It has been assumed that the growth rates evolve so that eventually in 2050 they reach the growth rates of the high capacity countries.

Priority sectors refer to sectors that will be the most affected by climate change in terms of damages. For example, Austria and Germany highlight that urgency will be a very significant criterion in prioritising adaptation actions. In addition, it is important to note that some sectors are expected to benefit from climate change. Indeed, many strategies also discuss the potential opportunities climate change can bring. For example, Finnish strategy discuss the potential benefits that climate change can bring to the agriculture but acknowledges that benefits do not realise automatically but may require cultivation of different crops, as an example. Therefore adaptation actions that are targeted to maximise the benefits of climate change may also have an investment cost.

The growth patterns of adaptation investments (for physical, technical and financial measures) are summarised in the table 1-8 below.

Table 1-8 Growth paths of adaptation expenditures in the reference scenario (physical, technical and financial measures)

Group	2015	2020	2030	2040	2050
1	50% DGR	50% DGR	75% DGR	75% DGR	75% DGR
2	50% DGR	50% DGR	75% DGR	75% DGR	75% DGR
3	25% DGR	25% DGR	50% DGR	50% DGR	75% DGR
4	25% DGR	25% DGR	50% DGR	50%DGR	75% DGR

Note: DGR refers to damage growth rate; GDP refers to the GDP growth rate

In addition all countries continue to invest in capacity building but low capacity countries will invest more in order to catch up reflecting the objectives in the EU adaptation strategy: promoting action (including building adaptive capacity) and building the knowledge. Low capacity countries will invest 75% of the damage growth rates whereas the high capacity countries will invest 50% of the damage growth rates in capacity building throughout the study period. Low capacity countries invest mainly in capacity building and start also invest in physical and technical measures more after 2020 by completion of the adaptation strategy. It was also assumed that there are no

[95] Investments are prioritised by damage costs: the higher the damage growth rates the larger the investments in the particular sector. We have used 50-75% of the damage growth rate.

constrains in investing in any sector affected by climate change or climate extremes aligned with EU climate proofing and mainstreaming objectives.

1.5.3 Ambitious scenario

The main source of information with respect to the ambitious scenario is the micro-level data that was collected from the bottom-up approach. This bottom up information was used to calculate the future adaptation expenditures. In this section the collected data by sector and assumptions taken to scale-up this information are described. All this information, calculations and correspondent results are processed in excel sheets by sectorial activities and Member State.

Up-scaling bottom-up data to national level across EU Member States

To be able to use bottom-up information in the analysis, particularly to construct the 'ambitious' scenario, it was scaled up to national level. The up-scaling to national level was based on the assumption that all regions in a given MS will adopt a local adaptation strategy/ plan. Detailed bottom-up data on investments related to adaptation measures (in EUR per unit) for a few cities was available – Rotterdam, Copenhagen or Stuttgart. This information was up-scaled to national level by using physical country, city and regional (NUTS3) level data on the number of units, e.g. population, km of roads, number of buildings, land use type and area and the price information coming from the bottom-up research. Publicly available data sources including series of Housing Statistics of EU, Urban Audit database and regional statistics of EUROSTAT were also used.

Mapping activities

The following table shows the mapping of activities considered to calculate the adaptation expenditures for the 'ambitious' scenario for each adaptation sector by type of activity (technical, physical and capacity building).

Table 1-9 - Mapping activities across the sectors by type of activity and the corresponding cost benefit ratio

Sector	No.	Activity	Type of activity	Cost Benefit Ratio
Agriculture	1	Rainwater harvesting	Physical	1.9
	2	Flood meadow	Physical	1.9
	3	Buffer strips	Physical	1.9
	4	Farm advisory service	Capacity building	1
	5	Irrigation systems	Physical	1.9
Built environment	1	Ventilation and shutters	Physical	3.5
	2	Buildings storm resilient	Physical	3.5
	3	Flash flood	Technical	0.957
	4	Green roofs	Physical	3.5
	5	Vertical green for buildings	Physical	3.5
Disaster preparedness	1	Early Warning Systems	Technical	0.957
	2	Coastal zones	Physical	3.5
	3	Mapping beach erosion	Technical	0.957
Forestry	1	Improve forest management	Capacity building	0.5
	2	Rehabilitation forest fires	Physical	0.5
Health	1	Health effects	Technical/Physical (50/50)	1.1/1.6
Transport	1	Maintenance fundaments of roads	Physical	1
	2	Asphalt of roads heat resilient	Physical	1
	3	Asphalt of airports heat resilient	Physical	1
	4	Rail infrastructure	Physical	1

Sector	No.	Activity	Type of activity	Cost Benefit Ratio
Water Management	1	Sewage system	Physical	0.957
	2	Rainwater retention pools	Physical	0.957
	3	Flooding mapping watercourses	Technical	0.957
Energy	1	Infrastructure of electricity grids	Physical	0.333333333

Sector activities

In order to clarify what kind of actions fall under the umbrella of each activity, presented in table 1-9, and to avoid double counting each activity is clearly defined. All the assumptions considered to scale-up the investments for each activity are also described.

2011 is assumed to be the base year for investment for all the activities. The investments are presented per year (MEUR/year), for every five years until 2050 (2011, 2015, 2020, 2025, 2030, 2035, 2040, 2045 and 2050), taking into consideration real GDP and population growth rates per MS for these periods. For Croatia, as the population growth rate is since 1960 slowly decreasing with an average of 0,3%, and GDP growth rate is since 2009 negative, the overall growth rate is assumed to stay low, also given the declining population (0,5%).

For "Mapping Beach Erosion", "Early Warning Systems" and Flooding Mapping Watercourses" the investment until 2030 as explained below is also considered. For some activities, GDP (EUROSTAT 2011[96]) is used to scale-up the investments and PPP (EUROSTAT 2012[97]) and in order to correct the outcome per MS, it is assumed that PPP will stay the same for the whole period considered.

The activities considered by sector and respective assumptions are described in the following table. The percentage of investment to be achieved during the timeline considered a more detailed description of the adaptation activities and further assumptions are referred in the spread sheets.

Table 1-10 Definition of the adaptation activities and description of the assumptions considered

Activity	Definition	Assumptions
Agriculture		
Rainwater harvesting	Rainwater harvesting is an effective adaptation strategy for areas with high rainfall variability. The systems can be divided between catchment of water and storage (Hjerp et al. 2012).	Assumption: the average investment for the whole EU, based on the minimum and maximum cost for installation, maintenance and operation, given by Hjerp et al. (2012). EUROSTAT dataset on irrigable area was considered to relate the total investment to the % of irrigable area per MS.
Flood meadow	Flood meadows (an area of grassland or pasture beside a river, subject to seasonal flooding) are a green measure utilizing natural landscape functions and thereby embracing the concept of ecosystem based adaptation. (Hjerp at al. 2012).	Assumption: the average investment for the whole EU (excluding crop yield losses), based on the minimum and maximum investment given by Hjerp et al. (2012). EUROSTAT dataset on permanent grassland area was considered to relate the total investment to the % of grassland and meadow area per MS.
Buffer strips	Buffer strips include woodland, hedgerows, strips of grassland along water bodies, grass margins, field corners, etc. (Hjerp et al. 2012).	Assumption: the average investment for the whole EU (excluding yield losses due to occupied land), based on the minimum and maximum investment given by Hjerp et al (2012). EUROSTAT dataset on soil erosion

[96] EUROSTAT (2011) Dataset on GDP per MS; available at: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/National_accounts_%E2%80%93_GDP

[97] EUROSTAT (2012) Dataset on PPP per MS; available at: http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do

		by water (km2) was considered to relate the total investment to the % of eroded soil per MS.
Farm advisory service	Advice and capacity building for team managers by knowledge transfer and information actions, as well as advisory services, farm management and farm relief services.	Assumption: the average investment for all MS, based on the minimum and maximum investment given by Hjerp et al. (2012). The assumed total investment was related to the total GDP of EU28 to get the % of total investment related to GDP.
Irrigation systems	The costs of irrigation include expenditure for purchase and installation of the infrastructure, recurring maintenance and repair costs, recurring operating costs (most important are energy and fuel costs), and costs for water consumption (Ecologic 2012).	Assumption: the costs for additional irrigation water requirement by 2030 from the study carried out by Ecologic (2012). This study has the additional costs for the most relevant countries (Italy, Spain, Greece, France and Portugal) and total for other countries. The figures for the relevant MS were taken and for the other MS the investment was related to % of GDP.
Built environment		
Ventilation and shutters to buildings	This measure includes investment in air conditioning and installation of shutters to increase shadow inside the buildings.	Assumption: the minimum cost of a ventilation/ air conditioning system and similar in the Netherlands. It was considered that the Mediterranean region will have to install these systems in 30% of buildings, and the other regions only in 15%. The number of buildings per MS was taken from a study carried by the JRC (2011). For the missing data the ratio of inhabitants per building was calculated, and the figures for missing MS (considering Finland as reference for Denmark and Sweden; Slovenia for Croatia; Italy for Malta; and Ireland for UK) were estimated.
Buildings storm resilient	This measure includes the construction of adaptive roofs and the installation of additional valves in the sewage system to prevent floods and damages to the sewer pipes (avoid the water to "return" inside the pipes). The overall outside structure is also considered on these estimations.	The investment needed per building to make it storm resilient was based on a study by Umwelt Bundesamt (2012). It was assumed that the Mediterranean and Eastern Europe regions will have to implement this measure in 10% of the buildings; and North Sea and Baltic/ Scandinavian regions in 20%. To get the missing data, the same assumptions as for the "ventilation and shutters to buildings" was taken.
Flash flood	Maintenance costs for green/blue infrastructure to avoid damages from flash floods resulting from heavy rainfall, based on assumption to allow maximum water level on land to 10 cm in case of 100 year rain falls.	A study carried by the Municipality of Copenhagen was considered as reference for this estimation. This figure was related to the population of Copenhagen in order to get the maintenance costs per capita needed to avoid flash floods. Extrapolations for all MS and corrected for PPP were then made.
Green roofs	A green roof is a roof of a building covered with vegetation, in order to lower urban air temperatures and mitigate the heat island effect.	Bottom-up research, such as Rotterdam, Nijmegen, Dusseldorf and Copenhagen, was used for the cost per m2 to implement green roofs. It was assumed that the Mediterranean region will have to implement this measure in 20% of the buildings; and other regions in 10%. It was assumed that 40 m2 of green roof will be implemented per building.
Vertical green on buildings	A vertical green for buildings or green wall is a wall partially or completely covered with vegetation, in order to lower urban air temperatures as for green roofs.	Rotterdam case study was used as reference. It was assumed that the Mediterranean region will have to implement this measure in 20% of the buildings; and other regions in 10%. It was assumed that 40 m2 of vertical green will be implemented per building.
Disaster preparedness		
Early Warning Systems	Early warning systems have the ability to respond to all types of threats and under all climate change scenarios. These systems comprise the provision of meteorological data that indicates the probability of extreme weather events, and the response to those events (Hjerp et al. 2012).	For this estimation, the maximum investment needed for whole EU from the study carried by Hjerp et al. (2012) was taken and the total investment was related to the % of GDP and extrapolated to all MS.
Coastal zones	Normal coastal protection and climate adaptation in Europe.	The future annual normal coastal protection expenditures (2009-2015) were considered based on a study carried by Policy Research Corporation (2009). It was assumed that all these future investments can

		be related to adaptation.
Mapping beach erosion	Mapping coastal erosion susceptibility.	The study by the Swedish Commission on Climate and Vulnerability was used as reference for the estimations. The total investment for Sweden was related to the % of GDP and extrapolated to other MS, correcting the outcome per MS for PPP.
Forestry		
Improve forest management	Forest management is based on the combination of a number of practices including forest monitoring, maintaining species diversity, pest and disease management, conservation of biodiversity, and fire management (Hjerp et al. 2012).	For this estimation, the investment needed for whole EU was taken from the study by Hjerp et al. (2012). It was assumed that 80% of the investment is addressed to Southern countries (Portugal, Spain, France, Italy, Cyprus, Malta and Croatia), considering the highest risks. The total investment was related to the % of total GDP and extrapolated to all MS, considering the different % of investment for these countries.
Rehabilitation forest fires	Establishing new tree plantation, including establishment costs and land.	Cycles of five years were assumed as time needed for rehabilitation. Different % of occurrence per region (southern: 30%; Western Europe: 5%; Northern Europe: 5%; Eastern Europe: 10%) were assumed. The study from the RFF was considered for the assumptions and reference investments. EUROSTAT dataset on total area of forests and woodlands per MS was taken to scale-up the investment figures.
Health		
Health effects	This activity considers the damage costs in terms of the health effects of climate change (heat related effects).	Although poorer areas will be affected more, this could be levelled by the fact that urban areas will be affected harder (related to ozone and heat effects). As such, the 2 billion (estimated by VOLY) will be distributed equally among MS pro rata the health expenditures (Hjerp et al. 2012). Assumed the health expenditures per capita from the study by the World Health Organisation (WHO) and calculated the total health expenditures per MS, based on the population figures. The health expenditures from Hjerp et al. (2012) were related to the WHO study, in order to estimate the % of expenditure related to climate change used per country in 2011.
Transport		
Maintenance fundaments of roads	Higher temperatures and increased rain fall will affect the structure of roads. The capacity increase of roads' drainage systems is the most appropriate adaptation measurement to precipitation increase. The drainage system for communal roads is designed in a way that two incidents a year are permitted. For motorways extreme events within a period of five years is consulted.	The Dutch study arrives at 100.000 euro per km/10 meters width; the Ecologic study arrives at 24.000 euro per km/10 meters width. An average 50.000 per km was taken and it was assumed that all roads have a width of 10 meters (will be higher for motorways, less for regional roads). The investment needed per km of road was calculated, summing the total length of motorways (EUROSTAT dataset 2012), length of main or national roads (European Commission data 2009) and secondary or regional roads (European Commission data 2009).
Asphalt of roads heat resilient	For renewal and possible adaptation to climate change only the surface course and in some cases the binder course have to be exchanged, while concrete asphalt has to be completely exchanged for renewal. The single layers have a different durability: surface course 15 years, a binder course 20 years and a base course 30 years.	Additional costs with a fifteen year cycle of renewal are taken into account as an average between minimum and maximum values (additional costs = 15% of the renewal cost). These costs were taken from the study carried by Ecologic. For Croatia, the investment for Slovenia was taken and adjusted for PPP.
Asphalt of airports heat resilient	A temperature increase may cause rut occurrence at airports like on roads. At airports also parking spaces, taxi ranks and especially runways will be affected. The possible adaptation measures and the limits are the same as for roads concerning increased temperature.	Additional costs with a ten year cycle of renewal are taken into account as an average between minimum and maximum values (additional costs = 15% of the renewal cost). These costs were taken from the study carried by Ecologic. For Croatia, the investment for Slovenia was taken and adjusted for PPP.

Rail infrastructure	Climate change has an effect on the condition of the rail network. Considered the increase in annual costs due to increased storm weather (with flooding, and falling trees) and extreme hot weather which could lead to the so-called track buckles (slightly bended rails).	Calculated the investment needed per km of railway, considering the total length of railway lines for the Netherlands (EUROSTAT dataset 2012). Extrapolated the investment for other MS based on the total length of railways per MS (EUROSTAT dataset 2012).
Water Management		
Sewage system	The current rate of piping renewal is about 0.4% a year. It's considered the estimate of current renewal costs, the expected gradually increasing renewal over 25 years and additional investments in hydraulically critical areas corresponding to 10-15% of the total sewage system.	The study carried by the Swedish Commission on Climate and Vulnerability was taken as reference for the estimations. The total investment for Sweden was related to the % of GDP and extrapolated to other MS, correcting the outcome per MS for PPP.
Rainwater retention pools	Rainwater retention pools to avoid waste water intrusion into nature.	In other MS, there are already retention pools and it was assumed that the extra capacity needed due to climate change adaptation is 20%. The investment needed for rainwater retention pools in Germany, based on Umwelt Bundesamt study was taken. The total investment for Germany was related to the % of GDP and extrapolated to other MS, correcting the outcome per MS for PPP.
Flooding mapping watercourses	The purpose of general flood mapping is to broadly identify areas at risk of flooding along watercourses.	The study by the Swedish Commission on Climate and Vulnerability was taken as reference for the estimations. The total investment for Sweden was related to the % of GDP and extrapolated to other MS, correcting the outcome per MS for PPP.
Energy		
Infrastructure of electricity grids	The total costs for adapting the electricity transmission network to the effects of climate change comprise investments costs for securing networks from storm damage, additional maintenance costs, and additional investment costs due to higher cooling energy demand.	The costs for electricity grids, calculated in the study carried out by Ecologic (2012) were taken and Germany's price level was assumed as reference. The length of grid infrastructures (km) per MS was taken from ENTSO-E and therefore related to the total investment needs.

Source: own calculations

1.5.4 Sensitivity analysis

To check the sensitivity of the results to the modelling assumptions, two of the assumptions underlying the model have been tested. The total number of jobs created in 2050 using those assumptions is compared to the base run (i.e. the model results presented in the previous sections of Chapter 6 related to the ambitious scenario).

First, the level of the cost-benefit ratio has been decreased and increased by 50%. shows the total number of jobs created in 2050 for the ambitious scenario for each of the different model runs. The minor differences between the different runs show that the results are not sensitive to this assumption.

Table 1-11 Results sensitivity analysis with respect to CBR

CBR	Total jobs created	difference w.r.t. base (%)
base	1002457.00	
increase with 50%	976880.05	2.6%
decrease with 50%	975091.71	2.7%

Source: own calculations

In Table 6-3 the sensitivity with respect to the capital-labour elasticity is shown. This table again shows that the total number of jobs created does not change much for different values of the elasticity.

Table 1-12 Results sensitivity analysis with respect to capita-labour sensitivity

Elasticity between capital and labour	Total jobs created	difference w.r.t. base (%)
base	1002457.00	
0.6	982777.39	2.0%
1.1	977727.96	2.5%
1.3	974660.01	2.8%
1.8	973364.73	2.9%

Source: own calculations

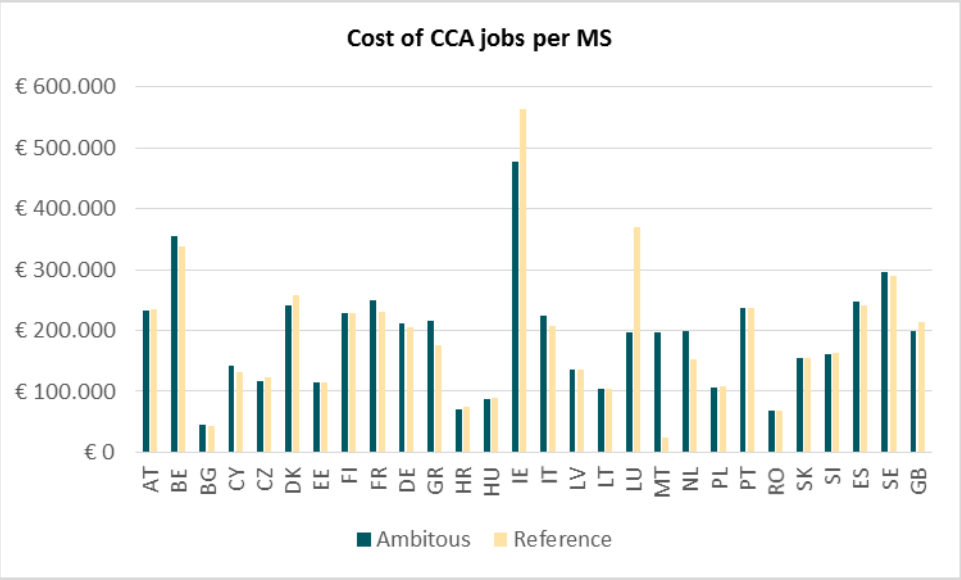
1.6 Additional results from the modelling

This section presents some additional results from the modelling.

1.6.1 Cost of jobs created

The main report presents the number of jobs created per billion EUR spent on adaptation. Another possibility is to consider the results as the cost of a climate change adaptation (CCA) job created. The following figure shows the costs per MS in the Reference and Ambitious scenarios. The highest costs for both scenarios are observed in Ireland which is also the country where the least amount of jobs is created per billion EUR spent on adaptation. Respectively, the cost of a CCA job created is lowest in Bulgaria for both scenarios as this is the country where most jobs are created per expenditure on adaptation.

Figure 1-2 Cost of a CCA job per MS for the Reference and Ambitious scenarios



1.6.2 Number of jobs created

Looking at the disaggregated effects per MS, higher amount of total jobs are created in the ambitious scenario compared to the reference – double or more for most MS.

The table below shows the development through time of the total jobs – both direct and indirect, created per MS.

Table 1-13 Total number of jobs created per MS in the Ambitious scenario

Country	2015	2020	2025	2030	2035	2040	2045	2050
AT	3.137	4.775	6.482	8.452	10.937	14.188	18.535	23.953
BE	1.566	2.413	3.386	4.597	6.185	8.294	11.046	14.634
BG	4.195	5.119	8.296	10.461	12.575	26.134	32.737	41.924
CY	316	422	596	697	818	1.335	1.633	2.039
CZ	4.074	5.373	8.511	10.970	13.537	27.259	34.043	43.123
DE	18.242	25.713	33.743	42.635	52.879	65.734	82.328	100.975
DK	2.478	3.065	3.881	5.661	6.375	6.117	7.035	8.027
EE	976	1.199	1.662	1.897	2.131	3.124	3.416	3.750
ES	12.363	21.370	29.551	35.486	40.849	47.230	55.249	67.149
FI	1.523	2.224	2.825	3.494	4.302	5.165	6.062	6.924
FR	19.001	30.428	43.225	58.437	77.704	101.072	132.588	173.622
GB	11.947	17.155	22.971	29.326	36.505	44.989	54.675	65.042
GR	3.203	3.457	4.425	5.005	5.515	7.561	8.120	8.872
HR	1.305	1.596	2.463	3.147	3.948	8.542	11.792	16.608
HU	3.157	4.498	8.609	11.334	13.836	30.509	38.915	50.649
IE	1.136	1.606	2.031	2.323	2.508	2.546	2.521	2.555
IT	14.586	24.983	35.850	46.332	57.870	70.988	86.905	106.081
LT	1.932	2.203	2.889	3.015	3.236	5.232	6.224	7.409
LU	367	426	455	515	583	680	714	727
LV	887	1.156	1.722	1.899	2.100	3.628	4.387	5.469
MT	175	204	263	301	355	2.996	649	753
NL	3.955	4.807	5.407	5.934	6.446	7.086	7.853	8.559
PL	9.954	13.342	21.732	27.073	33.095	69.213	86.474	106.894
PT	3.113	4.745	6.476	7.876	8.997	10.075	10.983	12.133
RO	7.316	8.361	13.903	17.585	21.109	47.003	61.011	81.991
SE	3.299	4.446	5.724	7.089	8.665	10.523	12.788	15.596
SI	823	1.014	1.623	2.046	2.471	5.579	7.418	9.945
SK	2.302	2.904	4.242	4.979	5.641	11.287	13.823	17.053

The further disaggregation of the results in the most affected sectors shows that in the ambitious scenario in 2050 most jobs are created in Education and Training and Other Business Services in France. In both sectors the created jobs favour males with medium education level. In terms of occupation type, Office Clerks is the favoured occupation in the sector education and training. For the top 20 sectors most jobs are created for the male population, nevertheless the sectors Research and Development in Bulgaria and Financial Services in Poland and Romania favour the female workers. For the majority of the cases, most jobs are created for people with medium level of education. A more detailed overview of the distribution of jobs created in the ambitious scenario per MS, gender, education and occupation type is presented in the following table.

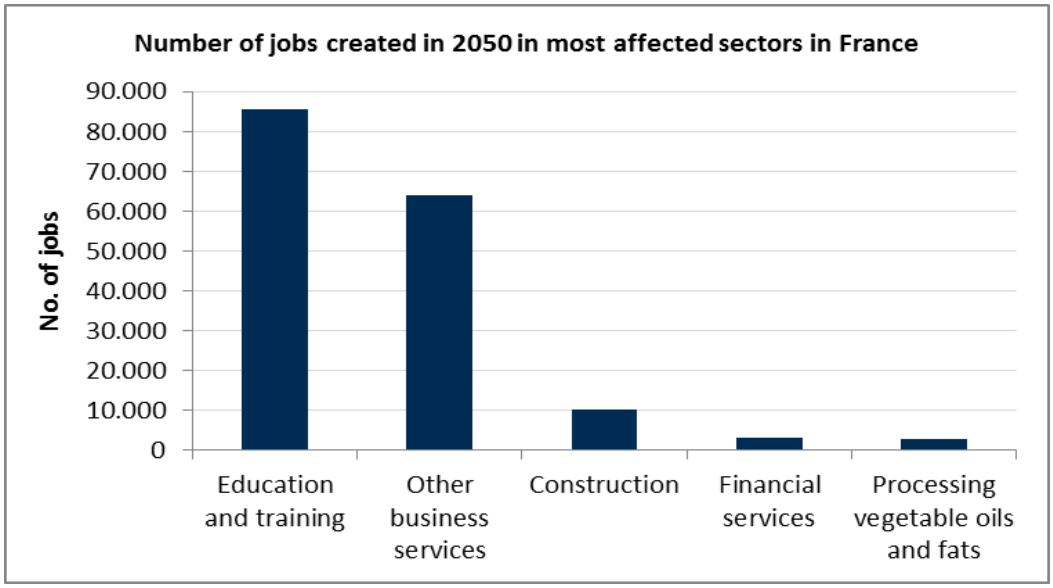
Table 1-14 The sectors with the largest number of created jobs in 2050 in the ambitious scenario – presented per MS, gender, education and occupation type

Ranking	Country	Sector	Total number of created jobs	Male	Female	Low	Medium	High	Other Associate Professionals	Personal And Protective Services Workers	Office Clerks	Sales And Services Elementary Occupations	Market-Oriented Skilled Agricultural And Fishery Workers
1	FR	Education and training	85.534	27.607	57.927	19.097	37.082	29.356	8.649	8.479	9.458	6.165	2.483
2	FR	Other business services	63.872	33.941	29.931	14.430	28.386	21.056	6.238	5.214	5.774	3.982	2.304
3	DE	Other business services	39.847	20.220	19.628	5.398	23.424	11.025	4.827	3.254	3.904	2.166	696
4	IT	Construction	35.646	33.690	1.956	14.373	16.048	5.225	3.477	1.876	2.543	2.031	1.038
5	PL	Research and development	32.378	16.450	15.928	2.442	20.947	8.990	1.994	2.525	1.951	1.611	3.838
6	IT	Other business services	31.323	16.629	14.694	10.933	14.730	5.659	3.481	2.352	3.304	2.232	689
7	RO	Research and development	29.277	16.141	13.137	7.379	17.203	4.695	1.433	2.050	1.080	2.185	7.097
8	BG	Research and development	27.458	10.676	16.782	3.572	15.896	7.990	1.418	3.093	1.838	2.120	1.112
9	PL	Financial services	26.922	8.634	18.289	1.928	16.870	8.125	1.762	2.418	1.874	1.436	3.190
10	DE	Construction	26.537	23.178	3.359	3.475	15.225	7.837	2.573	1.282	1.809	1.299	575
11	GB	Construction	26.150	23.355	2.795	4.691	12.136	9.322	1.586	1.868	1.507	1.923	467
12	ES	Construction	22.591	20.719	1.872	9.646	5.354	7.590	1.406	1.789	1.149	1.652	766
13	PL	Other business services	17.181	8.984	8.197	1.297	11.145	4.739	1.053	1.324	1.023	850	2.037
14	ES	Other business services	15.553	7.768	7.785	6.039	3.724	5.790	1.011	1.798	1.197	1.477	365
15	RO	Other business services	14.952	8.729	6.223	3.742	8.832	2.378	715	1.022	534	1.122	3.607
16	GB	Other business services	14.700	8.501	6.200	2.661	6.596	5.444	966	1.561	1.395	982	187
17	RO	Financial services	14.291	4.497	9.794	3.751	8.117	2.423	823	1.185	655	1.033	3.600
18	HU	Construction	14.248	13.125	1.123	1.542	9.691	3.015	727	1.043	581	688	498
19	DE	Education and training	14.062	4.372	9.689	1.939	8.373	3.750	1.886	1.400	1.603	805	214
20	PL	Construction	11.168	10.497	672	934	7.753	2.482	589	567	432	464	1.326

Results for France

The modelling results show that most jobs will be created, both directly and indirectly, in France in 2050 for the ambitious scenario. This is mainly due the share of CCA investments to GDP in France which was relatively large. For example, France will have 15% of EU working population in 2050 and CCA expenditures will be higher than 1% of its GDP in the ambitious scenario. This is the highest combination in the group of EU countries. The sectors in which the largest number of jobs is created and which contribute to France's leading position in the sample are Education and Training and Other Business Services. The amount of employment opportunities generated in other sectors is not as high as in other counties and they contribute relatively less to the total number of jobs created in France in 2050 as exhibited by the following figure.

Figure 1-3 Number of jobs created in the most affected sectors in France in 2050 for the Ambitious scenario

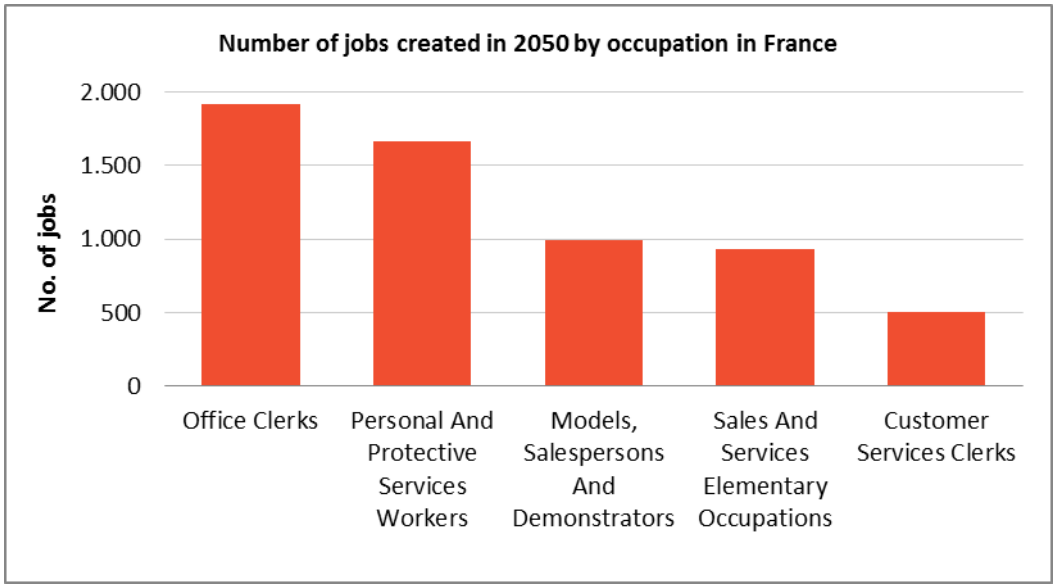


The results for occupation type show that Office Clerks and Personal and Protective Service Workers are the most favoured occupation types in France. Nevertheless, the differences in the number of jobs created for the top five occupations are not very large.

The explanation could be given as follows:

- Personal and protective services workers are mostly employed by the construction sector which is highly affected by the CCA expenditures
- Education and training sectors as well as other business services employ many office clerks and customer service clerks
- Sales and services professionals as well as sales persons are employed a bit everywhere but in particular in wholesale and retail which is inside of the other business services sector.

Figure 1-4 Number of jobs created by occupation in France in 2050 for the Ambitious scenario



2 Annex B1: Case Study: Copenhagen

2.1 Short description of the Case

Copenhagen is among Europe's most ambitious capitals when it comes to climate adaptation and mitigation. According to its 2011 climate plan – CPH 2025 Climate Plan – the city should become the first carbon neutral city by 2025. The climate plan, which mainly includes mitigation measures, was followed up by an adaptation plan – the Copenhagen Adaptation Plan – which identifies the main climate vulnerabilities of the city. In total about € 1 billion is allocated to adaptation measures but the division of the expenditure has not been determined.

2.1.1 Why climate change adaptation important

With roughly 1.2 million inhabitants in the urban centre and nearly 2 million in the metropolitan area, Copenhagen is the most populous city in Denmark, and an economic and cultural hub for the Öresund Region. Situated by the sea and criss-crossed by canals, water has become a major factor in the development of the city and a cause of increasingly large problems of floods. Consequently, the adaptation plan focuses on more and heavier downpour, rising sea-levels, and flooding. The plan estimates the costs of flooding from sea-water and rain-water to be DKK 350 million in 2010 annually, a number that rises to 570 million in 2060 and 1050 million in 2100. On top of the social and environmental problems that follow with the floods, the financial costs are simply deemed unacceptable by the municipality. Political support of the excessive downpour plan is likely to have been boosted by heavy rainfall and thawing snow resulting in major floods in the Copenhagen area in 2010 and 2011.

Copenhagen is clearly trying to frame the climate adaptation plan in terms of "green growth". The huge investments foreseen for adaptation are seen as a carrot for companies to engage in innovation and provide smart solutions to climate adaptation which could lead to growth in green tech and profiling the city in terms of climate smart solutions. The exact figures of the investments from the city towards these projects are unclear.

2.1.2 Adaptation related activities

Copenhagen has a well-developed climate adaptation plan adopted in 2011 which has been complemented by an adaptation plan for excessive downpour. The aim is be able to cope with one per 100 year event for the coming 100 years without any damages to the city. In 2012 and 2013, the city allocated DKK 96 million and DKK 42 million respectively for the downpour plan and DKK 56.7 million to climate (and fire) adapt the buildings of the municipality.[98] Future climate adaptation is likely to surge as the risk and intensity grows, however.

The emphasis of the adaptation plan is on infrastructural investments in risk-prone areas such as reducing the hydraulic load on water courses, and strengthening dikes and coastal defence. There are also a few more research related tasks such as setting up a monitoring system, early warning system, and information material.

[98] http://www.kk.dk/~/media/6D1F87E2D2B747FABB3CAD39CE7E9E12.ashx

The table below provides an overview of the activities.[99] For a more detailed overview, please see page 85 – 90 in the adaptation plan.

Table 2-1 Overview of adaptation activities in Copenhagen and their investment in (EUR)

	2011 (€)	2012 (€)	2013 (€)	2014 (€)	2015 (€) ->
Storm water	107 000	127 000	4 000 000	4 000 000	4 000 000
Sea	13 400	13 400			
Warming		73 700	6 700	6 700	6 700
Soil & Groundwater	50 200	10 000			
Buildings		40 000			
Greener city	33 500	100 000	53 600		
Green growth	33 500				
Financing	0	200 000	130 000	67 000	
Cross-cutting projects	0	200 000	200 000	200 000	

Source: Copenhagen climate adaptation plan

The overview should not be viewed as final but rather to illustrate how the distribution of funds is heavily geared towards measures to address problems with excessive downpour or storm water. The adaptation plan divided the city into seven catchment areas: Bispebjerg, Ryparken and Dyssegård[100]; Østerbro[101]; Nørrebro; Indre by; København Vest and Fredriksberg Vest[102]; Ladegårdsåen, Fredricksberg Øst and Vesterbro[103]; Amager and Christanshavn. For each area a detailed implementation plan proposal has been developed and is under different level of implementation. The table below summarises the numbers that are available for estimating the climate adaptation costs for each areas:

Table 2-2 Estimated costs for each catchment area in Copenhagen

Catchment area	Implementation costs (€)	Annual maintenance costs (€)
Østerbro	91.2 million	240 000
København Vest and Fredriksberg Vest[104]	569.2 million	8.3 million
Bispebjerg, Ryparken and Dyssegård	227 million	1.6 million
Indre by[105]	31.1 million	676 000
Ladegårdsåen, Fredricksberg Øst and Vesterbro[106]	284.6 million	5.5 million
Nørrebro	Only EIA without cost estimates available	Only EIA without cost estimates available
Amager and Christanshavn	Only EIA without cost estimates available	Only EIA without cost estimates available

Given the large financial investments in water management, adaptation to changes in precipitation, sea-level rise and other water related challenges will be the focus for the remainder of this case-study. Jobs related to construction will be given special attention since the bulk of investments are expected to take place in infrastructure.[107]

[99] Exchange rate of 1 DKK = 0,13 EUR
[100] Project proposal "Bispebjerg, Ryparken and Dyssegård" October 2013
[101] Project proposal "Skybrudsopland Østerbro" April 2013, p.93
[102] Project proposal "Konkretisering av skybrudsplan" November 2013, p.100
[103] Project proposal "Konkretisering av skybrudsplan" October 2013
[104] Costs to be borne by both municipality and utilities
[105] The project proposal estimates cost in a range from min. to max. Here the average is used.
[106] Two alternative plans are presented in the project proposal. Here Masterplan 1 is used which is slightly less expensive than Masterplan 2.
[107] Interview with Ms. Lykke Leonardsen, head of climate policy, Copenhagen municipality.

2.2 Employment Aspects

2.2.1 General employment trends in the sector / city

Copenhagen provides work to almost 360 000 people of which the construction section contributes with about 5 500 jobs.[108] As in most European countries, the construction industry experienced a slump in confidence and demand during the crisis years around 2009 but has shown a steady come back since then.[109] Copenhagen is also home to among the largest technical consultancies in northern Europe including Rambøll and COWI with 10 000 and 8 000 people employed world-wide respectively. The largest technical university in Denmark – Danmarks Tekniske Universitet (DTU) – is also situated in Copenhagen and hosts between 60 000 – 9 000 students in mainly technical education programmes such as engineering.

2.2.2 Adaptation related employment

The climate adaptation plan clearly spells out that the city perceives the future adaptation investments as an opportunity to showcase innovative demonstration projects and solutions. The plan mentions, that there are large possibilities to work, in particular, together with the publicly owned Copenhagen Utility (today called Greater Copenhagen Utility) in designing projects. The concrete steps toward realizing these potentials have been to try to set up innovation platforms and stakeholder forums to assess the potentials and enable a creative environment. Interviews with city representative confirm that so far has the adaptation planning been a collaborative process between public and private partners.

The city has started to map the effects on employment and skills needed to carry out the adaptation plan. The mapping indicates that while planning will require highly educated people in the fields of economics and engineering, the majority of the jobs will be blue-collar sector jobs related to water management such as surveyors, road-maintenance workers and other construction workers. Not only the construction of new infrastructure will create jobs but also the maintenance is expected to have a positive impact on employment.

The city does not expect a shortage in people with the right skills to carry out the tasks. The availability of people in large technical consultancies, the university and construction companies, both in Copenhagen and in Denmark in general, should be adequate to meet the demand for different positions. If anything, there may be occurrences when the timing of several infrastructure projects coincide which could hamper the availability of construction workers, however this is expected to be an ad hoc problem rather than a structural challenge.

Some training might be needed to prepare workers for specific adaptation needs however the collaborative process of developing the adaptation plan and measures between the city, companies and other stakeholder, should prepare employers for new challenges in skills needed. In this sense, the re-skilling is expected to "come by itself" within the companies and institutions such as the technical university, hence the city is not planning any major investments in training-programmes.

2.3 Occupation & Skills Aspects

2.3.1 Adaptation related occupations & disciplines

The adaptation measures for Copenhagen nearly all relate to investments in infrastructure, buildings and utilities, to cope with more rain-fall and raising sea-level.

[108] http://www.kk.dk/~/media/BA77851CF39E40289FD53242027C37CD.ashx
[109] Analysis from data from statbank.dk

The main occupation types that will benefit from the investments are within consulting, construction and planning.

To assess more in detail where the jobs will be created, a stylized model of infrastructure and construction project processes consisting of four major processes is assumed: the planning phase where decision-making material is produces in the shape of feasibility studies, impact assessments and decision-making material; the pre-construction phase of developing plans, start procurement and acquire permits; the construction phase of implementing the plans; and finally, the maintenance phase. Each phase requires its own skills. Planning and pre-construction requires high-skilled and educated engineers, technical consultants, economists, architects, etc. Implementation phase requires mainly blue-collar construction workers and to a lesser extent project leaders often with higher skills. Maintenance phase requires again highly skilled engineers to control the structures.

The following table provides a rough overview of the building process and the allocation of costs and related occupations:

Table 2-3 Overview of the building process and the allocation of costs and occupations

Phase	What	% of total costs[110]	Skills & occupations
Planning	Feasibility studies, EIAs, time-plan, models/sketches/printing, etc.	3 – 5 %	engineers, technical consultants, economists, architects
Pre-construction	Blue-prints, permits, procurement material, quality and environmental plans, etc.	10 – 15 %	engineers, technical consultants, economists, architects
Implementation	Ordering, construction, evaluation	75 – 85 %	mainly blue-collar construction workers and to a lesser extent project leaders often with higher skills
Maintenance	Maintain integrity and function of structure	N.A.	highly skilled engineers to control the structures

2.3.2 Adaptation related skills

In other European countries, such as the UK, market actors have started to explore how future climate challenges, in particular to water management, will transform the requirements in skills and training. For example, Energy & Utility Skills, an employer organisation in the UK, argues that "the 2030 water industry could see automated systems for leakage repair, universal water metering and a free-moving water grid linking a diverse network of suppliers and service providers" and that "It is likely that there will be a shift in emphasis and addition of new elements to existing training and qualifications, rather than a radical overhaul of the existing system. […] this will include greater importance placed on environmental issues and the integration of strategic and commercial skills development into existing roles" (EU Skills 2013 Water). Copenhagen expects similar trends in relation to water management currently there are too few engineers. However, there is currently no sign that Copenhagen will have any shortage of adaptation related skills but rather that companies, universities

[110] Based on estimates from Swedish construction company Higabgruppen (http://higabgruppen.se/upload/files/Byggprocess.pdf)

and other stakeholders will adapt to the new skills needs automatically. There is also an increasing interest in engineering from students and the sector has been successful in attracting young people.[111]

3 Annex B2: Case Study: Rotterdam Climate Proof

3.1 Short Description of the Case

The purpose of the Rotterdam case (executed in 2010) was to look at possible economic spin- off effects resulting from the two objectives that are included in the Rotterdam Climate Proof (RCP) programme (part of the overall Rotterdam Climate Initiative[112]). These two objectives are: "Rotterdam climate proof by 2025" and "Rotterdam water (knowledge) city number one and inspiring example for other delta cities in the world."

3.1.1 Why climate change adaptation important

Rotterdam, as one of the biggest ports in the world, accounts for 17% of the total Netherlands' production and – due to its location - it is vulnerable to climate change impacts. Rotterdam wants to become climate proof (and stay dry) also the coming decades and as such most priority is given to rely further on their system of storm surge barriers and dikes, canals and lakes, outlets, sewers and pumping stations. However, in this case study, Rotterdam also looked at climate adaptive measures in the city as such (not water related) and accessibility issues (roads, rail, etc.).

3.1.2 Adaptation related activities

In this case study answers were provided to the following questions:

1. What investments are necessary for the realization of the RCP target: "Rotterdam climate proof by 2025"?
2. What does the implementation of a climate proof Rotterdam means for direct and indirect employment?
3. What is the direct and indirect economic spin-off of the implementation and realization of the second RCP target: "Rotterdam water (knowledge) city number one and inspiring example for other delta cities in the world"?
4. What is the economic damage if nothing is done?

3.2 Employment Aspects

3.2.1 General employment trends in the sector/ city

Rotterdam counts nearly 600.000 people of which 69% between 16 and 54 years old (50%/50% gender split). The unemployment rate in Rotterdam was already higher than in other Dutch cities and increased slightly further just above 7% of the labour force (CBS, 2013). Reason for this is that the city contains a relatively larger group of lower educated people and the percentage of highly educated persons is low in comparison to the other major Dutch towns. There is also a noteworthy discrepancy in household earnings between ethnicities. In particular, Moroccan households have the lowest income. Correspondingly, there are relatively more non-western households living below the poverty line. In total, more than 44.000 households have less to spend than the minimum amount, which is 17% of all households (and is increasing further).

[111] Based on personal communication with Lykke Leonardsen, head of climate policy, City of Copenhagen.
[112] In 2012, RCI as an institute (part of the Rotterdam administration) was dismantled due to budget issues although the brand name continues to exist. People of the old RCI are still doing climate proof coordination activities, now working at the 'Sustainable Programme Office'.

3.2.2 Adaptation related employment

The below mentioned jobs[113] are related to the proposed investment plans at the time of writing the RCP strategy (2010). As background information, these investments will first be descried shortly.

The activities for climate resilient Rotterdam are divided into four groups of measures:

1. Outside the dike - solutions to flooding (housing, employment) in areas outside the dike area;
2. Urban water (or inside the dike area) - solutions to flooding and water shortage in the city;
3. Urban climate - provide cooling in the city and better air quality;
4. Urban climate and accessibility - solutions for flooded tunnels, the subway system and parking garages.

The starting point for the necessary investments in Rotterdam is the current worst case scenario of the KNMI (W+).

The estimated investments for each of the sectors/activities are listed in the tables below.

Table 3-1 Investments (in M euro, 2012-2025)

Theme	Min	Max
Outside dike area	228	330
Fortify existing dikes	2000	4800
Urban water system	89	93
Urban city climate	141	
Accessibility	1457	
TOTAL	**3915**	**6821**

Table 3-2 Employment (only water related activities) (in labour years)

Theme	Min	Max
Direct employment	10500	17059
Indirect employment	9400	15176
Temporally employment	8500	13765
TOTAL	**28400**	**46000**

Taking into account the themes 'outside the area, dike reinforcement and urban water system', the economic spin-off of these investments between 2012 and 2025 is estimated at min EUR 2,317 million - approximately 28,400 man–years to generate – and maximum EUR 5,023 million (generating 46,000 man-years).

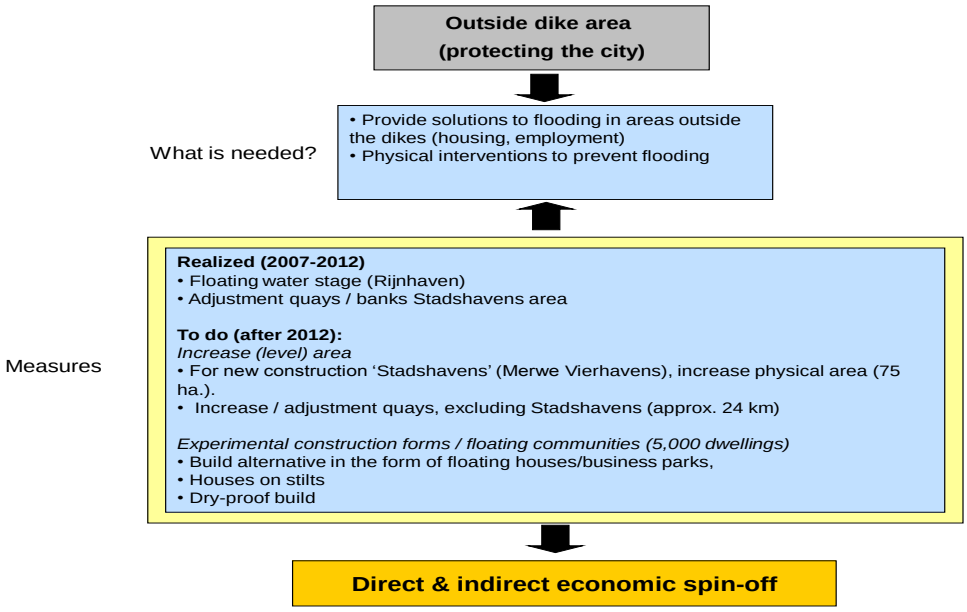
[113] The direct employment effect is the employment (in labour years) that occurs as a result of the implementation of the measures. Basis for calculating the impact on employment is the investment impulse. The relationship between investment and employment is through the output per person employed (based on the production and labour market statistics from the Central Bureau of Statistics (CBS). Dividing the estimated investment (by sector) by this value (by sector) gives the direct employment effect (by sector).
The indirect effect arises because other sectors benefit from the newly created (direct) employment. These indirect effects relate spin-off effects from purchasing and outsourcing by parties involved in the implementation. To determine these effects, an input-output analysis was used for the Rotterdam region, which gives a detailed description of the goods and service flows within the region.

3.3 Occupation & Skills Aspects

3.3.1 Adaptation related occupations & disciplines: outside dikes area activities

Although it was possible to focus on several adaptation activities in Rotterdam as explained in Table 4-1, the outside dikes area activities were chosen as most of these are already implemented and as such it is easier to say something about the occupation and skills aspects.

Figure 3-1 Outside dike area activities and measures



Floating water pavilion (Rijnhaven)

In the Rhine harbour of Rotterdam is since 2010 a climate-proof pavilion. The floating building is designed to receive 500 people at a time. It is moving along with the tide, so it is permanently protected against flooding. The floating pavilion is a pilot project for building climate resilient floating in Rotterdam and the cost was €6.2M. Of this €6.2M, nearly 40% of it went to the preparatory phase. In this phase (which took circa 2 years) all people involved (approx. 20 labour years, 10 people during 2 years) were higher educated people (Physical, Mathematical and Engineering Science Professionals), and senior officials (everything is nearly financed with public money). At this stage, all activities are related to applied research, permitting and financing and project development. From 10/209 up to 6/2010 the construction has been build and installed. Labour forces are dominantly Labourers in Mining, Construction, Manufacturing and Transport, Extraction and

Building Trades Workers and Metal, Machinery and Related Trades Workers, managed by Physical, Mathematical and Engineering Science Professionals. Exploitation and maintenance is done by a private company.

All labour (except exploitation and maintenance) is temporarily (related to the construction period).

Adaptation of the quays and banks in the Stadshavens' area (or City Ports)

Rotterdam City Ports' (see aerial photo) is the collective name for a large number of ports on both sides of the Nieuwe Maas. This area is located outside the area protected by the 'high' dikes and it is about 1,600 hectares. Parts of City Ports are below the normative high water. In the development of new fields in the City Ports' area, quays and banks will be adapted.

Figure 3-2 Map of the quays and banks in the Stadshavens' area

The distribution of labour is related to project development and planning on one hand and the construction. As this process is less innovative than the pavilion project, the proportion of the budget going to the pre-construction phase (thus R&D, project development/planning, permitting, financial closure) is much lower (circa 10-20%). As such, 70-80% of the labour is related to 'Mining, Construction, Manufacturing and Transport' and 'Extraction and Building Trades Workers'. Nearly all labour is temporarily in time (related to the construction period). Total investment is around €50M and number of labour years is estimated to be around 400 (of which most is low skilled work).

4 Annex B3: Case Study: Ancona

4.1 Short Description of the Case

Nearly the whole of Italy is at risk of landslide and flooding. Four out of five towns in Italy (82% of total) have areas at hydrogeological risk (as identified in local hydrogeological plans) affecting over six million people. A report by Legambiente[114] suggests that 21% of towns in Marche region have whole districts in high risk areas,

[114] Legambiente, Ecosistema Rischio 2013; Available from: http://www.legambiente.it/sites/default/files/docs/ecosistema_rischio_2013_def.pdf

and 82% of districts have at least some houses at risk. The risk of landslides is also very relevant for the local industry, with 66% of factories located in high risk areas.

Although the initial cause of this risk is generally heavy urbanisation and poor planning (and quite often illegal construction), heavy rain is normally responsible for triggering a landslide. Figure 5-1 presents the landslide risk areas in Italy.

Figure 4-1 - Landslide and flooding risk in Italy, Italian Institute Atlas[115]

In 1982 a massive landslide destroyed a large area in Ancona, the principal city of the Marche region. The landslide resulted in:

- 3661 homeless people;
- 280 total buildings destroyed, including large hospital facilities;
- Destruction of 31 farms, 3 industrial plants and 42 shops;
- Severe damage to transport and utilities infrastructure (railway, roads, gas and water pipelines);
- 500 people jobless;
- No deaths.

The landslide is still considered active, which means that the land is still moving and there is a high risk of a new major event. The investment required to completely reclaim the area at risk is estimated to be over €60 million. In addition to the expense, total stabilisation of the landslide would also have serious environmental impacts due to the extensive stabilisation measures. In 2006 the local administration decided to adopt a different strategy: to live with the landslide. The strategy involves building a sophisticated monitoring system to alert the population in time to abandon their houses and shut down services at risk (utilities, transport links etc.).

4.1.1 Why climate change adaptation is important

Ancona is located on the coastal area of Marche, a region which experiences frequent landslides and is at high hydrogeological risk. Changes in rainfall patterns and intensity in the future could potentially have devastating effects on an area already at high hydrogeological risk. A study published by the National Research Centre[116] analysed the number of days and the intensity of rainfalls in Italy between 1880 and 2002 and found clear evidence of a reduction in rainy days (-10% every 100 years) and an increase in its intensity (specifically a decrease in low intensity rainfalls and an increase in high intensity rainfalls). These less frequent but high intensity rainfall events are the types of weather events which are likely to cause landslides; several studies have linked rainfalls to landslides, including a wealth of papers that have analysed historical events in central Italy (Cardinali et al. 2006; Peruccacci et al. 2012).

[115] http://libreriaweb.edatlas.it/media/store/secure/APPR_16.pdf
[116] CNR http://www.dta.cnr.it/dmdocuments/pubblicazioni/volume_clima_07/AT_03/3-21_nanni.pdf

4.1.2 Adaptation related activities

The Commune of Ancona has recently presented its adaptation plan. The plan presents four areas at risk of climate change: landslides, coastal erosion, infrastructure and cultural heritage sites.

This case study relates to the landslide risk and its related actions, as it presents an innovative adaptation solution which is being replicated in several European countries (Michoud et al. 2013). In particular, it is described how the early warning system has led to the development of new technologies and new skills for the staff directly involved in the system. The expertise developed in the supply chain and local administration was also considered. The importance of early warning systems is acknowledged in the "preparedness" policy of ECHO (European Community Humanitarian Office)[117]. The development of early warning systems is included in the funding available through the Civil Protection Financial Instrument, and since 2007 various initiatives have been implemented in order to monitor seismological (earthquakes, tsunamis) and weather related (floods, forest fires) extreme events.

Ancona Early Warning System

Following several assessments carried out after the 1982 event, Ancona's landslide was classified as "deep sited" (complex and composite), highly sensitive to earthquakes and precipitation. The landslide involves clay, silty clay and sand layers, broken by several fractures and with multiple sliding zones. The fractures where the clay (mixed with other heterogenic and plastic soils) is located are the main reasons why rainfall has such a devastating effect, because it influences the system of underground water.

In 2002 Ancona's local administration decided to implement an innovative solution to provide a real time monitoring of the landslide area. The main scope of the action was the creation of an early warning system that will alarm local households after the first signs of a major landslide event appears. As a secondary role, the system provides detailed monitoring of the landslide area and allows targeted consolidation work. The system provides a 3D monitoring of the area:

- The surface monitoring system includes 8 robotic stations, 230 reflectors, 34 geodetic GPS and 25 high precision clinometric sensors and a network of solar panels to power each tool.
- The Geotechnical monitoring system, installed in 2009, is made of three columns of sensors bored in the ground up to 100 meters deep. Each column includes 85 biaxial clinometric modules, which are able to record depth and size of any underground land movement, and a set of other monitoring tools (to keep track of temperature and pressure at various depths).

The set of sensors is connected through a hiperlan network to the monitoring centre. Real time data is validated by an automated system, which sends immediate warning to the centre operators (including their mobile phones) in case of movements above set variables. The software is also able to record and analyse long term trends, and is currently providing a very detailed understanding of the area.

The system setup required a total investment of € 1.5 million, which was spent on the purchase of instruments, their installation on the landslide area, and the computerised system in the monitoring centre (hardware and software). The design of the system was carried out by the local administration geologist Stefano Cardellini, now

[117] http://ec.europa.eu/echo/policies/prevention_preparedness/preparedness_en.htm#ews

responsible for its operations. The operating costs amount to €250,000 per year, mostly used to pay the staff employed.

4.2 Employment Aspects

4.2.1 General employment trends in the sector/ city

Ancona has historically been an agricultural city. Recently its economy has been transformed, and now it is based largely on industry, commerce and tourism. Its commercial focus is mostly related to the port, one of the main in the Adriatic Sea. Due to the port itself, naval industry (particularly yachts) is raising its profile in the city.[118]

4.2.2 Adaptation related employment

The early monitoring system provides a cost-effective approach to climate change adaptation. While the large majority of disaster money is usually spent into post-disaster recovery, the monitoring activities carried out through the system have a pivotal role in coordinating preventive actions. For example, in the last three years the Italian Government had to allocate over €1 billion for hydrogeology related emergencies (flooding and landslides), although it is estimated that total damage amounted to three times as much[119]. The total investment required to prevent hydrogeological risk have been estimated at €45 billion, but less than 10% of it has been allocated to local basin authorities to carry out these works since 1990.

In terms of jobs, as the monitoring system is a new function, it does not cause any relevant displacement. The monitoring systems effectively support additional jobs in related traditional activities, and avoid the displacement of jobs for companies located in areas at risk (e.g. 500 people lost their jobs following the 1982 event).

4.3 Occupation & Skills Aspects

4.3.1 Adaptation related occupations & disciplines

Main occupation types and disciplines

Ancona's early warning system directly employs ten technicians and one coordinator. They are a team of surveyors, engineers and geologists (ISCO 21 and ISCO 31) which provide a 24 hour warning service and are directly responsible for software and hardware maintenance.

While their main activity is the early warning, i.e. to alert the population in case of signals of a serious landslide, their monitoring data is used to target and coordinate many other tasks:

- Studies and surveys: the system provides high quality data in terms of monitoring. This allows the local administration to learn more and more about the landslide. In 2011 over €200,000 was spent on studies (commissioned to local universities and local geological sector businesses), which are further improving the understanding of the landslide, forecasting its movements and generally building knowledge on hydrogeology.

[118] http://www.an.camcom.gov.it/sites/default/files/4_2013%20I%20numeri%20dell'economia%20impaginato.pdf

[119] Legambiente: http://www.legambiente.it/sites/default/files/docs/i_costi_del_rischio_idrogeologico_dossier_di_legambiente_0.pdf

- Emergency planning: it involves local administration and planning department employees, in cooperation with local safety services, including police, firefighters and road traffic control. The system also requires sensitisation and public information campaigns.
- Risk reduction interventions: data from the monitoring system result in two to three interventions per year, often in response to heavy rains, which would destabilise some areas that may trigger larger landslides. Typical interventions will involve surface and depth drainage, bulkheads, etc. Budget and jobs created by these interventions are difficult to assess, as they are on a case-by-case basis; usually at least 15 people will be employed (from engineers, to surveyors to building sector workers).

The early warning system does not totally eliminate the risk of damages from a major landslide. For this reason, besides local and national emergency planning, the increased frequency of landslide events will require investments to rebuild infrastructure, houses and other urban buildings. Reconstruction activities will require the traditional set of professions and skills, from construction workers to planners, engineers and architects.

4.3.2 Adaptation related skills

The Ancona early warning system is a bespoke system built and developed by the local administration in cooperation with private sector contractors that have supplied the hardware and supporting expertise.
The following skills/job roles have been required at various stages:

- **Supply chain:** electronic and software engineers, geologists and geotechnicians, supported by laboratory and testing engineers.
- **During installation, maintenance and operation of the system**: geologists and geotechnicians, surveyors, telecommunication and GPS engineers, hardware for geological monitoring engineers, software and systems integration.
- **Supporting roles:** the system's main role is to alarm the local population on time if a major landslide event is due to happen. The success of this system relies on
  - Public safety services
  - Local disaster planning
  - Information and sensitisation campaigners.
- **Related risk reduction actions:** geologists and civil engineers (studies and assessments, prioritisation of actions), town, transport and country planners, engineers, earthworks workers and mobile-plant operators (risk reduction operation on the field).

Skills gaps

Due to the extremely innovative nature and complexity of the system, there is a clearly identifiable skill gap. According to Stefano Cardellini[120], only a handful of firms in Italy were able to support the delivery of this system at the commissioning phase (starting in 2006), while experts in the operation of this type of systems were virtually non-existent. The current team received basic training from the hardware suppliers; afterwards they have been teaching themselves how to run and maintain the equipment and are involved in planning for its extension to other areas of the region. Recent international exchange (with Sweden and the UK), involving the local administration and suppliers, suggests that this type of skills shortage is not unique to Italy.

[120] Geologist on the local administration and responsible of the early warning system.

The supply chain is made of small to medium enterprises which are generally able to deliver the required tools with no additional investments. However there is a gap in the availability of the required expertise in the job market. . The reasons behind the skill gap are clearly identifiable:

- Developing these systems requires technical workers expert both in geology and engineering.
- It is a niche sector, still very new and which has a limited number of applications.
- It is a sector largely dependent on public investment in monitoring technologies. However, often the public budget is used in remediation actions (post disaster) which are much more expensive. The result is that there is very little investment in monitoring.

The supply chain companies often have to further invest on the training of new recruits. Our source within the industry estimates that training activities require up to two years. The supply chain is often connected with universities, but most of the exchange and research projects rely on EU and national funding.

The skills gap is mostly related to the monitoring system, while there is no evident gap to deliver the supporting activities (supporting roles and risk reduction interventions). The main issue related to the supporting activities is the availability of funding to regularly carry out these actions.

Skill shortages

Skills shortages are more clearly identifiable in the industry rather than in the public sector. This is due to the very limited number of public investments currently made in geological monitoring. The supply chain has the opportunity to expand to the private sector and to other services. For example, similar systems can be applied to the remote monitoring of railway lines. In terms of appeal to the job force, companies in this sector can count on a high number of graduates and mid-level technician that show interest in this type of application but that, as described in the previous paragraph, will require extensive training.

Skill needs

Recent plans concerning the expansion of the system to the whole Marche region will require more staff, in particular technicians able to service the monitoring stations. The monitoring activity would not require substantial increase in operators, as it is essentially an automated system. The local administration is planning to support the introduction of two university degree courses that will be able to produce experts with the correct mix of skills required.

There will still be the need to have more experts able to manage early warning and monitoring systems across Italy and Europe. The demand from the private sector is instead highly correlated with the economic activity, as investment in monitoring and prevention systems are usually suspended during economic downturns.

Besides the early warning system, the increased frequency of catastrophic events may encourage a forward-looking approach to reconstruction, for example new regulations requiring planners and engineers to design buildings and infrastructure able to withstand hydrogeological events up to a certain threshold as in Japan.

To conclude, the early warning system requires a mix of high level skills to cover the operational phase of the monitoring system and a very high level set of skills in the supply chain. The main skill gap identified concerns the specific combination of technical and organizational skills. The development and production of instruments

require a high level of technical and scientific knowledge. However, the operation phase (once the instruments have been installed) requires the coordination of work of various departments and services.

4.3.3 Gender balance

At the moment, Ancona monitoring centre is run entirely by men. However, the engineering and geological sector workers employed in the supply chain have recently had an inversion of trends, with the majority of new recruits being females. It reflects the increasing trend that women are pursuing a career in a technical university.

5 Annex B4: Case Study: Energy

5.1 Short Description of the Energy Sector

The energy sector is of vital importance for Europe's economic performance. Climate change has far reaching consequences for the sector's stability, sustainability and resilience (McCallum et al. 2013). The increased frequency of extreme weather events and changing temperatures is expected to have an impact on the energy sector. As such, the urgent need to invest in adaptation measures for electricity facilities is foreseen in the near future (Rademaekers et al 2010).

5.1.1 Why climate change adaptation important

A study carried out by Ecorys in consortium with ECN and NRG for the Directorate-General for Energy in the European Commission states the fact that a minority of the power plants in Europe evaluated the risks to, and vulnerability of, their power plants to climate change and formulated a long-term strategy regarding these risks. Based on the results of the energy sector study, investment needs are identified in four of the eight considered climate change indicators and these are considered as severe climate change impacts:

- A decrease in precipitation will require preventive investments for hydro power plants in the Mediterranean region;
- An increase in the sea level will require preventive investments for offshore wind power plants in all European Seas;
- An increase in the occurrence of floods will require preventive investments for thermal generation technologies all over Europe, except for the North Sea region;
- An increase in the occurrence of storms will require preventive investments for networks all over Europe, except for the North Sea region.

Two other climate change impacts are categorized as medium, meaning that these climate change impacts are not yet expected to require investments for the scenarios consulted, but would require investments in the event that climate change impacts prove to be more severe than expected:

- An increase in water temperature would decrease the output of all thermal generation technologies;
- The changes in the level of precipitation is mixed, with increases in the North, largely unaffected in the North Sea and Central European Regions, while there is a projected decrease in the south (already mentioned under severe impacts).

Finally, a number of climate change impacts will only have a minor impact on power plant operation leading to a relatively small drop in generation output:

- An increase in air temperature would decrease the output of all thermal generation technologies;
- A decrease in average wind speeds (in the North Sea and Mediterranean regions) would decrease the output of onshore and offshore wind parks;

- An increased frequency of flooding events could pose a threat to concentrated solar power, geothermal and grids;
- An increased frequency of heat waves would decrease the output of all thermal generation technologies, but also of solar PV and would additionally increase the resistance of electricity transmission through grids with consequent increased transmission losses;

An increased frequency of storm events would decrease the output of some renewable generation technologies, namely hydro, onshore and offshore wind, solar PV and concentrated solar power.

5.1.2 Adaptation related activities

The implementation of adaptation measures in the energy sector is urgent, given the implementation lifetime of the relevant options, and the need to consider them as part of standard operations and maintenance procedures. Adaptation should therefore be considered in the planning and operating of energy systems and at all levels. In addition, a great number of mitigation measures and policies already have the potential to include and mainstream adaptation actions (McCallum et al 2013).

Adaptation measures will help to create a more resilient electricity grid, lowering the risk of large power outages (Ecologic 2012). Some studies, such as McCallum et al (2013), IEEP (2012) and Ecologic (2012), define adaptation measures for the electricity grids, supply/ demand and energy efficiency. The table below presents some examples.

Table 5-1 - Main adaptation measures for the electricity grids, supply/ demand and energy efficiency

ADAPTATION MEASURES	
CLIMATE-PROOF THE GRID BY:	
Transmission	- Increase robustness of transmission grids to storm damages - Install additional network capacities - Detect vulnerability hot spots in the overhead networks by monitoring mass movements, storms, floods and overheating - Install underground cables at vulnerability hot spots - Expand aisles through forests to the degree necessary
Transmission/ Distribution	- Slope stability measures (e.g. terraces and fences) - Early warning systems due to high demand and extreme events - (Re-) locate flood-prone transformers and substations to higher/safer ground - Support the establishment of small/regional distribution networks
Storage	- Install of additional storage facilities to adapt to higher volatility in base load energy supply - Explore potential of other storage methods - Make use and maintain existing gas distribution network for CH4 transmission and storage
SUPPLY:	
Water	- Optimize hydropower plants to extreme events (e .g. build desilting gates to flush reservoirs; adjust upsurge operation) - Avoid erosion in hydropower catchments by land management decreasing sedimentation - Install additional capacities
Wind	- Adjust construction and power control of wind turbines for wind speeds to increase efficiency - Combine/ connect wind power plants with local storage systems to avoid losses due to network overloads
Solar	- Enhance efficiency of PV installations by solar tracking

ADAPTATION MEASURES	
Thermal	- Storm and hail-proof PV installations - Improve robustness of mining installation - Retrofitting to increase robustness in coastal areas - Site power plants in flood-secure places - Ensure cooling of thermal power plants
DEMAND:	
Water	- Promote water saving technologies to reduce cooling water demands by thermal power plants (e.g. through reuse or partially closed circles)
Solar	- Install decentralized solar-powered air conditioning to cut demand peaks during heat waves

There are already some studies estimating the investment needs of adaptation measures, for example the study carried out for the Directorate-General for Energy in the European Commission estimates that EUR 15-19 billion per year are necessary (from now until 2080) to adapt EU's electricity sector to climate change. For example, the largest investments will be needed for electricity generation from offshore wind to adapt to sea-level rise (over EUR 4 billion), followed by investments in electricity grids to adapt to more intense storms and higher temperatures (EUR 2-4 billion). The increased incidence of flood impacts on thermal power plants (nuclear, biomass, and fossil-fuel based) amount to EUR 3-6 billion (Rademaekers et al. 2010).

The Ecologic (2012) climate proofing report also estimates the adaptation costs for electricity grids in Europe, more than EUR 600 million for both scenarios considered. For the cooling of thermal power plants the estimation is as well above EUR 600 million for the EU27, while for the cooling of nuclear power plants is estimated an investment need around EUR 560 million.

5.2 Employment Aspects

5.2.1 General employment trends in the sector

The energy sector in Europe is divided into three subsectors – *electricity, gas, and steam/ hot water supply*. The electricity subsector is the largest of the three subsectors, comprising a total share of 77% of the total number of persons employed for the energy sector (European Foundation 2008).

In an interview with Energy & Utility Skills organisation in the UK working in the energy sector, it became clear that, there are no major changes expected on employment for the next ten years. However, these projections are directly related to the government priorities for the coming years and the ability to ensure the private sector a return of their investment. For the time being the public investment in renewable energy is slowing down, especially for wind energy.[121] Even though in 10-15 years this trend is expected to change in some energy subsectors. For example, the offshore wind is expected to grow strongly in 10 years, as soon as the grid implications and connections are solved.

5.2.2 Adaptation related employment

Throughout the energy sector, adaptation measures tend to follow the direction of the main risks associated to the implementation site and government priorities to invest in the sector. The impacts on jobs are therefore directly related to the potential of different energy subsectors. [122] Considering the adaptation measures presented

[121] Interview with Head of Research at the UK Energy & Utility Skills
[122] Interview with Head of Research at the UK Energy & Utility Skills

alongside with the risks associated to climate change and link them to the implementation site and to the capacity of the government to implement such measures, we will have clear view of the adaptation related employment.

For the UK, one of the main concerns is floods, hence it is expected that adaptation measures to decrease this risk will be adopted also in the energy sector. It became clear from the stakeholder interview that new jobs in UK directly related to floods are likely to be combinations of existing competencies with the current ones. It is expected that jobs will be created for traditional engineers (civil mainly) to implement the projects, research and development activities and advanced technicians. In addition, the timeline of implementation will depend on the adaptation measure and how politically important it is, although these new activities in 10 years are expected to streamline and become more established in the so-called "business as usual".[123]

5.3 Occupation & Skills Aspects

5.3.1 Adaptation related occupations & disciplines

In the energy sector, it is expected that jobs will be created for traditional engineers (civil mainly) to implement the projects, research and development activities and advanced technicians. In the implementation phase the highest share of job creation (man power) will be related to construction workers. [124]

We linked the main adaptation activities in the sector to the main occupation types and disciplines. The main occupation throughout all the adaptation activities is manufacture & installation, mainly related to the installation of additional capacity of plants, as well as for the implementation of devices or means to increase the efficiency. Engineering services have also a great share of the occupation types in the energy sector due to the design of upgraded plants or the need to identify techniques to adjust construction or to improve the operation systems. Other occupations include monitoring, in terms of detecting vulnerability hot spots, operation & maintenance of the new and upgraded facilities and early warning systems, R&D to explore potential of other storage methods, higher/ safer locations for transformers and substations, management and administration & consulting.

5.3.2 Adaptation-related skills

The introduction of new technologies will lead to a growth in requirement for electrical installation skills. Skilled personnel will be required to integrate new technologies into existing systems (EU Skills Group 2013). There will also be a continued need for more generic, cross-sector skills, including first line management, engineering skills and project management.

McCallum (2013) identified several knowledge gaps associated with climate change adaptation activities in the energy sector, such as costing of adaptation options, technical know-how to suggest amendments in standards and regulations or mapping hot spots of vulnerable transmission infrastructure (with regard to its physical resistance towards extreme events). These are not skills gaps per se, but they nevertheless show areas where research activity is missing.

Since skills mismatches are mostly due to the increase of technological change they are of high importance for the energy sector, and will depend on the countries' capacity to promote measures across the entire sector. Currently stakeholders are

[123] Interview with Head of Research at the UK Energy & Utility Skills
[124] Interview with Head of Research at the UK Energy & Utility Skills

aware of the existing gaps and shortages, as well as the associated trends and are willing to fill the gaps.

Many aspects of the energy and utility sector are not seen as attractive to young people considering their career choices, despite the potential salaries and opportunities on offer. Young people do not fully understand the benefits of choosing a career in the energy sector, or within the range of career options classed as 'engineering' (EU Skills Group 2013). This may have implications for skills gaps and shortages in key engineering disciplines in the future.

It is also becoming clear that there will be a need to attract and develop high-level Science Technology Engineering and Mathematics (STEM) skills which are expected to be key across all technologies, with a focus on boosting higher technical skills, R&D and engineering skills. As such, the development of the new demand-management technologies will require higher-level STEM skills. Monitoring and network management skills will also be affected by this trend, depending on the extent to which consumers adopt and use these new technologies (EU Skills Group 2013).

It is also important to mention that in the implementation phase of the projects, man-power with low skilled positions for construction will have the biggest numbers in terms of job creation. However, these jobs are likely be either lost or transferred to other sectors after the construction phase.[125]

Up-skilling or new skills
Since a major rate of retirement in the sector is projected, particularly from the highly qualified and experienced management levels, the current levels of investment into recruitment and training will need to be increased to replace both the knowledge and experience of these retirees. Up-skilling of existing employees especially with higher skills becomes an increasingly important element of the resource plan (EU Skills Group 2013).

UK is already taking a step forward to identify the anticipated demand for skills of the water industry related to the energy sector and adaptation. Some specific new skills / up-skilling needed are as follows (EU Skills Water 2013):

- In terms of supply and demand balancing, smart networks will create a need for knowledge and understanding around 'big data analytics'
- More specialist process engineers to develop knowledge in most efficient technologies and to lead research studies in order to reduce error rates
- Engineering skills in different operation systems, such as transmission networks
- More commercial awareness skills in order to better inform customers (e. g. smart meters);
- Additional modular qualifications to installers (e. g. smart meter installations);
- Up-skilled analysts, network operatives and planners due to the more complexity of the systems.

5.3.3 Gender balance

Energy sector is currently male dominated, especially Transmission & Distributions and this holds also for adaptation jobs in this sector. This is expected to change over time as many skilled workers in the current workforce approach retirement and women are likely to have a more significance in these positions.[126]

[125] Interview with Head of Research at the UK Energy & Utility Skills
[126] Interview with Head of Research at the UK Energy & Utility Skills

6 Annex B5: Case study: The Alpine tourism sector

6.1 Short description of the Alpine tourism sector

The Tourism industry generates over 5% of the EU GDP and employs directly around 5.2% of the European labour force (9.7 million jobs)[127]. The induced economy, especially in sectors such as construction and transport is equally important. Tourism is highly related to climatic conditions, with the summer season in the Mediterranean Sea and the winter season in the Alps being the main attraction poles. Every year between 60 and 80 million people visit the Alps (Agrawala 2007), an area which covers 190,000 km^2 and has 15 million inhabitants.

In the Alps, Tourism activities generate close to €50 billion turnover a year, supporting 10 to 12% of local jobs in France, Switzerland, Austria, Italy and Germany. However, these jobs are concentrated in only few locations and have a highly seasonal trend (snow cover generally lasts from mid-November to May).

6.1.1 Why climate change adaptation important

Winter tourism is a relatively new mass phenomenon and it started to become popular only after the 1970s. It is, however, already under a threat of climate change. According to the OECD (Agrawala 2007), the effects of climate change in the Alps are three times higher than the world average[128]. Currently, over 90% of skiing areas in the main five countries rely on natural snow (609 out of 666). A simulation exercise suggests that an increase of 1 °C in temperature would reduce the areas that can survive on natural snow to 500; an increase of 2 °C would reduce the number to 404, while a 4°C increase would lead to only 200 areas operating on natural snow. These effects will vary across countries, however. Another adverse effect is that climate change may exacerbate natural hazards, such as floods and avalanches, although in many cases it is difficult to quantify the direct effect.

A JRC study (Barrios and Ibanez Rivas 2013) suggests that the climate plays a significant (economically and statistically) role in explaining hedonic valuations of tourism services and that climate change will alter the attractiveness of tourism areas in the EU. However, the report does not specifically consider winter tourism. A report by OECD warns that some adaptation strategies in the tourism sector may actually pose new problems and could therefore be considered as mal-adaptation. For example, snow-making is water and energy intensive; the grooming of ski slopes can reduce slope stability, while moving ski operations to higher altitudes can have adverse impacts on fragile environments (Agrawala 2007). In general, public policy can choose from two paths regarding climate change adaptation policies:

- Measures to maintain the status quo, such as deployment of snow cannons. These strategies require generally large investment and may have severe environmental impacts.
- Measures to adapt to the changing conditions, such as de-seasonalisation of the offer and conversion of skiing facilities to summer tourism.

These two strategies are pursued not exclusively in relation to climate change. For example, the use of water cannons and the move of ski operations to higher altitudes is a strategy used to extend the skiing season which are generally pursued by bigger operators that are able to cover the substantial investments required. On the contrary, smaller operators have tried to extend the offer to summer months. In fact, smaller

[127] EU business – Tourism in Europe. http://www.eubusiness.com/topics/tourism

[128] For example temperatures in the Swiss Alps are projected to increase by about 1-5 °C in the summer and about 1-3 °C in the winter by 2050, relative to 1990.

operators often rely on local workforce which finds itself unemployed during the low season, while larger resorts attract in general seasonal workers from other areas of the country.

6.1.2 Adaptation related activities

Alps adaptation plan and Isere adaptation plan

The Department of Isere is located in the Rhone-Alpes, in the east of France. It has several ski areas, including two large resorts on the Oisans massif, which account for the majority of overnight stays. In 2010 there were 15.5 million overnight stays, 50% of which concentrated during the winter season[129]. However, since the early 2000, the Isère Departmental Council have identified the high vulnerability of the tourism offer: low lying resorts suffered unpredictable snowfall, there were not enough artificial snow equipment, the ski-lift stock was aging and there was a lack of non-ski activities.

Therefore the Council adopted a wide strategy to diversify the tourism offer and of de-seasonalisation of the tourism. The strategy has mainly been implemented through diversified development contracts which provide financial supports to investments in activities that increase the diversification of the touristic offer. The strategy fits in within the Alpine Action plan on climate change[130], both under mitigation and adaptation strategies. In particular, the adaptation strategy for the tourism sector has the main objective of adapting winter tourism and diversifying the tourism offer[131], to be achieved with measures such as:

> *1 – Support local authorities which diversify their activities and offer an alternative to Alpine skiing in winter, and spread the information in order to attract new customers.*
> *2 – Aim at a better complementarity between summer and winter tourist seasons by favouring inter-seasonal tourism.*

Several initiatives have been identified to implement the strategy: creation of leisure parks, adventure playgrounds, education trails, outdoor activities and sports (climbing, mountain bike trails, roller ski trails, orienteering courses, theme routes, via ferrata, equestrian activities), and creation of cultural facilities such as cinemas and museums. Other measures are aimed at improving the offer of spa resorts and supporting services to the workforce (child care, recreational centres).

Diversified development contracts (DDCs)

DDCs are an initiative to support the diversification of the tourism offer, grouped under the program "Projet de développement durable pour les espaces valléens de Rhône Alpes"[132]. The program provides financial support to smaller Alpine Resorts (local partnerships and local administrations)

The program has the following characteristics

- Overall budget €800,00
- Sponsors project up to 40% of total costs
- Activities allowed:

[129] Alpine Convention, Isère Departmental Council «Diversified development contracts». Available at http://www.alpconv.org/(X(1)S(0udunwjy15hkgv55smmfro45))/en/ClimatePortal/territorialexamples/isere/pages/default.aspx?AspxAutoDetectCookieSupport=1

[130] Alpine Convention (2009) ACTION PLAN ON CLIMATE CHANGE IN THE ALPS. Available at http://www.alpconv.org/en/ClimatePortal/Documents/AC_X_B6_en_new_fin.pdf

[131] Ibid, 2009

[132] Communauté de Communes des Vallées du Valbonnais, Convention Stations durables and Arlysere, convention de stations durables 2010-2013. Available at http://www.arlysere.fr/modules/tinycontent/content/MAJ/rubrique_projets/tourisme/CSDMM_beaufortain%20_VA.pdf

- Research and evaluation (assessing tourism potential and identifying new activities), training and formation, engineering studies, management of the project and salaries of people involved in its coordination.
- Long term coordination of the project.
- Structural investments, material expenses related to the development of all-year tourism. The program explicitly excludes any investment in equipment related to winter tourism (such as ski lifts).

Isere has used the support provided by DDCs to identify new activities, help with completely abandon snow-related activities in resorts with the least snow (removal of skiing infrastructure), to improve facilities such as accommodation and transport and to promote other tourism-related activities[133]. An example of activities sponsored by this type of instrument in Isere is the "Odyssée Verte – Gresse-en-Vercors", a requalification and valorisation of a local forest. The project included the creation of a treetop pathway[134].

6.2 Employment aspects

6.2.1 General employment trends

Alpes-sud-d'isere has a growing population of over 70,000 people of which over 16,000 are directly employed by the touristic sector. The job market has a high annual variability: there is a high demand for seasonal workers during winter months. In fact, nearly 80% of the job openings are classified either as occasional or temporary.[135] The largest sectors are accommodation (26% of jobs), catering (14%) and commerce (11.5%). Most common professions are kitchen staff, waiting staff, animation and leisure activities, reception and floor staff in hotels. The tourism sector also creates supply chain and induced economy jobs, such as shop assistants (sport apparel, groceries shops and logistics), public and private services (industrial cleaning, carers) and various services (transport etc.). In general, jobs requiring higher skills are more stable during the year (the demand for high level managers and technicians is less sensitive to the number of tourists), although some of the seasonal jobs will also attract international professionals (chefs, ski instructors etc.).

6.2.2 Adaptation related employment

Climate change imposes a serious threat to tourism in the Alpine region but strategies and actions plans are already under way in many areas. Interestingly the diversification of the tourism industry in Isere did not initially start as a response to climate change although it fits well with the developed adaptation strategy. The main demand for new skills is the knowledge and understanding of the new market (summer tourism). Also partnerships are important to address the bottlenecks and ensure efficient use of resources when diversifying to new activities.

Evolution of the offer and diversification strategies

Isere tourism operators face two types of challenges depending on their size:

- **Large resorts** (there are two in the area) employ large numbers of people for the winter season and they draw them from a national or even international pool of labour. They may struggle as they are seen as less attractive employers

[133]Isere Tourisme Rapport d'activités 2013 http://pro.isere-tourisme.com/images/3157-1-rdv6-bilan-d-activite-2013-isere-tourisme-pdf.pdf

[134]Repport Développement durable du Conseil général de l'Isère 2010. Available at http://www.isere-interactive.fr/Documents/DocumentsCGII/environnement/RAPPORT%20developpement%20durable%202012.pdf

[135]Pôle Employ (2011) Territoire Alpes Sud Isère - Marché Du Travail. Presentation for Direction Territoriale Isere.

than other stations (in general less benefits and lower pay). In regard to climate change, they have a profile of lower vulnerability but high risk: they are less vulnerable to climate change as they are higher up and with a more secure supply of snow; they have also found it convenient to invest in artificial snow machines, which allow to operate even when the snow cover is not sufficient ("maintaining the status quo" strategy). However, under the worst climate change scenario they would have little opportunity for diversification as the only other activity beyond skiing being cycling in the summer.

- The **smaller resorts** are located at lower altitudes and mostly employ local people. They are already aware of climate change due to the high vulnerability and very likely to experience even lower snow falls. However, they do not have the financial resources to invest in artificial snow or man-made winter sports facilities. They have been moving towards diversification as part of the development of an all-season and therefore also a more stable economy with better employment opportunities for their residents. The regional authorities have already recognised the issue as there are 'Conventions Stations Rurales' between the region, Europe and the local area to help small resorts to adapt to future challenges (see diversified development contracts above).

6.3 Occupation and skills aspects

Adapting the Alpine tourism sector to climate change essentially requires the application of similar strategies to offer diversification and de-seasonalisation, which have already been pioneered for reasons other than climate change. Hence, most of the new jobs and skills required have already been identified and do not appear particularly challenging to source, either among locals or among seasonal workers. However, the knowledge of the specific market (summer and mid-season mountain activities) requires high skills that are not present locally in sufficient quantity.

In regard to the prospects of low skilled jobs the key issue faced by operators is to achieve a sufficient demand to new services to justify the full time employment. For example, if a local operator decides to provide bike hiring services, it may find more convenient use a local bike shop for the servicing rather than hiring an employee that could provide a more complete service (from maintenance to booking to guide in local paths). Using the funding provided through the CDDs, the Region Rhone-Alpes has effectively sponsored several actions aimed at creating partnerships between local businesses to overcome these types of barriers[136].

[136] See for example "Appui au développement des entreprises, basé sur les filières porteuses du territoire-Animation économique du CDDRA et appui au secteur de l'ESS", described in the 2012 report http://www.territoires.rhonealpes.fr/IMG/pdf/DV8I_Contrat_definitif_Actions_CP_04-10-12.pdf

7 Annex C: Adaptation strategies & plans reviewed

Country, region or city	Adaptation Strategy available via Climate-ADAPT	Adaptation action plan available via Climate-ADAPT	Review completed
Finland	✓	✓	Yes (action plan)
Denmark	✓	✓	Yes (action plan)
UK	✓**	✓**	Yes (action plan)
Ireland	✓	X	Yes (strategy)
Germany	✓	✓	Yes (strategy and action plan)
Netherlands	✓	✓	Yes (strategy and Delta programme)
Belgium	✓	X	Yes (strategy)
France	✓	✓	Yes (action plan)
Spain	✓	✓	Yes (action plan and second monitoring report)
Portugal	✓	X	Yes (strategy)
Austria	✓	✓	Yes (strategy and action plan)
Lithuania			Yes (Strategy for National Climate Management Policy)
Poland			Yes (strategy)
Sweden			Sweden facing climate change (2007)
Hungary	X***	X	Yes (strategy)
Malta			Yes (strategy)
Baltic Adaptation Strategy	*Strategy and action plan published on 3-4 September 2013*		Yes
London	*Adaptation strategy published in 2011*		Yes
Rotterdam	*Adaptation programme and various other documents available*		Yes
Ancona	*Local adaptation plan*		Yes
Bullas	*Local adaptation plan*		Yes
Alps	*Adaptation strategy*		Yes

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Sources related to the bottom-up approach are reported in a separate document – List of reviewed cases at local level.

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