Assessing Vulnerability of Agriculture in the Carpathian Region to Climate Change

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Abstract: The study compiles and summarizes the existing knowledge about observed and projected impacts of climate change on agriculture in the Carpathian region, putting it in the context of rural development and giving suggestions for regional adaptation strategy.

There are some differences in the social and age structures, stability of settlements and rates of unemployment within the Carpathian region. Adaptive capacity is higher in the Northern and Western Carpathians where there are more non-agricultural employment opportunities that could act as a safety net in case of loss of the harvest. Indicators show gradual decrease of well-being from North-West to South-East, which coincides with projected changes in the precipitation and severity of climate impacts. Southern part of the region (Romania and the Republic of Serbia) is identified as the most vulnerable.

To achieve broader goal of sustainable agriculture in the face of climate change, the economic structure of rural areas should be reformed towards diversification of employment options, improvement of infrastructure and better access to services. Rich in biodiversity and beautiful landscapes, the Carpathian region offers significant opportunities in the field of eco- and rural tourism development. A regional adaptation strategy should focus on raising awareness to facilitate autonomous adaptation, climate proofing of the policies and creating favourable conditions for social entrepreneurship and green business.

Key words: climate change, vulnerability, agriculture, Carpathian region, sustainable development

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DISCLAIMER. This thesis was written within a framework of the CARPIVIA project. Parts of the study were previously published in the Interim Report which can be found on the project web-site (www.carpivia.eu). Written by the same author, they cannot be considered plagiarism.

Conclusions, interpretations or recommendations presented in this work do not necessarily reflect opinion of the CARPIVIA project team or its partner organisations.
Assessing vulnerability of agriculture in the Carpathian Region to climate change

OLEKSANDRA KOVBASKO


Abstract: Climate change is considered one of the top challenges of our time. During the last century global average temperature has increased by 0.74°C and according to the projections, may grow by 1.1°C - 6.4°C till the end of the century. How will this change influence agriculture and farmers in the Carpathian region? While yields of wheat and maize may slightly increase due to warmer summers and higher concentration of the carbon dioxide in the atmosphere, farmers may not be able to seize the opportunity. Socio-economic problems have been driving young people out of the villages in search of better life for more than two decades. Any adaptation strategy should aim, first of all, to improve well-being and coping capacity of the local population: more employment opportunities, better infrastructure, access to education and market for their produce, and raise awareness about climate change.

Key words: climate change, vulnerability, agriculture, Carpathian region, sustainable development

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1 Introduction

The Carpathian mountain chain is the longest (1500km) and the most well-preserved area in the Continental Europe. The Carpathians stretch through the territory of 7 countries starting from the Czech Republic in the northwest, then running east and southwards through Slovakia, Poland, Hungary, Ukraine, Romania and Serbia. In total, the Carpathians are home to 16-18 million people.

The long tradition of human presence in this mountainous area developed a farming system based on methods of mixed sheep and cattle grazing and mowing, mobile pastoralism on long and short distances. As a result, species richness and the concentration of endemic and rare species on relatively small plots of land are high (Beaufoy et al., 2006).

Traditional farming practices are one of the key elements for biodiversity conservation and are part of centuries-old lifestyle. Until recently the area has known little development, allowing preservation of not only original landscapes and biodiversity but culture and traditions (Carpathian Handbook, 2007). However, changes in climate may become a significant driver in the process of long-term transformation.

Climate change is considered one of the top challenges of our time (UNFCCC, 2009). During the last century global average temperature has increased by 0,74°C and according to the projections, may grow by 1,1°C - 6,4°C till the end of the century (Solomon, 2007). This will be accompanied by the major changes in the water cycle: changing annual precipitation and seasonal patterns, more low-flow and extreme weather events and major shifts in ecosystem balance. Current mitigation measures and the pace of international negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) cannot guarantee limiting climate change to 2°C – a threshold under which scientific community believes possible to avoid disastrous consequences for the planet ecosystems and society (Allen, 2009). In response, a number of countries have already started research and planning adaptation activities.

Comprehensive adaptation strategy is usually built on the findings of the vulnerability assessment where climate change impacts are put in the broader context of socio-economic situation. To be prepared to address current and future challenges of climate change, the Carpathian Convention together with the European Commission (EC) have initiated two large-scale research projects – CARPIVIA and CarpathCC. Carpivia will perform climate vulnerability assessment using information available and analyse adaptation measures that are already implemented or planned. CarpathCC will address knowledge gaps identified by the Carpivia and deliver in-depth assessments of climate threats for the ecosystems and ecosystem-based production systems (Carpivia project, www). Projects’ findings together with stakeholder input will be the ground for development of Regional Climate Adaptation Strategy. This study is part of the Carpivia project and contributes to the Interim report.

1.1 Aim and objectives

Previous climate studies, mostly financed by the European Commission (FP6, FP7) have focused on the region of Central and Eastern Europe as a whole, leaving out peculiarities of mountainous areas; research activities supported by the countries are limited to national borders. International research projects modelled future climate conditions or explored climate change impacts on various sectors of economy, including agriculture (CECILIA, CLAVIER, CLIVAGRI, ADAGIO, COST 734) but none was looking specifically at the Carpathian region.

The aim of the study is to assess present and future vulnerability of the agriculture in the Carpathians to climate change.

Objectives:
- Identify future risks and opportunities for agriculture in the Carpathian region exacerbated or brought in by climate change by year 2050;
- Propose a set of adaptation measures that would reduce vulnerability of the sector.
In the second Chapter we provide general description of the region and its economic structure (Case study description); in the Chapter 3 we present concepts of vulnerability and sustainable adaptation; Chapter 4 gives an insight into methodology, including its limitations and assumptions; Chapter 5 is the main part of the study, elaborating on current and future changes in climate, socio-economic situation and institutional capacity in the region; and Chapter 6 analyses risks and opportunities stemming from climate change, discussing potential adaptation options in its second part. Conclusions give final touch to the paper shortly summarising main findings.
2 Case study description

Study area was chosen according to the delineation of the region by the Carpathian Convention (Figure 1).

Fig. 1. Map of the Carpathian Region, delineation of project boundaries (Kathrin Renner, EURAC)

From the national perspective, country most influenced by the Carpathians is Slovakia - it has almost 80% of its territory covered by the mountains. However, larger part of the mountain chain is situated in Romania.

2.1.1 Economy

Wide areas of the Carpathians are predominantly rural areas with only few municipalities not classified as rural. In 2007 rural population in Romania constituted 45% from the total, with the EU average of 24% (Institutul Național de Statistic, 2008). After accession of Romania to the EU in 2007, even bigger part of the region became the Eastern border of the European Union. Now all Carpathian countries except Ukraine and Serbia are in the EU. The difference in economic development and income opportunities have led to build up of a number of semi-legal or illegal activities, such as smuggling of alcohol, cigarettes and other goods (Heidelbach, 2002).

Access to public services varies from country to country. Only 33% of rural population in the Romanian Carpathians is connected to water supply system and 10% to sewage system. In Poland situation is similar: 20-
40% of inhabitants are connected to water supply system. Hungary and Czech Republic are leading the way with 60% coverage (Kwast, Bergsland, 2010).

Major economic activities vary from country to country. In the South and South-East agriculture employs up to 50% of population, while in the North and North-West service industry dominates the labour market. Economic growth though is limited by low productivity and high unemployment rate - only about 50% of population between 15-64 years old is in the workforce (EU average is 64%).

Despite contributing a minor share to the GDP of the Carpathian countries (highest in Serbia – 15%, then Romania and Ukraine - 7%, 2007), agriculture plays an important role on a regional scale. Agricultural lands constitute 39.8% of the territory of the Carpathians, providing income for about 20% of local population (SARD-M, 2008).

In the North of the region (Slovakia, Hungary, Czech Republic and Poland) over 30% are employed by the industry. On the border of Hungary and Slovakia and all the way to the South of Poland leading car producers (Audi, Suzuki, Volkswagen, Peugeot, Toyota, Hyundai, Siemens, Fiat, Opel) have manufacturing or assembling plants, employing around 20 thousand people in this area (VASICA, 2009).

Mining industry has existed here for decades, supplying Europe with gold and silver, salt and hard coal. Nowadays, only few salt mines and coal mines are in operation. If in 1970 mining provided approximately one million jobs, in 2006 sector employed only 340 thousand, half of which was in Poland. Mining is on one hand, viable employment opportunity for local populations in Poland and Romania, and source of air pollution and contamination of fertile soils by expansion of brownfields on the other (Webster et al, 2001).

Carpathians offer rich possibilities for rural and eco-tourism. Pristine landscapes preserved in a number of national parks, mineral waters, rural crafts and culture if properly marketed, have high potential to attract significant number of tourists. Known among the national populations, Carpathian area is a white spot for neighbouring countries and broader public. If Western Carpathians (Poland, Slovakia) have already emerged on the tourist map due to its ski resorts, Southern and Eastern Carpathians are still terra incognita mostly due to remoteness of the region and its low accessibility (VASICA, 2009). The mountains are passable via 12 railway lines and a number of motorways that connect major cities. Smaller villages and national parks are harder to access.

2.2 Agriculture in the Carpathian region

Even though forestry is a dominant land use in the region, agriculture has been traditional practice for centuries, more important in some countries than in the others. Farmland occupies up to 56-59% of the Carpathian territory in Serbia and Hungary, having lowest share in Ukraine - only 21.3%. Farms are located mostly in the foothills and in the sub-montane part up to the 1000 metres altitude. Semi-subsistent, they combine crop farming (wheat, rye, barley, potatoes, vegetables and fodder crops) in forelands and cattle grazing on the mountain grasslands in the summer (Guzik, 1995). Mostly rain-fed small-scale farming creates mosaic of crops and landscape features, providing unique habitat conditions for different species. Combination of cattle and crop farming enables farmers to use manure as an organic fertiliser, making farming even more environmentally friendly.

Figure 2 presents the structure of agriculture in different countries. Permanent grasslands dominate the agricultural landscape in all Carpathian countries except Czech Republic and Hungary. Grasslands are meadows with little or no tree cover. Orchards and vineyards play a minor role in the Carpathian region, except for Hungary and Czech Republic topping the list with about 7% of the area under vineyards (Ruffini et al, 2008).
Small-scale agriculture (up to 5ha) prevails in all countries except Slovakia. In the Czech Republic 79% of farms are less than 5 ha (2004), in Poland – 83% (1996) and in Romania out of 4.25 million farms, 99.5% are privately owned with average area of 2.1 ha (SARD-M, 2008). Fertile soils in the valleys are used for crop-production, mostly of cereals, potatoes and fodder crops. High altitude grasslands for centuries have provided pastures for the cattle.

Farmers have limited access to the market. Until the beginning of the XXth century small and medium towns at the foot of the mountains were centres of agricultural trade – goods from plains, mountains and industry were sold and exchanged there. These towns lost their role when large state enterprises took over food procurement during socialist times and did not recover ever since (Iles, 2008).
3 Theoretical framework
This section introduces main concepts and ideas used in the study; it is a prism through which research and analysis were conducted.

3.1 Ecoregional approach
Ecosystems and species do not acknowledge legal borders, and measures to protect biodiversity in one country can have little impact if neighbouring countries continue harmful practice. Therefore, conservation organisations are applying an ecoregional or bioregional approach. An ecoregion is a significantly large area of land-mass or water that is characterised by common geographical traits and environmental conditions, shares majority of species and has unique cultural value for local population (WWF, www; Brunckrost, 2000). This approach was pioneered in the global governance by the Alpine Convention. The Carpathian countries have followed the suit and agreed to act together to promote and ensure efficient use of natural resources and preservation of biodiversity by establishing a Carpathian Convention. The Convention aims to unify legal regime in the region, foster knowledge exchange and facilitate the political dialog towards sustainable development (Carpathian Convention, www).

3.2 Vulnerability
The concept of vulnerability has been widely used in geography and natural hazards research before it made to the natural sciences. In order to decide on appropriate adaptation strategy and specific measures, vulnerability of the specific territory to potential climate impacts should be assessed. According to the Intergovernmental Panel on Climate Change (IPCC), vulnerability is ‘the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes’ (2001). Generally accepted approach in the literature is to view vulnerability as the function of impact, sensitivity and adaptive capacity (e.g. Turner et al., 2003; Adger, 2006; Tol and Yohe, 2007). Exposure is the extent to which community, area or economic sector are exposed to the climate impacts. For example, houses in the very proximity of the river will be more likely affected by floods. Sensitivity ‘is the degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise)” (IPCC, 2001, p.993). Together, exposure and sensitivity

Fig. 3. Vulnerability framework
determine potential impacts for the community without adaptation action. Figure 3 graphically shows the relations between exposure, sensitivity and adaptive capacity. *Adaptive capacity* is ability of a community or an ecosystem to adjust to impacts and recover from stress. Chambers (1989) distinguishes between two aspects of vulnerability – exposure to hazards and coping potential, that way recognising the role of socio-economic conditions to mitigate or amplify climate impacts. IPCC and other authors view vulnerability as a function of adaptive capacity; therefore capability to get over a stress is a starting point of the analysis. On the other hand, Kelly and Adger argue that ‘the level of vulnerability is determined by the adverse consequences that remain after the process of adaptation has taken place’. In this study we regard adaptive capacity as initial conditions of a community or a region that determine response to a hazard. Stable demographic structure of population is first pre-requisite for high adaptive capacity, while aging and emigration are signals of social imbalance. Access to education and higher average educational level facilitate adaptation process, as people are more open to new technologies and information.

Vulnerability is spread unevenly across the regions, economic sectors and social groups (e.g. Bohle et al, 1994, Handmer et al, 1999). Main variables are different natural conditions, state of ecosystems, economic development, and political situation in the country, level of social security, access to education, financial institutions and health care (Bohle et al., 1994; Downing et al., 1999; Kelly and Adger, 1999). Second IPCC Report states that wealthier countries with strong institutions are less vulnerable to climate change because they have more resources to recover from stress. Detailed climate vulnerability assessment should aim to obtain holistic view of the system, taking into account interests of various stakeholders, identifying existing problems and opportunities that might be created or amplified by climate change.

Vulnerability assessment (VA) is an evaluation of a given system's susceptibility to adverse climate impacts. Vulnerability assessment was used in the context of livelihoods, food security, natural disasters before it became a tool to prepare ground for the climate adaptation strategies. There’s no single one-fit-all methodology of how to conduct a vulnerability assessment. Depending on the time-frame, resources and information available, the study could be either quantitative or qualitative, using scenarios or climate change vulnerability index (Brooks 2003, Luers et al. 2003, Downing and Patwardhan 2004, Metzger et al. 2005, Füssel 2007).

There are a lot of uncertainties embedded in the climate change projections. Knowing where they come from, helps understanding the quality of information we are basing our decisions upon. There are three main categories of uncertainty: natural variability, model uncertainty and greenhouse-gas (GHG) emissions scenario uncertainty. On-going natural variations in climate are chaotic, making it hard to predict conditions over the time-scales shorter than a decade. Model uncertainty is stemming from our lack of understanding of how climate system works. We don’t know exactly how sensitive the climate system is to the emissions we are putting in the atmosphere. This means that our models are incomplete and limited, particularly at local and regional scale. Uncertainty increases when climate models are coupled with hydrological and vegetation models (Latif, 2010).

### 3.3 Adaptation principles

Despite high uncertainty of climate change impacts on ecosystems and economy, there’s a common understanding of the need for adaptation and 15 European Union member states have already developed National Adaptation Strategies (European Climate Adaptation Platform, 2012). In 2009 the European Union (EU) has published White Paper on Adaptation that introduces two-step process to compliment national efforts: integrating climate change into key EU policies and introducing EU climate change adaptation strategy by 2013. As part of the process, European Commission has published guidelines on how to integrate adaptation issues into river basin management plans, required by Water Framework Directive (EC, 2009b) and financially supported development of adaptation strategy guidelines for a region by Ribeiro et al. (2009). However guidelines for all levels of decision-making are missing (Prutsch et al, 2010).
DEFRA (UK Environmental Agency), front-runner in adaptation activities, has published DEFRA’s Climate Change Plan 2010 that contains basic principles that are recommended by Austrian and German Environmental Agencies for other countries to consider:

- Adaptation should be **sustainable**, meaning that our actions are not supposed to reinforce climate impacts or undermine the capacity of other actors of society to adapt. Adaptation actions shouldn’t shift the problem from one place to another – responses must avoid any negative impacts on other parts of society and environment;
- Measures should be **flexible**. Long-term uncertainty is too high, we should be able to reverse or adjust the measures;
- Actions should be **evidence-based** – developed considering latest research, information available and local knowledge;
- Actions should be **prioritised** in order to address area most vulnerable or those that might suffer the biggest losses;
- Measures should be **efficient** (benefits outweigh costs), **effective** (without negative externalities) and **equitable** (benefiting whole society or some part without placing greater burden on the other part).

Agriculture is the sector where adaptation should go hand in hand with mitigation, as it is accountable for 9.6% of greenhouse gases in the EU, being the major source of methane (CH₄) and nitrous oxide (N₂O) (Bolla & Pendolovska, 2008). Nitrous oxide emissions are the result of application of nitrogen fertilisers and animal waste management systems. Agricultural emissions of methane are mainly caused by enteric fermentation of ruminants and by manure management (Brink et al. 2000). Due to the different agricultural policies adopted and the different agricultural practices implemented, its role - both as a source of and as a sink for greenhouse gases - varies significantly across Europe. To be sustainable in the long run, agricultural sector has to move towards climate-friendly organic practices, that way reducing GHG emissions and increasing its role as a sink. For example, decreasing the number of animals and the use of fertilisers, switch to lower-emissions manure storage systems, prevention of anaerobic decomposition of manure or stimulation of the (controlled) manure fermentation in special reactors with the recovery of CH₄ (which can be used for heat and electricity production) are potential ways to decrease greenhouse gas emissions.

One of the corner stones of successful adaptation is stakeholder engagement on all stages of development and implementation. This will ensure higher awareness and acceptance of the measures, suitability for local conditions and ownership of the process by local stakeholders (Bardsley, 2010).

There is no recipe or definition of successful adaptation strategy. Some authors (e.g. Adger et al., 2005) prioritise the result, stating that successful adaptation is the one that mitigates the risks without negative consequences for society. Others concentrate on the process of development and implementation (Frankhauser et al. 1999, Smith & Lenhart 1996, Lemmen et al. 2008). Used complimentary, they will potentially lead to great results.

UNECE (2009) differentiates four types of adaptation options: win-win options, no-regret, low-regret and flexible adaptation measures:

- **win-win options**

Cost-effective adaptation measures that have positive social or environmental externalities; or contribute to climate change mitigation.
Example: increasing resilience of communities; encouraging efficient use of (particularly hot) water - reducing demand on water resources, mitigating climate change by reducing carbon emissions from water heating

- No-regret options

Cost-effective measures that will have positive impact regardless of the scale of changes. No-regret measures address current climate variability and extreme weather events.

Example: raising awareness, restoring, reconnecting and protecting ecosystems rich in biodiversity, applying adaptive management or early warning systems.

- Low-regret options

Adaptation measures of relatively low costs but that will deliver significant impact only if climate scenarios turn out accurate

Example: constructing drainage systems with a higher capacity than required by current climatic conditions often has limited additional costs, but can help to cope with increased run-off

- Flexible adaptation measures

Measures that have potential to be modified and adjusted when the climate conditions change.

Example: Influencing the design of a reservoir so that its capacity can be increased at a future date, if necessary.

- Maladaptation

Actions that directly or indirectly increase vulnerability to climate change in the long-term.

Example: installing irrigation system in the area where frequency of droughts is expected to increase (Burton, 1997)

Due to the high level of uncertainty, scientists recommend investing in win-win or ‘no-regret’ adaptation measures. As effects of climate change will be seen gradually over time, successful adaptation strategy should be a mix of structural and non-structural, regulatory and economic instruments and measures, education and awareness-raising to address short, medium and long-term climate impacts. However, many adaptations occur autonomously and without the need for conscious response by farmers and agricultural planners (Brooks et al. 2005).

Some sources, mostly from biodiversity and nature protection background, advocate ecosystem-based approach to adaptation (EBA), while the others from humanitarian or development sector stand for community-based adaptation (CBA). Community-based adaptation doesn’t have one single definition but could be described as a bottom-up process to empower and prepare people to cope with impacts of climate change, based on local needs, resources and cultural beliefs (Reid et al., 2010). It refers mostly to local level and doesn’t include ecosystems. On the contrary to CBA, EBA has an official definition, given by Convention on Biological Diversity’s Second Ad-hoc Technical Expert Group on Biodiversity and Climate Change: “Ecosystem-based approaches to adaptation – the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change” (CBD, 2009). As we can see, the goal is to help people adapt, while maintaining ecosystem services. For instance, restoration of wetlands mitigates flood risks, improves water purification, decreasing amount of organic matter in the main river channel, and creates jobs for local people (e.g. during the process of physical removal of reconnection of a wetland, monitoring, collection of medicinal plants, etc). Except benefits for communities, this approach brings significant conservation gains: improved lateral connectivity, additional spawning sites for fish and nesting grounds for migratory birds (Doswald and Osti, 2011).
Climate change manifests itself as both acute or chronic stress (Reser, Swim, 2010). Natural disasters and extreme weather events will lead to acute stress, while gradual change in temperature will slowly squeeze plants towards the limit of their favourable temperature range causing chronic stress. Not all elements of ecosystems will be impacted in the same way. Thermophiles will befit from temperature increase and might become dominant species until water or nutrient availability is a limiting factor. Therefore, ecological zones are gradually shifting poleward and to higher elevations (IPCC, 2007). Adaptation measures should address changes on all scales – community, institutional, regional, national etc. Especially important is river basin or ecoregional scale, as they allow for systemic interventions (WWF, 2012).

As we can see, adaptation process has many dimensions, demanding cross-sector cooperation, engagement of stakeholders, long-term planning and adaptive management at the same time.
4 Materials and methods

4.1 Methods of data collection

The goal of the study is to assess present and future vulnerability of the agriculture in the Carpathians to climate change. To achieve this, we analysed sectoral vulnerability according to IPCC framework of exposure, sensitivity and adaptive capacity. For each component three groups of indicators according to the UNDP Adaptation Policy Framework were identified (Lim, 2004). The indicators are presented in the Table 1.

Table 1. Indicators of vulnerability

<table>
<thead>
<tr>
<th>Aspect of vulnerability</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exposure</strong></td>
<td></td>
</tr>
<tr>
<td><em>Environmental</em></td>
<td>Changes in temperature and precipitation; frequency and magnitude of climate extremes;</td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
<td></td>
</tr>
<tr>
<td><em>Environmental</em></td>
<td>Sensitivity of crops to changes in the environment and future yield changes;</td>
</tr>
<tr>
<td><em>Economic</em></td>
<td>Population employed in agriculture (%); level of income; access to insurance</td>
</tr>
<tr>
<td><em>Social</em></td>
<td>Age structure of population; population of working age; number of unemployed; migration; access to education/education level of population;</td>
</tr>
<tr>
<td><strong>Adaptive capacity (potential to adapt)</strong></td>
<td>Agricultural policies take climate change impacts/adaptation into account; national adaptation strategy addresses climate change impacts on agriculture</td>
</tr>
<tr>
<td><em>Institutional</em></td>
<td></td>
</tr>
</tbody>
</table>

Indicators will help identifying current vulnerability. Future vulnerability will depend on the future climate impacts and the direction of socio-economic development in the region.

To identify future climate impacts we will use IPCC emissions scenarios A2 until year 2100. It represents a very heterogeneous world with continuously increasing global population and regionally oriented economic growth that is more fragmented and slower than in other storylines. Under A2 scenario global average annual temperature is expected to increase by 2-5,4°C and the concentration of carbon dioxide will reach 900 ppm by the end of the century, second highest among the scenarios (IPCC, 2007).

To put results of climate modelling into the socio-economic context of the Carpathians we will use three regional scenarios: reference scenario or business-as-usual, EU policies and Carpathian dream. All three scenarios were developed until 2020 but we are assuming these trends will continue further into the future. The “Business as usual” scenario forecasts rapid globalization in the world where governments support economic growth and profit maximization at any cost, leading to further farm-land abandonment due to low profitability, larger social divide, major environmental catastrophes and loss of local cultures (KEO, 2007).

The ‘EU Policy First’ scenario considers successful integration of EU environmental policies into national legislation and strong governmental commitment to green economy and sustainable development. Using funds
available for regional and social cohesion and sustainable agriculture, social divide in the Carpathians is reduced, transregional cooperation ensures better environmental protection and area of Natura 2000 sites increases.

The ‘Carpathian Dream’ scenario suggests that green economy becomes dominating paradigm, meaning that both producer and consumer behavior changes towards environmentally friendly and fair. Technological innovations, restructuring of the policies encourages use of renewable energy, passive houses, supports extensive organic agriculture and reintroduction of native species.

Each of the scenarios will either mitigate or enhance vulnerability to climate change. In the Chapter 6 (Discussion and Recommendations) we suggest adaptation options that could contribute both to the stabilising socio-economic situation in the region and reducing vulnerability to climate change.

Next chapter contains information on these indicators. United Nations Framework Convention on Climate Change (UNFCCC) Guidance on Vulnerability Assessment and Adaptation and other sources recommend assessing future climate impacts on socio-economic scenarios or projections for the same time-frame, as well their implications for vulnerability. In the Chapter 6 we analyse risks and opportunities for agriculture from climate change and what each of socio-economic scenarios would mean for vulnerability of agriculture. Based on the analysis and adaptation principles introduced in the Chapter 3 recommendations for adaptation strategy are suggested. These recommendations are region-specific and to achieve highest benefit for the communities, they should be (and will be) subject of stakeholder appraisal.

4.2 Materials
The study is synthesis of already existing data from EU research projects, project reports, peer-reviewed publications and primary statistical information.

In this study we follow delineation of the region by the Carpathian Convention focusing on the mountainous area. In our work we used materials of the Carpathian Project (2005-2008) that looked at the possibilities to integrate European spatial development policies and management of the fragile mountain ecosystems in the region including Pannonian plain and almost the whole territory of Romania.

CECILIA, CLAVIER, COST 734 projects modelled climate change impacts on the Central-Eastern Europe without distinguishing the role and peculiarities of the Carpathian Mountains.

CLAVIER project produced predictions of future yields of wheat, maize, barley, potatoes and lucerne in North-West of Romania, underlining that the projections are valid only for this region.

4.3 Limitations of the study
There has been little research done on the level of Carpathians. Even though the Carpathian Project has brought together a lot of information on the regional scale, only recently Carpathian-wide climatologic maps were created; past records of observations on the national level and results of national research are hardly accessible and are most of the time in the language of the country, therefore information presented here may be partial.

Agriculture in the mountainous area of the Carpathians is a complex system of semi-subsistent small-scale farms scattered around the region. While usually one farm would both have cattle and grow crops, the study will focus only on crop production (main agricultural crops considered are winter wheat, maize and potatoes), leaving out in depth analyses of climate change impacts on grasslands and livestock as those are analysed in detail in other parts of the Carpivia project. Due to time constraints, I will not take into account differences in age groups’ and gender roles, assuming that both men and women are equally impacted by climate change.
5 Results
This section presents exposure, sensitivity and adaptive capacity of the Carpathian agriculture to climate change. First, current climate and future projections are described, then potential impacts on crop yields and finally, we look at broader socio-economic situation that defines adaptive capacity in the region.

5.1 Exposure
Following the indicators presented in the methodology section, in this sub-section natural variability and predicted future changes in temperature and precipitation, as well as magnitude of climate extremes are highlighted.

5.1.1 Current climate trends
Carpathian Environmental Outlook (2007) describes climate in the region as mild continental, with warm summers and snowy winters. Average annual temperature and sum of precipitation highly depend on the altitude.

Analysis of historical measurements (1961-2000) reveals that the temperature change has a clear geographical distribution: the magnitude of warming is decreasing from west to east and from the lower altitudes to the higher ones. Higher average annual temperature has shown an upward trend of 0.3-0.5°C in Bucegi Mountains (South-Western Carpathians), 0.5-0.7°C in Semenic Mountains and 0.7-0.9°C in the South-Eastern Carpathians in Romania (Csagoly, 2007). While in Slovakian mountains average annual temperature has increased by +1.6°C during 1881-2009 (Melo et al., 2010). Across the region warming has the same seasonal pattern: temperature growth is more prominent in summer season, while in winter even slight negative trend can be noticed. Number of warm nights, hot days and heat wave duration index has increased during 1961-2001 (Bartholy et al., 2007).

Changes in precipitation exhibit north-south divide on the annual scale and are highly mosaic if looking at the seasonal trends (Figure 4). Slovakian and Ukrainian Carpathians have seen a slight increase in yearly precipitation while southern Romanian Carpathians experienced a decrease.

![Fig. 4. Changes in annual precipitation sum, 1961-2010 (Carpatclim, 2012)](image)

Even though precipitation occurred more rarely, the annual number of days with heavy precipitation has increased significantly during 1976-2001 (Bartholy et al., 2007). Storms, heavy rains and heat waves became more common and the trend is expected to continue (KEO, 2007). On-going changes in the precipitation regime might have long-term implications for the runoff and frequency of floods and droughts.
5.1.2 Future climate trends

Studies of temperature change over the Carpathian Basin largely agree on the range of future temperature increase. The Carpathian Mountains might experience an increase between 3.0°C in the north-western part to 4.5°C in the south-east until the end of century following A2 scenario. Two maxima of temperature change are projected, one in winter and one in summer (PRUDENCE Project, WATCH, Bartholy et al., 2007; CLAVIER Project, 2007). The change in winter maximum is less pronounced than the change in summer maximum (Figure 5).

Carpathian mountain range lies in a transition zone between Northern Europe, where increase in precipitation is expected, and Southern, where precipitation will decrease. Model studies largely agree in projecting a small increase in winter precipitation and a significant decrease in summer precipitation. Shorter and thinner snow cover can be expected in the North-East and West of the region. Climate change projections suggest more irregular rainfall and a warmer climate in the Carpathian basin (Láng, 2006; Bartholy et al., 2007). Although the mean annual value of precipitation will remain almost constant, decreases in summer precipitation are projected of above 20% and increases in winter precipitation in most areas of between 5 to 20%. The wettest winter season now may become the driest in the future, and the driest summer is expected to be the wettest by the end of the 21st century. Figure 6 maps changes in precipitation (Bartholy et al, 2007).

Changes in the water cycle may lead to increased magnitude and frequency of extreme weather events. Floods have been more frequent in the past years in Ukraine and Romania, leading to soil erosion and damage of property. Flash floods and mud slides will become more common (Melo et al., 2010).

Increase in the number of tropical days (air temperature at night higher than 25°C) and extended droughts during summer can be expected (Bartholy, Pongrazs, 2010).
Fig. 6. Seasonal precipitation change (%) expected by 2071-2100 for the Carpathian basin using the outputs of 16 RCM simulations, A2 scenario (Bartholy et al., 2007)

Next section discusses implications of above mentioned changes for agriculture in the Carpathian region.

5.2 Sensitivity

5.2.1 Sensitivity of crops to changes in the environment

Main agricultural crops in the region are winter wheat, maize and potatoes. There’s very limited amount of studies on impacts of temperature and water regime variability on these crops in mountainous area of the Carpathians. Therefore we used results of research from other European areas with similar climate.

**Wheat.** Effects of increased CO2 level on wheat grain quality could be minimal if fertilisation is adequate. Crops grown with limiting levels of nitrogen might have poorer grain quality and higher CO2 atmosphere content are likely only to decrease it (Kimball et al. 2001).

Water logging for 44 days at 93 days after sowing in 2002, and 58 days at 64 days after sowing in 2003, decreased grain yield in lab conditions by 20% and 24% respectively. Drought during grain filling further decreased yields but there was no evidence that winter waterlogged plants were more susceptible to damage from drought the following summer, the effects of the two stresses being additive (Dickin & Wright, 2008).

Water stress (drought) during the spike growth period sharply decreases grain number (Hochman, 1982) and if close to anthesis, it accelerates development (Simane et al., 1993). Water stress during grain-filling reduces grain weight (Hochman, 1982; Kohata et al., 1992). However, severity of drought impacts highly depends on yield potential as well as the phenology of the genotype (Acevedo, 1991b).

It has been consistently found that barley and tall bread wheats have higher drought resistance while semi-dwarf wheats are intermediate and durum wheats are most susceptible (Fischer and Maurer, 1978; Sojka et al., 1981).

Research has shown that host plants such as wheat and oats become more susceptible to rust diseases with increased temperature; and some forage species become more resistant to fungi with increased temperature (Coakley et al 1999).
Maize. Drought stress greatly reduces the maize yield, which is dependent on the level of defoliation due to water stress during early reproductive growth. And grain yield of maize is particularly sensitive to water stress during flower initiation, tasseling and silking (Kamara et al., 2003).

Potato. Increase in CO2 concentrations will lead to tuber yield increase across Europe (Wolf & Van Oijen, 2003). Stem length is significantly affected under water stress (Heuer & Nadler, 1995). Reduced precipitation at tuber formation is associated with yield penalties (Peltonen-Sainio et al., 2010).

High precipitation during grain-filling in grain and seed crops and at flowering in oilseed rape has negative effects on yields. Elevated temperatures have harmful effects for cereals and rapeseed yields (Peltonen-Sainio et al., 2010).

Most of the studies above are lab-based or in situ, which allows analysing only the impact of a single factor. To predict the consequences of changes in multiple growth factors (temperature, CO2, precipitation, nutrients intake etc) agro-climatic models are used. However no modelling was done for the whole region. Next section presents available projection for the yield changes in the region (periods of 2020-50 and 2050-80).

5.2.2 Projected yield changes in the region

As much as people have developed technologies to make natural conditions more favourable for agriculture, e.g. through irrigation, use of pesticides and fertilisation, small-scale farmers in the Carpathian mountain area continue traditional practices, relying mostly on the weather, natural soil conditions and organic fertilisers. Higher temperatures, rising CO2 concentrations, change in the seasonality of precipitation will affect both productivity and quality of agricultural outputs in the region. The changes are presented according to the time-scale - mid-term (2020-50) or long-term (2050-2100).

2020-2050: In terms of effective global radiation and number of effective growing days the Czech Republic, Hungary, Poland, Romania, Slovakia and Ukraine show an increase in the mean production potential. A warmer climate may lead to an increase in the northern range over which crops such as soy and sunflowers may be grown and potential increases in yield from the longer growing season may be expected (Iglesias et al., 2007). However in the Pannonian plain further water deficits will limit rain-fed agriculture.

Earlier occurrence of phenological development stages can be expected. According to CECILIA project, favourable conditions and sowing date will shift 3 days (ECHAM model) or almost 10 days (NCAR and HadCM) due to prolonged drought (esp. in lowlands). The good news is that an increase of temperature by 1 °C during the grain filling phase reduces the length of this phase by 5%. Therefore total duration of growth may be reduced under A2 scenario by up to six weeks in 2050. Spatial analysis carried out for the winter wheat yield concerning altitude suggests that yields should increase especially in highlands, where increasing temperature will provide favourable conditions, rainfall will remain sufficient and soil conditions are still relatively good (CECILIA, 2010). Good for winter wheat, the same conditions are projected to decrease maize yields in the lowlands. One of the threats is widening of the pests’ (Colorado potato beetle and the European corn borer) areas and an increase in their generation number by 2050.

In general, the more substantial water deficit during the critical part of the growing season (spring) in Central Europe may lead to a shift to winter crops; however harvesting conditions in June will not improve.

CLAVIER project produced predictions of future yields of wheat, maize, barley, potatoes and lucerne in North-West of Romania, underlining that the projections are valid only for this region (Figure 7). In the period of 2020-30, region has potential to benefit from higher yields of wheat and maize, while lucerne and clover will experience drop in productivity.
Fig. 7. Change in crop yields in the North-West region in 2020-2030 compared to the reference period 1975-2000 according to different climate scenarios (CLAVIER, 2009).

Fig. 8. Change of winter wheat yields in Romania in 2041-50 (COST 734, 2008)

As we can see on the Figure 8, Romania will have little winter wheat yield gains, except for North-East and North-West, which is in agreement with the CLAVIER projections. Average tuber yields of potato are predicted to increase all over Europe in a response to higher CO2 levels (Wolf & Van Oijen, 2003). Vineyards in the
Carpathian area are not irrigated and increasing droughts will lead to lower quality and quantity of the yields (SK 5th communication to UNFCCC, 2009).

2050-2080: Level of uncertainty grows proportionally to the extent of the time-frame in the model, so the following predictions will be true if the trends are supported by instrumental measurements. Warmer climate may lead to potential yield increase due to longer growing season and further increase in the northern range for soy and sunflower. In Hungary, Serbia and Romania a temperature increase of 3-5°C and decrease in annual rainfall are predicted, which may lead to reduced yields of maize and wheat. However, yields of crops with a greater requirement for heat may increase (CLAVIER, 2009).

5.3 Adaptive capacity
In different countries, due to historical developments, the share of the population working in agriculture varies significantly: from 2,3% in Slovak mountain regions to 47,7% and 50% in Romanian and Ukrainian Carpathians respectively (Zingstra et al., 2009; Šeffer et al., 2010). Table 2 illustrates significance of agriculture in the region.

Table 2: Significance of agriculture in different Carpathian countries (Sources: National SARD-M Reports, 2008)

<table>
<thead>
<tr>
<th>Country</th>
<th>Territory of Carpathians as part of territory of a country, %</th>
<th>Agricultural lands in the Carpathian region, %</th>
<th>Population employed in agriculture in the Carpathians, % from total in the region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slovakia</td>
<td>69,8</td>
<td>41,2</td>
<td>2,3</td>
</tr>
<tr>
<td>Romania</td>
<td>29,4</td>
<td>37,6</td>
<td>47,7</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>12,2</td>
<td>53,9</td>
<td>11*</td>
</tr>
<tr>
<td>Republic of Serbia</td>
<td>9,7</td>
<td>56</td>
<td>17,3*</td>
</tr>
<tr>
<td>Hungary</td>
<td>7,3</td>
<td>59</td>
<td>4</td>
</tr>
<tr>
<td>Poland</td>
<td>6,2</td>
<td>42</td>
<td>n/a</td>
</tr>
<tr>
<td>Ukraine</td>
<td>3,1</td>
<td>21,3</td>
<td>50</td>
</tr>
</tbody>
</table>

* from country population

Small-scale agriculture (up to 5ha) prevails in all countries except Slovakia. In the Czech Republic 79% of farms are less than 5 ha (2004), in Poland – 83% (1996) and in Romania out of 4,25 million farms, 99,5% are privately owned with average area of 2,1 ha (SARD-M, 2008).

50% of those employed in agriculture can be considered as latent unemployed because number of workers per 100 hectares exceeds EU average more than 10 times (63 Annual Work Units/100 ha in Romania, 30 AWU/100 ha in Poland and 5 AWU/100 ha in the EU) (Kulikowski, 2009; Iorio and Corsale, 2010). Overall, there is an ongoing shift from employment in agriculture to service sector (Csaki & Jambor, 2009). Figure 9 shows employment structure in the region.
Romanian part has aging population (average age 38 years), 704,861 family heads are over 40 years old, which represents 72% of the entire number of families. This can be explained by migration to cities in the past two decades. Poor infrastructure and limited access to public services makes region unattractive for young people. In Ukrainian part of the Carpathians average age is 40 and depopulation trend persist due to low birth rates. These trends are not so prominent in Poland where workers chose to commute from villages to their work in the city (SARD-M, 2007).

During last 20 years abandonment of traditional way of life has been an increasing tendency - overall crops and livestock production has been reduced, 15-20% of cropland has been abandoned and became fallow (Kuemmerle et al. 2008). Withdrawal of grazing and abandonment of meadows in the Czech Carpathian grasslands has led to the overgrowth of dominant species, degradation of mountain grassland habitats, and diminished diversity of landscapes, habitats and species (KEO, 2007).

Delivery of public services in the region is quite limited due to their high dispersion. Police, schools and health care may be on significant distance or underfunded (Institutul Național de Statistic, 2008; KEO, 2007). For example, there are 25 physicians for 10,000 people in Ukrainian Carpathians. Just 15% of farm leaders in Poland have education above primary level (Kulikowski, 2009). Similar situation is in Romania, Slovakia, which significantly limits farmers’ employment opportunities in other sectors (SARD-M, 2007; Istvan et al., 2009). Public transportation system reaches only larger villages. Access to the means of production is among the highest in Polish Carpathians - on average each ninth farmer has a tractor and there are ten horses on 100 ha of land (Kulikowski, 2009). In Romania situation is significantly more dramatic – it is the poorest region not only in the Carpathians but in the whole EU. 77% of rural household income is derived from in kind payments, while the total monthly family income was €2839 in 2006. Rural households have very limited access if any to credit
markets (Ministry of Agriculture & Development, 2007). During the last two decades rural areas in Eastern Europe have shown an economic decline and a strong underdevelopment (Heidelbach, 2002).

Agriculture in the Carpathians is mostly rain-fed. The results of the 2002 General Census of Agriculture in Romania revealed that only 5.6% of the holdings had an irrigation system, out of which only 31.8% utilized it.

Carpathians are rich in both surface and groundwater resources and only small part of them is currently used: up to 20% in Ukraine and Poland and only 6.3%, 6.2%, 3.6% in Serbia, Slovakia and Hungary respectively. Romania uses 12% of its water resources. Most of the drinking water (80%) comes from groundwater abstraction (KEO, 2007).

5.3.1 Institutional capacity

This sub-chapter analyses national and international policies with respect to their potential to facilitate adaptation to climate change adaptation or enhance the hazards.

With all cultural, political, economic differences between the countries, there’s one body that is set to represent the region as a whole. Carpathian Convention is a forum for cooperation, joint strategic planning for sustainable development and dialog between the stakeholders. Convention recognises climate change as a direct threat to ecosystems and well-being in the region, and in February, 2012 Working Group on Adaptation to Climate Change was set up. Main goal of the Working Group is to review scientific evidence available and provide guidance and recommendations on development of policy documents relevant to climate change adaptation. The Working Group will cooperate with other Working Groups, raising awareness and looking for ways to cooperate. Climate change is not a priority problem in the region, therefore integration of adaptation into sectoral policies will take time.

In 2005 Euromontana, the European association for development and cooperation in mountain regions has introduced European Charter for Mountain Quality Food Products that aims to support farmers in the mountainous areas through better identification of the products on the market. So far, very few Carpathian products have applied for this opportunity.

Common Agricultural Policy is currently undergoing revision and approval of regulations is expected by the end of 2013 with changes coming into force from 1 January, 2014. Among main suggestions are: a) reserving 30% of direct payments for environmentally friendly agriculture to ensure retention of soil carbon, the delivery of water and habitat protection by the establishment of ecological focus areas and improvement of the resilience of soil and ecosystems through crop diversification; b) to double the budget for research and innovation starting from 2014 to enhance knowledge-based agriculture in the time when we need both more food and sustainable management of natural resources. The finance would not only support applied research but as well training and transmission of the results to farmer organisations; c) to encourage formation of professional associations and enhance ways of direct marketing which will be beneficial both for farmer and consumer; d) to support agri-environmental measures adapted to specific region; e) financial support of young farmers during their first 5 years of operation; f) Start-up kit – financial support for entrepreneurs in the rural areas; g) enhance financial support to agriculture in the disadvantaged areas (e.g. due to sloping terrain, less fertile soil, climate conditions); h) reduce bureaucracy, simplify procedures for direct payments for small-scale farmers. If accepted, these measures can build farmers’ resilience, create incentives for people to stay on the land and lay foundation for sustainable rural development.

As we can see, EU and international initiatives encourage climate- and environmentally friendly agricultural practices. However, on the country level, even when integrated into national legislation, green initiatives get stuck on the implementation phase. For many countries the process of evolution from centralised and sectoral institutions to decentralised and inter-sectoral cooperation is painful and takes years.

National Adaptation Strategies (NAS) were endorsed in all Carpathian states, except Slovakia and Serbia, where they are still in preparation. NAS of all countries include analysis and adaptation options for water-related issues.
of agriculture (precipitation, changes in the runoff, future availability of drinking water etc). Irrigation is addressed by all except Hungary. National Adaptation Strategies do not give much importance to agricultural sector and, according to the results of FAO stakeholder workshop, Ministries of Agriculture have little technical capacity to deal with adaptation topic.

EU policies lead the way in environmental and climate protection, but as most of the Carpathian countries are new member states, it takes time for EU policies to reach the effects on the ground.
6 Discussion and Recommendations

6.1 Discussion

The crops grown in the Carpathian region may not be severely impacted and in some places may even benefit from climate change if planting dates and cultivars are adjusted accordingly. Water being critical factor for agriculture, higher probability of extreme weather events such as torrential rains, floods and droughts may lead to more often crop damage and loss. Climate change presents as well an opportunity: growing warm-loving crops on higher altitudes.

There are differences in the adaptive capacity in the North and South of the region. Adaptive capacity is higher in the Northern and Western Carpathians where there are more non-agricultural employment opportunities that could act as a safety net in the case of loss of the harvest. Indicators show gradual decrease of well-being from North-West to South-East (high levels of poverty and unemployment, low education levels, poor access to sanitation facilities, schools and healthcare), which coincides with projected changes in the precipitation and climate impacts. This means that Southern part of the region (Romania and the Republic of Serbia) is the most vulnerable. On the other hand, one of the largest areas of old-growth forests in Europe, numerous castles and springs of mineral water are situated in Romania. The country has high touristic potential which if managed sustainably, could bring numerous benefits to local communities.

Carpathians are one of the last corners of wilderness in Europe, hosting numerous endemic and threatened species. Traditional extensive practices are key to preserving and maintaining high levels of biodiversity in the region. A comparison of several land-use–biodiversity loss gradients showed that ecosystem quality decreases as agricultural practices intensify: agro-forestry systems have an ecosystem quality of 50%, extensive agriculture of 25% and intensive agriculture as little as 10% (Reidsma et al., 2006). For instance, in Sibiu County, Romania, semi-natural vegetation occurs on 60% of all farmed land, most of which is managed extensively. This area hosts 5500 plant species (67% of Romania’s total), and at least 11 hay meadow plant associations can be distinguished on high natural value grasslands (Beaufoy et al., 2006). Unfortunately, it is characterised by aging population and emigration, which means fewer farmers with traditional knowledge in the future.

Putting potential scenarios of the regional development in the climate change context, we can think of the future of agriculture at the end of the century.

The “Business as usual” scenario forecasts rapid globalization in the world where governments support economic growth and profit maximization at any cost, leading to further farm-land abandonment due to low profitability, larger social divide, major environmental catastrophes and loss of local cultures (KEO, 2007). This scenario basically eliminates extensive diverse agriculture from the regional map. Enhanced by the climate change, the rate of biodiversity loss will increase, leading to unpredictable large-scale changes in the ecosystems and drastic decrease in ecosystem services (water purification, soil formation, pollination etc.)

The ‘EU Policy First’ scenario considers successful integration of EU environmental policies into national legislation and strong governmental commitment to green economy and sustainable development. Using funds available for regional and social cohesion and sustainable agriculture, social divide in the Carpathians is reduced, transregional cooperation ensures better environmental protection and area of Natura 2000 sites increases. This scenario is favorable for the region, might lead to intensification of agricultural practices; better access to health care and education, more employment opportunities in eco-tourism can be expected. Resilience of the farmers would be improved, as well as quality of life. Some deterioration of local culture and traditions is possible due to better accessibility for tourists.

The ‘Carpathian Dream’ scenario suggests that green economy becomes dominating paradigm, meaning that both producer and consumer behavior changes towards environmentally friendly and fair. Technological innovations, restructuring of the policies encourages use of renewable energy, passive houses, supports extensive organic agriculture and re-introduction of native species. Contributing both to mitigation and adaptation to
climate change, in this case agriculture has all chances to become resilient and sustainable. However, this scenario needs substantial financial backing which will be difficult in the increasing competition for resources for mitigation of the consequences of extreme weather events.

6.2 Recommendations

As we can see from the previous chapter, the situation in the region is complex and requires multi-dimensional approach. Adaptation measures should proactively address main drivers of change, rather than treating the symptoms (Dawson et al, 2010; Stirling, 2008).

Socio-economic factors that hinder adaptive capacity could be addressed through comprehensive region-wide rural development policy. Carpathian Convention has already made first steps in this direction in the framework of Sustainable Agriculture and Rural Development Initiative (SARD-M). SARD-M analysed current structure and state of agriculture, existing policies and institutions responsible for agriculture and sustainable rural development and based on that gave recommendations to the Carpathian Convention and the EU for future policies. However, this analysis didn’t take future climate change impacts into account.

Considering high uncertainty of extreme weather events predictions and possible gains in wheat yields, all conditions should be created to turn climate threat into opportunity. Action is needed on all levels – from farm to the region as a whole.

On the farm scale potential adaptation options can include changes in sowing dates and crop varieties, improved water-management and irrigation systems, adapted plant nutrition, protection and tillage practices. Adaptation measures should take into consideration improvement of soil tillage and water management, which will improve resilience and address current climate variability.

Considering the diversity of the region and national development priorities, to operationalise Regional Adaptation Strategy, we suggest focusing on:

- Climate proofing existing policies to avoid further incentives for projects contributing to climate change;
- Introduce cross-compliance for new infrastructure, energy and development projects;
- Raise public awareness to facilitate autonomous adaptation process on the farm level: don’t give fish to people - teach them how to fish;
- Long-term monitoring & research will allow us in 5-10 years to see the pace of change, showing which projections and models were accurate and say if applied adaptation measures are working;
- Early-warning system to minimise impacts of natural disasters;
- Create favourable conditions for social entrepreneurship and green business. The region has high touristic potential, using which more investments can be attracted to the region for infrastructure development (schools, hospitals, roads) and nature conservation.

In a way, regional climate adaptation strategy, in case of its thorough implementation, can become important driver and ambassador of sustainable development in the region.
7 Conclusions

Livelihoods of small-holder farmers in the South-East are under threat from climate change and extreme weather events. Vulnerability decreases from South-East to North-West, where farmers can even benefit from warmer climate.

To achieve broader goal of sustainable agriculture and rural development, alterations on a policy level that will create synergy with autonomous adaptation should be considered (Urwin, Jordan, 2008). On the national/regional level, priorities should include placing greater emphasis on the climate proofing of policies, raising awareness to facilitate adaptation process and cross-sectoral water resources management, using river basins as resource management units.

There is a need for change in the economic structure of the countryside and the creation of an attractive environment for living as well as favourable business environment, including the conditions for small entrepreneurs, i.e. to support a creation of new jobs by the diversification of economic activities, as well as to use general policy measures for improvement of the quality of life in the rural areas via eco- or rural tourism.
References


AEA Energy & Environment and Universidad de Politécnica de Madrid. Report to European Commission DG for Agriculture and Rural Development


Bolla, V., Pendolovska, V., 2008: Driving forces behind EU-27 greenhouse gas emissions over the decade 1999-2008


29


Carpathian Handbook, www

Carpathian Convention, www

Carpathian Project, 2009: VASICA: Visions and Strategies in the Carpathian Area. Protection and sustainable spatial development of the Carpathians in a transnational framework
http://www.mtnforum.org/sites/default/files/pub/vasica_24112011email_0.pdf [Last accessed on 05.05.2012]

Carpivia Project, www
www.carpivia.eu [Last accessed on 10.05.2012]

CECILIA - Central and Eastern Europe Climate Change Impact and Vulnerability Assessment, 2010: 1.1.6.3.1.3.2: Climate change impacts in central-eastern Europe. Charles University, Periodic activity report.

www.cecilia-eu.org/Y3_PAR.pdf [Last accessed on 04.03.2012]


Clavier project
www.clavier-eu.org/?q=node/881 [Last accessed on 04.03.2012]


CEC (Commission of the European Communities), 1998: Communication of the European Commission to the Council and to the Parliament on a European Community Biodiversity Strategy, Com (98) 42
http://europa.eu.int/comm/environment/docum/9842sm.htm
[Last accessed on 13.04.2012]


European Climate Adaptation Platform, Adaptation strategies.
[Last accessed on 30.04. 2012]

European Commission, 2009a: Adapting to climate change: Towards a European framework for action - White paper. COM (2009), 147/4 final, Brussel


http://ec.europa.eu/clima/policies/international/negotiations/future/docs/brochure_2c_en.pdf [Last accessed on 03.03. 2012]


Hostert P, Kuemmerle T, Radeloff VC, Müller D., 2008: Post-Socialist land use and land cover change in the Carpathian Mountains. *International Human Dimensions Programme on Global Environmental Change (IHDP) Update* 2, 70–73.


Impacts of and Adaptation to Climate Change in the Danube-Carpathian Region. Overview study commissioned by the WWF Danube-Carpathian Programme. 2008. Central European University (CEU), Department of Environmental Sciences and Policy


Istvan, P., Reka, V.I., Ervin, T., 2009: Assessment of the competitiveness of the dairy food chain in Romania


Kwast, E., Bergslund, G., 2010: The water and waste water sector. A study of selected markets in Central and Eastern Europe, Asia and Middle East, 405.

Láng, I., 2006: The project “VAHAVA”, Executive summary. Ministry for the Environment and Water Management (KvVM) and the Hungarian Academy of Sciences (MTA), Budapest.


Reser, P., Swim, K., 2010: Adapting to and coping with the threat and impacts of climate change. Psychology and global climate change, 1-40.


UNECE, 2009. Guidance on water and adaptation to climate change


[Last accessed on 20.02.2012]