Third Meeting of the Carpathian Convention Working Group on Adaptation to Climate Change with participation of experts of Carpathian Region and Alpine Convention - 12 – 13 March 2014, Vienna, Austria

The Carpathian region is a mountainous areas of outstanding natural beauty. The CARPIVIA, CarpathCC and CARPATCLIM projects assessed the vulnerability of the Carpathian region to climate change in combination with other anthropogenic pressures. The conclusions are summarised below.

Key climate change pressures (temperature and precipitation)

Temperature Change - Rising winter and summer temperatures threaten local and national policy objectives related to agriculture, winter tourism, rural development and a host of economic and social issues. The Carpathian mountains are projected to experience an increase between 3,0 ºC in the north-western part to 4,5ºC in the south by the end of this century. The change in winter maximum is less pronounced than the change in summer maximum.

Precipitation Change - Most studies indicate an increase in winter precipitation and changes in snow cover. Although the mean annual values of precipitation do not show a very clear trend, reductions in summer precipitation are projected of above 20 % and increases in winter precipitation in most areas of between 5 to 20 %.

Vulnerability of water resources

Reduced snow cover, unforeseen heavy rains caused by climate variability, and changes in precipitation patterns will alter flood regimes and increase the risk of flood events. Extreme high precipitation over a short period of time will add to erosion and risks of land slides. In other times of the year, lower river discharges and drought periods are expected to increase. The change in average runoff values for the dry months is between a 4% increase and a 19% decrease until 2050. Overall, a decline in total annual river discharge is predicted for southern and eastern parts of the Danube basin, while western and northern parts might experience increases. In particular, southern parts of Hungary and Romania as well as the Republic of Serbia, are expected to face severe droughts and water shortages. Groundwater recharge is likely to be reduced, whilst more frequent droughts in summertime will reduce low flows and result in water shortages. There may be impacts on the quantity and quality of drinking water for communities dependant on mountain streams.

Annual water temperature is projected to change by 1.74˚C between 1971–2000 and 2021–2050. Projections of average water temperature change in the summer months reach 4˚C or above. In addition, the number of days with extreme water temperature (>28˚C) increases. This would have definite impacts on aquatic ecosystems. There is clear spatial variation in the identified climate-induced trends in thermal and runoff conditions, and consequently in the impacts on aquatic ecosystems. While the northern part of the Carpathian region is insignificantly or moderately affected, the southern part is expected to be highly affected. As opportunities for adaptation are relatively well shared yet depend on financial resources. The southern (sub-)basins are expected to be the most vulnerable as well.

Recommended adaptation water resources

The legal framework is crucial to support pro-active planning and the implementation of adaptation measures. Here the cooperation in implementing the water framework directive could be used to streamline activities. It will offer opportunities for the development and application of adaptation measures in the framework of river basin management plans in order to achieve and sustain good ecological status. Such adaptation measures could include *non-technical measures*, such as floodplain restoration, afforestation of catchment areas, adjustment of permits for water abstraction/water use/pollution discharge, the management of catchment land use to reduce diffuse nutrient loading and soil erosion, warning systems and awareness programmes, as well as *technical measures* like dams, dikes or retention reservoirs. Lessons can be learned from other mountainous areas like the Alps that are aimed at increased efficiency of water use, infiltration and water saving.

Vulnerability of Forests and Forestry

In forests increasing temperatures and higher incidences of drought will lead to shifts in species composition, especially at lower altitudes towards more drought-resistant tree species. More frequent and increased drought stress can increase pests and pathogenic damages, as well as damage from fire. The tree-line will move upwards, and the occurrence of species will migrate up- and northwards. Some species and communities might collapse as a result of these shifts especially where connectivity and ecological corridors are limited. Particularly vulnerable species include spruce at lower altitudes, beech, maple, oak and lime. Increased soil erosion will add to the risk of landslides in lower mountain areas. Assessment indicates high to very high forest vulnerability in most of the Carpathians. Only the Ukrainian Carpathians and Polish part of the Outer Eastern Carpathians were rated at moderate to low vulnerability. Different factors determine forest vulnerability across the Carpathians. High forest vulnerability in the Western Carpathians (CZ, SK, PL) is mainly related to the presence of highly sensitive secondary spruce forests, and to direct or indirect effects of drought (SK, HU). The main factors causing high forest sensitivity in the Romanian and Serbian Carpathians are drought together with the related biotic damage, acting mostly upon broadleaved forests. High frequency of windstorms and subsequent bark beetle outbreaks are impact factors throughout the Carpathians. In Poland, low climatic exposure along with good forest structure and low biotic risk reduces vulnerability. The assessment stresses the importance of developing specific forestry measures in a trans-national context, to focus on mapping and designation, identification of refuges, cross-border linkages, and management measures such as thinning, fire management and invasive species management. Changes in forest management can be progressively implemented, e.g. after an extreme weather event or logging causes significant forest loss.

Recommended adaptation forests / forestry

- Promote (transnational) *sustainable forest management* enabling natural processes (concepts like close-to-nature-forestry,reduced clear-cutting,natural regeneration).Erosion control measures (close to villages) reduce impact of (illegal) logging and flash floods
- Increase in the share of drought tolerant species, mainly of oaks, including Mediterranean species in exposed sites, reduction of vulnerable water demanding conifers, and beech in lower elevations
- Support and harmonize regional and European forest monitoring schemes, including transboundary monitoring of newly emerging pests and pathogens. Promote Integrated Pest ManagementPromote risk rating in forest management rather than currently applied indicators of forest productivity
- Avoid forest fragmentation and support connectivity of larger forest areas to support species natural migration and gene flowsFinancial support to promote and encourage introduction of locally adapted tree species in lowlandsIncrease awareness on the importance of integrated watershed management and effects of forests on water retention and drinking water

Vulnerability of Wetlands

High altitude wetlands are crucial for both flood management (acting as sponges and thus levelling off flood peaks in winter and low flows in summer) and for biodiversity. Increased temperatures will lead to drying out of wetlands, compounded by higher incidence of drought. Further wetland loss would reduce habitats for the many dependent plant and animal species, and lead to habitat fragmentation which could threaten migratory birds and amphibians at a regional scale. The most vulnerable wetland habitats are peat lands, because of their limited resilience to climate variability, and their sensitivity to human activities and changes in land use. Less vulnerable are halophytic habitats and some types of water and river banks habitats. These habitats can adapt to climate fluctuations, yet are highly sensitive to human activities and changes in land use. The lowest vulnerability is found in habitats already subjected to regular flooding, for subterranean wetlands and for some river bank and water habitats. They are most likely to be able to cope with even more extreme fluctuations in climate. However, human intervention can represent important threats also in this case.

Recommended adaptation wetlands

- Develop and support ecosystem monitoring systems, network to monitor the state of waters and aquatic ecosystems in the region
- Integration of wetland protection with flood control practices: Support programmes aiming for wetland and peatland restoration, floodplain rehabilitation and creation of new wetland and lakes to enhance local water retention capacity and support biodiversity
- River and floodplain restoration
- Small scale water retention in lowland forests

Vulnerability of Grasslands

Carpathian grasslands are among the richest grassland biotopes in Europe. Their high biodiversity value is a direct result of hundreds of years of traditional management and animal husbandry. Temperature increases, more extreme droughts and floods, soil erosion and an upward shifting tree line are all expected to reduce grassland quality and coverage, leading to habitat fragmentation and loss of species. Whilst for the time being arable agricultural intensification and abandonment of traditional grazing practices are a more immediate threat, the longer-term impacts of climate change are expected to be severe. Long established and stable grassland communities (e.g. mountain hay-making meadows) are more tolerant to climate change, than grasslands with short history. Maintaining therefore appropriate – usually traditional – management methods is vital. Adaptation measures can only be successful when also striving for an economically viable country side. Results show that impacts depend on both altitude and geologic substrate. For example alpine and subalpine grasslands on calcareous substrates are very vulnerable to climate change due to their dependence on soil type and limited opportunities to migrate. Conversely, species-rich Nardus grasslands in (sub)mountain areas are considered moderately vulnerability as grassland management can moderate impacts. Five main management measures are the most widely applied within the Carpathian, namely; grazing, abandonment, mowing, mulching and fertilization. Grazing and mowing was found to be of high importance to be maintained in the future. However, abandonment as a conservation measure will be less suitable in the future due to forest encroachment and increasing timberline. Mulching and using fertilizers to increase the nutrient input is expected to be less suitable due to the presence of invasive species which thrive in higher nutrient conditions. Finally, agro-environmental programmes can offer indispensable support for maintaining connectivity and grassland management.

Recommended adaptation grasslands

- Implement agri-environment measures & Natura2000 management plans
- Diversify species and breeds of crops and animalsManage through grazing, mowing, not abandonment, mulching, fertilization

Vulnerability of Agriculture

Due to changing precipitation, temperature, and seasonality, agriculture will experience significant pressures. Agriculture may become feasible at higher altitudes. In some parts of the Carpathians maize and wheat yields will decline, whilst elsewhere sunflower and soya yields might increase due to higher temperatures and migration of these crops' northern limit. Likewise, winter wheat is expected to increase. In general a shift during spring planting towards winter crops will be possible. Unfortunately, vulnerability to pests is predicted to rise, and increasing productivity losses are also expected as a result of soil erosion, groundwater depletion, and extreme weather events. Deeper analysis of socio-economic trends is necessary to identify the most vulnerable areas in the Carpathians but preliminary results show that small-scale farmers in remote villages in Romania and Serbia could be among the most vulnerable. Pastures in the Carpathians are especially vulnerable through the combined impacts of climate change and socio-economic dynamics. In particular, the pastoralist -that grasslands depend on for both their existence and the implementation of potential adaptation measure-, are abandoning grazing and land management activities.

The traditional mixed agro-ecosystems in the Carpathians may disappear through a combination of land abandonment, land use change and increased advancement of forest area, encouraged by climate change.

Recommended adaptation

- Support small-scale traditional farms as important economic activity delivering multiple ecosystem services.
- Agro-environment programmes are critical to maintain and enhance biodiversity and viability of semi-natural grasslands and mixed agro-ecosystems

Vulnerability of Tourism

Tourism will experience both positive and negative impacts from climate change. Ecotourism, summer tourism, health tourism and vocational tourism can be positively influenced by climate change. Rising temperatures in summer both in the Carpathians and elsewhere, for example the Mediterranean, can bring more tourists to the mountains for comfortable temperatures. On the other hand, the possibilities of winter sport will become more limited. Projections of snow duration and depth indicate significant change for the coming 50 years. However, as tourism in the Carpathians is presently very diversified, only a small part of the visitors depends on the snow availability. Thus snow cover and snow depth changes will not have such a large impact on the entire tourism turnover as was formerly supposed. Besides, the profile of the old, winter sport-based resorts is changing and the majority of the tourists visit the hotels and pensions in the summer periods nowadays, meaning that tourism in higher mountains is already adapting to new conditions. It is estimated that climate change can bring 60-75.000 additional tourists per year with 9,6-12 million EUR additional revenue for the region. A Southeast-Northwest gradient of vulnerability is reported, with the South-Carpathians' tourism the most vulnerable.

Recommended adaptation tourism

Continue diversification of resorts and markets

Strategic Agenda on adaptation to climate change

At a regional level, linking different policies of nature conservation, river basin management and sustainable farming, could significantly strengthen the Carpathian region and its resilience to climate change impacts. Regional cooperation platforms, like the Carpathian Convention, could be a critical vehicle to mainstream this in different countries. Countries in the Carpathian region can increase their resilience and tap into European resources by mapping out a path towards a climate-proof future which draws upon, and conserves, the unique natural and cultural values of the Carpathian region. The added value of increased transnational cooperation and joint activities is especially strong when planning for climate change adaptation, as much of the predicted impacts of climate change relate to seasonal and geographical shifts. This is true for species and communities (forests, tree-lines, northern limits) as well as for socio-economic aspects (tourist arrivals, tourism seasons). Many of the possible measures are thus best planned using a geographical scale of the eco-region, rather than the nation-state. Further, many of the tools and capacities required for climate change adaptation which are currently missing, such as the capacity for designation and mapping of future refuge habitats for wetlands and grasslands, are either only possible at the transnational level, or are equally missing in each country, meaning that joint initiatives with external funding could fill these gaps and build cooperative capacity at the same time. Financial resources are limited. A key action is to create flexible and equitable financial instruments that facilitate benefit - and burden-sharing, and that support a diverse set of potentially better-adapted new activities rather than compensate for climate impacts on existing activities. To succeed, new partnerships between government, civil society, the research and education institutions, the private sector and international organisations will be key. Essential components of such partnerships will be capacity building and information sharing, climate-proofing of infrastructure and investments, climate-cross compliance, and design of eco-system based adaptation measures to make biodiversity management more dynamic.