StartClim2010

Adaptation to climate change: further contributions to the development of a policy paper for adaptation to climate change in Austria

Final Report

September 2011

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Project Leader

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Contracting Parties

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Austrian Federal Ministry of Health
Austrian Federal Ministry of Economic Affairs, Family and Youth
Austrian Federal Ministry of Science and Research
Austrian Federal Forests
Austrian National Bank
Austrian Hail Insurance
Federal Environment Agency
Verbund AHP

Administrative Coordination
Federal Environment Agency

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Vienna, September 2011

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Abstract

StartClim has been dealing with the topic of adaptation to climate change since 2008. StartClim2010 worked on further topics as a contribution to the development of an adaptation strategy for Austria, which are described here.

As a result of the mechanisms of climate change and especially because of the heat island effect, the quality of life in urban areas will change in the future. The way in which we react to these changing climate conditions will directly influence the urban quality of life. More and more cities are therefore asking themselves if they are equipped to face climate change.

Open and green spaces play a central role in this context, influencing temperature and hydrology management in the cities. Because of their cooling effect they can attenuate temperature increases, and they delay rainwater drainage, preventing local flooding in the event of heavy precipitation. The design of open and green spaces is therefore a crucial part of urban adaptation strategies. An analysis of international good practices in terms of their relevance for Austrian cities resulted in the identification of eight central areas of action for the adaptation of urban open spaces: water management, soil management, preservation and development of urban biodiversity, urban planning strategies, open space design and maintenance, promotion of recreational activities, awareness raising and stakeholder networking, and further research requirements. In these areas recommendations for action were described and their feasibility for Austrian cities was reviewed in a stakeholders' workshop. Examples of existing instruments and initiatives are documented to show the most suitable fields of implementation of the recommendations. The "Umweltplan Innsbruck", for example, shows how adaptation issues might be taken into account. As a dynamic instrument it aims to improve the quality of life and environment. Another example is the promotion of the redesign of interior courtyards in Graz as a strategy to improve the local city climate.

Options that are rarely discussed at present in Austria are described, such as the use of open spaces like sports fields, squares and car parks to avoid flooding. These multifunctional spaces are flooded during extreme rainfall and then used for retention. Because of these manifold interactions, integrated planning and implementation are crucial for forward-looking adaptation of urban open spaces. Awareness raising and better networking between private and public stakeholders are essential. The exchange of experiences between cities could be enhanced by implementing a good-practice pool.

Compared with other types of green space, public parks in cities have specific attributes and characteristics and considerable complexity in their conception and maintenance. They must therefore be considered separately from other types of green and open spaces.

Climate change threatens the quality and functionality of public parks and hence their significance for a city. To protect the quality of parks and to facilitate affordable maintenance, it is important to consider climate change at the planning and design stage. The area most affected in Austrian parks at present is park maintenance. Problems are caused in particular by the impact of extreme events such as storms, heavy rain, drought and high temperatures but also the secondary effect of milder winters such as the invasion of new pest insects, changes in the soil structure and all-year-round park use). Because of the absence of a strategic approach, adaptation is mostly reactive. The continuous repair of damage entails enormous additional work and expense. Together with the financial constraints of park maintenance this increases the vulnerability of parks to climate change.

Many different actors are involved in planning and maintaining a park. Adaptation to climate change – from the development of strategies and the adoption of required solutions to implementation and monitoring the effectiveness of measures – also necessitates cooperation between the public sector, particular the parks department, and the private sector. They all need to be aware of the problem of climate change and learn how to deal with it. In the framework of the project the relevant stakeholders, their responsibilities and the

required knowledge were therefore identified. A communication structure now needs to be provided to ensure that the required information about climate change adaptation in public parks is forwarded to the persons responsible and that the need for further research can be indicated to relevant research institutions. Information can be passed on effectively at conferences, in journals and through the Parks Committee of the Austrian Association of Cities and Towns.

The intensification of the heat island effect due to climate change in cities has an influence both on the urban population and on city tourism, which is at its peak during the summer months (July, August). An increasing proportion of tourists are in the 60–79 age group, who are in general particularly heat-sensitive. The tourists themselves as well as tourism industry, city administration and city planning therefore have to consider adaptation strategies for hot days. Measures concerning tourism architecture (e.g. greening of roofs and facades, light-coloured building materials), city, spatial and landscape planning (e.g. preservation of green areas and fresh air corridors, evaporative cooling through moving water), infrastructure (e.g. drinking fountains, shaded seats) and organisation (e.g. heat warning system, opening of cooling centres) would be useful in this regard. A survey of tourists and a discussion among experts carried out within the framework of a world café have shown that there is need for action especially with regard to greening, information for tourists (e.g. indicating drinking fountains and cool places in maps, providing adequate sightseeing tips on hot days in the accommodation and via Internet apps) and additional training for tourism experts. A special feature both of Vienna and of other Austrian cities is the easy access to high-quality drinking water. On the basis of all results, the elements of an adaptation strategy for city tourism were elaborated in the form of a Management Letter in order to assist the tourism industry, city administration and city planning in developing and implementing suitable adaptation measures.

Drought is one of the major agro-meteorological risks to agriculture and is expected to increase in the middle and high latitudes in the next decades. Hence, it is important to quantitatively analyse the relationship between drought events and fluctuations in crop yields throughout Austria and to investigate the economic and environmental effects and the negative external impact of possible adaptation measures in agricultural production. Based on historical data sets (1975–2007), moderate and extreme drought scenarios for Austria were devised. They predicted an increase in dry days between 2008 and 2040 and a significant decrease in crop yields for corn, winter wheat and barley under standard cultivation conditions without irrigation of 60 to 90 per cent.

Especially in the Pannonian region Marchfeld, one of the most important and driest crop production areas in Austria, irrigation of vegetables and other high quality products is already indispensable today. The importance of irrigation systems to adapt to climate change and also the need to sustain groundwater resources increase with more frequent drought events. Sprinkler irrigation would be a profitable adaptation measure in the Marchfeld region, almost doubling crop yields compared with management without irrigation. But it could also considerably increase the pressure on regional groundwater aquifers. Investing in more water-efficient but also more expensive drip irrigation systems is unlikely without subsidies for equipment. According to studies economic instruments such as a change in water prices would not increase the willingness to invest in a drip irrigation system. On the contrary, such instruments would reduce the likelihood of investment in either of the two irrigation systems.

The European larch (*Larix decidua* MILL.) is the second most prevalent conifer tree species in Austria, and covers an area of 4.6 per cent of the forest land. Under the conditions of natural forest succession, competition from climax tree species has a decisive impact on its occurrence. Hence, because of its wide physiological amplitude, the larch can be found within forest stands from the submontane zone up to the subalpine zone. Yet only within subalpine forest communities of stone pine and larch and within natural subalpine larch forest communities is it a dominant tree species. Its natural distribution has been highly extended by human activities. Because of the increasing instability of forests dominated by Norway spruce, forest managers are more and more concerned about diversification of tree species within forest stands so as to reduce vulnerability to windthrow and insect infestations. As a deep-rooted tree species that is highly resistant to strong windstorms, the European larch is likely to be of growing importance in this context. For the period from 2071 to 2100, climate scenarios generated by the simulation model REMO-UBA A1B show an increase in the annual mean temperature of 3.5°C to 4.5°C in large parts of Austria, while the future total annual precipitation is expected to vary across the country. Under the climate change scenario, the future growth conditions will still be favourable for larch in montane to subalpine altitudes. In the submontane zone, however, the climatic boundary conditions for European larch will not be fulfilled in many parts of Austria, in particular because of increased temperatures. In the more difficult climatic conditions at these lower altitudes, larch cultivation will be at increasing risk of damage. A shift in the area of larch provenance to the higher altitudes of the montane zone should therefore be investigated. Given the fact that extreme climate events like dry spells or heavy rainfall are likely to occur with greater frequency in the future, the larch could play a crucial role, depending on the specific forest site conditions, as a stabilising tree species in mountain forest ecosystems.

The need for adaptation to climate change affects not only cities and their green spaces, but also a large number of other sectors, stakeholders and policy makers at different administrative levels. It is often difficult to decide which of the many adaptation options should be implemented or which one should be implemented first. For that purpose, an Excel-based decision support tool was developed guiding the user through a criteria catalogue to identify the pros/cons and constraints of a particular adaptation measure. The tool takes account of both economic criteria, such as benefits (avoidance of damage) and costs, and non-economic criteria such as urgency, synergies, climate policy trade-offs and flexibility in the face of uncertain climate developments and changing conditions. The main criteria for “good adaptation”, such as suitability as no/low regret or win-win measures, are also integrated. In addition to a basic variant (all criteria weighted equally), the user can choose between an economic, ecological/sustainable or uncertainty-driven bias and thereby find out which measures are especially robust. The main contributions of the decision-support tool are to visualise the impact of a measure in terms of decisive key criteria and to identify synergies and trade-offs with respect to different policy goals reflected in the criteria. Furthermore, the tool shows the information required for decision-making and the gaps in the data. Test runs reveal that different measures with a common adaptation target differ mainly in terms of flexibility and economic performance, while a comparison of measures from different areas shows additional differences in terms of avoidance of damage, urgency and interaction with mitigating climate change.

Because of the growing number of disasters due to climate change there is a need for better and closer networking of the relevant players. The integration of partners from government agencies, action organisations, research institutions, industry and the population is an essential prerequisite for efficient and proactive civil protection.

Germany and Switzerland have well-equipped and well-established platforms that permit knowledge transfer in an institutionalised context of integrated disaster management. Especially in view of increasing climate change-induced hazards, such a platform is also needed in Austria to discuss new challenges in modern disaster management at the strategic level, such as in the management of heat waves. The main tasks of such platforms are the networking of all players, the collection of information from publications and reports and the dissemination of these resources via a literature database that is accessible to all interested people and at suitable events. Public agencies such as authorities or emergency organisations formulate requirements that can be passed on to researchers to generate knowledge for use by the public agencies.

There is a great interest in a national platform on the risks of climate change and natural hazards, particularly in regard to ongoing exchange and dialogue to improve networking and the prevention of and response to disaster events. According to an online survey of 72 relevant players from all five pillars of disaster management, the majority of natural hazards were thought to be increasing “rapidly” or “quite rapidly”, with the result that the number of disasters was also likely to increase and present new challenges.

Recommendations for the area of disaster management in the Austrian climate change adaptation strategy have therefore been elaborated. Nine recommendations were formulated based on existing demands by the National Crisis and Disaster Protection Management (SKKM) and on measures that have been implemented or planned in Germany and Switzerland.

1 The StartClim research programme

The StartClim climate research programme is a flexible instrument. Because of the short project duration it can react quickly to topical aspects of climate and climate change. It is financed by a donor consortium consisting of nine institutions (see page 4).

StartClim has been dealing with the topic of adaptation to climate change since 2008. It provides valuable contributions to the development of an Austrian strategy in this regard.

The projects in StartClim2010 deal with the adaptation of open and green spaces in urban areas and the measures required for city tourism. Adaptation measures for agriculture and forestry are also discussed. A decision-support tool to evaluate different adaptation measures and a concept to optimise strategies for handling natural hazards are described.

The StartClim2010 report contains an overview of the results in German and English along with separately bound documentation in which the individual projects are described in detail by the respective project teams. All reports and documents about StartClim2010 will be made available for download at http://www.austroclim.at/startclim, the StartClim website. A limited number of CDs with all StartClim reports and folders with a short summary will also be published.

2 StartClim2010.B: Recommendations for the adaptation of urban open and green spaces in Austrian cities and city regions

As a result of the mechanisms of climate change and especially because of the heat island effect, the quality of life in urban areas will change in the future. Cities and urban regions are highly sensitive areas because of the high housing density, the concentration of assets and the critical infrastructure. More and more cities are therefore asking themselves if they are equipped to face climate change. The city climate is characterised by the interaction between urban open spaces and buildings and is affected by anthropogenic influences such as lost heat and pollutant emissions .The exact impact of these effects is strongly influenced by the type and degree of the structural environment, the structure of the city itself and its integration in the surrounding region.

Open and green spaces play a central role in this context. Under certain circumstances they can counteract the rising temperatures and enhance urban resilience to changing climate and weather extremes. Through their structure and distribution in the city (amount of greening, size of green spaces, infiltrative soils, water evaporation, air corridors) their cooling effects and water retention or evaporation function play a core role in temperature and hydrology management. This is accompanied by positive health effects through improved air quality, the mitigation of the heat island effect and the potential use for local recreation. Interconnected urban open spaces therefore make a crucial contribution to resilient urban development. The developing of an urban open space network and the a targeted promotion of urban open and green spaces are not yet used adequately as a strategic action or control instrument in urban planning.

Current research focuses on urban open spaces, hydrology management and the increase in thermal comfort. Recommendations for action have been devised on an interdisciplinary basis and with the integration of local stakeholders in projects such as *Future cities – urban networks to face climate change* and *Klimzug-Nord Strategische Anpassungsansätze zum Klimawandel in der Metropolenregion Hamburg*. Scientific studies such as a typological differentiation of urban soils frequently provide the basis for adaptation actions.

Existing European adaptation strategies for urban open spaces and European and international good-practice examples range from practical measures to transform impervious surfaces into pervious surfaces (New York, Chicago) and multifunctional urban open spaces (Watersquares, Netherlands) to networking strategies by stakeholders within a city council (Koordinierungsgruppe Klimawandel Frankfurt am Main – City of Frankfurt Climate Change Coordination Group).

Eight essential areas of action for urban open and green spaces were identified on the basis of international good-practice examples and outcomes of research programmes. Measures are required in water management, soil management, preservation and development of urban biodiversity, urban planning strategies, open space design and maintenance, promotion of recreational activities and awareness raising and improving stakeholder networking. Further research requirements were also identified. In these areas eight recommendations for action and their feasibility for Austrian cities were reviewed with the involvement of stakeholders. They include details about the importance, links with existing instruments, information about the state of implementation, further steps required and indications regarding the stakeholders who need to be involved.

Responsibility for urban open spaces within the city council and their ownership are spread across a number of bodies. A network of stakeholders within the city council is crucial to facilitate coordinated development, exploit synergies and prevent negative impact on other areas. The complexity of the administrative structure and the distribution of responsibility in Vienna are shown by way of example (see Fig. 1).

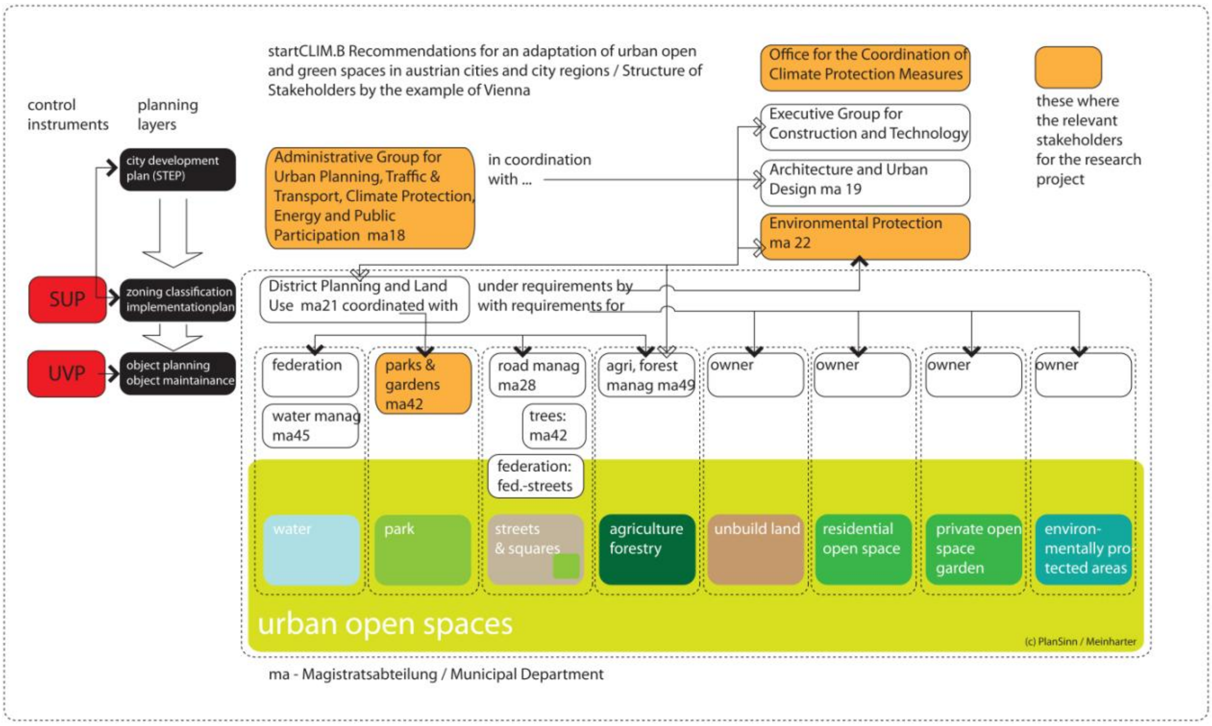


Fig. 1 Administration structure for the urban open space in Vienna as example © Meinharter

Examples of existing instruments and initiatives are documented to show the most suitable fields of implementation for the recommendations. The example of the *Raumentwicklungskonzept REK* (Regional Development Perspective) for the city of Salzburg, implemented in 2007, and its underlying environmental information technology (typologies of cultural landscape, environmental protection plan) shows clearly that the urban planning instruments already exist and can be used in conjunction with climate-relevant findings and data to develop strategies for urban open spaces to adapt them to climate change. The “Umweltplan Innsbruck”, for example, shows how adaptation issues might be taken into account. As a dynamic instrument it aims to improve the quality of life and the environment. Another example is the promotion of the redesign of interior courtyards in Graz as a strategy to improve the local city climate. The “Stadtwandern mit dem LUP” (City walking with the LUP) project in St. Pölten is a good example of a suitable information policy. The LUP city bus provides access in a climate-friendly way to large green spaces called “grüne Adern” (green veins). This initiative supports the implementation of the LAKS 2010 Landscape Development Programme, which is designed to maintain and enhance the quality of life.

In general, local development programmes and city development strategies containing environmental protection data on urban open spaces (Graz, Vienna, Dornbirn, St. Pölten. Salzburg, etc.), provide a basis for adding climate-relevant data and taking it into account in further planning. Options that are rarely discussed at present in Austria are described, such as the use of open spaces like sports fields, squares and car parks to avoid flooding. These multifunctional spaces are flooded during extreme rainfall and then used for retention (see Fig. 2)

Fig. 2 : Images of the waterspace © Studio Marco Vermeulen/Urban Affairs in cooperation with (i.s.m.) De Urbanisten/VHP

Because of these manifold interactions, integrated planning and implementation are crucial for forward-looking adaptation of urban open spaces. Awareness raising and better networking between private and public stakeholders are essential. The setting up of a good-practice pool would enhance the exchange of experiences between cities and provide city stakeholders with an overview of strategies that have already been successfully implemented. To further the implementation of adaptation recommendations an exchange of experience between cities should be encouraged.

3 StartCim2010.A: Fields of action and responsible actors for climate change adaptation of public parks in cities

Public parks are important for the quality of urban life. They fulfil ecological, economic and socio-cultural functions within the urban structure. Climate change and secondary effects threaten their quality and functionality. Changing climatic conditions require adaptation. The diverse fields of action (planning, design, construction, maintenance, usage) are affected by climate change impacts of different intensities. A detailed literature review and interviews with experts and stakeholders in the nine provincial capitals were conducted to describe the fields of action in public parks in connection with climate change impacts and to identify the institutions and persons responsible for adaptation. Currently the most affected and vulnerable field of action in Austrian public parks is park maintenance. In particular the impact of rising temperatures, extreme weather conditions and the effects of winters with mild temperatures (e.g. new invasive pest insects, all-year-round park use) present challenges. Because of the absence of a strategic approach, adaptation is mostly reactive. The continuous repair of damage entails enormous additional work and expense. Together with the financial constraints of park maintenance this increases the vulnerability of parks to climate change.

To protect the park quality and to facilitate affordable maintenance, adaptation measures in planning and design are necessary (e.g. installing irrigation and drainage systems). Reactive adaptation measures are usually more expensive. It is therefore important for designers to consider climate change during the park planning process.

Many actors and institutions with different responsibilities, competence or expertise play a role in the different adaptation phases. Municipal parks departments are involved in all adaptation phases. They are professionally competent and formally responsible. Climate change adaptation coordinators function as data and action networkers. Private sector stakeholders (e.g. planning offices) also bear responsibility for climate change adaptation. They must therefore be trained and informed via different platforms such as professional representations, associations, schools and higher education institutions. Policy papers by parks departments and maintenance or park development plans are important guiding instruments for both municipal and private stakeholders. Such instruments should in future therefore include climate change adaptation guidelines. Adaptation concepts for parks could fulfil this function in existing parks.

An efficient communications structure is the basis for successful climate change adaptation. Information must be exchanged between responsible persons, and adaptation measures must be passed on to executing authorities. Because of the changing climatic situation it is also necessary to communicate new findings to responsible persons to include them in the ongoing development of strategies and measurements.

Conferences and scientific journals are sources of information and vehicles for passing on information. They are therefore an appropriate platform for connecting municipal and private stakeholders, scientists and researchers in the field of public parks. The Parks Committee of the Austrian Association of Cities and Towns, to which all involved stakeholders have at least indirect access, is an important functional platform.

The fundamental aim of investigations into climate change adaptation in public city parks is the sustained protection of their quality and usability. The identified fields of action, responsible persons and their crosslinking, and appropriate strategic adaptation instruments should improve the continuity and effectiveness of adaptation measures and hence their success. The project will therefore contribute to the Austrian national climate change adaptation strategy by developing strategic recommendations for action.

	phases of adaptation	stakeholders / fields / institutions	role
1	Initiation of strategy development	federation, federal states (cities, communities)	political responsibility
		science / research institutions	professional responsibility
		stakeholders municipality (city gardens / higher departments)	professional responsibility and , expertise and cognizance about necessity
2	development of adaptation strategies	climate change coordinators	organizational competence
		research institutions (science)	professional responsibility
		stakeholders practice (municipalities and private sector)	professional competence, practice know-how / involvement
3	adoption of required resolutions and implementation of adaptation strategies	federation, federal states (cities, communities)	legislation, implementation instruction
		municipal departments responsible for parks / stakeholders park management	professional competence
4	execution of adaptation strategies	planners and designers of parks	expertise to execute implementation
		specialists working in the parks (maintainers) (municipalities and private sector)	expertise to execute implementation
		training schools, further education institutions, professional associations, representations and societies	responsibility for passing on knowledge
5	monitoring of implementation and execution monitoring effectivity of measures	federation, federal states (cities, communities)	political responsibility
		climate change coordinators	organizational competence
		municipal departments responsible for parks	expertise / practice know-how / professional responsibility

Fig. 3 : Roles of involved stakeholders within the adaptation phases (1-5)

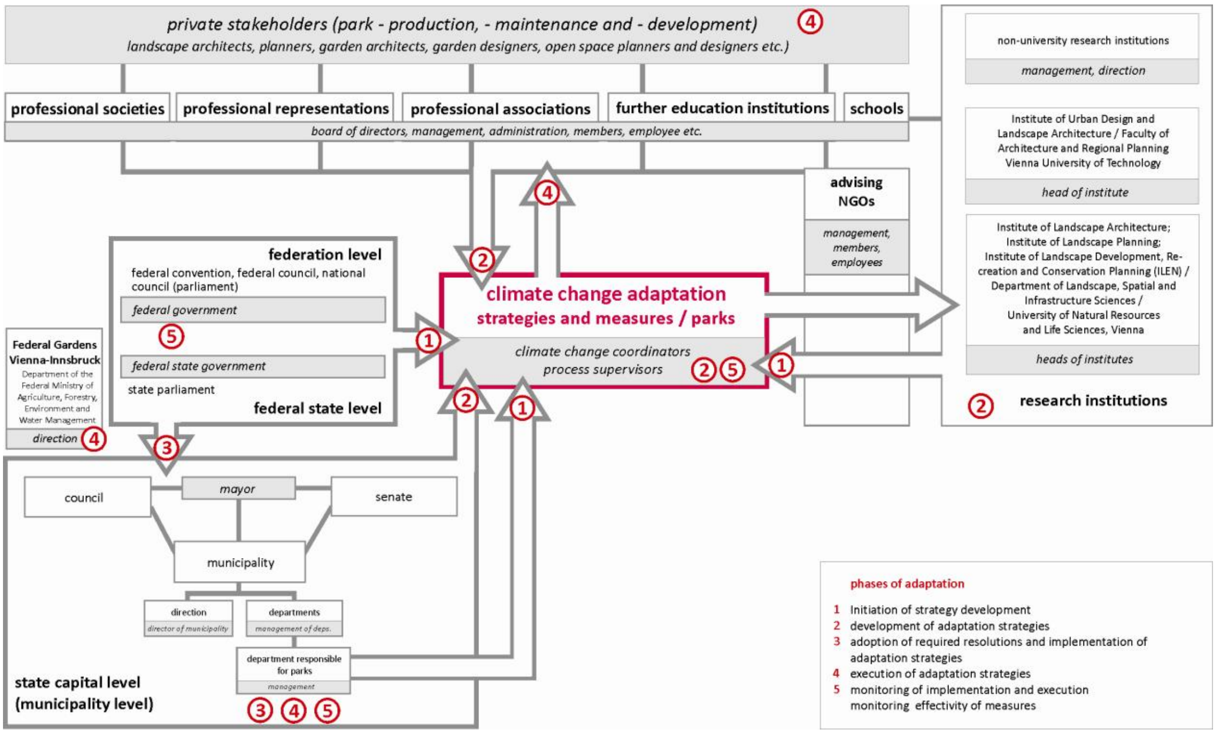


Fig. 4 : Responsible persons during the five adaptation phases

4 Startclim2010F: Hot town, summer in the city – effects of hot days on recreational and leisure behaviour and sightseeing programmes of city tourists as exemplified by the case of Vienna

The rise in temperature expected due to climate change causes an intensification of the heat island effect, especially in urban agglomeration areas, both during the day and at night. Tourism in Vienna is affected especially in the peak summer months (July, August). As a result of demographic changes, an increasing proportion of tourists are in the 60–79 age group, who are particularly heat-sensitive, and they will thus be of increasing importance for tourism in the future – especially city tourism. This study therefore aimed to identify both adaptation strategies in terms of location and activities of city tourists on hot days by means of a standardised survey, and the key elements of strategies on the part of the tourism industry, city administration and city planning in adapting to the impact of the anticipated increase in the heat island effect. For this purpose, a literature search – including internationally implemented measures – was carried out and a world café with the participation of experts from different disciplines organised. On the basis of all results, the principles of an adaptation strategy for city tourism were elaborated in the form of a Management Letter.

Results of the survey

The survey was carried out on three days – directly after a hot day[1] – in the vicinity of tourist attractions in Vienna. In total, 365 interviews were carried out with tourists from 57 different countries: Germany (33.2%), the USA (6.6%), the Netherlands (5.2%), Switzerland (4.9%) and Austria (3.8%). More than half of the interviewed tourists were on holiday in Vienna for the first time, staying in the city on average for six nights.

Despite the heat on the day before the survey two thirds of the tourists indicated that they had not adjusted their programme to the high temperatures on the previous day. Those who stayed in Vienna only for a few days adapted their sightseeing programme to a lesser extent than those who stayed longer. Strategies by respondents who changed their programme including allowing for longer breaks or deliberately visiting cooler places such as parks/recreation areas. Especially (monumental) buildings were mainly avoided.

The tourists were also asked which sights, shopping streets or restaurants they had visited on the previous hot day and whether they regarded the temperatures there as annoying. The temperatures in restaurants were considered most comfortable (70.7% comfortable/very comfortable), and more than half of the respondents were also satisfied with the temperatures at sights. The high temperatures in shopping streets/shopping centres were regarded as most annoying. In all three categories the desired measures against high temperatures most commonly stated were “air-conditioning” and “shade”. According to the authors there is need for information on alternative cooling techniques.

The respondents would also like their accommodation to have better cooling (air conditioning or fan) as the primary measure against the heat.

Finally the respondents were asked to classify different measures against high temperatures in Vienna by their importance. The tourists rated “more water dispensers/drinking fountains” as the most important measure. More shaded seats in public open spaces and more air-conditioned public transport were also classified as very important measures by about two thirds of the respondents. Slightly more than half of the interviewed tourists regarded more shaded areas around the sights, more shaded pedestrian areas/pavements and outdoor

[1] A day when the daily maximum temperature reaches at least 30°C.

dining areas cooled with spray as an important step to make their stay in Vienna more pleasant at high temperatures.

Results of the literature search and the world café

In the course of the literature search four primary categories were identified to which the individual measures were assigned.

Measures concerning tourism architecture

The overheating of buildings in summer can be reduced by passive cooling techniques such as night-time ventilation, thermal insulation, shading of facades by trees or overhanging roofs and by the reduction of heat sources within the buildings ("internal loads"). The use of light-coloured building materials (for roofs or pavements) can also contribute to the reduction of overheating. These are contrasted with "active" cooling techniques such as geothermal, remote or solar cooling (operation of refrigeration machines by thermal solar systems). Furthermore, lower temperatures can be achieved in the floors underneath through the use of roof ponds or roof spray systems. Apart from the cooling effect, green roofs and facades can also be promoted as a potential tourist sight. In implementing these measures, however, it has to be borne in mind that some of them have so far been tested only in areas with warm winters.

Measures concerning city, spatial and landscape planning

By removing impervious surfaces and greening streets and tramway tracks, and also through parks (e.g. pocket parks), city and regional planning can contribute to reducing the heat island effect. In order to diminish the heat load in the city centres by attracting fresh and cold air, there should be enough open space in the surrounding countryside as well as green areas and air corridors within the city. Moving water in the form of fountains, water sprayers or rainwater drained off using open channels contributes more to evaporative cooling than standing waters. Shaded areas (e.g. arcades in very sunny shopping streets) are regarded as further adaptation strategies. Impacts of the heat island effect should therefore be considered in zoning and building plans as well as in building regulations and generally be included in planning. The creation of an overall climate concept (see e.g. Masdar City) as basis for city planning is recommended.

Infrastructural measures

By overlaying the main tourist routes with thermal images (heat island cadastre), countermeasures can be taken directly at the hot spots in both senses of the word, i.e. heavily heat-exposed and much frequented tourist destinations. These include the creation of shaded seats (through awnings, for example) and cooling rooms and the use of water in different forms: drinking fountains (high-spring water as USP), spray in open areas (outdoor dining areas, bus/tram stops, arcades, etc.), hydrants with spray caps or motion-activated splash pads (a ground-level water fountain that is open on all sides and sprays water in all directions). The use of waterways for transport should be considered as well.

Organisational measures

Heat warning systems and an information management customised to heat stress could reduce the health risks of heat waves. Once a specified critical temperature has been reached, the city administration could take specific measures such as the opening of cooling centres (e.g. air-conditioned administration buildings), free entry into swimming pools, extended opening hours (e.g. swimming pools, churches, shopping centres, exhibitions) or water distribution. Providing maps on which cool places, drinking fountains and shortcuts (through public passages) are indicated would facilitate the sightseeing programme of tourists on hot days, as would heat-related information (e.g. excursion tips) made available at the hotel reception, via online platforms, Internet apps or texting services. Further measures are the promotion of cycling and cool means of transport in the city and the inclusion of local recreation areas in tourist programmes. The adaptation of day programmes by providing attractions (e.g. cool places, entertainment programmes) and trips to the underground would enable tourists to avoid especially the hot noon and afternoon hours. Training of tourist experts in heat-related measures (e.g. adapted ventilation, adaptation to architecture, cost-benefit calculations of adaptation strategies) is recommended.

Tab. 1: Excerpt from the Management Letter: measures recommended for implementation

Measure	Description
Measures to improve the supply of drinking water for tourists	Increasing the number of drinking fountains near sights, in shopping streets and along tourist routes (e.g. by providing drinking attachments on fire hydrants) – possibly in cooperation with shops/tourist institutions (e.g. Tichy at Vienna's Reumannplatz) in the form of sponsorship.
	Marketing of high drinking quality as unique selling proposition.
	Installation of water dispensers in buildings heavily frequented by tourists.
	The hospitality sector and shops can inform tourists about the distribution of free drinking water with the use of special pictograms and/or multilingual information.
Measures to improve the outdoor atmosphere for tourists	Tourist routes, shopping streets, areas in front of sights and waiting areas should be optimised by greening, mainly shade trees (if this measure is not possible or useful – e.g. in Baroque gardens – awnings should temporarily be used), the installation of seats in shaded areas, the creation of shortcuts (e.g. opening of passages – possibly with the public sector or tourist institutions nearby assuming liability).
	A "heat map" for tourists should be provided in print (distribution of free maps and inclusion in guidebooks) and as Internet apps for mobile phones, in which all drinking fountains, "cool routes", cool places (e.g. churches, arcades, open public buildings, cool public transport etc.) are indicated.
Measures to adapt the sightseeing programme and to pass on heat-related information to tourists	Multilingual information on alternative programmes on hot days tailored to target groups should be provided by the reception staff at the accommodation, on an online platform, in the form of Internet apps or by texting services.
	Providing attractions at the accommodation during hot hours (e.g. documentaries on the city).
	Passing on heat alerts to tourists at the accommodation (e.g. by a notice at the reception, up-to-date information folders).
	Offering a heat-adjusted sightseeing programme by city guides ("Cool tours").
	For the implementation of the measures mentioned above training of the staff at the accommodation and of city guides is necessary together with the adaptation of training and further education curriculums.
Measures to boost energy efficient cooling[2] in institutions used by tourists	Intensifying energy efficient cooling methods such as passive cooling (e.g. concrete core activation[3], insulation), solar cooling[4] and evaporative cooling (e.g. roof spray) as well as greening roofs and facades (marketable also as tourist attraction) for accommodations and buildings of tourist interest.
	Intensifying energy-efficient cooling methods for public transport (coaches, stops) through cooperation with tourism or sponsorship by companies.
	Tourists should be informed of which kind of cooling is used in the respective institution or why there is no cooling (e.g. due to heritage protection).
	Establishing an information centre ("climate coach") especially for the tourist sector, which gives advice on the implementation of energy-efficient cooling methods, funding possibilities, heritage protection, possibilities of marketing, information of tourists etc.
	Training tourist experts (staff at the accommodation, in buildings of tourist interest etc.) in heat-related behaviour such as correct ventilation and passing on this information to tourists.
	Companies in the hospitality sector that are too little adapted to heat should – e.g. by funding – be encouraged to take adequate measures (shade, spray etc.).

[2] Although the majority of the interviewed tourists wanted air conditioning, the aim of climate conservation (i.e. high energy efficiency with carbon dioxide output as low as possible) was taken into account regarding the measures.

[3] Accessible parts of concrete serve as cooling elements.

[4] Operation of refrigeration machines by thermal solar systems.

5 StartClim2010.D: Integrated precautionary and adaptation measures for the Marchfeld region

Drought is one of the major agro-meteorological risks as it can occur with high frequency, covers large areas and can cause major losses to agricultural production. A meteorological drought is commonly defined as deficits in precipitation over a defined period and region as compared to climatological average values. Furthermore, agricultural droughts result from the shortage of water for agricultural crops, leading to reduction of annual crop yields and crop production in the affected regions.

For the next decades, several regional climate models (RCMs) project a greater warming trend in summer in central and southern Europe. Furthermore, many areas in Europe will be affected by more extreme drought events with uncertainty on the extent and spatial distribution. These climatic changes will affect agricultural production in numerous ways. On the one hand, higher mean temperatures can increase the length of the potential growing season, and more ambient carbon dioxide in the atmosphere could increase the utilisation of water and trace elements of plants. On the other hand, higher temperatures will induce higher potential and actual evaporation rates, causing a higher soil moisture deficit, and most likely also increase heat stress and enhance the duration to maturity of certain species. This could potentially reduce crop yield quality and quantities. This effect is intensified if the increase in temperatures is accompanied by decreasing precipitation.

Consequently, it is also important to carry out a quantitative analysis in Austrian agricultural production of the relationship between drought events and fluctuations in crop yields and to investigate the economic and environmental effects and the negative impact of adaptation measures.

Based on a daily climate dataset with spatial resolution of one km², we have developed a drought index showing the daily proportion of dry area in Austria in the period 1975–2007 (see Fig. 5).

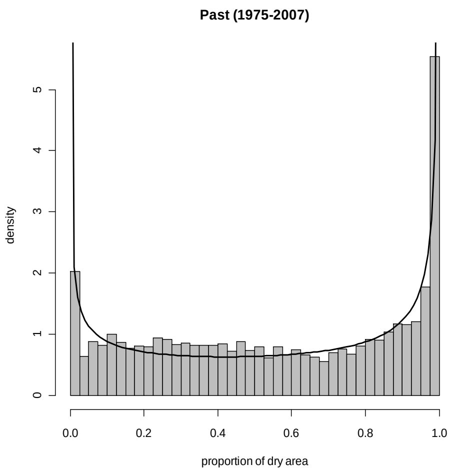


Fig. 5 : Empirical distribution of daily proportion of dry area in Austria in the period 1975-2007.

Note: 0 means that the whole Austrian area is wet; 1 means that the whole Austrian area is dry.

The empirical beta-distribution of our drought index, which is shown by the black line in Fig. 1, is taken for the period 2008–2040 and is defined as our base run scenario. For two more drought scenarios, we manipulated the beta-distribution to increase the sampled proportion of dry days in Austria. It means that frequency and intensity of drought events will increase.

We simulated the impact of increased drought events on crop yields using the EPIC biophysical process model. Figure 6 shows percentage changes in corn yields between the most extreme drought scenario and the base run scenario. Corn yields decrease between 60 and 90 per cent.

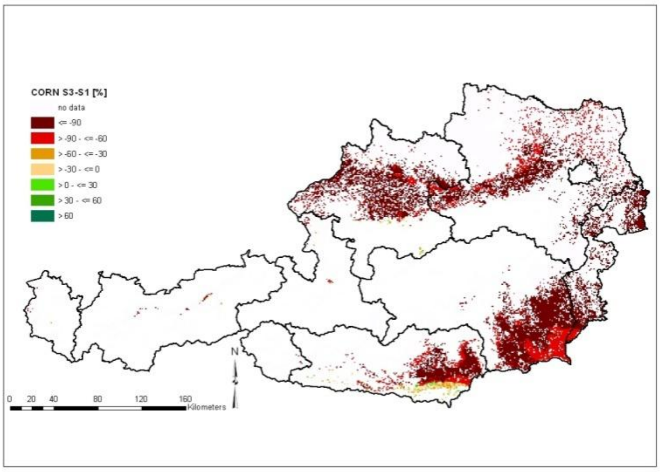


Fig. 6 : Differences in corn yields between the extreme drought scenario and the base run scenario [%]

For the Marchfeld region – one of the most important and driest crop production areas in Austria – we investigated the cost effectiveness of potential adaptation measures,[5] which could mitigate possible negative effects of climate change and especially more frequent drought events. In this study, we focused on two different kinds of adaptation measures: drip and sprinkler irrigation and adjustments to nitrogen fertilisation rates. We thus investigated how the choice of management measures could change under warmer and drier climatic conditions (e.g. decrease in mean annual precipitation sum by 20 per cent), focusing on the changes in regional producer surplus, percolation, nitrate leaching, topsoil organic carbon, and irrigation water use (Fig. 7).

Climate change can lead to substantial increases in water use for irrigation. Higher nitrate concentration levels in groundwater aquifers and decreases in regional producer surpluses also occur. All effects will be much greater if precipitation decreases by 20 per cent in 2031–2040. Crop production could potentially increase slightly through the widespread application of irrigation measures. Regulating the stream of environmental effluents such as nitrate leaching would significantly decrease nitrate concentrations in percolation but also increase both the loss in producer surplus and irrigation water use. Some of these results are shown in figure 7.

One further major result shows that sprinkler irrigation would be effective in reducing the economic costs of climate change, although it could considerably increase the pressure on the regional groundwater use in Marchfeld. Drip irrigation systems are more water-efficient but they are also more expensive, and the extent of their use would greatly depend on investment subsidies. If water prices were introduced, the probability of adopting drip irrigation would remain zero and the probability of adopting sprinkler irrigation systems would decrease.

[5] A comprehensive list of adaptation measures in agriculture can be found in the recently published study on the national adaptation strategy by the Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW).

In future studies, it will therefore be appropriate to identify and include a wider range of adaptation measures that positively affect water availability, such as conservation tillage, organic farming[6], as well as windbreak hedges or precision farming. It may also be worthwhile to allow for a combination of irrigation and fertilisation measures as well as alternative land use options (e.g. energy crops or agro-forestry systems).

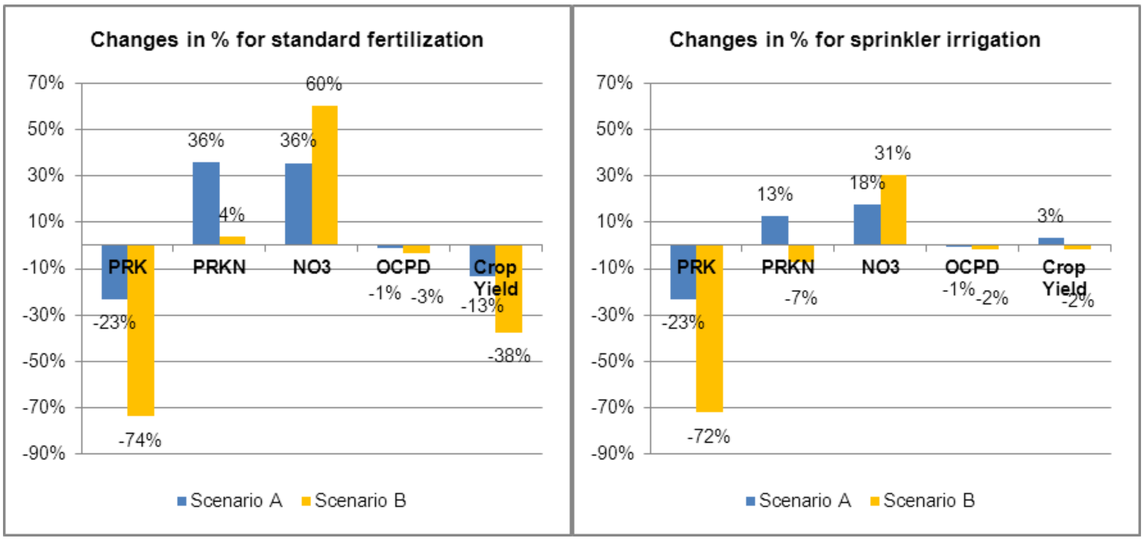


Fig. 7 : Relative changes in average annual environmental outcomes with standard fertilisation (left) and sprinkler irrigation (right) compared to the reference period 1996–2005.

Note: PRK percolation water; PRKN nitrate leaching; NO_3 nitrate concentration in percolation water; OCPD soil organic carbon content; Scenario A: temperature trend of 0.05°C per year and distribution of precipitation similar to the past; Scenario B: same temperature trend and decrease of mean total annual precipitation by 20 per cent

[6] Organic farming may lead to a bigger humus layer and therefore to a higher field water capacity.

6 StartClim2010.E: Ecological and silvicultural characteristics of European larch (*Larix decidua* MILL.) – consequences for forest management in Austria in consideration of climate change

The European larch (*Larix decidua* MILL.) is the second most prevalent conifer tree species in Austria, and covers an area of 4.6 per cent of the forest land. The core distribution area is the higher areas of the Austrian Alps. As a dominant tree species in forest stands derived from natural forest succession it can be found in subalpine stone pine and larch forest communities and in high montane to subalpine larch forest communities. As mixed or subdominant tree species, the European larch grows in various forests communities from the submontane to the subalpine altitudinal zone. Within this context, its wide physiological amplitude with respect to climatic and forest site conditions comes into play. The wide natural distribution of European larch shows that the tree species adapts to climate, soil types and geological conditions in different forest sites. Nevertheless, it is a dominant tree species only in the highest subalpine forest communities. It is more the competition from shade-tolerant tree species than its own forest site requirements that ultimately decides on the occurrence of the European larch within the forest stands. As a tree species capable of regenerating it prefers sites with rudimentary soil conditions, The establishment of larch may be hindered by dense ground vegetation layers and huge humus formations, which are the main reasons for its frequent absence in natural forest succession. The current distribution of the European larch in Austria is highly influenced by human silvicultural intervention. Clear-cutting, fire clearance and pasturing have contributed to a considerable extension of its natural area.

The Austrian network of natural forest reserves (NFR) provides the opportunity to analyse the occurrence of the larch under natural conditions across all altitudinal zones and forest areas of Austria. Vegetation surveys within the NFR have shown that larch prefers sites with northern aspects and in contrast avoids sites with southern exposure. The focal point of larch distribution within the subalpine zone was confirmed by the NFR data. Under natural conditions, larch would occur only sparsely within the submontane and montane altitudinal belt (200 – 1200 m above sea level).

Because the effects of climate change on Austrian tree species cannot be estimated with sufficient accuracy, forest owners have to make decisions with a certain degree of uncertainty. Interviews with forest experts showed the possible significance of the European larch under the influence of future climate change. Three out of four interviewees accorded a higher relevance to larch in the upcoming decades due to its higher high resistance to strong winds and an increasing desire for more diversification compared with Norway spruce. Other important aspects cited were the economic significance of the larch with high adaptability to climatic and site conditions and its qualities as a pioneer tree species. The majority of interviewees therefore believed that the European larch would gain in importance in the future as a mixed tree species, mainly at the expense of Norway spruce, which is currently threatened by strong windstorms and bark beetle infestation.

In the context of the silvicultural management, risks have to be examined more closely if this tree species is to be of greater importance in the future. Despite the fact that larch is currently regarded as a stable tree species, about 75 per cent of the interviewees saw the augmentation of pests and complex diseases as potential future threats to it. Over the last few years several types of damage have been detected. There is a wide range of pests and fungal diseases, and the larch may also be threatened by frost damage during late spring periods. If the percentage of larch in Austrian forests increases, problems in terms of forest protection will grow as well. The extent to which the larch will be affected by these threats in the future will largely depend on the management of the forest stands.

As a tree species with high tolerance to site and climatic conditions whose natural distribution has been highly extended by human activities, it is hard to assess the ecological behaviour of larch. Because of the huge differences in site conditions within the distribution area of larch

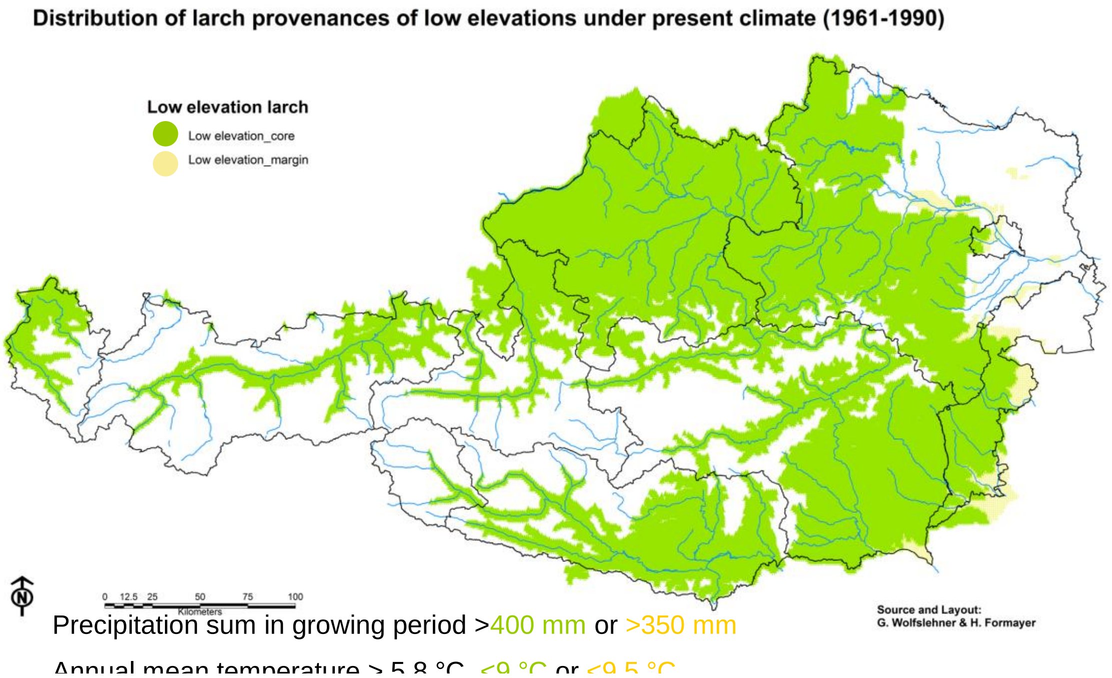


Fig. 8 : Distribution of low-elevation larch provenances under present climate

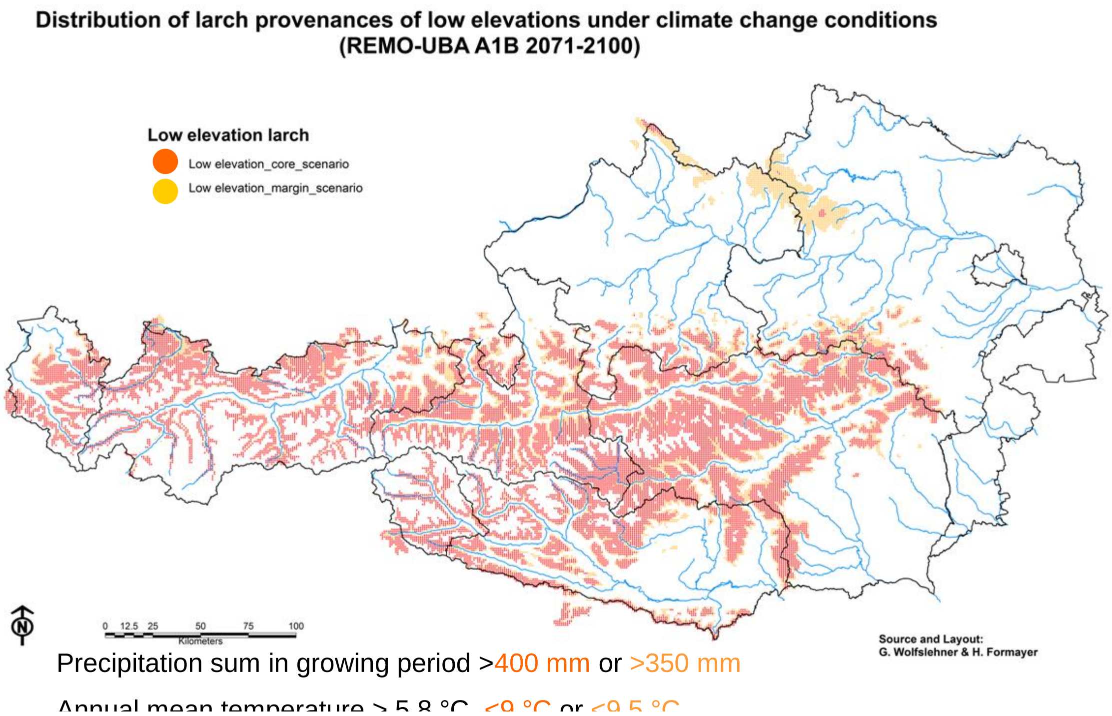


Fig. 9 : Distribution of low-elevation larch provenances under climate change conditions (2071–2100)

in the Alps, it is necessary to distinguish whether it originates from high or low elevations, especially for the task of defining climatic boundaries. Larch occurs at low elevations from the colline to the lower montane zone. It can be found almost all over Austria and is mainly artificially fostered by silvicultural activities. Only in some areas from the north-east to the south-east of the country, does it actually reach the limits of its distribution. These areas are characterised by high mean temperatures and low precipitation rates.

Under scenario conditions simulated by the REMO-UBA A1B model, the regional distribution of the larch provenances could shift from lower to higher elevated areas, mostly on account of the significantly higher temperatures anticipated for the period from 2071 to 2100. Despite the simulated higher temperatures in this period, however, many areas of Austria could also face higher annual precipitation sums. At the moment it is not possible to determine how the larch will respond to higher temperatures and higher precipitation sums. In the simulation with elevated temperatures, the risk of drought stress and possible feedback between different disturbance agents is likely to increase for areas with low precipitation sums. Hence, the larch cultivation in these areas will have to be re-evaluated. In the event of relatively higher precipitation sums of 400 mm during the vegetation period, it is also difficult to estimate how the larch will perform under the influence of significantly higher temperatures, and the degree to which the interdependencies between larch and pests and diseases will come into effect.

At higher elevations, the larch will still find climatic conditions under scenario conditions in conformity with its current distribution area. However, the conditions will frequently be similar to those of the current low-elevation larch provenance. The climatic conditions of the current high-elevation larch provenances will shift upwards, in many cases above the present timber line. If low-elevation larch provenances were planted in the montane zone under current climatic conditions, they would face a considerable threat because of the exposure to frost during late spring periods on account of their very early sprouting period. The ability of low-elevation larch provenances to adapt to the environmental conditions in the montane zone should thus be tested.

When estimating any potential future distribution regions of the European larch, it should be pointed out that the model simulations are climate scenarios with a high degree of uncertainty. The climatic boundary conditions for the distribution of larch defined in the course of this work (upper annual temperature limit 9.5°C and lower precipitation limit 350 mm during the vegetation period) also have to be discussed, especially the upper temperature limit for low-elevation larch provenances in the context of the simulated relatively high annual precipitation sums.

Generally, it can be assumed that climatic events like dry spells will occur more frequently in the future. Up to now, strong windstorms have had a major impact on Austrian forests. In the last few years they have mostly occurred during the late winter period, causing widespread damage in the forest areas. As a result of the ability of larch to repopulate cleared forest areas in a relatively short time, it could be of growing importance in mountainous forest areas. The deliberate introduction of the European larch in mixed forest stands could help to stabilise forest ecosystems endangered by strong windstorms and could speed up reforestation after disturbance events.

7 StartClim2010.C: The social costs of adaptation: approaches to an evaluation of adaptation options (SALDO)

Adaptation is set in a complex environment of sectors, stakeholders and policymakers at different policy levels. SALDO's prime objective is to develop a decision support tool to facilitate the selection of adaptation measures for different actors that is applicable across sectors as well as within a sector. The tool was developed in an Excel format to allow for a broad application by different users. The user is guided through a criteria catalogue to identify the pros/cons and constraints of a particular adaptation measure. Comparing each measure criterion by criterion allows for a cumulative evaluation of different (up to five) measures at criteria level as well as a ranking of measures. Based on other national studies in the United Kingdom, the Netherlands and Germany, SALDO takes account of both economic criteria such as benefits (avoidance of damage) and costs and non-economic criteria such as urgency, synergies/trade-offs with mitigation, no/low regret measures, flexibility potential in response to the demands that uncertainty places on adaptation, and the mainstreaming potential of measures in other policy domains. The user can choose between an ecological, economic or uncertainty-driven bias in the indicator weighting. The functioning of the tool is demonstrated using four examples of adaptation measures. The main contributions of the SALDO tool are to visualise the impact of a measure in terms of decisive key criteria and to identify synergies and trade-offs with respect to different policy goals reflected in the criteria. The tool also shows the information required for decision-making. When comparing different measures with a common adaptation target, the decisive criteria are no/low regret, flexibility and the economic evaluation, while measures from different areas show additional differences in terms of urgency, impact and importance.

Adaptation to climate change needs to be tailored towards the specific sector and region addressed by the measure. Moreover, it involves private and public actors and decision-makers at different administrative and policy levels. Different types of adaptation can be distinguished: autonomous vs. policy-induced, proactive vs. reactive, infrastructural vs. planning vs. ecosystem-improving. Because of this complexity, a coordinated approach to adaptation is needed, taking account of the relevant time scales (planning period; short/medium term vs. sustainable benefits of adaptation options; early action) and the uncertainties involved in climate variability and occurrence of extreme events.

In order to support decision-making for Austria's adaptation strategy both during planning and implementation, an assessment tool for adaptation options was developed in the project SALDO. By requiring reflection on important attributes of measures and comparison across measures, the tool supports the decision-making process rather than coming up with a concrete selection of measures. It is suggested that the relevant criteria for decision-making be selected in a stakeholder process and the results of an assessment discussed with stakeholders.

The development of the decision support tool was based on an assessment of existing methods for selecting adaptation measures. In particular, progress in precursor countries in respect to national adaptation plans was taken into consideration, such as the UK Climate Impacts Programme, the Ruiteplaner in the Netherlands, and the German Adaptation Strategy. Based on this international best practice, a primarily qualitative, Excel-based tool was developed for evaluation and comparison of adaptation options. The tool is suitable both for experts and lay people.

The assessment is based on seven criteria, both economic and non-economic (see Figure 10). Guiding principles of good adaptation and go and no-go criteria were considered as well:

- *Importance*: The measure has large potential for avoiding damages (both irreversible and reversible, monetary and non-monetary) (go criterion: irreversible damage)

- *Urgency*: damage has occurred already or is expected in the near future (leading criterion: timely action); measure has a long handling time; measure implies long development paths
- *Climate policy goals*: measure leads to (additionally) positive effects for mitigation or adaptation in other areas (leading criterion: win-win measure)
- *Environmental and social effects*: measure leads to (additionally) positive effects for the environment (leading criterion: win-win measure); measure has no negative consequences for sensitive/valuable protected commodities (go criterion); measure has positive consequences for fairness, security, wealth, health
- *Flexibility*: measure is suitable for a wide range of future climatic developments; measure can be modified and adapted to changed general conditions
- *Economic performance*: benefit to society is larger than costs under different climatic developments (leading criterion: no-regret measure)
- *Feasibility*: complexity of the measure (potential for mainstreaming where applicable), political relevance, social acceptance

The user is guided through a questionnaire, which combines the answers to the different indicators in a multi-criteria analysis. Next to a basic variant where all criteria are equally weighted the user can choose between an ecological, economic or uncertainty-driven bias of the indicators weighting. Up to five measures from either one or different adaptation areas can be compared for each criterion and – if desired – in total.

The applicability of the tool is described for four adaptation measures already implemented in Austria: a construction programme for avalanche barriers (construction and afforestation), wet wood storage after storm damage (temporary storage with sprinkling), passive flood protection by resettlement (of farm and residential buildings), and active flood protection by mobile elements (e.g. by steel and wood structures, sandbags). Figure 11 illustrates how the measures perform for the different criteria, with points more distant from the centre having a higher score.

Based on these analyses we find that measures with a common adaptation goal such as flood protection differ mainly in the criteria flexibility and economic performance, while measures with different adaptation goals also differ in their potential for avoiding damage, in their urgency and in their implications for mitigation. The criterion of environmental and social effects leads to diverse results independent of the sectoral focus.

In the future, we plan to develop the tool along the following lines:

1. It is planned to foster exchange with neighbouring countries (especially Germany) on the applicability of the tool and to work on a common solution for a prioritisation of adaptation measures. In addition to that, an English version of the tool might be useful.
2. The tool is currently targeted towards the national level (as a part of the Austrian Climate Change Adaptation Strategy), but should be extended and adjusted towards public decision-makers at the local and regional level and potentially also towards private decision-makers at the company level. This also requires intensive testing and use of the tool – both at the national level as part of the adaptation strategy and in subsequent research projects at provincial and regional level.
3. Finally, additional research is needed to elicit the different preferences of stakeholders and how these preferences can be merged to a common weighting of criteria and optional ranking of measures. This requires consensus building among stakeholders. The current weighting options of an equally weighted, ecologically biased, economically biased and uncertainty driven variant serve as a starting point in that direction.

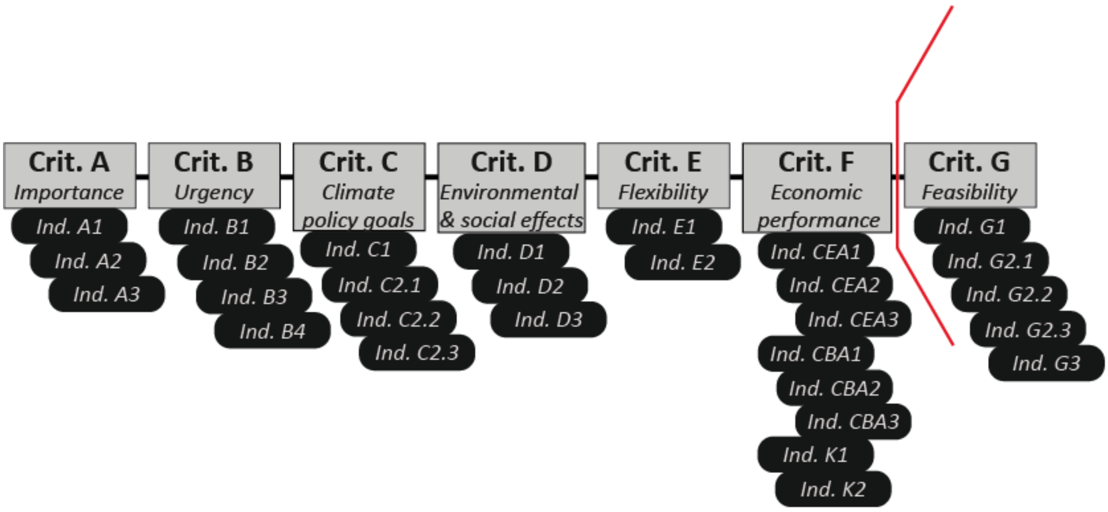


Fig. 10 : Structure of the assessment tool

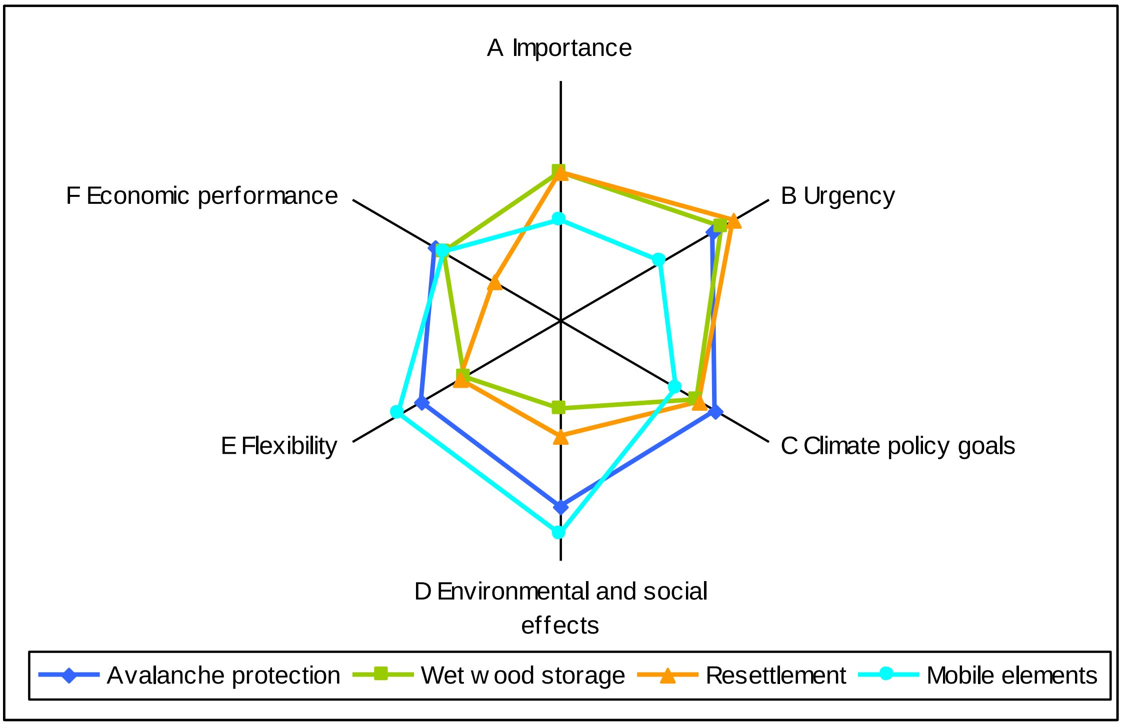


Fig. 11 : Illustrative result of the SALDO assessment tool – comparison of adaptation measures avalanche protection, wet wood storage, resettlement and mobile elements for flood protection:

Mobile elements for flood protection have the lowest environmental and social effects and the highest flexibility, but perform worse at importance and urgency. Resettlement is not a flexible measure because it cannot be easily reversed and is also relatively expensive. Such a measure can nevertheless be urgent when e.g. an overhead hang becomes unstable because of climate change.

8 StartClim2010.G: Knowledge-based platform to optimise strategies for handling natural hazards

The growing number of disasters due to climate change requires a better and closer networking of all relevant players. The integration of partners from government agencies, action organisations, research institutions, industry (e.g. operators of critical infrastructure, media, insurance industry), and the population is an essential prerequisite for efficient and proactive civil protection.

Currently, Austria has no platform for knowledge transfer in an institutionalised context of integrated disaster management. Other countries such as Germany or Switzerland have well-equipped and well-established platforms. Especially in view of increasing climate change-induced hazards such a platform is also needed in Austria to discuss new challenges to modern disaster management at the strategic level, such as the management of heat waves.

The main tasks of such platforms are the networking of all players, the collection of information from publications and reports and the dissemination of these resources via a literature database that is accessible to all interested people and at suitable events. Figure 1 shows the function of such a platform. On the one hand, knowledge will be supplied by researchers in the form of publications or reports integrated into a database and then made available to public agencies (e.g. action organisations) for their work. On the other hand, public agencies need to formulate requirements and provide data that can be passed on to researchers and used by them. Thus, the main players are involved in an ongoing dialogue which is the basis for a good network. In addition to the involved stakeholders, society can access the platform and its database for information purposes.

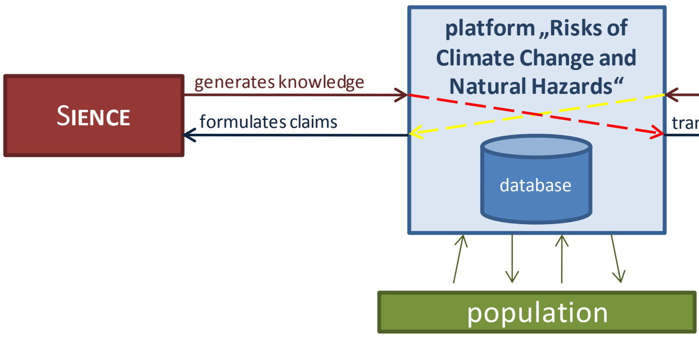


Fig. 12 : Function of a platform for natural hazards

Two main constellations for a Risks of Climate Change and Natural Hazards platform in Austria were identified by the Institute of Production and Logistics at the University of Natural Resources and Life Sciences, Vienna. The first constellation ties the platform to a federal authority and thus sets it in a larger context. A second possibility is to establish a contact point whom the interested parties can contact, located for example at the Institute of Production and Logistics or another institute at the University of Natural Resources and Life Sciences and set in a smaller context. In both cases, major tasks are keeping up to date a specially developed database for literature, projects and initiatives within a convenient knowledge management system and organising special events for the dissemination of acquired knowledge.

A study of the existing Austrian literature on climate change and natural disasters showed that there research already exists in this field. Literature on this topic can also be found outside Austria, but the results of this research cannot be transferred directly to Austria. There is still need for research on this topic, since some natural hazards seem to be underrepresented despite their relevance to climate or have not yet been sufficiently studied with regard to climate change.

An anonymous online survey of 72 relevant players from all five pillars of disaster management (government agencies – 12, individuals – 6, action organisations – 30, business – 9 and research community – 15) shows that research is needed according to the respondents, most urgently for floods and hailstorms (see figure 13), followed by landslides and strong winds. In all cases around 65 per cent of all respondents felt that there is a “very large” or “relatively large” demand for research.

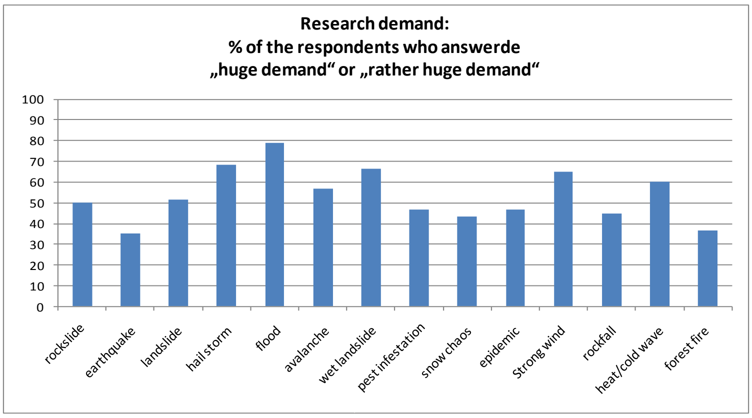


Fig. 13 : Results of question about the need for research

Research is very strongly integrated in the respondents’ work (Fig. 14): 57 per cent said that research was used “a lot” or “quite a lot” at work. This shows that the willingness by the relevant players to use research certainly exists and should be encouraged.

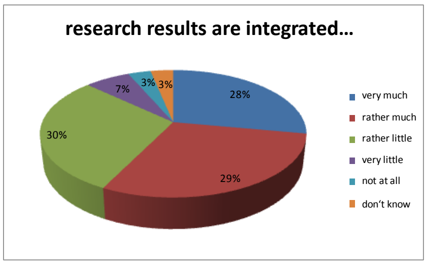


Fig. 14 : Results for the question about the influx of research in everyday work

The interviewed players described most of the natural hazards as increasing “rapidly” or “quite rapidly”. Climate change and problems in building (wrong building, increased development for building purposes) are highlighted as reasons for this.

If the trend towards natural hazards is increasing in general, this also means that disasters will probably also increase. Those responsible for disaster management will be asked to find solutions and will therefore have to adapt to new circumstances. Moreover, in some areas, there is still need of further research, especially with regard to the impact of climate change on the extent of damage and the incidence of disasters. Furthermore, it should be clear how involved players can help to minimise the extent of damage and protect the population against imminent harm as effectively as possible. Last but not least, a broad networking and a periodical exchange between the players is an essential measure for this purpose.

There are recommendations for the Austrian climate change adaptation strategy in the area of disaster management that also refer to this. They include the creation of a national action programme for integrated disaster management, the creation and establishment of a “Risks of Climate Change and Natural Hazards Platform” in Austria and the expansion of the

Austrian education and training provision for disaster management. Figure 15 summarises the nine recommendations, based on the claims of National Crisis and Disaster Protection Management (SKKM) and the experience of actions implemented and planned in other countries (notably in Germany and Switzerland).

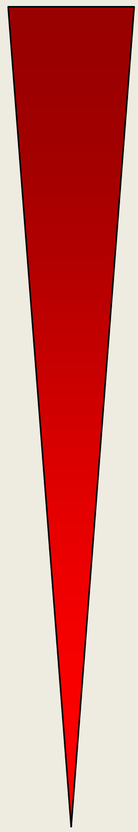
PACKAGE OF ACTION	PRIORITY
1. Continuous review, adaption and implementation of the strategy 2020 of SKKM taking into account the effects of climate change. Political commitment of all stakeholders to SKKM Strategy 2020	
2. Establishment of a national multi-sectoral communication platform for risk reduction - transfer of knowledge through partnership	
3. Receipt of appropriate frameworks for volunteer work in the field of disaster management	
4. Flexibility of financing and funding instruments in the field of disaster management	
5. Improve risk communication in the field of disaster preparedness, coordination of risk communication on results of risk analysis, pooling all activities in this area	
6. Development of training supply in the field of disaster management	
7. Realization of risk analysis at the country level as a basis for planning activities in the area of integrated disaster management	
8. Development of participatory methods for integrating all players in the field of disaster management	
9. Concentration of research activities related to disaster management	

Fig. 15 : Recommendations for the Austrian climate change adaptation strategy – disaster management

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StartClim2010.A

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Annex

All following reports can be found on the StartClim2010-CD-ROM and on the StartClim website (www.austoclim.at/startclim/)

Subprojects of StartClim2003

StartClim.1: Quality control and statistical characteristics of selected climate parameters on the basis of daily values in the face of extreme value analysis
Central Institute of Meteorology and Geodynamics
Wolfgang Schöner, Ingeborg Auer, Reinhard Böhm, Sabina Thaler

StartClim.2: Analysis of the representativeness of a data collected over a span of fifty years for the description of the variability of climatic extremes
Central Institute of Meteorology and Geodynamics
Ingeborg Auer, Reinhard Böhm, Eva Korus, Wolfgang Schöner

StartClim.3a: Extreme events: documentation of hazardous events in Austria such as rock avalanches, floods, debris flows, landslides, and avalanches
Institute of Forest and Mountain-Risk Engineering, BOKU
Dieter Rickenmann, Egon Ganahl

StartClim.3b: Documentation of the impact of extreme weather events on agricultural production ARC Seibersdorf research: Gerhard Soja, Anna-Maria Soja

StartClim.3c: Meteorological extreme event data information system for the eastern Alpine region - MEDEA
Federal Environment Agency, Martin König, Herbert Schentz, Johann Weigl
IIASA, Mathias Jonas, Tatiana Ermolieva

StartClim.4: Development of a method to predict the occurrence of extreme events from large-scale meteorological fields
Institute of Meteorology and Physics, BOKU Andreas Frank, Petra Seibert

StartClim.5: Testing statistical downscaling techniques for their applicability to extreme events in Austria
Institute of Meteorology and Physics, BOKU -
Herbert Formayer, Christoph Matulla, Patrick Haas
GKSS Forschungszentrum Geesthacht, Nikolaus Groll

StartClim.6: Adaptation strategies for economic sectors affected heavily by extreme weather events: economic evaluation and policy options
Austrian Humans Dimensions Programme (HDP-A)
Department of Economics, Karl-Franzens-Universität Graz
Karl Steininger, Christian Steinreiber, Constanze Binder, Erik Schaffer
Eva Tusini, Evelyne Wiesinger

StartClim.7: Changes in the social metabolism due to the 2002-flooding in Austria: case study of an affected community
Institute of Interdisciplinary Studies of Austrian Universities (IFF)
Willi Haas, Clemens Grünbühel, Brigitt Bodingbauer

StartClim.8: Risk-management and public prosperity in the face of extreme weather events: What is the optimal mix of private insurance, public risk pooling and alternative transfer mechanisms
Department of Economics, Karl-Franzens-Universität Graz
Walter Hyll, Nadja Vetters, Franz Prettenthaler

StartClim.9: Summer 2002 floods in Austria: damage account data pool
Centre of Natural Hazards and Risk Management (ZENAR),
BOKU - University of Natural Resources and Applied Life Sciences
Helmut Habersack, Helmut Fuchs

StartClim.10: Economic aspects of the 2002 floodings: data analysis, asset accounts and macroeconomic effects
Austrian Institute of Economic Research (WIFO)
Daniela Kletzan, Angela Köppl, Kurt Kratena

StartClim.11: Communication at the interface science - education
Institute of Meteorology and Physics,
BOKU - University of Natural Resources and Applied Life Sciences
Ingeborg Schwarzl
Institute of Interdisciplinary Studies of Austrian Universities (IFF)
Willi Haas

StartClim.12: Developing an innovative approach for the analysis of the August 2002 flood event in comparison with similar extreme events in recent years
Department of Meteorology and Geophysics, University of Vienna
Simon Tschannett, Barbara Chimani, Reinhold Steinacker

StartClim.13: High-resolution precipitation analysis
Department of Meteorology and Geophysics, University of Vienna
Stefan Schneider, Bodo Ahrens, Reinhold Steinacker, Alexander Beck

StartClim.14: Performance of meteorological forecast models during the August 2002 floods Central Institute of Meteorology and Geodynamics
Thomas Haiden, Alexander Kann

StartClim.C: Design of a long term climate/climate-impact research programme for Austria Institute of Meteorology and Physics, BOKU:
Helga Kromp-Kolb, Andreas Türk

StartClim. Reference database:
Implementation of a comprehensive literature database on climate and climate impact research as a generally accessible basis for future climate research activities
Institute of Meteorology and Physics,
University of Natural Resources and Applied Life Sciences
Patrick Haas

Subprojects of StartClim2004

StartClim2004.A: Analysis of heat and drought periods in Austria: extension of the daily StartClim data record by the element vapour pressure
Central Institute of Meteorology and Geodynamics
Ingeborg Auer, Eva Korus, Reinhard Böhm, Wolfgang Schöner

StartClim2004.B: Investigation of regional climate change scenarios with respect to heat waves and dry spells in Austria
Institute of Meteorology, BOKU: Herbert Formayer, Petra Seibert, Andreas Frank, Christoph Matulla, Patrick Haas

StartClim2004.C: Analysis of the impact of the drought in 2003 on agriculture in Austria – comparison of different methods
ARC Seibersdorf research: Gerhard Soja, Anna-Maria Soja
Institute of Meteorology, BOKU: Josef Eitzinger, Grzegorz Gruszczynski, Mirek Trnka, Gerhard Kubu, Herbert Formayer
Institute of Surveying, Remote Sensing and Land Information, BOKU
Werner Schneider, Franz Suppan, Tatjana Koukal

StartClim2004.F: Continuation and further development of the MEDEA event data base
Federal Environment Agency: Martin König, Herbert Schentz, Katharina Schleidt
IIASA: Matthias Jonas, Tatiana Ermolieva

StartClim2004.G: "Is there a relation between heat and productivity?" A project at the interface between science and education
Institute of Meteorology, BOKU
Ingeborg Schwarzl, Elisabeth Lang, Erich Mursch-Radlgruber

Subprojects of StartClim2005

StartClim2005.A1a: Impacts of temperature on mortality and morbidity in Vienna
Medical University of Vienna, Centre for Public Health, Institute of Environmental Hygiene
Hanns Moshammer, Hans-Peter Hutter
Institute of Meteorology, BOKU
Andreas Frank, Thomas Gerersdorfer
Austrian Federal Institute of Health Care
Anton Hlava, Günter Sprinzl
Statistics Austria, Barbara Leitner

StartClim2005.A1b: Nocturnal cooling under a changing climate
Institute of Meteorology, BOKU
Thomas Gerersdorfer, Andreas Frank, Herbert Formayer, Patrick Haas
Medical University of Vienna, Centre for Public Health, Institute of Environmental Hygiene
Hanns Moshammer
Statistics Austria, Barbara Leitner

StartClim2005.A4: Impacts of meteorological extreme events on safety of drinking water supply in Austria
Institute of Sanitary Engineering and Water Pollution Control, BOKU
Reinhard Perfler, Mario Unterwainig
Institute of Meteorology, BOKU
Herbert Formayer

StartClim2005.C2: Studies on the distribution of tularaemia under the aspect of climate change
Gesellschaft für Wildtier und Lebensraum – Greßmann & Deutz OEG
Armin Deutz
HBLFA Raumberg Gumpenstein, Agricultural Research and Education Centre
Thomas Guggenberger

StartClim2005.C3a: Impacts of climate change on agricultural pests and antagonists in organic farming in Eastern Austria
Bio Forschung Austria
Bernhard Kromp, Eva Maria Grünbacher, Patrick Hann
Institute of Meteorology, BOKU
Herbert Formayer,

StartClim2005.C3b: Risk analysis of the establishment of the western flower thrips (*Frankliniella occidentalis*) under outdoor conditions in Austria as a result of the climate change
The Austrian Agency für Health and Food Safety, AGES
Andreas Kahrer
Institute of Meteorology, BOKU
Herbert Formayer,

StartClim2005.C5: An allergenic neophyte and its potential spread in Austria – range dynamics of ragweed (*Ambrosia artemisiifolia*) under influence of climate change
VINCA, Vienna Institute for Nature Conservation & Analysis
Ingrid Kleinbauer, Stefan Dullinger
Federal Environment Agency
Franz Essl, Johannes Peterseil

StartClim2005.F: GIS-sustained simulation of diminishing habitats of snow grouse, black grouse, chamois and capricorn under conditions of global warming and heightening forest limits
Joanneum Research
Heinz Gallaun, Jakob Schaumberger, Mathias Schardt
HBLFA Raumberg-Gumpenstein
Thomas Guggenberger, Andreas Schaumberger, Johann Gasteiner
Gesellschaft für Wildtier und Lebensraum - Greßmann & Deutz OEG
Armin Deutz, Gunter Greßmann

Subprojects of StartClim2006

StartClim2006.A: Particulate matter and climate change – are there connections between them in north-eastern Austria?
Institute of Meteorology, BOKU: Bernd C. Krüger, Irene Schicker, Herbert Formayer
Medical University of Vienna, Centre for Public Health, Institute of Environmental Hygiene: Hanns Moshammer

StartClim2006.B: Risk Profile for the autochthonous occurrence of Leishmania infections in Austria
Medical University of Vienna: Horst Aspöck, Julia Walchnik
Institute of Meteorology, BOKU: Thomas Gerersdorfer, Herbert Formayer

StartClim2006.C: Effects of climate change on the dispersion of white grub damages in the Austrian grassland
Bio Forschung Austria
Eva Maria Grünbacher, Patrick Hann, Claus Trska, Bernhard Kromp
Institute of Meteorology, BOKU: Herbert Formayer

StartClim2006.D1: Sensitivity of Austrian summer tourism to climate change
Institut für touristische Raumplanung: Volker Fleischhacker
Institute of Meteorology, BOKU: Herbert Formayer

StartClim2006.D2: Effects of climate change on the climatic potential of tourism
Institute of Meteorology, University of Freiburg
Andreas Matzarakis, Christina Endler, Robert Neumcke
Central Institute of Meteorology and Geodynamics
Elisabeth Koch, Ernest Rudel

StartClim2006.D3: See-Vision: influence of climate change-induced fluctuation of water level in Lake Neusiedl on the perception and behaviour of visitors and locals
Institute of Landscape Development, Recreation and Conservation Planning, BOKU
Ulrike Pröbstl, Alexandra Jiricka, Thomas Schauppenlehner
Simon Fraser University, Burnaby, Canada
Wolfgang Haider

StartClim2006.F: Climate change impacts on energy use for space heating and cooling in Austria
Institute of Technology and Regional Policy, Joanneum Research (1);
Wegener Center for Climate and Global Change, University of Graz (2);
Institute for Geophysics, Astrophysics and Meteorology, University of Graz (3);
Institute for Meteorology and Geophysics, University of Vienna (4);
Institute of Energy Research, Joanneum Research (5)
Franz Prettenthaler[1,2], Andreas Gobiet[2,3],
Clemens Habsburg-Lothringen[1], Reinhold Steinacker[4],
Christoph Töglhofer[2], Andreas Türk [2,5]

Subprojects of StartClim2007

StartClim2007.A: Enlargement and completion of the StartClim dataset for the element daily snow depth. Update of the already existing StartClim datasets (air temperature, precipitation and vapour pressure) until April 2007
Central Institute of Meteorology and Geodynamics: Ingeborg Auer, Anita Jurković, Reinhard Böhm, Wolfgang Schöner, Wolfgang Lipa

StartClim2007.B: Health risks for the Austrian population due to the depletion of stratospheric ozone
Institute of Meteorology, University of Natural Resources and Applied Life Sciences, Vienna: Stana Simic
Institute of Medical Physics and Biostatistics, University of Veterinary Medicine Vienna: Alois W. Schmalwieser
Medical University of Vienna, Centre for Public Health, Institute of Environmental Hygiene: Hanns Moshammer

StartClim2007.C: Adaptations of insect pests to climate change in crop production of eastern Austria: conception of a long-term monitoring system
Bio Forschung Austria: Eva-Maria Grünbacher, Patrick Hann, Bernhard Kromp
Institute of Meteorology, University of Natural Resources and Applied Life Sciences, Vienna: Herbert Formayer

StartClim2007.D: Consequence of the climate-induced upwards shift of the timberline on the release of greenhouse gases - dynamics of soil organic matter
Federal Forest Office: Robert Jandl, Andreas Schindlbacher, Sophie Zechmeister-Boltenstern, Michael Pfeffer
Department of Forest and Soil Sciences, University of Natural Resources and Applied Life Sciences, Vienna:
Klaus Katzensteiner
Federal Environment Agency: Sabine Göttlicher
University of Vienna: Hannah Katzensteiner
Tiroler Landesforstdirektion: Dieter Stöhr

StartClim2007.E: Global change and its effect on runoff behaviour of glacierised basins with regard to reservoir power stations
Institute of Meteorology and Geophysics, University Innsbruck:
Michael Kuhn, Marc Olefs, Andrea Fischer

StartClim2007.F: ALSO WIKI – Alpine summer tourism in Austria and the potential effects of climate change
Austrian Institute for Regional Studies and Spatial Planning: Cornelia Krajasits, Gregori Stanzer, Adolf Anderl, Wolfgang Neugebauer, Iris Wach
Central Institute of Meteorology and Geodynamics
Christine Kroisleitner, Wolfgang Schöner

StartClim2007.G: Integrated modelling of the economy under climate change in application of the STERN report (STERN.AT)
Wegener Centre for Climate and Global Change, University of Graz: Olivia Koland, Karl Steininger, Andreas Gobiet, Georg Heinrich, Claudia Kettner, Alexandra Pack, Matthias Themeßl, Christoph Töglhofer, Andreas Türk, Thomas Trink
Joanneum Research, Institut für Technologie- und Regionalpolitik: Raimund Kurzmann
University of Natural Resources and Applied Life Sciences, Vienna: Erwin Schmid

Subprojects of StartClim2008

StartClim2008.A: Impacts of adaptation measures on the acute mortality risk due to extreme temperature in Vienna
Institute of Environmental Hygiene, Centre for Public Health, MUW: Hanns Moshammer, Hans-Peter Hutter
Institute of Meteorology, BOKU: Thomas Gerersdorfer

StartClim2008.B: Which adaptations of soil erosion protection measures can be recommended for expected climate change impacts?
Institute of Hydraulics and Rural Water Management, BOKU: Andreas Klik
Institute of Meteorology, BOKU: Josef Eitzinger
Institute of Agronomy and Plant Breeding, BOKU: Peter Liebhard

StartClim2008.C: Practical testing of the monitoring concept "Adaptations of insect pests to climate change in crop production of eastern Austria" by investigating the distribution of current cutworm (*Agrotis segetum, Schiff.; Fam. Noctuidae*) damage as a function of site-related and climatic factors
Bio Forschung Austria: Patrick Hann, Claus Trska, Eva Maria Frauenschuh, Bernhard Kromp

StartClim2008.D: Organic agriculture in the mountains of Tyrol—contributions to mitigating climate change and adaptation strategies
Division of Organic Farming, BOKU: Michael Dorninger, Bernhard Freyer

StartClim2008.E: Development and economic valuation of landscape structures to decrease evapotranspiration on agricultural acres with account taken of climate change and biomass production
Institute of Landscape Development, Recreation and Conservation Planning, BOKU: Christiane Brandenburg, Bernhard Ferner, Sonja Völler, Brigitte Allex
Institute of Meteorology, BOKU: Josef Eitzinger, Thomas Gerersdorfer
Division of Organic Farming, BOKU: Bernhard Freyer, Andreas Surböck, Agnes Schweinzer, Markus Heinzinger
Institute of Agricultural and Forestry Economics, BOKU: Enno Bahrs

StartClim2008.F: Perception and evaluation of natural hazards as a consequence of glacier retreat and permafrost degradation in tourism destinations—a case study in the Tux Valley (Zillertaler Alps, Austria)
Institute of Landscape Development, Recreation and Conservation Planning, BOKU: Ulrike Pröbstl
University of Regensburg, University Eichstätt-Ingolstadt: Bodo Damm

StartClim2008.G: Adaptation of forest soils to a changing climate
Federal Research and Training Centre for Forests, Natural Hazards and Landscape: Barbara Kitzler, Verena Stingl, Sophie Zechmeister-Boltenstern
Institute of Meteorology and Climate-Research – Atmospheric Environmental Research, Garmisch: Arjan De Brujin, Ralf Kiese, Klaus Butterbach-Bahl

Subprojects of StartClim2009

StartClim2009.A: Vegetation change according to different climate and management conditions in Austrian mountain grassland – a case study on Styrian mountain grasslands
Institute of Botany, BOKU: Gabriele Bassler, Gerhard Karrer,
Institute of Meteorology, BOKU: Herbert Formayer
LFZ-Raumberg-Gumpenstein: Andreas Schaumberger, Andreas Bohner, Walter Starz
Bio Ernte Steiermark: Wolfgang Angeringer

StartClim2009.B: Climate-growth response of Norway spruce provenances in the Alpine region – an opportunity for adaption of the Austrian forestry
Federal Research and Training Centre for Forests, Natural Hazards and Landscape: Silvio Schüler, Stefan Kapeller,
Central Institute of Meteorology and Geodynamics: Johann Hiebl

StartClim2009.C: Analysis of vulnerability and adaptation to climate change in the Wienerwald biosphere reserve
Institute of Silviculture, BOKU: Stefan Schörghuber, Werner Rammer, Rupert Seidl, Manfred J. Lexer

StartClim2009.D: Humus assays as a practical tool for farmers to support carbon sequestration in agriculture
Bio Forschung Austria: Wilfried Hartl, Eva Erhart

StartClim2009.E: Adapting office buildings to climate change: optimisation of thermal comfort
Danube University Krems: Tania Berger, Peter Pundy

StartClim2009.F: AlpinRiskGP - estimation of present and future risk potential for Alpine tourists and infrastructure caused by glacier retreat and permafrost changes in the Grossglockner-Pasterze glacier area (Hohe Tauern, Austria)
Geography and Regional Science, Karl-Franzens-University Graz: Gerhard Karl Lieb, Katharina Kern, Gernot Seier,
Andreas Kellerer-Pirklbauer-Eulenstein, Ulrich Strasser,