# CLIMATE CHANGE AND HUNGARY: MITIGATING THE HAZARD AND PREPARING FOR THE IMPACTS

(THE "VAHAVA" REPORT)

Budapest
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The VAHAVA Report is the outcome of the VAHAVA Project,
which was implemented in the period of 2003-2006 with some follow-up activities
during 2007-2008. The basic objective of the Project was the synthetisation
of the scientific results on the climate change hazard, assessment of its impacts in our region,
and the science-based national mitigation and adaptation response policy options.

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# FOREWORD

Climatic variability and the occurrence of various extreme meteorological and hydrometeorological events had always their significant imprints on socio-economic activities and the natural systems in the Carpathian basin. According to observations, the number and intensity of these extreme events have increased for the recent decades. Such a tendency could be detected especially for droughts, floods, heavy rainfalls and heat waves. Concerning the longer-term tendencies, there is a clear increasing trend in the annual average surface temperatures detectable from the beginning of the systematic observations in the region. These tendencies well coincide with the regional characteristics derived from the climate change scenarios, which are developed by means of various global and regional climate models.

The research community called attention long ago to the hazard of global climate change, its man-made factors and its potential adverse implications. Based on the scientific results, high-level decisions-makers agreed on initial measures in order to cope with this hazard and adopted a framework convention on climate change in 1992 with the subsequent Kyoto Protocol in 1997. The latter one included concrete emission control commitments for the developed countries. After acceding to the European Union, Hungary fulfils the relevant national mitigation policies by taking into account the specific Community instruments, such as the EU's emission trading scheme (by specifying emission quotas for various installations), provisions regulating the use of renewable energy sources etc. Mitigation measures should be set and implemented for quite many economic sectors, for instance, for energy management (both production and consumption), transport, industry, agriculture, forestry (in terms of its carbon sequestration capacity).

Besides mitigation approach, it is already unavoidable to make preparations for adaptation to the anticipated changing environmental conditions. It is essential also for many sectors, which are especially vulnerable to the impacts of the above-mentioned extreme events; these include for example water management, agriculture, forestry, health. Obviously, these measures can be implemented efficiently only if their interrelations are taken into consideration and there are also proper mechanisms for coordination.

In June 2003 the Hungarian Ministry for the Environment and Water Management and the Hungarian Academy of Sciences have launched a joint research project under the title of "Global climate change, Hungarian impacts and responses". The name "VAHAVA" of this project is an abbreviation of the Hungarian first letters of the key words "Changes-Impacts-Responses" (VÁltozás-HAtás-VÁlaszadás). The primary purpose of this endeavour was to consolidate the scientific basis for policy-making in context of the climate change hazard. The project mobilized the experts representing all key scientific disciplines. Apparently, the project considerably contributed to raising the public awareness on this critical issue and it also resulted in elaboration of a national climate change strategy. This publication presents the basic thematic areas and it also summarizes the main findings of the project.

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# 1. INTERNATIONAL CLIMATE POLICY COOPERATION AND HUNGARY

Scientists had long ago called attention to the possibility of the global climate change, caused by human activities, but nearly a century had to be elapsed until politicians and decision makers also started to deal seriously with this issue. From the early 1970s some high ranking politicians recognized the significance of this hazard and took more seriously the increasing amount of information from the scientific circles on the changes of quantities of greenhouse gases in the atmosphere, the long-term trends of global climate characteristics and the scenarios derived from the simple early numerical models. At the UN Conference on Human Environment held in Stockholm in 1972 and in the documents adopted by the participants, the risk of the changing climate as caused at least partially by anthropogenic activities was mentioned already in very general terms. The need to cooperate at international level on emerging large-scale environmental problems – that time primarily focusing on the acidification - has been reinforced in the Final Act of the Helsinki Conference in 1975.

Complex field experiences and dynamic climatological modelling studies were carried out in the second half of the 1970s in the framework of the interdisciplinary and intergovernmental Global Atmospheric Research Programme (GARP) that was jointly coordinated by the WMO and the ICSU. This programme lasted 15 years and contributed also to strengthening of the cooperation of those scientific centres, which were dealing with various aspects of the climate system. The World Climate Conference (WCC), held in Geneva in 1979, was the first global gathering of scientists devoted expressively to the state and changes of the global climate. The conference reviewed the results gained that far and identified the areas of future research activities and collaboration. It adopted a declaration with a call "to foresee and to prevent potential man-made changes in climate that might be adverse to the well-being of humanity". Hungarian scientists actively contributed to both the cooperative work of the GARP and to activities of this conference *(Czelnai, 2006)*[1].

The real breakthrough in the relation between climate change science and climate change policy, i.e. the researchers and the policy-makers happened in the 1980s and this resulted in commencement of international cooperation on elaboration and implementation of the response policies. The World Climate Programme (WCP) was launched and several international conferences were held on various aspects of the changing climate. The UN General Assembly in 1987 adopted a resolution on the report of the Brundtland Commission (World Commission on Environment and Development), which *inter alia* emphasized the danger of the anthropogenic change of climate. Upon the initiation of the WMO and the UNEP, the Intergovernmental Panel on Climate Change (IPCC) was established in 1988.

The Brundtland Report proved to be of great significance of this era also having a large influence in forming the international environmental policy cooperation[2]. The UN General

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1 Czelnai R., 2006: Commemoration on the first World Climate Conference convened by the WMO (in Hungarian); Megemlékezés a Meteorológiai Világszervezet (első) Éghajlati Világkonferenciájáról. Légkör, 51. évf., spec. issue

2 Láng I., 2002: History of the environmental protection to save the Earth (in Hungarian); A Föld védelmében; a környezetvédelem történetéből, 1962-92. História, 05-06

Assembly decided to convene in 1992 the UN Conference on Environment and Development (UNCED), and also passed a decision on the elaboration of an international agreement on the protection of Earth's climate. Both the Second World Climate Conference of 1990 and the first assessment report of the IPCC issued in the same year considerably motivated the preparatory negotiations of that agreement.

Hungary contributed to and participated also in these events. A special national report was presented to the Second World Climate Conference[3], and the President of the Republic of Hungary delivered an important statement regarding the need for international cooperation in combating the climate change[4]. Studies were published in Hungary in relation to carbon dioxide emissions to the atmosphere[5]. A Climate Subcommittee of the Meteorological Scientific Committee of the Hungarian Academy of Science was established and prepared in 1991 the statement of the Academy on climate change and the necessary actions[6]. In Hungary, preparatory activities started also under the auspices of the ministries of the environment and foreign affairs on the participation in the UN Conference on Environment and Development *(UNCED, 1992).* As part of this process, comprehensive analyses were completed and published on the risk, causes and potential impacts of climate change, and on the options of the various response measures[7].

## International agreements and national tasks

International negotiations on various components of the future climate change convention were conducted in the period of 1991-1992, under the auspices of the United Nations. Parallel to that, regular intergovernmental meetings were held to develop a legal instrument on the conservation of the Earth's biological diversity. Concerning the formulation of the Hungarian position for the climate negotiations, the Climate Change Sub-Committee of the Hungarian National UNCED Preparatory Committee was established. The Committee was composed of representatives of all interested national organizations (ministries, National Academy of Sciences, civil organizations) and was engaged in the general coordination of the national preparations for the Rio Summit (UNCED).

According to the international schedule, the two independent negotiating processes were to be finalized by the time of the Summit in order to open for signature both multilateral environmental agreements. The minister of environment appointed a chief negotiator for the climate negotiations (the author of this chapter). Already in this period, there was a close cooperation of the ministries and professionals of environmental protection, energy

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3 Antal E., Starosolszky Ö., 1990: Role of the climate and climate change in the life of Hungary: Contribution of Hungary to the Second World Climate Conference. Hungarian Ministry for Environment and Regional Policy, Budapest

4 Göncz Á., 1990: Statement of the President of the Republic of Hungary to the Second World Climate Conference

5 Lévai A., Mészáros E., 1989: Energy production and carbon dioxide emission in Eastern Europe with special reference to Hungary. Időjárás, pp.196-204

6 HAS, 1991: Statement by the Meteorological Scientific Committee of the Hungarian Academy of Sciences on the future of our climate. Hungarian Academy of Sciences, Budapest

7 Faragó T., Iványi Zs., Szalai S. (eds.), 1990-1991: Climate variability and change vol. I, vol. II. Ministry for Environment and Regional Policy, Hungarian Meteorological Service, Budapest (authors: T. Faragó, E. Führer, L. Garbai, Zs. Iványi, Z. Járó, T. Jászay, L. Márkus, J. Mika, Å. Molnár, B. Nováky, T. Práger, S. Szalai, G. Szász, T. Szentimrey, F. Tóth)

management and forest management and it made possible to take into account of the critical relationship between these sectors in terms of control of the greenhouse gas emissions.

The Government decided on the most essential elements of the national standpoint in the closing phase of these negotiations[8]. The regular consultations with the representatives of the European Community and the Central European countries with “economies in transition” had a significant influence on the forming and presentation of the Hungarian position. (The association agreement between the EC and Hungary was in force since 1 January 1991.) Dutch experts also assisted Hungary to more precisely assess the energy related emissions within the framework of a Dutch-Hungarian cooperation agreement by the environmental ministers[9]. All these preparatory processes provided a solid basis for Hungary to actively support the objectives and provisions of the projected international climate change agreement, including the acceptance of the commitment by the industrialized countries on stabilisation of emissions as a first step towards global climate protection.

The United Nations Framework Convention on Climate Change was eventually adopted and opened for signature in 1992. It should be emphasized that: in spite of the still relatively high scientific uncertainty level (concerning the causes, the processes and the potential longer term impacts of the global climate change hazard), consensus on the basic commitments could be reached because of the acceptance of the precautionary approach by all parties.

According to this international agreement, the developed countries committed themselves to stabilize their emissions by 2000 at the level of these emissions in 1990[10]. The countries with economies in transition, and among them Hungary, could have some flexibility in this regard, since the level of their emissions in 1990 could not be considered as an adequate reference level due to the deep economic recession. Several such countries (e.g. Hungary, Poland) requested the opportunity of setting the reference (or base) level for years preceding the start of the prolonged recession.

Besides the stabilization of the emissions, the Convention set other obligations for the acceding parties. In particular, the tasks for the developed countries included the following: adoption and implementation of national programmes of mitigation and adaptation activities, development of detailed inventories of anthropogenic sources and sinks of greenhouse gases; support of scientific and technological cooperation; provision of financial and technological assistance to the developing countries. In Hungary, the national Commission on Sustainable Development was established in 1993 and became also responsible for supervision of the national implementation of this Convention.

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8 Declaration of the Government of the Republic of Hungary on emissions of greenhouse gases, climate change, limitation of emissions from energy consumption and on the international climate change framework convention. (in Hungarian) A Magyar Köztársaság Kormányának nyilatkozata az üvegház-gázok kibocsátásáról, az éghajlatváltozásról, az energiafelhasználásból eredő hazai szén-dioxid kibocsátás korlátozásról és a nemzetközi éghajlatváltozási keretegyezményről. 1992. ápr.16.

9 Faragó T., Szerdahelyi G., Poós M., Rijsberman F. R., Gupta J., 1994: Energy use and carbon-dioxide emissions in Hungary and in the Netherlands: estimates, comparisons, scenarios; contribution to the national energy and environmental policy-planning in relation with the energy-climate issues.. Hungarian Commission on Sustainable Development, Budapest (based on technical paper of 1992)

10 Faragó T., Pálvölgyi T. (eds.), 1992: The United Nations Framework Convention on Climate Change. (in Hungarian). Hungarian National Committee for the UNCED, Budapest (authors:: T. Faragó, I. Gyebnár, I. Lánszki, I. Mersich, J. Mika, T. Pálvölgyi, M. Poós, J. Sudár, S. Szalai, Gy. Szerdahelyi, M. Szoboszlay)

In the meantime, the IPCC continued its activities and had a substantial role in providing scientific support for the international climate policy cooperation. The second assessment report of the IPCC was issued in 1995 and was followed by the third one in 2001. The fourth report was finalized and published in 2007. These reports provided increasingly unambiguous evidence, scenarios and evaluation of the global climate change hazard and its implications. Basic outcomes of these reports have been disseminated and utilized in Hungary, as well.

It was obvious that the emission related objectives of the UN Framework Convention on Climate Change could be considered only as a "small step forward": the provisions on the emission control were neither legally binding, nor universal. Consequently, Parties to the Convention made a decision already at their first session held in 1995 in Berlin on launching a new round of negotiations, which eventually resulted in the Kyoto Protocol. According to the Protocol[11], the developed countries shall achieve an about 5% annual emission reduction for the commitment period of 2008-12, in comparison to the emission level of 1990. The country-by-country contribution to this average is listed in an annex to the Protocol, which in particular indicates for Hungary a 94% target. It means a threshold for our average annual greenhouse gas emissions from human activities for the above mentioned commitment period as compared to the same reference level set for Hungary under the Convention. This Protocol provides for calculating the greenhouse gas emissions in carbon-dioxide equivalent, more concretely it identifies those gases, which emissions should be taken into account and communicated, and it also requires developing concrete measures for mitigation of these emissions and also for adaptation.

The most specific elements of this Protocol are the "flexibility mechanisms". These allow for a developed country Party in addition to the national level measures, to fulfil the prescribed emission mitigation objective, by acquiring additional emission allowances either from another developed country Party through the "emission trading", or by means of technology investments in another developed or developing country, which result in emission reduction.

Representatives of Hungary also directly assisted the work of these international organisations: in 2003-2004 the elected chairman of the Bureau of the Convention was the Hungarian environmental minister; later, upon the ministerial invitation extended to the IPCC, it held its 23rd session in Budapest in 2008; the first chairman of the scientific advisory body of the Conference of the Parties to the Convention during 1995-97 was a representative of the Hungarian environmental ministry (author of this chapter). Several Hungarian experts took active part in the international negotiations and also in the preparation of the IPCC's reports.

Hungary has become a Party both to the Convention and the Protocol. The national tasks relating to these international agreements and the results of the IPCC had a significant impact on development and strengthening of the Hungarian climate policy[12,13,14]. In turn, these national policy mechanisms also facilitated the fulfilment of the obligations under those international agreements, including the development of the relevant policies and programmes, regulatory instruments, monitoring of the greenhouse gas emissions and reporting, etc. *(Fig. 1).*

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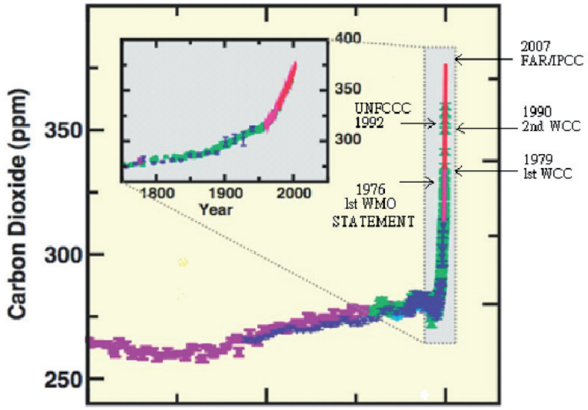
11 Faragó T. (ed.), 1998: Reduction of the greenhouse gas emissions: the Kyoto Protocol to the UN Framework Convention on Climate Change and the national tasks. Hungarian CSD, Budapest

12 Pálvölgyi T., Faragó T. (eds.), 1996: The climate change hazard: causes, impacts, mitigation and adaptation opportunities (IPCC 2nd Assessment Report, SPM). Hungarian Commission on Sustainable Development, Budapest (in Hungarian)

13 Takács-S. A. (ed.), 2005: Climate change at global level and in Hungary. (incl. IPCC 3rd Assessment Report, SPM). Alinea, Budapest (in Hungarian)

14 Mika J. (ed.), 2008: Climate Change – 2007 (IPCC 4th Assessment Report, SPM). MoEW, Budapest (in Hungarian)

*Fig. 1.* **Climate change policy relevant events and the increasing atmospheric GHG concentration (C.Y.Lam, 2007)**
1979: World Climate Conference (WCC), 1990: 2nd WCC,
1992: adoption of the convention (UNFCCC),
2007: IPCC’s 4th Report (and the Convention’s session deciding on negotiations on further emission reductions)




Events related to climate change relative to the carbon dioxide content in the atmosphere

Regarding the policy formulation, the first National Environmental Programme adopted in 1997 was dealing with these issues in general terms, e.g. by taking into account the greenhouse gases emission stabilization commitment or by means of enhancing the climate change related research and development work. The second and the third Programmes for the period of 2003-2008 and 2009-2014, respectively, already included a detailed thematic action plan on national climate change response policies and measures. The National Climate Change Strategy was finalized in 2008 and it defines all the important areas of action such as, the requirements to meet our obligations under the international agreements, measures to control the anthropogenic processes contributing to the climate change hazard, mitigation of greenhouse gases emissions and preparation for the environmental and socio-economic impacts. The solid scientific basis of forming this programme and strengthening of climate change awareness was provided to a large extent by a research project (the “VAHAVA project”), which was completed within the framework of cooperation between the environmental ministry and the Hungarian Academy of Sciences in the period of 2003-2007[15]. It also catalysed the initiative to compile and issue again a concise, science-based document on various aspects of climate change and the various factors, which should be taken into account in course of development of further national mitigation and adaptation policies[16].

We underline again that the development of the international cooperation in the field of the global climate change was a crucial motivating factor regarding the above mentioned research programme and more generally, all the relevant national sectoral and cross-sectoral policy development activities of the past two decades with the participation of government institutions and non-governmental organizations[17].

[15] Láng I., Jolánkai M., Csete L. (eds.), 2006: The Vahava project – summary (in Hungarian) MTA, Budapest

[16] Faragó T., Láng I., Harnos Zs., Csete L. (eds.), 2009: Statement of the Committe of Environmental Science of the Hungarian Academy of Sciences on climate change and related tasks. reprint from: Magyar Tudomány, 2009/10, 1258-1266 (in Hungarian)

[17] Faragó T., 2008: Climate Change and International Cooperation (in Hungarian); ”Klíma-21” Füzetek, 52.

## Tasks stemming from EU membership: its internal and external dimensions

Hungary became a Member State of the European Union in 2004, which has been playing a leading role in forming the international climate change policy since its early days. The common policies and regulatory instruments were developed in such a way that to enable the Community and its Member States to comply also with their relevant international commitments. In relation to the enlargement, on the one hand, the new Member States had to adjust to the requirements of policies and legal instruments that were adopted before their accession and, on the other hand, after 2004 they were involved already in further development of the "acquis communautaire", in particular in the field of the EU's climate change policy. Their EU membership also meant for these countries to participate in the international negotiation processes primarily in form of contributing to the common position and its representation.

The general framework of the climate change policy of the Community is provided by the European Climate Change Programme (ECCP), which was adopted in 2000 and updated as its second phase (ECCP-II) in 2005. Objectives, policies and means related to climate change are also forming a key component of the Environmental Action Plan and the Sustainable Development Strategy of the EU. Besides these policy instruments, certain sectoral (energy, transport, agriculture, research etc.) programmes also integrated various aspects of climate change mitigation and adaptation aspects and requirements (e.g., the recently adopted climate-energy package).

Among the concrete regulatory means, the Emission Trading Scheme (ETS) of the EU is gained the most attention. The transposition and implementation of this system in Hungary was a very complex task both from regulatory and institutional perspectives. Along with developing the relevant national legal framework, including the respective act[18], more than 200 Hungarian industrial installations were subject to permitting, reporting and quota allocation procedures for the pilot period of 2005-2007. It was followed by a basically similar procedure for the period of 2008-2012, which is actually coincides with the first commitment period under the Kyoto Protocol.

In addition to these tasks, there is a series of matters, which needs specific attention: policy measures, regulatory action or institutional setup in order to meet the provisions of the related international agreements and/or the EU requirements. These include *inter alia* such issues as further development of inventories of the greenhouse gas emissions and reporting, regulation of participation in the joint implementation projects and international emission trading (quota transactions) including the operation of the national (quota) registry etc.

## Recent policy related developments and the perspectives

There is already a global political consensus on the need to strengthen and accelerate the international efforts to combat the climate change hazard. By considering the latest results and recommendations of the IPCC presented in its Fourth assessment report (2007) and endorsing the use of the *precautionary approach*, leading politicians worldwide have agreed that the atmospheric concentration of greenhouse gases be kept below a certain critical level (around or even well below 450 ppm). To do so the present anthropogenic emissions of these gases should be reduced at least by 50% by the middle of this century. Based on this

[18] Act XV of 2005 on the greenhouse gas emission trading (in Hungarian); A 2005. évi XV. törvény az üvegházhatású gázok kibocsátási egységeinek kereskedelméről

generally accepted goal, Parties to the UN Framework Convention on Climate Change at their session in 2007 decided to launch a new round of international negotiations with the intention to elaborate a new global agreement (e.g. a new protocol under the Convention and/or an extension of the existing Kyoto Protocol) by the end of 2009. This was the decision on the Bali Action Plan, which included the negotiation mandate and the roadmap.

The European Union and its Member States had a clear-cut position, according to which: (i) the group of developed countries should contribute to the global mitigation efforts with a 30% emission reduction by 2020 and (ii) the developing countries (primarily those with rapid economic development and increasing emission levels) should ensure that their further development will be associated with more moderated increase of the greenhouse gas emissions (i.e. economic growth with lower carbon intensity or in other worlds, significant “decoupling” of this growth from the environmental pressure in terms of greenhouse gases emissions).

Until such international agreement is achieved, the EU is committed to cut “unilaterally” these emissions by at least 20% by 2020 in comparison to its 1990 level. For this purpose, the distribution of emission mitigation efforts among the Member States must have been agreed (“effort sharing”), the Community’s emission trading scheme should be extended and strengthened, the energy efficiency should be significantly improved, the share of renewable energy sources should also be considerably increased. The effort sharing process has been a rather sensitive issue because of the significant differences in the Member States’ emission levels and emission reduction potentials *(Fig. 2)*.

The recently adopted EU’s climate-energy package incorporated all these policy and regulatory requirements. Hungary gave a full support to the basic climate-protection measures of the EU with a clear articulation of principles of solidarity and proportional responsibility in context of the effort sharing. We also actively participated in the formulation of the EU’s common position for the international negotiations after 2007, which were guided by the above-mentioned mandate (Bali Action Plan).

Unfortunately, those international negotiations could not be concluded by 2009: the Conference of the Parties in Copenhagen has produced lengthy draft negotiating documents and the world political leaders (the “Climate Summit”) could only agree on a few corner elements of the future international cooperation.

Nevertheless the ultimate objective of all these efforts is unchanged, i.e. to avoid a dangerous level and rate of global environmental change by taking into account the precautionary approach. In order to meet this objective, all States, including the EU Member States should do considerably more than before: by mitigating their greenhouse gases emissions, enhancing the sinks and preparing for the presumably unavoidable changes. This is challenging for the research community because there is a need for a much clearer picture on drivers, processes, and impacts of the global environmental change and for an even better understanding of the options and effects of the various response policies and measures. This is also challenging for the policy-making society since the postponement of relevant mitigation and adaptation actions would enhance the risk of already unmanageable environmental changes.

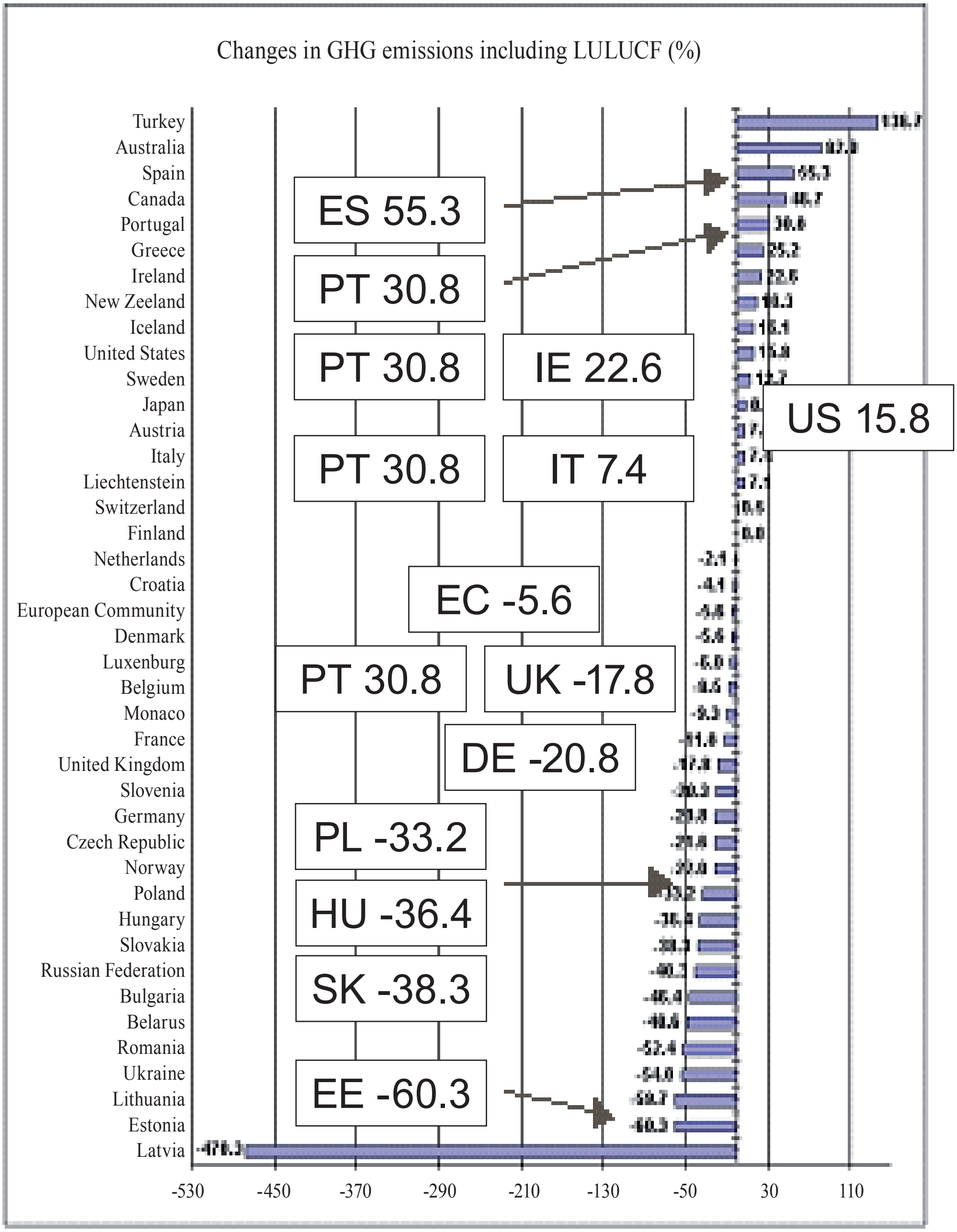



*Fig. 2.* **GHG emissions of EU Member States and other countries listed in Annex I of the UNFCCC, 1990-2007**
(2007 emissions in percentage of the 1990 level)

# 2. CLIMATE CHANGE SCENARIOS FOR THE CARPATHIAN BASIN

Spatial resolution of global climate models (GCMs) is inappropriate to describe regional climate processes; therefore, GCM outputs may be misleading to compose regional climate change scenarios for the 21st century. In order to determine better estimations for regional climate parameters, fine resolution regional climate models (RCMs) can be used. RCMs are limited area models nested in GCMs, i.e., the initial and the boundary conditions of RCMs are provided by the GCM outputs. Due to computational constrains the domain of an RCM evidently does not cover the entire globe, and sometimes not even a continent. On the other hand, their horizontal resolution may as fine as 5-10 km. *Fig. 1* illustrates how the coarse resolution GCM outputs and the finer resolution RCM outputs may differ significantly. The GCM projections suggest that the late summer precipitation in Hungary will increase by 0-10%, while the RCM suggests a 30-40% decrease for 2071-2100.

The first project completed in the frame of the European Union V Program is the PRUDENCE (Prediction of Regional scenarios and Uncertainties for Defining European Climate change risks and Effects), which involved 21 European research institutes and universities. The primary objectives of PRUDENCE were to provide high resolution (50 km) climate change scenarios for Europe for 2071-2100 using dynamical downscaling methods with RCMs (using the reference period 1961-1990), and to explore the uncertainty in these projections. Results of the project PRUDENCE are disseminated widely via Internet *(http://prudence.dmi.dk)* and several other media, and thus, they support socio-economic and policy related decisions.

In this study, the regional climate change projections are summarized for the Carpathian basin using the outputs of all available PRUDENCE simulations. Results of the expected

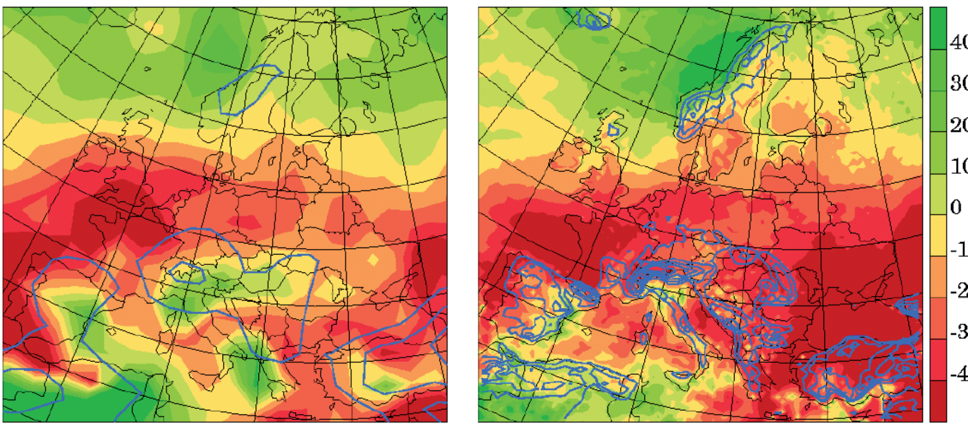



*Fig. 1.* **Expected late summer (JAS) precipitation change in Europe estimated by ECHAM GCM (with 300 km res.) and HIRHAM RCM (with 50 km res.) for A2 scenario (The blue contour indicates the model topography.)**

mean temperature and precipitation change by the end of the 21st century are discussed using composite maps. Furthermore, the expected changes of the extreme climate indices following the guidelines suggested by a joint WMO-CCl (World Meteorological Organization Commission for Climatology) / CLIVAR (World Climate Research Programme addressing Climate Variability and Predictability) Working Group formed in 1998 on climate change detection are also analysed.

## Data

Adaptation of RCMs with 10-25 km horizontal resolution is currently proceeding in Hungary, namely, at the Department of Meteorology, Eötvös Loránd University, and at the Hungarian Meteorological Service (HMS). Results of these RCM experiments are expected within 1-2 years; however, impact studies and end-users need and would like to have access to climate change scenario data much earlier. Also, for the National Climate Change Strategy (accepted by the Parliament in March 2008) climate change input data needed for Hungary. Therefore, in order to fulfil this instant demand with preliminary information, outputs of PRUDENCE simulations (for the 2071-2100 and 1961-1990 periods) are evaluated and offered for the Carpathian basin. Composite maps of expected temperature and precipitation change cover the Carpathian basin (45.25°-49.25°N, 13.75°-26.50°E). Since the project PRUDENCE used only two emission scenarios (i.e., A2 and B2), no other scenario is discussed in our study. In case of the A2 scenario 16 RCM experiments are used, while in case of B2, only outputs of 8 RCM simulations are available *(Table 1).*

According to the A2 global emission scenario, fertility patterns across regions converge very slowly resulting in continuously increasing world population. Economic development is primarily regionally oriented, per capita economic growth and technological changes are fragmented and slow. The projected $CO_2$ concentration may reach 850 ppm by the end of the

*Table 1.* **List of RCMs with their driving coupled GCMs used in the composite analysis**

| | Institute | RCM | Driving GCM | Scenario |
|---|---|---|---|---|
| 1 | Danish Meteorological Institute | HIRHAM | HadAM3H/HadCM3 | A2, B2 |
| 2 | | HIRHAM | ECHAM4/OPYC | A2 |
| 3 | | HIRHAM high resolution | HadAM3H/HadCM3 | A2 |
| 4 | | HIRHAM extra high res. | HadAM3H/HadCM3 | A2 |
| 5 | Hadley Centre of the UK Met Office | HadRM3P (ensemble/1) | HadAM3P/HadCM3 | A2, B2 |
| 6 | | HadRM3P (ensemble/2) | HadAM3P/HadCM3 | A2 |
| 7 | ETH (Eidgenössische Technische Hochschule) | CHRM | HadAM3H/HadCM3 | A2 |
| 8 | GKSS (Ges. für Kernenergie. in Schiffbau & Schiffahrt) | CLM | HadAM3H/HadCM3 | A2 |
| 9 | | CLM improved | HadAM3H/HadCM3 | A2 |
| 10 | Max Planck Institute | REMO | HadAM3H/HadCM3 | A2 |
| 11 | Swedish Meteorological and Hydrological Inst. | RCAO | HadAM3H/HadCM3 | A2, B2 |
| 12 | | RCAO | ECHAM4/OPYC | B2 |
| 13 | UCM (Universidad Complutense Madrid) | PROMES | HadAM3H/HadCM3 | A2, B2 |
| 14 | International Centre for Theoretical Physics | RegCM | HadAM3H/HadCM3 | A2, B2 |
| 15 | Norwegian Meteorological Institute | HIRHAM | HadAM3H/HadCM3 | A2 |
| 16 | KNMI (Koninklijk Nederlands Meteo.Inst.) | RACMO | HadAM3H/HadCM3 | A2 |
| 17 | Météo-France | ARPEGE | HadAM3H/HadCM3 | A2, B2 |
| 18 | | ARPEGE | ARPEGE/OPA | B2 |

21st century, which is about triple of the pre-industrial concentration level (280 ppm). The global emission scenario B2 describes a world with intermediate population and economic growth, emphasizing local solutions to economic, social, and environmental sustainability. According to the B2 scenario, the projected $CO_2$ concentration is likely to exceed 600 ppm, which is somewhat larger than a double concentration level relative to the pre-industrial $CO_2$ conditions.

In order to evaluate the model performance, temperature bias is determined for each RCM output fields using the simulations for the reference period (1961-1990), and the CRU (Climate Research Unit of the University of East Anglia) database. In general, the RCM simulations overestimate the temperature in most parts of the Carpathian basin, and small underestimation is detected at the western and north-eastern parts of our domain. In Northern Transdanubia and Northern Great Plains the temperature is overestimated by 0.5-1.0°C, while in the north-eastern part of the country the overestimation is only 0-0.5°C. The largest overestimation in Southern Hungary does not exceed 1.5°C.

In case of precipitation, the RCM simulations generally overestimate the observations in most parts of the Carpathian basin; however, underestimation can be seen in the south-western subregion. In Hungary, the bias is not exceeding 15% in absolute values. The precipitation is slightly underestimated in the western/south-western part of the country, while precipitation in the other large parts (including the entire Great Plains and Eastern Transdanubia) is slightly overestimated.

### Expected temperature increase in the Carpathian basin

*Fig. 2* presents the expected seasonal temperature change for A2 and B2 scenarios (left and right panel, respectively). Similarly to the global and the European climate change results, larger warming can be expected for A2 scenario in the Carpathian basin than for B2 scenario. The largest temperature increase is expected in summer, while the smallest in spring. In case of the summer daily mean temperature the expected increase is 4.5-5.1°C (A2) and 3.7-4.2°C (B2). The daily maximum and minimum temperature in summer expected to increase by 4.9-5.3°C (A2) and 4.0-4.4°C (B2), and 4.2-4.8°C (A2) and 3.5-4.0°C (B2), respectively. For spring, the expected temperature increase inside Hungary is 2.8-3.3°C (A2) and 2.3-2.7°C (B2).

### Expected precipitation change in the Carpathian basin

Similarly to temperature projections, composites of mean seasonal precipitation change are mapped for both A2 and B2 scenarios for the 2071-2100 period. *Fig. 3* presents the expected seasonal precipitation change for A2 and B2 scenarios (left and right panel, respectively) for the Carpathian basin. The annual precipitation sum is not expected to change significantly in this region, but it is not valid for seasonal precipitation. According to the results shown in *Fig. 3,* summer precipitation is very likely to decrease (also, slight decrease of autumn precipitation is expected), while winter precipitation is likely to increase considerably (slight increase in spring is also expected). In summer, the projected precipitation decrease is 24-33% (A2) and 10-20% (B2). In winter, the expected precipitation increase is 23-37% (A2) and 20-27% (B2). Based on the seasonal standard deviation values, the largest uncertainty of precipitation change is expected in summer, especially, in case of A2 scenario (the standard deviation of the RCM results exceeds 20%).

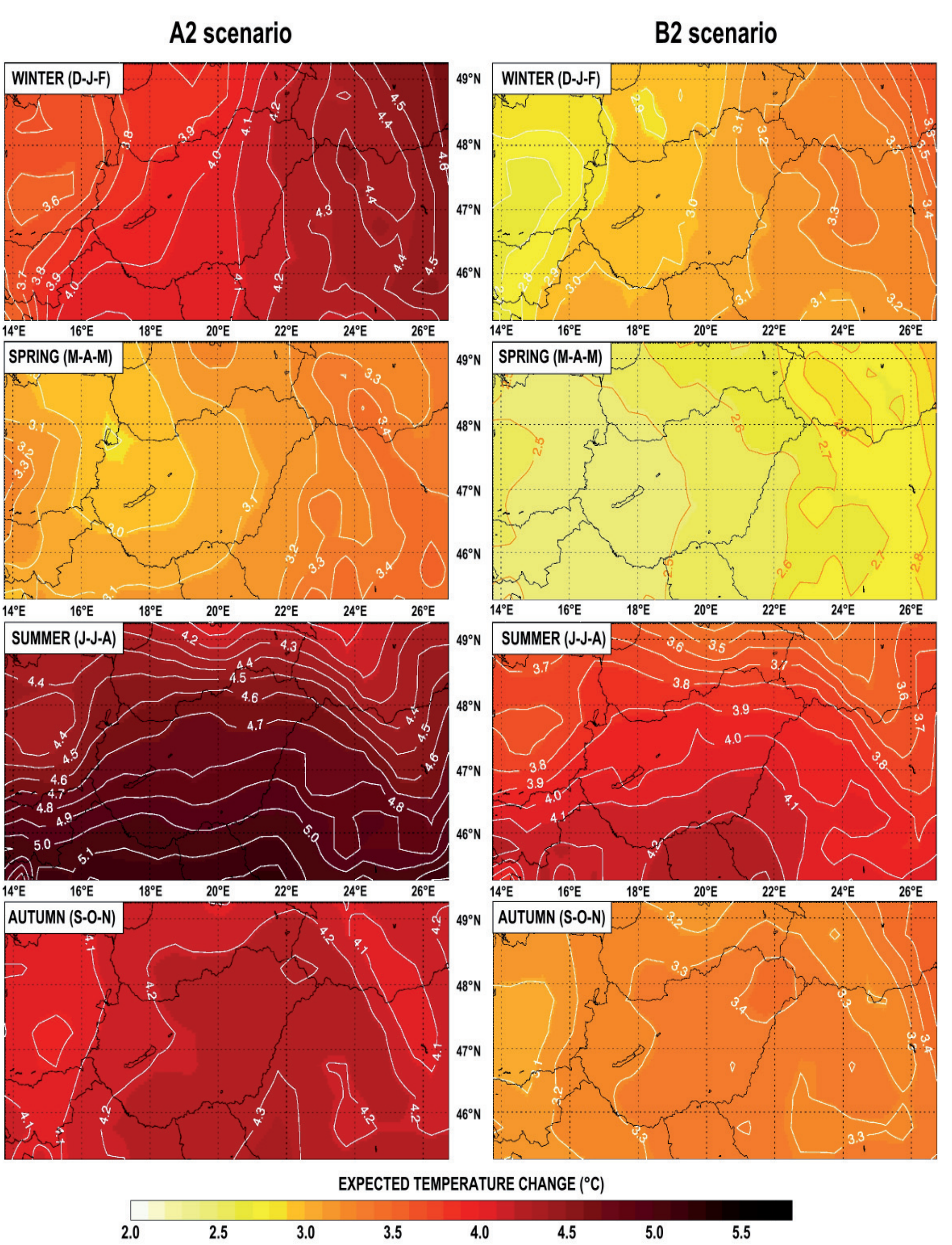



*Fig. 2.* **Seasonal temperature change (°C) expected by 2071-2100 for the Carpathian basin using the outputs of 16 and 8 RCM simulations in case of A2 and B2 scenarios, respectively (Reference period: 1961-1990)**

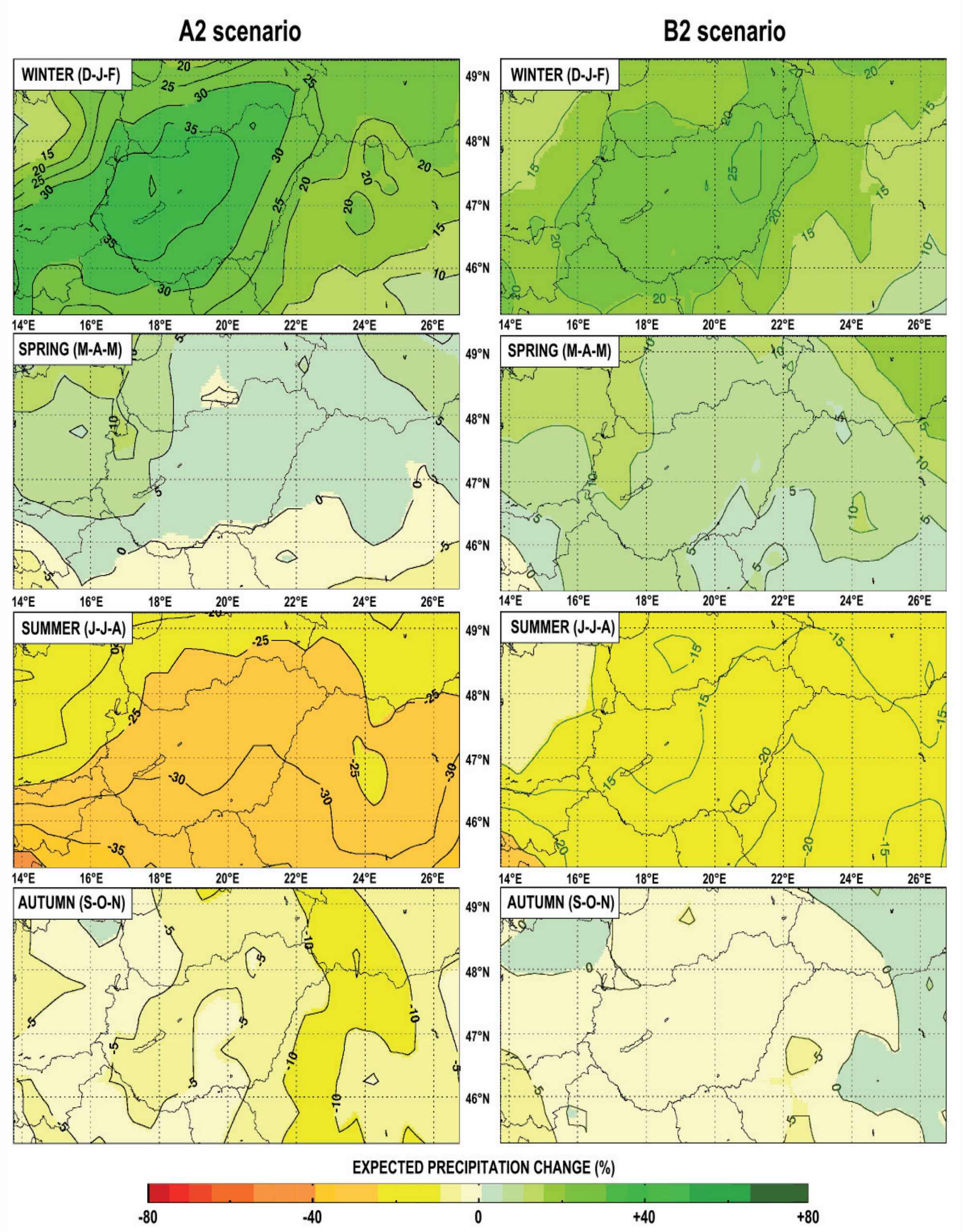



*Fig. 3.* **Seasonal precipitation change (%) expected by 2071-2100 for the Carpathian basin using the outputs of 16 and 8 RCM simulations in case of A2 and B2 scenarios, respectively (Reference period: 1961-1990)**

The expected seasonal change of precipitation for Hungary in case of A2 and B2 scenarios are summarized in *Fig. 4.* Green and yellow arrows indicate increase and decrease of precipitation, respectively. According to the reference period, 1961-1990, the wettest season was summer, then, less precipitation was observed in spring, even less in autumn, and the driest season was winter. If the projections are realized then the annual distribution of precipitation will be totally restructured, namely, the wettest seasons will be winter and spring (in this order) in cases of both A2 and B2 scenarios. The driest season will be summer in case of A2, while autumn in case of B2. On the base of the projections, the annual difference between the seasonal precipitation amounts is expected to decrease significantly (by half) in case of B2 scenario (which implies more similar seasonal amounts), while it is not expected to change in case of A2 scenario (nevertheless, the wettest and the driest seasons are completely changed).

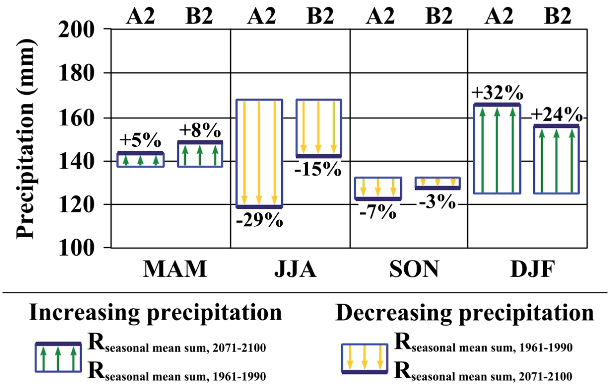



*Fig. 4.* **Expected seasonal change of mean precipitation (mm) for Hungary by 2071-2100 (Reference period: 1961-1990)**

## Expected climatic changes in Hungary in case of 1°C global warming

The target period of PRUDENCE simulations covers the end of the 21st century (2071-2100). On the other hand, impact studies would require regional climate change scenarios for earlier periods, preferably for the next few decades. The only information source currently available with fine (i.e., 50 km) horizontal resolution for Hungary and other European countries is a special comprehensive assessment based on the PRUDENCE simulations. This country-by-country based analysis is conducted for both the mean temperature values and the precipitation amounts. In order to avoid the specific characteristics of A2 or B2 scenario, a pattern scaling technique has been applied, thus, the changes are expressed relative to a 1°C global warming. Uncertainties in the estimates of projected changes are due to the use of different GCMs and RCMs, as well, as natural variability. As a result, mean and standard deviation of 25 estimates of temperature and precipitation change are provided for each country. Furthermore, these main statistical parameters are used to fit a normal probability distribution function for the projected change. *Table 2* summarizes the mean, the standard deviation, the 5th and the 95th percentiles of the seasonal and annual projected temperature and precipitation changes for Hungary (which is covered by about 30 gridpoints).

In case of temperature, all seasonal, as well, as annual temperature increase expected in Hungary is larger than the global 1°C warming, which implies that this region is quite sensitive to the global environmental change. The projected summer and autumn regional warming (1.7°C and 1.5°C, respectively) is larger than the annual increase (1.4°C), while the expected winter (1.3°C) and spring (1.1°C) warming is smaller than the annual temperature increase.

*Table 2.* **Statistical characteristics of expected change of temperature and precipitation for Hungary relative to 1°C global warming using 25 RCM simulations. In case of percentiles, the values in brackets indicate the 95% confidence intervals**

| **Temperature** | **Annual** | **Spring (MAM)** | **Summer (JJA)** | **Autumn (SON)** | **Winter (DJF)** |
|---|---|---|---|---|---|
| Mean | 1.4 | 1.1 | 1.7 | 1.5 | 1.3 |
| Standard deviation | 0.3 | 0.3 | 0.4 | 0.3 | 0.3 |
| 95th percentile | 1.9 [1.8-2.1] | 1.6 [1.5-1.8] | 2.4 [2.2-2.6] | 2.0 [1.8-2.1] | 1.9 [1.7-2.1] |
| 5th percentile | 0.9 [0.7-1.0] | 0.6 [0.5-0.8] | 1.0 [0.8-1.2] | 1.0 [0.8-1.1] | 0.8 [0.6-0.9] |
| **Precipitation** | **Annual** | **Spring (MAM)** | **Summer (JJA)** | **Autumn (SON)** | **Winter (DJF)** |
| Mean | -0.3 | 0.9 | -8.2 | -1.9 | 9.0 |
| Standard deviation | 2.2 | 3.7 | 5.3 | 2.1 | 3.7 |
| 95th percentile | 3.4 [2.2-4.6] | 7.0 [5.0-9.0] | 0.5 [(-2.3)-(3.2)] | 1.5 [0.4-2.7] | 15.0 [13.0-16.9] |
| 5th percentile | -3.9 [(-5.1)-(-2.8)] | -5.2 [(-7.2)-(-3.3)] | -16.9 [(-19.5)-(-14.1)] | -5.3 [(-6.4)-(-4.2)] | 3.0 [1.0-5.0] |

*Table 3.* **Expected climate change for Hungary by 2030 using the PRUDENCE (25 RCMs) simulations, GCM outputs (22 GCMs) and empirical approach (5 techniques). Reference period: 1961-1990.**

| **Methodology** | **Temperature change (°C)** | **Annual** | **Summer (JJA)** | **Winter (DJF)** |
|---|---|---|---|---|
| PRUDENCE | Average | 1,4 | 1,7 | 1,3 |
| IPCC 2007 | Average | 0,9 | 1,3 | 1,0 |
| EMPIRICAL | Average | n.a. | 1,1 | 2,0 |
| | | | | |
| **Methodology** | **Precipitation change (%)** | **Annual** | **Summer (JJA)** | **Winter (DJF)** |
| PRUDENCE | Sum | -0,3 | -8,2 | 9,0 |
| IPCC 2007 | Sum | -0,7 | -3,7 | 1,9 |
| EMPIRICAL | Sum | -2,2 | -19,7 | 7,6 |

According to the results presented in *Table 2* for the precipitation, the annual amount in Hungary is not expected to change significantly. On the other hand, considerable precipitation decrease and increase are projected for summer and winter, respectively. Slight changes are expected for autumn (some decrease) and spring (some increase). These results confirm the conclusions drawn from the precipitation maps in the previous section, which implies that the expected shift in the annual distribution of precipitation starts quite early.

Expected regional changes in case of 1°C global warming presented in *Table 2* can be compared to regional climate change estimations using different other methodologies. Our main aim with this comparison is to evaluate whether or not different techniques lead to similar estimations of the future climatic changes in the Carpathian basin. Besides the PRUDENCE RCM projections (with 50 km horizontal resolution), outputs of 22 GCMs (with about 200 km horizontal resolution) used in compiling the IPCC Fourth Assessment Report (2007) serve as rough estimations. The empirical approach group of the HMS considers 0.5°C global warming rate using regression technique and three different paleoclimatic analogues (6 thousand years, 122 thousand years and 4 million years before present) of the Carpathian basin climate.

Expected seasonal and annual climate change is compared in *Table 3* for Hungary. It can be seen that in case of temperature all projections are likely to exceed the global warming rate (by 2030). For the annual precipitation, slight decrease can be expected on the base of all the three methodologies. Similarly to the results shown in the previous section, all the three methodologies suggest drier summers and wetter winters in the coming decades than in the reference period (1961-1990). The fact that other approaches suggest similar results to the PRUDENCE projections, justifies the key findings of our analysis based on PRUDENCE outputs.

## Expected changes of extreme indices

In order to analyse the past and future trends of the indices, extreme temperature indices are compared in *Table 4* for the reference period and the end of the 21st century using the daily temperature outputs of the RCM experiments of DMI. The annual values are calculated as a spatial average of all the grid points located in Hungary. It can be seen that negative extremes are expected to decrease while positive extremes tend to increase significantly. Both imply regional warming in the Carpathian basin. The largest increase due to this warming trend can be expected in case of extremely hot days (Tx35GE), hot nights (Tn20GT), hot days (Tx30GE), warm nights (Tn90), and warm days (Tx90) by more than 100%. The expected changes are larger in case of the more pessimistic A2 scenario than in case of B2, the ratio is about 1.3-1.7. The expected warming trends of all the temperature indices are completely consistent with the detected trend in the 1961-2001 period.

*Table 4.* **Comparison of extreme temperature indices in the reference period (1961-1990) and in case of A2 and B2 scenario (2071-2100) based on the daily outputs of the RCM of DMI**

| Temperature index | Reference period: 1961-1990 | A2 scenario: 2071-2100 (Expected change) | B2 scenario: 2071-2100 (Expected change) | Detected trend (1961-2001) |
|---|---|---|---|---|
| Tx90: Warm days ($T_{max} > T_{max,90\%,1961\text{-}90}$) | 36 days/year | 80 days/year (+123%) | 68 days/year (+88%) | + |
| Tn90: Warm nights ($T_{min} > T_{min,90\%,1961\text{-}90}$) | 36 days/year | 88 days/year (+143%) | 75 days/year (+108%) | + |
| SU: Summer days ($T_{max} > 25$ °C) | 80 days/year | 122 days/year (+54%) | 109 days/year (+37%) | + |
| Tx30GE: Hot days ($T_{max} \geq 30$ °C) | 30 days/year | 74 days/year (+156%) | 61 days/year (+109%) | + |
| Tx35GE: Extremely hot days ($T_{max} \geq 35$ °C) | 4 days/year | 33 days/year (>+300%) | 20 days/year (>+300%) | + |
| Tn20GT: Hot nights ($T_{min} > 20$ °C) | 24 days/year | 75 days/year (+229%) | 62 days/year (+169%) | + |
| Tx10: Cold days ($T_{max} < T_{max,10\%,1961\text{-}90}$) | 36 days/year | 10 days/year (-73%) | 20 days/year (-46%) | – |
| Tn10: Cold nights ($T_{min} < T_{min,10\%,1961\text{-}90}$) | 36 days/year | 9 days/year (-75%) | 17 days/year (-52%) | – |
| FD: Frost days ($T_{min} < 0$ °C) | 73 days/year | 27 days/year (-64%) | 46 days/year (-37%) | – |
| Tx0LT: Winter days ($T_{max} < 0$ °C) | 18 days/year | 3 days/year (-82%) | 6 days/year (-65%) | – |
| Tn-10LT: Severe cold days ($T_{min} < -10$ °C) | 6 days/year | <1 days/year (-95%) | 1 days/year (-87%) | – |

*Table 5.* **Expected change of extreme precipitation indices in cases of A2 and B2 scenarios (2071-2100) based on the daily outputs of the RCMs of DMI, ICTP, KNMI, and ETHZ (reference period: 1961-1990). In case of the detected trends, signs in parentheses indicate regional mean coefficients being not significant at 95% level**

| Precipitation index | A2 scenario | | | B2 scenario | | | Detected trend |
|---|---|---|---|---|---|---|---|
| | year | January | July | year | January | July | 1976-2001 |
| Rx1 ($R_{max}$) | +17% | +29% | -2% | +13% | +23% | -5% | – |
| Rx5 ($R_{max,5\ days}$) | +10% | +26% | -11% | +11% | +17% | -11% | + |
| SDII ($R_{year}$/RR1) | +10% | +16% | +13% | +7% | +12% | +1% | (+) |
| R95 ($R_{day} \geq R_{95\%,1961\text{-}90}$) | +7% | +60% | -30% | +14% | +35% | -22% | + |
| R75 ($R_{day} \geq R_{75\%,1961\text{-}90}$) | -9% | +19% | -35% | +0% | +8% | -21% | + |
| RR20 ($R_{day} \geq 20$ mm) | +60% | +233% | +66% | +68% | +212% | -24% | + |
| RR10 ($R_{day} \geq 10$ mm) | +14% | +95% | -11% | +20% | +58% | -14% | + |
| RR5 ($R_{day} \geq 5$ mm) | -1% | +52% | -30% | +7% | +28% | -22% | (–) |
| RR1 ($R_{day} \geq 1$ mm) | -10% | +19% | -31% | -2% | +6% | -19% | – |
| RR0.1 ($R_{day} \geq 0.1$ mm) | -11% | +9% | -30% | -3% | +1% | -10% | – |
| R95T ($\Sigma R_{day:\ when\ R_{day}>R_{95\%,1961\text{-}90}}$ / $R_{total}$) | +16% | +27% | +9% | +14% | +23% | +0% | + |

*Table 5* summarizes the expected future trends of the extreme precipitation indices determined using the climate simulations of four selected RCMs (i.e., HIRHAM4 of DMI, RegCM of ICTP, RACMO2 of KNMI, and CHRM of ETHZ) for the 1961-1990 and the 2071-2100 periods. Expected changes of annual precipitation indices are generally consistent with the detected trends in 1976-2001. However, the expected regional increase or decrease is usually small (not exceeding 20% in absolute value), except of RR20, the number of very heavy precipitation days. Much larger positive and negative changes are projected in January and in July, respectively. These results together with the composite maps shown in *Fig. 3* suggest that the climate tends to be wetter in January and drier in July in the Carpathian basin. Since the projected increases of the RR20, RR10, and R95 (these indices describe very extreme precipitation events) exceed 60% in January for A2 scenario, and the expected increases of RR0.1 or RR1 (these indices are not related to extreme precipitation) is 9% and 19%, respectively, the extreme precipitation events are expected to become more intense and more frequent in January. Similar but smaller changes are expected for B2 scenario. Furthermore, drought is projected to become more severe in July by the end of the 21st century, which can be derived from the robust decrease of precipitation indices. The largest decrease rates (exceeding 30%) in July are expected in case of the R75, RR1, RR0.1, RR5, and R95 indices for the A2 scenario. The projected monthly changes are smaller for the B2 scenario.

## Conclusions

On the basis of our results, the following conclusions can be drawn using the RCM experiment outputs of the PRUDENCE project.

- Expected seasonal temperature increase for the Carpathian basin in case of the A2 scenario is larger than in case of the B2 scenario, which is in good agreement with the expected global and European climate change results. The smallest difference between the A2 and B2 scenarios is projected for spring (0.6-0.7°C), while the largest for winter (1.0-1.1°C).

- The largest daily mean temperature increase is projected for summer, 4.8°C (A2) and 4.0°C (B2), while the smallest seasonal warming is expected in spring, 3.1°C (A2) and 2.5°C (B2).
- The largest increase of maximum and minimum temperatures is expected also in summer for both scenarios. In case of maximum temperature, the interval of the expected warming is 4.9-5.3°C (A2) and 4.0-4.4°C (B2), while in case of minimum temperature; these intervals are 4.2-4.8°C (A2) and 3.5-4.0°C (B2). Expected increase of the daily maximum temperature exceeds that of the daily minimum temperature, except in winter.
- The annual precipitation sum is not expected to change significantly in our region. On the other hand, summer precipitation is very likely to decrease (by 24-33% (A2) and 10-20% (B2)), and slight decrease of autumn precipitation is also expected. Winter precipitation is likely to increase considerably (by 23-37% (A2) and 20-27% (B2)), and slight increase in spring is also expected.
- In the reference period (1961-1990), the wettest season was summer, while the driest season was winter. If the projections are realized then the annual distribution of precipitation will be totally restructured: the wettest season will be winter in case of both A2 and B2 scenarios; the driest season will be summer in case of A2, while autumn in case of B2.
- The extreme temperature indices associated with cold climatic conditions are projected to decrease in the Carpathian basin by 2071-2100 while the positive extremes tend to increase significantly. The expected changes of the extreme temperature indices are larger for A2 scenario than B2 scenario.
- Expected changes (for 2071-2100) of annual precipitation indices are small, but generally consistent with the detected trends in 1976-2001. The projected changes in winter and in summer are opposite to each other, which mean that large positive and negative changes of monthly precipitation indices are projected in January and in July, respectively. Projected increase of very extreme precipitation events exceeds 60% in January, while the expected increases of not extreme precipitation indices do not reach 20%. These results imply that the extreme precipitation events are expected to become more intense and more frequent in January. Furthermore, drought is projected to become more severe and a general decrease of extreme precipitation indices is expected in July.

# 3. THE “VAHAVA” PROJECT

In the summer of 2003 an extreme heat wave rolled through Europe, including Hungary. This natural phenomenon has increased the concern of the society and within this that of the politicians and the media about the impacts of extraordinary meteorological events. Scientific research also got a new impetus in this field.

### Organisation of the project

In June 2003 the Hungarian Ministry for the Environment and Water Management (KvVM) and the Hungarian Academy of Sciences (MTA) have launched a joint research project of the title of “Global climate change, Hungarian impacts and responses”. The name “VAHAVA” of this project is an abbreviation of the Hungarian first letters of the key words ”Changes-Impacts-Responses” (VÁltozás-HAtás-VÁlaszadás).

In preparing the thematic structure of the Project the participants relied on the recently increased role of *climate-policies.* In doing so they considered the need for mitigating the emissions of greenhouse gases and the must for the adaptation to the changes. In this context they formulated three phases; those of the prevention, defence and rehabilitation. The international implications of climate policies were recently recognised as these may have a bearing on both piers (mitigation and adaptation) of combating climate change. (Such international implications include the decreasing of the dependency of Hungary on imported fossil fuels.)

The National Environmental Programme is dealing with the Hungarian tasks of decreasing the emissions of greenhouse gases. Consequently the Project VAHAVA focused primarily on the tasks of adaptation.

The steering body of the Project was called the Scientific Committee. The president of the Steering Committee was *István Láng* (protection of the environment), while the members included: *László Csete* (agro-economy), *Tibor Faragó* (climate policies), *Ernő Führer* (forestry), *Kornél Harkányi* (hydrology), *Zsolt Harnos* (information technology), *István Ijjas* (water management), *Márton Jolánkai* (crop production), *Mátyás Kovács* (nature conservation), *Ferenc Ligetvári* (irrigation), *György Major* (meteorology), *Ferenc Schweitzer* (earth sciences), *Gábor Szász* (agro-meteorology), *Viktória Szirmai* (sociology), *Ottó Veisz* (plant breeding) and *Gábor Vida* (ecology). *István Teplán* and *Erzsébet Ligetiné-Nechay* also assisted the coordination of the project activities on behalf of the Hungarian Academy of Sciences (MTA) and the Ministry for the Environment and Water Management (KvVM), respectively.

The schedule of the implementation of the Project was as follows:

June 2003 – December 2003: Preparatory phase
January 2004 – September 2005: Implementation of basic tasks
September 2006 – March 2006: Finalisation phase
April 2006 – December 2006: Dissemination of results
February 2007 – Publishing the report in the form of a book, in Hungarian.

The major methodological feature of the project VAHAVA was the *synthesis of large systems.* This means that no basically new research programmes were launched but the knowledge, data and experiences gained in the past decades were summarised and synthesised, creating in this way new intellectual products. This methodological feature required *interdisciplinarity* and *multi-sectoral approaches* also demanding wide spreading *partnership relations*. The final report of the project, being prepared at the time of this document, will contain the results of several hundred Hungarian experts. One of the critical points of this synthesis is the estimation of the risks of climate change. Experts participating in the project said an unambiguous yes to the question whether there will be climate change or not. The basic concept was that *climate has ever been changing and such changes are expected to continue also in the future*. The two most important causes of the changes are the natural processes and the anthropogenic factors. The latter means the production and consumption of six and half billion people. The participants of the Project also agreed that both causes will have their effects on the changes and they will sometimes amplify mitigate the unfavourable impacts. The expert’s opinions were partly different regarding the share of these two causes in the changes, but most of the specialists considered the anthropogenic factor the dominating one.

The working hypotheses of the project were as follows: (i) the warming of the climate will be stronger in the Carpathian Basin; (ii) we may expect the decreasing of annual average precipitation; (iii) the number and intensity of extreme weather events will be increasing.

**Strategic objectives and impact areas**

In the Project VAHAVA we formulated two strategic objectives:

- To get the Hungarian people and economy prepared to face the occurrence of the likely increased extreme weather events and to bear warmer and drier time periods and their expectable impacts.
- To create and develop the organisational, technical, infrastructural and financial conditions that will be needed for a rapid response of people (of the society) to the harmful impacts of unexpectedly occurring extreme weather events.

Climate change, as a process, is composed of a chain of *extreme meteorological events*. The disadvantageous impacts include: floods, excess inland water inundations, droughts, deluvian rainstorms, hails, heat waves, increasing UV radiation, early and late frosts, snow jams, wind storms, forest and bush fires, appearance of new pathogens and pests.

The *impact areas* of extreme meteorological events cover wide ranges. Nearly all sectors of the economy are facing such impacts, including; nature conservation, water management, agriculture, forestry, power generation, transportation, settlements, regions and small-regions, environmental-health, labour-health, tourism, catastrophe prevention, insurance systems, public awareness and open-air mass performances.

Calculation and assessment activities made in the framework of this Project resulted in an estimated total average annual cost of 150-180 billion HUF (roughly 1% of the GDP) as the sum of the damages, and of the costs of preventive and remedial actions of earlier years in combating unfavourable extreme meteorological events. This sum might be significantly increased with the progress of the climate change.

**Publications and communication activities**

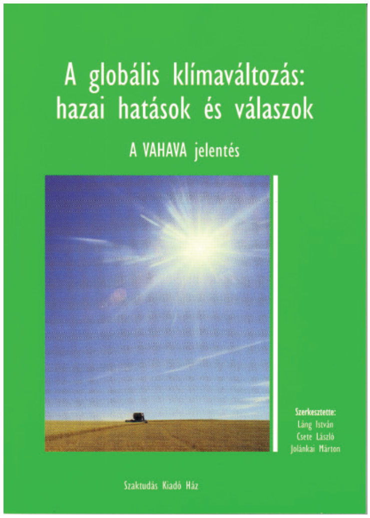
In implementing the Project VAHAVA efforts were made to get the widest possible professional and social cycles involved in disputing partial results. This also enabled the drawing of the attention of decision makers to this problem area. The project had a very active and target oriented communication and dissemination work. In the period 2003-2006 more than 200 articles have been published in newspapers and journals, and about 150 radio and TV interviews were broadcasted on the topic of climate change and that of getting prepared to face it. A decisive majority of these described the Project VAHAVA or mentioned it.

Among the publications and conferences of the Project VAHAVA the following may be mentioned:

- *Expert reports*: Representatives of various professional fields were invited to prepare studies on climate change related subjects. 50 studies of a total of 1700 pages were written.
- *The serial “AGRO-21”*: Eighteen volumes of this serial, focussing on climate change and the needed responses, were published with a total of 176 articles of 305 authors in these volumes. (The editor of the serial is *L. Csete*.)
- *The VAHAVA Hírlevél (Newsletter)*: Six of this coloured four-page newsletter, containing short communications, were published in 3 thousand copies each (editor: *M. Zágoni*). This newsletter reached wide cycles of decision makers.
- The book “*Climate Changes and the Horticulture in Hungary*” in Hungarian *(editors: L. Csete and J. Nyéki)*. This book attempts to describe the steps to be made in economic sectors prone to weather for getting prepared and adapted to the changes and the remedial actions for decreasing losses, with a view to save the market positions of these sectors.
- *Impacts and Responses in Central and Eastern European Countries. Conference Proceedings.* The international conference was organised by the Hungarian Academy of Sciences jointly with the Regional Environmental Centre of KvVM in Pécs, Hungary, in the period 5-8 November 2005. The size of these English language proceedings is 317 pages.
- *Preliminary summary report on Project VAHAVA.* This summary report was disseminated for the purpose for supporting regional expert discussions. The schedule of these meetings were as follows: Debrecen, 05 October 2005; Miskolc, 06 October 2005; Veszprém, 19 October 2005; Pécs, 20 October 2005; Szeged, 27 October 2005; Budapest, 16 November 2006. The preliminary summary report contained 57 pages. About 400 experts participated on the meetings and there were about 70 discussions.
- Publications of the closing conference (9 March 2006).
  - The preliminary report of the project was summarised in 66 pages.
  - In the panel discussions of the closing conference 12 well known experts presented their opinions on the climate change and the actions that are needed to prevent or counteract harmful impacts. The text of this panel discussion was published in Volume 48 of the series “AGRO-21” in 2006, in 83 pages.
  - There was a poster exhibition organised along with the closing conference. 150 posters were presented by Hungarian researchers on their results relating to the changes of the weather and the climate, on the impacts of these changes and on the options of responses. The poster documents have been edited into a CD version and published. It contains about 400 pages.
- *Conceptual basics of the National Strategy for Climate Change.* It is a summary publication of 38 pages made for supporting the professional and public discussions that were held in the main building of the Hungarian Academy of Sciences. The subjects and dates of these conferences were as follows: Infrastructure, architecture and environmental health, 28 September 2006; Agriculture, forestry and nature conservation, 12 October 2006; Proposals of non-governmental organisations, 25 October 2006; Flood, excess water, storms and droughts 06 November 2006; Youth

forum 23 November 2006. The total number of participants of these conferences was about 300 and there were about 50 discussions.

- *Professional conferences*. In addition to the above-mentioned forums of debate there were further 16 thematic conferences organised in the framework of the implementation of the project. The total number of participants was about 1200.
- *Documentary films*. A series of three popular-scientific documentary films of 30 minutes length each were produced (*L. Hollós*, producer and *M. Zágoni*, expert reporter). The films are presenting extreme weather events and discuss the preparatory activities needed for combating climate change.
- *The final report of VAHAVA*. The final report of the project, containing proposals and suggestions, has been published in a book format in February 2007. The book contains 220 pages.




**The cover page of the book on the Project VAHAVA**

## Experiences with the organisation of the project

Below we summarise those project organisation experiences that could be useful in other countries, when facing similar tasks:

- In the case of such a large and synthesising project like VAHAVA it is extremely important to gain the support of some leading politicians, government officials and respectful scientist. For this project we obtained the support of the President of the Committee for the Environment of the Parliament, the Head of the Ministry for the Environment and Water Management and of the President of the Hungarian Academy of Sciences.
- Guarantee for the financial support of the project should be obtained. In this respect the leaders of the Ministry for the Environment and Water Management and of the Hungarian Academy of Sciences made an agreement. During the three years of the project duration the VAHAVA got a total support of Euro 550 thousand. The costs of publications, dissemination materials and of the TV film were included in this sum.
- The personal participation of leading experts of climate change and of the combating of the impacts (of about 30 persons) had to be organised for the project implementation.
- The draft of the project’s work-plan has been discussed by 33 scientific committees of the Hungarian Academy of Sciences (separately). These committees covered a wide professional range, spanning from nature conservation to sociology, and secured large publicity from the beginning of the project.
- Existing, but so far hardly utilised, research results of a round 300 experts were built into this synthesising work. This was secured by personal motivation and interest.
- Active and constructive working relationships were developed with the leading green organisations (NGOs).
- A good collaboration with the media was established.
- A secretariat consisting of six active organising personnel was created.

## Implementation of the proposals of the project

The report of Project VAHAVA contained 30 important proposals. The most important of these was that the Parliament should adopt a National Climate Change Strategy, as a directive, for a period of 20-25 years. Next the Government shall develop a 2 years action programme for the implementation of the Strategy and inform the Parliament in each year on the implementation of the programme. This proposal has gained an ever-increasing political support from the members of the Parliament from both the government-side and the opposition. Eventually international events have also promoted this procedure (the 4th Assessment Report of IPCC, the Stern Report, the annual conferences of the UN Framework Convention on Climate Change and the decisions of the Commission of the European Union).

The Hungarian Parliament has, on the 29th of May 2007, univocally adopted the Act LX of 2007, which included provisions for the sake of meeting the country’s obligations under the Kyoto Protocol. This Act also specifies the need for developing a National Climate Change Strategy. Item 1 of paragraph 3 of the Law stated the followings: “The Parliament adopts a National Climate Change Strategy, which is dealing with the related objectives, measures, and priorities with special regard to the Hungarian research tasks concerning the processes and impacts of climate change, and to the determination of means for reducing the greenhouse gas emissions of the country and for getting prepared to handle the impacts of climate changes in Hungary.”

Item 3 of Paragraph 3 orders the following: “The Government adopts a National Climate Change Programme for the implementation of the National Climate Change Strategy and for complying with the related international obligations and for the need for adapting to the impacts of climate change. This programme cares for the determination of the reduction of emissions, dealing with the fulfilment of obligations related to the reductions and limitations of emissions and for the control and monitoring of expected results.”

The Climate Change Programme should be determined for periods of two years, taking the relevant EU programmes, policies and regulations into account. The Government reports annually to the Parliament on the implementation of the programme and on the experiences gained during the implementation. From the point of view of further research the following statements of item 4 of paragraph 3 of the Law are of special importance: the Climate Change Programme has the following important items, namely (i) compliance with the international obligations that regulate the decrease of greenhouse gas emissions; (ii) main measures of adapting to the impacts of climate change in Hungary; (iii) research priorities relating to the cost-efficient decrease of Hungarian emissions and to the determination of the climate change impacts in Hungary, including the means of financing these research activities.

The draft Strategy has been prepared by the staff of the Ministry for the Environment and Water Management (KvVM) and experts of the Project VAHAVA helped this work. The draft was subject to wide-scale social debate in the second half of the year 2007. The Hungarian Parliament unanimously adopted the Strategy in March 2008.

It should also be mentioned that based on the outcomes of the Project, a new strategic research initiative was adopted by the assembly of the Hungarian Academy of Sciences. It was entitled as “Environmental outlook: environmental and climate security”. Many experts took part in this endeavour, and the summary of their studies and basic recommendations has recently been published[19].

[19] Bozó L. (ed.), 2010: Environmental outlook: environmental and climate security. Hungarian Academy of Sci.

# 4. NATURE CONSERVATION AND THE CLIMATIC FACTORS

Hungary, like many other European countries is dominated by man modified landscapes. Natural self-sustaining ecosystems exist only in relatively isolated mosaics and the connection between these patches is steadily decreasing due to the anthropogenic impact. This makes them even more vulnerable and sensitive to the impacts of climate change.

According to one of the reports of a group of international scientists of the UN Hungary is one of the most vulnerable countries of the world in respect to the impacts of climate change on natural ecosystems and on biodiversity. While in other countries only some area fall into the category of high ecological vulnerability, in Hungary there are hardly any places that do not fall to this. In Europe situations worse than in Hungary are found only in Belgium.

The process of the rearrangement of ecosystems due to the changes of the climate results in vulnerable simplified communities and this opens a door to the immigration of the usually easily spreading invasive species.

Upon the climate's warming up a bit more than a few degrees the natural zones of the ecosystems will shift to such an extent, which will not allow the staying of the communities in their present form and on their present site. This situation is further aggravated when the transition is not gradual but rapid. If the climate changes substantially then the task of nature conservation organs must, in addition to their efforts of preservation, get prepared to accept some changes and the relating natural processes (migration of species, local extinction of some other ones and settlement of newly immigrated ones).

At the present state of the art the climate-change vulnerability of habitats can be assessed in the following way: The directly endangered habitats include the wetlands and/or the habitats of species that require cool microclimate (e.g. bogs, fens, marshlands, etc); Zonal forests and grasslands become vulnerable due to the changes of the species composition; Floodplains, sandy grasslands, forest-steppes are indirectly endangered by the forecasted further propagation of invasive species.

In Hungary the natural ecosystems will be subject to the following more important changes upon the impact of climate changes:

- Shifting of the border of vegetation zones.
- Rearrangement of biotic communities and food webs.
- Disappearance of native species, especially in isolated habitats.
- Decrease of biodiversity on the long term.
- Spreading of invasive species, appearance of new invasive species (spreading of pests, insects and weeds).
- Habitats become drier (wetland habitats disappear, sandy-dune habitats will be desertified).
- Functions of ecosystems will be damaged.
- Drying of soils, damage to the biological processes of the soils.
- Fire accidents become more frequent.

## Tasks of adaptation

The IPCC group dealing with climate impacts, vulnerability and adaptation has formulated, in respect to adaptation, the following aspects:

- The society has always been adapting to the impacts of the climate with preventive of defence actions, but the methods and techniques are outdated and locally isolated. Nevertheless these techniques should be considered as a starting point.
- The vulnerability of various regions of the globe depends not only on the risk of climate impacts, but also on the development level of those regions.
- The realisation of the objectives of sustainable development can make the countries more resistant to the impacts of the climate change.
- Actions of adaptation must not be antagonistic to the reduction of emissions of GHGs.
- The above listed aspects may help the formulation of both, the tasks of professions and those of horizontal actions.

The natural ecosystem adapts to the changes in two different ways: Owing to the self-sustaining and self-regulating capacities of the ecosystem it can adapt to the changing environment (autonomous adaptation), but human actions may also enhance the process of adaptation (planned adaptation). The major objective of the actions, formulated in the strategies, is to maintain and if possible enhance the natural adaptive capacities of the ecosystem. The mitigation of the harmful impacts of climate changes on the ecosystems can be best supported by improving the adaptation capacities of the habitats.

At the scale of the history of Earth the natural ecosystems had been exposed to climate changes also in the past. Nevertheless, the magnitude and rate of these changes were of natural character and the Globe was covered by natural ecosystems only, and this gave better chances to the populations of species for migration. The present situation is different.

The adaptation capacity of the biota depends basically on the state of its habitat. The more natural and more variable is the system (the more diverse its species composition and habitat) the more resilient is this biological system. Similarly important is the natural character of the immediate environment of the habitat (habitat mosaic). The variability and species richness of the habitat and the conditions of crossing the surrounding cultural landscape by the species of the mosaic habitats concerned are also important factors and therefore the maintenance and restoration of the natural connections between such mosaic habitats are also very important tasks.

The conventional economic evaluation approach cannot be really followed in the case of nature conservation. Our economic and social life is supported by limited natural resources and we enjoy the various benefits of the ecosystems (their services) without expressing these in monetary terms. Although there are certain methods available to assign financial data to benefits gained from ecosystem services, the exact calculation of the benefits and damages of the impacts of climate changes and of the strategies planned (damage prevention and mitigation) cannot be made in the case of nature conservation issues.

While under stable environmental conditions many species and their habitats can be preserved with a good chance by protecting natural areas of appropriate size, the situation is different under changing climate. In this situation the migration of species and the shifting of habitat borders are expected and conditions of the wider environment get larger importance. The major problem is that this wider environment is managed mostly by government sectors other than nature conservation. Therefore in the case of substantial changes of the climate (that has a good chance in the coming decades) the major task of preserving biodiversity is to integrate the aspects of nature conservation to each of the economic sectors. No successful adaptation strategy is possible without intersectoral cooperation and harmonised regulations. These will require mostly the successful completion of the ongoing programmes (the environmental programme of agriculture and forestry; forest management assuring continuous forest coverage; the Water Framework Directive of the EU, which is based on an ecological approach) and their further development towards the strengthening of the ecological aspects.

The tasks to be implemented can be sorted into two main groups:

Supporting in situ adaptation aiming at the preservation and enrichment of biodiversity and at the conservation of natural conditions (and not only in protected areas):

- *Nature conservation:* Establishment of the priority list of habitats and species, which are sensitive to climate changes; Protection of biological diversity at all levels (landscape, species, gene, etc.) and the regeneration of the natural diversity of the sites; Restoration of the water storage capabilities of wetland habitats and the planning of potential water supplementation means for these wetlands; Implementation of the reconstruction of the needed habitats and the continuation of these efforts; Maintenance of the heterogeneity and mosaic character of the habitats along with the maintenance of the various stages of succession; Introduction of management methods, which will decrease the expectable danger of the invasive species, aiming at management means that enhance the acceptable (least worse) colonisation processes; Supporting he monitoring of the processes that cause the impacts.
- *Water management:* Termination of the enforcement of drainage; Operation of reservoirs in such a way as to consider ecological aspects; Review of the legal procedure of issuing water consents (e.g. permits to use shallow and deep groundwater). Implementation of the complex system of water management, as required by the WFD of the EU, along with the consideration of requirements of nature conservation.
- *Forestry:* The possible widest application of forest management based on natural processes; The maintenance of continuous forest cover and the use of natural forest-renewal methods; The conversion of forests that are not suiting to the given habitat and contains non native tree species; Maintenance of non-closed canopy in the forest steppe zone; The best possible preservation of the diversity of forests (in terms of the landscape, habitat type, succession, species and gene), along with the preservation of natural values and processes; Assurance of buffer zones around the sensitive habitats.
- *Agriculture:* Reinvention and maintenance of traditional elements of land use and landscape management (cutting and harvesting the grass of meadows and/or grazing animals on them), establishment of buffer zone in the vicinity of sensitive areas. Promotion of less intensive land management techniques in sensitive areas and also in other places, in order to reduce environmental pressure, change of land use forms.

Measures to assure the better conditions for migrations around natural sites (with special regard to sites not yet protected):

- *Nature conservation:* Securing options for the migration of species between sites of natural fauna and flora; Evaluation of areas of various level of protection, and of the National Ecological Network, from the point of view of the changing climate and for identifying points of conflicts; Development of nature conservation sites and the sites of “Natura 2000” with the regular review of their borders so as to follow the displacement/migration of species and their communities.
- *Water management:* Ecologically concerned water management following the requirements of the Water Framework Directive of the EU; Restoration of the water storage capacities of the habitats and the development of options for potential water

supplementation. Efforts should be made to establish near natural water regime and water supply conditions with the meaning that the originally water-inundated and excess water ridden areas be returned to nature, in harmony with the respective parts of Hungary's new flood control plan called the VTT. Transforming the management of flood prone areas to those of the traditional and natural one (called the "fok management", the essence of which was the letting the flood to inundate the wetlands and other depressions, holding the water there, then slowly releasing it through narrow gates called "fok", thus assuring good hatching and catch of fish and the watering of grasslands to be grazed afterwards by the cattle), so as to increase the wetland area along the river.

- *Forestry:* Distinction in regulation between natural (semi natural) forests and tree plantations; Application of climate change oriented forest research results in the renewal of forests; Propagation of the forest management techniques that ensure continuous forest cover (as of the Pro Silva principle), and the reduction of areas where clear cutting is allowed; Afforestation of large areas using suitable native species; Creating a system of "protecting forest strips"; Increasing the area of pastures with trees in both the present forest ranges and in the forest steppe regions of the Great Plain (Alföld).
- *Agriculture:* Increasing the heterogeneity and mosaic character of agricultural landscape (ridges, hedges, alleys, smaller cultivated lots); Application of soil- and water saving technologies, promotion of extensive and ecological farming methods.
- *Traffic and transportation:* Consideration of nature conservation aspects in planning the routes of transportation corridors, enforcement of the relevant existing regulations; Creation of ecological passages (wild game passages) across main roads and motorways, using native species for planting the hedges and forest strips along these passages.

Horizontal tasks:

- Development of a climate policy of nature conservation and the harmonisation of this with those of the forestry, agriculture, power generation and water management:
  - realisation of the nature conservation aspects in the legal regulations and subsidizing mechanisms of other economic sectors;
  - harmonisation of the climate policy of nature conservation with the programmes of agriculture, forestry and environmental protection, and also with the implementation of the Water Framework Directive and the country-development programme;
  - incorporation of the ecological aspects of coping with climate changes (preservation of biological diversity) into general development plans and into the system of the permitting procedures of the relevant authorities. The system of tools to be developed for assuring sustainable land use shall also comply with these aspects.
- Establishment of an intersectoral climate policy consulting body to aid the development of adaptation strategies and to integrate them into all sectors concerned.
- Broadening the scientific basis of adaptation with the launching of new research programmes and the continuation of the relevant older ones in the field of identifying the ecological impacts of climate changes and in developing appropriate adaptation techniques.
- Raising the awareness of the problem in the society and the involvement of the widest possible circles of the citizens in making the decisions of the relevant measures and in the implementation of these measures.
- Establishment of a national monitoring network to follow the ecological changes caused by that of the climate and integrating this system into the relevant international networks.

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# 5. WATER MANAGEMENT AND CLIMATE CHANGE

Hungary is geographically located in such an area of the Carpathian Basin, which is prone to high risks of flooding, inland excess water inundation and drought. Following a nearly two decades long dryness and drought period, four highly dangerous floods passed through the Hungarian part of the River Tisza in the period 1998-2001. In 2006 there were two simultaneously occurring extreme floods in the Tisza and in the Danube. Due to the extreme weather conditions of the past years there were serious inland excess water damages and other locally occurring inundations. Excess water, a speciality of the Hungarian plains and flat lands, occurs when precipitation or snowmelt water cannot infiltrate into the soil (mostly due to semi-impermeable upper soil layer) and fills the depressions of the flat land. In Hungary the elimination of water-damages became a task of strategic importance in the past years, due to the increasing frequency of extreme events. One would need global or at least catchment basin based thinking for the design of regional and local strategies. Evidently bi- or multi-later international co-operation is needed for such an approach.

Flood and excess water fighting/control have great traditions in Hungary. In the past 150 years main-levees of a length of about 4200 km were built along the rivers. The height of the levees (the design flood level) was calculated as the hundred-year flood level (of 1% probability of occurrence) plus 1.0 metre safety height. The objective was to enhance the rapid passing of flood hydrographs without causing damages. In the case of floods exceeding the design flood level the opening of emergency storage reservoirs facilitated the reducing of flood peaks.

Flood levels have been considerably increased in the past decades. This was partly due to the weather's becoming more extreme and to the decreasing of the flow carrying capacity of the flood-channel. Anthropogenic impact on the catchment basin also contributed to increasing and flashier runoff. Further rising of the height of flood levees will not provide an efficient means of flood control.

Extreme weather events of the past years and the associated floods and droughts unambiguously indicated that the earlier water management practices couldn't be continued. Instead of the approach of "fighting the floods" the concept of "living with the floods" should be followed. Similar changes in the approach are needed in handling excess water and drought problems, which should be aimed at changing land uses and thus reducing the potential damage. Sufficient spaces should be secured for waters and as much water should be stored as possible, diverting these waters to places in water shortage. This new concept is reflected in the new flood control programme of the Government, called the "Further Development of the Vásárhelyi Plan (VTT)", as this programme is based not only on the flood defence actions, but also on minimizing the periods with water shortage by appropriate water storage and diversion techniques.

Upon the series of extreme floods of the 1990-ies over entire Europe and the high floods of the Danube and Elbe in 2002, the EU Commission under Dutch Presidency had decided in 2004, with expressive and accepted Hungarian support, to launch a programme on the flood risk management planning and actions. This programme was based on the document on the prevention of floods, flood protection and the best practices, which was compiled in 2003 with the support of the "water directors" of Norway, Switzerland, the EU member states and also with the support of the water directors of the candidate countries.

In the meantime, the development of the Sustainable Flood Control Action Programme was started, upon the initiative of Hungary in 2001, in the framework of the International Commission for the Protection of the Danube River. This programme was adopted by the ministerial meeting of the ICPDR in 2004. Implementation of this programme is under way and aimed at the development of flood control action plans for the sub-catchments (partial river basins).

The draft directive on flood control was issued in 2005 and has been adopted in 2007, while its implementation started in 2008. The objective of this directive is to reduce the risk of flooding and floods impact on human health, the environment and on economic activities. The directive gives only the frames of flood defence and control activities, while concrete measures and the details of the strategies remain the tasks of the Member States.

In Hungary the flood control development plan VTT concentrates on the improvement of flood security along the Tisza River, namely it plans to improve the flow carrying of the greater flood channel (e.g. of the flood plain) and the construction of emergency flood storage reservoirs.

Investigating the strategies needed for the improvement of the flow carrying of the greater flood channel a development schedule was made for the period 2004-2007, that contained the following technical measures:

- Cutting a flood carrying clearance, a corridor, within the floodplain, in the dense vegetation.
- Development of plans for restructuring, displacing or removing the so called “summer-dikes” of the floodplain (internal dikes protecting objects within the floodplain).
- Tasks related to channel forming sand bars.
- Constructing river training structures.
- Considerations related to the changing (displacement) of the main levees along the river, so as to broaden the flood channel, where needed.

The improvement of the flow-carrying capacity of the flood-channel should be made in association with nature conservation activities, with the revitalisation of the floodplain ecosystem. The measures have been implemented first in the downstream sections, within the southern country border and Szolnok and in the vicinity of the narrow channel upstream of the bridge at Tivadar. Results of a hydraulic investigation of the entire Hungarian Tisza section indicated that the measures to be applied on the floodplain will help achieving the desired objectives at the most critical upper and middle reaches of the Tisza, that is the returning to the channel conditions of the 1970-ies in the downstream reaches.

The plans of the emergency flood storage system if the Tisza Valley (floodplain reactivation with the help of controlled flood-peak release) was subject to investigations and it was found that the selection of reservoir sites was correct. According to the original plans the construction of five reservoir systems was contemplated for the period of 2004-2007, also utilizing EU funds.

In the case of a flood of 1000 years return period the five flood-peak storage reservoirs will be able to affect the entire Hungarian Tisza reach. The planned 60 cm reduction of the flood peak will be achieved both locally and also along the whole course of the river.

The reservoirs will be activated in each $30^{th}$ – $40^{th}$ year and the probability that all reservoirs will be filled simultaneously is less than 1%. When extreme flood, exceeding the design flood level, occurs and creates the risk of levee failure, the operation of the emergency reservoirs must be immediately started with the inlet of flows from the river. In order to achieve effective reduction of flood peaks the emergency flood storage reservoirs of the Upper Tisza should be filled for about 3-10 days and the total residence time (the period of inundation) is about one month. Flow release into the reservoirs of the Middle Tisza is continued for about 10-20 days and the residence time is also roughly a month.

Development of the so-called non-structural means of flood control is also an important task. To this category belong the organisational tasks, the monitoring network, the information systems, flood forecasting services and the infrastructure of flood defence activities (defence centres, roads, telecommunication, materials, defence- and localisation plans, etc.).

Flood forecasting is one of the most important parts of the non-structural means of flood defence, as they forecast the expectable flood situation along the river. The present flood forecasting system of Hungary has been developed in the period 1979-1986. Flood forecasts are being made at nearly each of the 12 water directorates (the KÖVIZIGs) of the country, while the forecasting centre, the National Flood-forecasting Service, is located at the “VITUKI Environmental and Water Management Research Institute” in Budapest. This Service makes continuous forecasts for 48 gauging stations even outside the flood periods. In the flood periods, in the period of flood preparedness, the KÖVÍZIGs and VITUKI make flood forecasts together for about 130 gauging stations.

The lead-time and reliability of hydrological forecasts have been considerably improved as a result of the research/development project Forecast 2000. At the present forecasts are made with 6 days lead-time, thanking also the highly improved meteorological forecasts that are needed as inputs to the hydrological forecasting models. Forecasts are also available on the Internet along with the maps of the hydrometeorological parameters that induce the flooding events (precipitation, temperature, snow condition, etc.).

International co-operation is unconditionally needed for the successful prevention of water damages in the Tisza River Basin, shared by five countries. In Hungary the issues of transboundary water management are regulated by bi-lateral agreements between neighbouring countries and in the Tisza Basin also by a five-sided co-operation called the Tisza-Forum.

An example of the effective and successful international co-operation was when Hungary gave assistance to Ukraine and Romania at time of the series of flood catastrophes of the past years in these countries.

In Hungary one of the basic piers of creating safety against the damages of water is the provision of flood-safety. The second pier is the defence against excess inland water, also in harmony with flood defence operations. The actual tasks in this context include the development of more cost-efficient and ecologically more concerned excess water defence methods. Water-environmental and agricultural ministries are working jointly on this R&D programme.

After flood and excess water defence then next task of water-damage prevention is the securing safety against local water damages. They occur mostly due to heavy but local rainstorm that will cause high runoff, which results in high floods of local, usually small, streams, inundating villages, washing away the dams of small reservoirs, etc. High erosion or even mud avalanches may also be the result of such extreme local weather events.

Local water damages should be prevented and this needs a nation wide programme, as such damages may occur at any point of the country. Characteristically they concern 1-2 settlements, but the probability of occurrence is not known, cannot be calculated. For forecasting and timely information of the population concerned there is need for the co-operation of several ministries (environmental, water, agricultural, economy, etc.) and organisations (such as meteorological service, catastrophe prevention organisation, environmental and water directorates, local governments, etc.) and therefore a government resolution was needed for the implementation of this complex programme.

In order to reduce the risk and damages that may be caused to human life and properties by catastrophes induced by extreme weather events, a government resolution was released and this ordered the establishment and operation of forecasting-warning system of emergency situations that may be caused by extreme precipitation events.

The solution of the management and drainage of the excess- and precipitation waters of settlements became a task that cannot be postponed. Planned management and control strategies are needed for this development work, especially in settlements where excess and precipitation waters create increasingly dangerous situations. Local water damage events of the past years indicate that the most vulnerable locations are the settlements of the Northern Middle-Mountain Ranges – mainly in the mountains Mátra, Cserehát, Zempléni and in the valley of the River Hernád. Storm-water storage options must be surveyed, also utilizing the analysis of meteorological data, and on the long term this must also be made for the flatland regions.

Drainage of the precipitation waters of settlements is the task of the local governments. Nevertheless, the resources of local governments are insufficient for the construction of storm-water storage reservoirs that could lessen the danger of inundation. Therefore appropriate financial support of local government, by expanding the by tender-available financial frames, is needed. At the present only decentralized “targeted subsidies” are available for such investments. In developing the tendering system for this purpose the settlements that are prone to local water damages need to have priorities. A ranking system is needed, which should be based on professional surveys and justification. The annual number of bids submitted to get support for urban water management are ten times as many and their monetary magnitude is fifty times higher than the available resources. Due to this magnitude, the development tasks can only be performed within the frames of a long-term programme.

The development of the forecast of precipitation and the establishment of a warning/alarm system is a very important element of the system of the prevention of water damages, and can be independently implemented even on the short term. Therefore this development should be increasingly supported.

In Hungary drought is also a serious problem, sometimes in the same place and in the same year where and when excess water and/or flood inundation occurs. It is relatively uncertain what is the definition of drought, unlike flood or excess water. The relevant literature gives several definitions, but each of them refers to lower than average precipitation and its impact on agriculture, water resources and on socio-economic activities. One of the most recent definitions, that also consider the guidelines of the World Meteorological Organisation (WMO), states that drought is a water shortage that substantially exceeds earlier general (or usual) shortages.

In Hungary there were always heavy drought periods that had tragic outcomes several times. There were a series of drought years in among the first years of the 21st Century. Among them 2003 needs special attention. In this year low precipitation was associated with high temperatures: the number of heat-days, when the maximum temperature exceeds 30°C was 45 in national average and this was breaking earlier records. Damage done to the agriculture in this year by drought was estimated to amount to 50–55 billion HUF.

Damages done to agriculture in the past decade by drought and the assumed increase of the probability of the occurrence of drought years, due to climate changes, makes the development of a “drought strategy, and urgent and justified task.

The objective of drought strategy is to define and create a system that consists of the terms, methods, steps and resources that need to be utilised in the fight against drought by the responsible decision makers of the society. This shall also focus on preventive actions and on the decreasing of the probability of drought, on the preserving of the available water resources and also on alleviation of damages caused by drought and on the tolerability of drought impacts. This strategy provides the basis for the development of short-term action programmes. The basic principles of drought strategy are: prevention, integration and water management that are based on habitats.

Considering internationally observed trends one has to be prepared, in the field of water management, to face alternating and more frequently occurring abundance and lack of water. In water management and in governing flows more concern should be given to the establishment of water storage facilities (with the least possible cost). This should include: storage of precipitation waters, river waters, construction of small and medium size reservoirs and securing of the options of water diversion among regions of differing climate. Harmonisation of the activities of various economic sectors is also needed.

Irrigation needs special attention, as this is the best means of reducing drought damages. New complex agricultural water management programmes should be developed (combining irrigation, fishery and excess inland water management).

Although Hungary is rich in both surface and subsurface waters, the protection of water resources is a real challenge, considering the geographical location of the country.

The frames of the protection and sustainable use of waters is given by the Water Framework Directive (WFD) of the EU, which sets new requirements in respect to the former Hungarian and European practices of water management. The most important objective of the WFD is the reaching of the good status of waters by 2015, in respect to chemical and ecological parameters of the surface waters and in respect to quantities and chemical quality of subsurface waters. The “good status”, as of WFD, does not only means the cleanliness of waters, but also the reaching of the possible most natural conditions of aquatic habitats and the provision of appropriate quantities of water. Consequently in addition to the protection of the quality of waters, to the reduction of pollutant loads into waters, one need to ensure the protection of the quantity of water, that is the enforcing of rational and sparing uses of waters.

In reaching these objectives the river basin or catchment management concept must get a special emphasis. Hungary belongs to the Danube Basin, which is shared by 19 countries and 95% of our surface waters arrive from abroad and therefore the river basin management concept requires the close co-operation of the countries concerned. The international harmonisation of activities means several advantages to Hungary, but evidently also represents obligations. An advantage is, for example, that upstream countries are required to reduce the pollution loads into surface waters, but the same obligation requires Hungary to do the same for the interest of downstream countries.

Further expectations of the WFD relate to the complex analysis of the effects of all management strategies, the wider application of economic means, information of all interested parties and the achieving of their support for the contemplated strategies. In compliance with these expectations the good ecological state of waters must be achieved by the harmonized measures of flood and excess water control, development of settlements, including sewage treatment, drinking water supply and the development of inland navigation. Harmonisation of various development plans can only be achieved by involving all interest groups, all stakeholders (industrial, agricultural and other water users, environmental organisations, etc.) in the planning process of control measures.

On the basis of our present knowledge it is difficult to assess the impacts of global climate changes on the frequency of occurrence of flood events. It is especially difficult to plan the flood control strategies of smaller streams, as their floods are induced mostly by large rainfalls of smaller spatial extent, for which the various climate change models give no forecasts or estimates. In our larger rivers where the high floods occur mostly upon the joint effects of snowmelt and rainfall the peak flood levels may be rising and may occur at earlier point of time than nowadays.

The long-term strategies of managing excess waters will not be basically changed by the changing climate. We will have to get prepared for the occurrence of extreme excess water inundations in the end of the winter and early spring also in the future. The control of excess waters will be much more affected by the changes of land use and therefore the planning of excess water control and the development of land uses must be closely harmonised.

It is highly probable that climate change will affect the high flows of the rivers to some extent, but it cannot yet be justified that these changes will be dominating. Another two affecting factors are the anthropogenic changes on the catchment and the occurrence of weather situations that have not yet been recorded. Therefore the level of flood protection must be anyway increased. It is highly probable that more and more extreme floods will occur, although their time of occurrence cannot be assessed. Technical and organisational means and their combinations can assure protection against water damages.

In the summer of 2002 the organisation of water management has been changed. The *Ministry for the Environment and Water Management* was established, re-uniting after 12 years of separation the organisations of water management, environmental protection and nature conservation.

The General Directorate of Environmental Protection and Water Management provides a continuous day-and-night duty for handling events of flood, excess water, and water pollution and orders various levels of preparedness and releases warning or alarm messages to organs or parties that are authorized for control or defence actions, when so required by the relevant guide-books.

Flood and excess water control and defence actions, falling under the compliance of the ministry, have been performed by the organisations of water management at high level, during the extreme flood situations of the past years, providing professional aid also to neighbouring countries.

# 6. AGRICULTURE, SOIL MANAGEMENT AND CLIMATE CHANGE

Agriculture is one of the fields that are highly affected by climate change. Amount and distribution of precipitation, anomalies and extremities of temperature as well as various manifestation of air movement from standstill to storms are some of the main factors that may influence agriculture. The climate has not been constant. It has gone through dramatic past changes, but there is increasing evidence that human activities are altering our climate at an unprecedented rate. Global climate change is one of the major issues today. A continuous rise in temperature escorted by the increasing frequencies of weather anomalies is observed.

There are some doubts and uncertainties concerning the nature of global climate change. However there are some facts all scientists and experts agree in. First of all there is an evidence of global temperature change, which has a measurable magnitude and an observed ascending trend during the past centuries. Another fact is the rapid rise of atmospheric $CO_2$ concentrations. There are also fields like climatic variability, weather cycles, environmental, economic and social impacts, or the anthropogenic causes of the changes, which are subject of further studies yet. In case of Hungary two facts can be observed in the Carpathian basin.


*Fig. 1.* **The Carpathian basin**

In first place the ascending levels of temperature rise, with a magnitude of 1°C. The other one is the decreasing trend of annual precipitation: during one century 83 mm rainfall has “disappeared”. Human activities are significantly altering the natural carbon cycle. During the past two centuries human activities such as the burning of fossil fuels and deforestation have accelerated, and both have contributed to a long-term rise in atmospheric $CO_2$.

Hungary is a country in the centre of Europe with a most peculiar geographic location regarding the possible impacts of any sort of climatic changes *(Fig. 1)*. The climate of the region has always been highly variable. Extreme meteorological events, especially droughts, water loggings and floods, frost damages, local deluges, storms, as well as hailstorms frequently afflicted agriculture and other branches of the national economy.

*Main climatic characteristics*

| | |
|---|---|
| Annual precipitation | 580 mm |
| Annual mean temperature | 11°C |
| Altitude | 78-1014 m |
| Heat amount in vegetation period | 1280-1465°C |
| Dry matter production | 8.3-17.6 t/ha/year |
| Photosynthetic active radiation | 1518-1612 MJ/$m^2$ |
| Annual snow coverage | 41 days/year |

Expert teams of various fields of agriculture started their work from 2003. The main task of this work was to study climate change impacts and possible responses in the respective fields. The working hypotheses of the project were as follows: (i) the warming of the climate will be stronger in the Carpathian Basin; (ii) we may expect the decrease of annual average precipitation; (iii) the number and intensity of extreme weather events will be increasing. As a result of these studies, important conclusions have been drawn and many recommendations have also been formulated.

## Basic results and recommendations

1. Climate change impacts in crop production can be prevented or reduced by the following measures: water preserving soil tillage that may contribute to storage of higher amounts of annual precipitation; increment of irrigation; novel crop production technologies; breeding and use of drought tolerant crop varieties; establishment of appropriate cropping structures and crop rotations.
2. Water supply of crop production involves three major sources: (i) annual precipitation in rainfed cropping depending on the amount and distribution as well as the preservation and storage of that; (ii) irrigated cropping where rainfall is considered as additional or modifying means of water supply only; and (iii) flood irrigation systems that are mainly independent from precipitation impacts. In favour of preventing harmful climate change impacts the two latter cropping systems should be given priority in the future *(Fig. 2, Fig. 3)*.
3. Climate change impacts may have an influence on the trends of temperature as well as on the vegetation period of various field crops. Ascending levels of temperature induce alterations in the physiological requirements of heat amount. This may result in a change of duration of crop variety, vegetation periods, and also, there is a chance for alterations in yielding ability, winter hardiness, phenological phases etc.

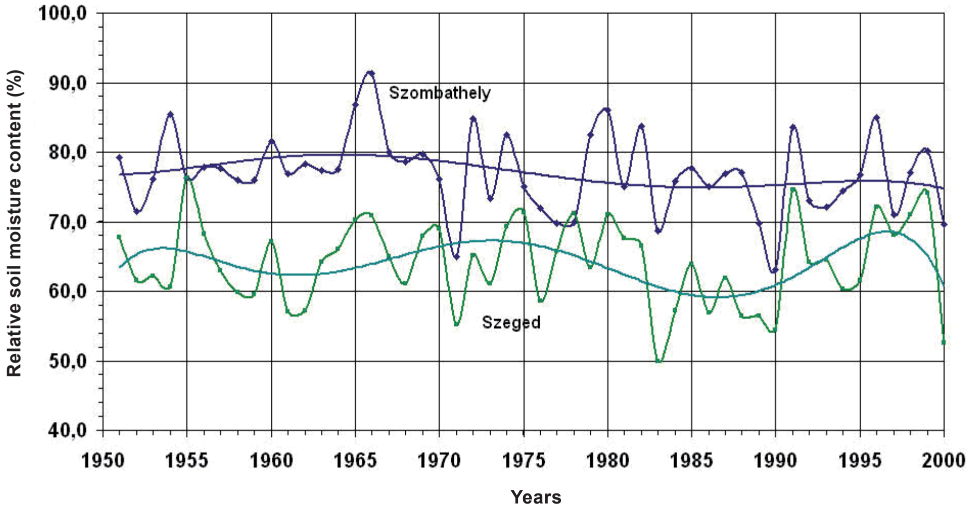


*Fig. 2.* **Annual changes in soil moisture content**
(source Varga-Haszonits 2007)

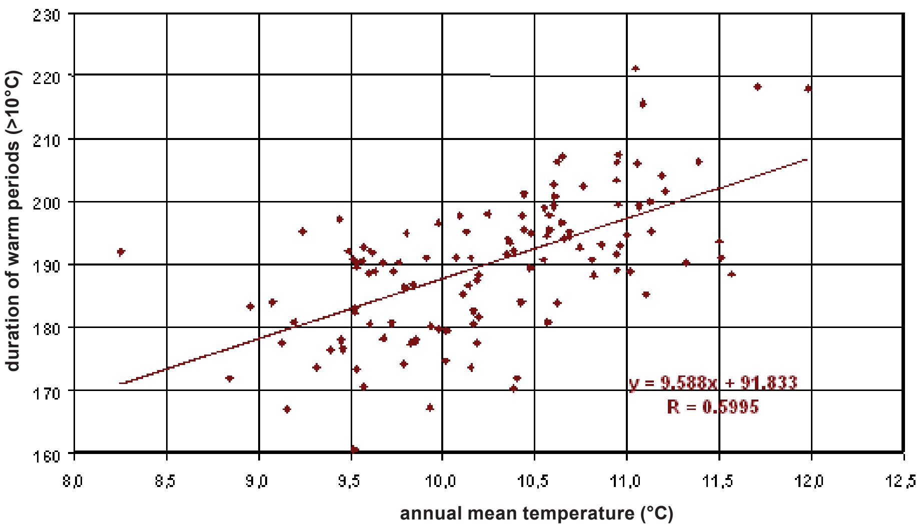


*Fig. 3.* **Correlation between the annual mean temperature and the duration of warm periods (>10°C)**
(source Varga-Haszonits 2007)

4. Warming and drying may have an effect on plant nutrition. In general there is scientific evidence that high levels of mineral fertilization may counteract the harmful effects of drought. In particular there are several crop species that may respond with yield declines in case of permanent drought. Abundant nutrient supply may result in higher concentrations that may be less beneficial to crop performance. Optimal soil conditions are required for better crop plant development.

5. Abiotic stress resistance of wheat varieties is a major issue in Hungary. The major task of plant breeding is to provide high yielding wheat varieties of marketable quality that are less susceptible to climate change impacts. Any variety has to meet a threefold demand: grain quality, quantity and yield stability.

6. Seed production is a field where climate change impacts may have both positive and negative effects. Arid conditions and weather extremities may risk the results of seed production and processing. On the other hand climate change may contribute to favourable conditions that is essential for producing seed of new species and varieties.

7. Agricultural mechanization is facing six new challenges induced by climate change. They are as follows: (i) technology improvements (water preserving tillage technologies); (ii) combined or reduced number of field operations (to prevent or lessen unfavourable soil conditions); (iii) more quick, flexible and efficient machinery (for less time consuming agrotechnically optimal operations); (iv) security equipments (installation of special machinery for emergency uses only); (v) propagation of tram line production systems; (vi) low pressure wheel machinery (use of caterpillars, and reduced side wall tyres). Agricultural mechanization may have a major role in mitigation processes, like $CO_2$ emission control and carbon sequestration. Specific tillage technologies, mulching and appropriate stubble operations may contribute to a better soil water budget.

8. Plant protection is highly affected by climate change. There is an invasion of new plant diseases, insect pests and weed species. To counteract the harmful effects improved methods of prevention, defence and remediation are needed. The major fields of that are as follows: comprehensive and efficient forecasting systems, extension services, integrated pest management, application of high tech implements, site specific precision methods. Genetic resistance and/or tolerance of crop plants have to be improved by breeding. Means of biological control has to be studied and applied.

9. Animal husbandry is exposed to climate change impacts regarding two aspects: one is the uncertainty of and anomalies in water supply that may affect livestock, fodder, pastures, and the economic pressure, what is manifested in technology failures, husbandry methods and measures, quantity and quality of animal products. According to economic forecasts predict stability regarding dairy and beef cattle, a further reduction in pigs, what may be recovered by strong investments only. Poultry, especially broilers may provide a new challenge. There will be no, or only minor improvement in egg production. New fields and novel methods are to be applied (turkey boom, other new poultry species, etc). Cost effective techniques are to be established.

10. Animal nutrition is influenced in various ways. Animal husbandry based on the use of grain crops is less sensitive to climate changes. Other means of nutrition, like hay, silage, fresh food, grazing based husbandries are more sensitive. Weather anomalies and uncertainties may have severe economic impacts on the fodder and feed market. Sufficient grain storage facilities, improved granary techniques, fodder quality preservation may provide prevention. A new specific aspect of this field is the rapid development in the renewable energy industry; biodiesel and bioethanol production, which may be beneficial regarding the use of surpluses, but may induce fodder and alimentary risks at the same time.

11. Trends in warming and direct and indirect effects of that may cause rise in the production costs of animal husbandry. Plants, buildings, sheds and their installation, improved insulation, ventilation, adaptation of pastures, afforestation in surroundings of animal plants are the major fields of preventing climate change effects. Special emphasis should be given to efficient and secure water supply. Temperature rise may also have an impact on handling of by-products, manure, sewage, slurry and sludge. Biogas plants can be one of the technical solutions for counteracting animal husbandry borne GHG emissions like $CO_2$, $N_2O$, and $CH_4$.

12. Veterinary aspects of climate change are manifold. Epidemics, their control and the condition of livestock are the main aspects of prevention. New parasite species and diseases as well as new or modified vectors in spreading of them represent new challenges for veterinary measures. The most important task is the preparation of veterinary services for efficient handling of climate change induced problems.

13. Fisheries. In Hungary there are several freshwater, lake and pond fisheries covering some 130,000 ha. Climate change impacts may have a direct deteriorating effect on the amount and quality of water as well as on the biological characteristics of fish habitats. Fish production, husbandry, processing, transport and storage are the main fields of protection.

14. A most peculiar field of agriculture is the grassland and pasture management. In Hungary over 1.1 million hectares of grasslands are exposed to climate change impacts, but on the other hand provide new adaptation chances for agriculture and for the country as a whole.

In horticulture five fields have been studied.

1. *Pomology.* Fruit production has always been exposed to weather extremities in Hungary. Drought and frost damages are of special importance. In accordance with the ascending temperatures and dryer conditions the probability of production risk in the field of frost damages and hailstorms may increase with about 50%. The production safety of fruit species is rather diverse; cherry, walnut, plum and apple will be less endangered in the future in comparison with other species. The major fields of prevention are the production site optimalisation, the use of ecotolerant varieties, appropriate plant protection, irrigation, hail storm prevention, and improved management practices.

2. *Viticulture.* Climate change impacts may result in a northward extension of grape production geographic zones. The higher frequency of weather anomalies may have negative impacts as well. Frost, drought, rot damages and the reduction of the length of plant life, as well as deterioration in wine quality can be the main forms of harm. To counteract negative climatic effects there is a need to change the varietal structure in viticulture. Also, new technologies and management techniques are needed in the field of irrigation, plant protection, phytotechnical operations, and wine processing and storage.

3. *Vegetables.* There are 15-20 species in vegetable production by now, and the number of them may be twofold in the near future with the increment of pre- and secondary cropping. The biological requirements of vegetables are extremely diverse regarding temperature and water supply. Cultivation of heat tolerant species – red pepper, tomato, cucumber, watermelon and sweet corn has been developed during the past decades. The production of cold tolerant vegetables – green peas, cabbages – has been stable in the same period. Climate change impacts may be prevented or reduced by the use of improved growing facilities, green houses, folies, irrigation techniques, plant nutrition, ridge tillage etc.

4. *Medicinal and aromatic herbs* are highly affected by climate change impacts. There are some 180-200 medicinal and aromatic herbs produced and/or collected in this country. Collected natural species are more vulnerable regarding unfavourable impacts. These species

have rather diverse responses; there may be alterations in the quantity and quality of specific substances, and in the amount of biomass as well.

5. *Ornamental plants*. The main task of plant breeding is to improve drought tolerance, disease resistance and permanent flowering. In general those ornamental plants may have a perspective, that are less susceptible to weather extremities.

## Further research results

Weeds increase the yield loss in the dry periods caused by the global climate change Eight of the ten most important weeds in the Carpathian basin have $C_4$-type photosynthesis. These species (*Amaranthus* spp., *Sorghum halepense*, *Echinochloa crus-galli*, *Panicum* spp., *Cynodon dactylon*, *Portulaca oleracea*, etc.) are capable of effective photosynthesis and water utilisation even in high temperature and dryness, when the stomata are closed.

The spread of western corn rootworm (*Diabrotica virgifera virgifera*) is much influenced by climatic conditions. This insect was brought to Europe during the Yugoslav war in 1992 to the Belgrade airport from where huge tracts of Eastern Europe were then occupied. The very peculiar year of 1999 when spring drought was followed by moist summer allowed a 150 km distance migration. The insect pest has been present over the whole territory of the Carpathian basin by 2006.

The negative effects of climate change can be limited by changes in crops and crop varieties, improved water-management and irrigation systems, adapted planting schedules and tillage practices, and better watershed management and land-use planning. Deforestation processes should be stopped, and deforested areas are to be converted into vegetation complexes or arable systems of $CO_2$ sink pattern. The global potential of carbon sequestration through management practices may offset one-fourth to one-third of the annual increase in atmospheric $CO_2$.

The cropping structure of the region has been highly influenced by a range of political and administrative issues. Investment into the alternative energy sectors has been encouraged focusing mainly on bioethanol and biodiesel and partly on other fields of biomass production. In our research agronomic use of 24 potential energy crops have been studied (grain crops, legumes, oil seed crops, root and tuber crops and energy grasses). The possible production area and the regional distribution have been identified. In grain ethanol trials maize genotypes x agrotechnical interactions have been studied. Energy conversion and cost-benefit relations were evaluated and found to be rather diverse. Cost-benefit calculations suggest, that renewable energy in most cases has a negative turnover in comparison with fossil fuels regarding net prices of the period examined.

Energy cropping side effects have been examined. The problems of any of these fields are manifold: low energy conversion efficiency (1:1 to 1:6 maximum); economic losses in comparison with conventional energy sources (fossil fuels, nuclear power, etc); deterioration of environment by abusing organic matter cycles; exploitation of natural resources; lack of sustainable long term vertical and horizontal technology structures; uncertainties in industrial by-product outputs and technology side effects. Counteracting of food security while producing energy crops on areas dedicated to food supply or when alimentary crops or edible grain yields are converted into biofuels.

Soil factors highly influence the life of plants. Soil structure is composed by its ingredients, i.e. organic and inorganic components, their amount, size, distribution and geometrical orientation. The latter of soil particles determine the soil texture. Soil is a medium providing water and nutrients to plants. At this geographic latitude plants require 250-400 g of water

| | % | clod: ≤ 10%, crumb: ~80%, dust: ≤ 10% | clod: 10-20%, crumb: 50-70%, dust: 10-20% | clod: 10-20%, crumb: 30-50%, dust: 30-50% | clod: 20-30%, crumb: ~30%, dust: 30-50% |
|---|---|---|---|---|---|
| Ration of soil aggregates (clod-crumb-dust) | 10 | | | | |
| | 20 | | | | |
| | 30 | | | | |
| | 40 | | | | |
| | 50 | | | | |
| | 60 | | | | |
| | 70 | | | | |
| | 80 | | | | |
| | 90 | | | | |
| | 100 | | | | |
| Soil sensitivity | | mild | mild-medium | medium-strong | strong |
| Harmful climate impact | | weak | medium | strong | very strong |

*Fig. 4.* **Agronomic value of soil conditions (source: Birkás, 2007)**

to build 1 g of dry matter. Since cultivated plants produce far more dry matter compared to natural vegetation, consequently their water demand is higher as well. From an aspect of soil management water storage and supply abilities of soils of a certain field should be determined. A model of soil sensitivity in relation with climate impacts is presented in *Fig. 4.*

In Hungary fertile soil of arable land is one of the most valuable, potentially renewable, natural resources. Rational and sustainable use and the protection of the conditions and the multiple functions of this resource are the basic tasks of the protection of the environment and of the production of biomass and thus these are the basic elements of sustainable development and of the common interest of the society. In terms of climate policy and within this in terms of the adaptation strategies the most important function of the soil is its water household property because the soil is Hungary's natural water reservoir of the largest water storage capacity.

Consequently the preservation and improvement of the water holding capacity of the soils are the important factors of the adaptation to the changes of the climate, along with the use of proper soil cultivation and conservation techniques, including the use of organic manure. The value of the soil is defined more and more by the water resource it contains instead of other parameters of soil fertility.

Water erosion may occur in increasingly extreme forms due to the changes of the climate. This means that due to increasing forces of rainfall and of runoff water endangers the soil and objective oriented water management techniques are required for counteracting erosion. Overall data indicate that the erosion damages are observable on 2.3 million hectares (that is about 25% of the country's territory). Protection against erosion enhances the preservation of the quality and quantity of the soil. Therefore the mitigation of the harmful effects of water erosion also belongs to the means of adaptation strategies, actually of the preventive strategies. Protective soil cultivation, appropriate crop rotation and perennial sods play important role in soil conservation. Prevention involves three types of tasks:

- Soil cultivation techniques, which enhance the infiltration of precipitation water into the soil.
- Coverage of the soil surface (mulching) in periods out of the growing season in order to avoid erosion, maintenance of soil texture and the preservation of soil properties that enhance cultivation.

- Provision of obstacles to runoff water, keeping precipitation where it falls in a growing season, with various tillage techniques and soil formations (ridges and protective strips formed with stubble worked into the soil).

The characteristics of soil usage aimed at decreasing the damages of the changing climate can be summarized as follows:

- Protection of the favourable physical and biological conditions of the soil as an environmental element.
- Protection and improvement of the qualitative properties of the soil (organic content, crumbly and loose structure, water content) with appropriate cultivation techniques.
- Avoidance of soil use, which results in the degradation of the soil (compaction, dust- and clod formation) and, when damage occurs, the carrying out of measures that improves the degraded soil.
- Keeping the favourable biological effects of the crop sequence with protective cultivation and the improving of the favourable effect of protective cultivation with the biological effects of the crop.
- Forming the state of the soil surface and the root zone, in a given year, as required by the impacts of the climate (damage mitigation and increasing the security of harvest).
- Preserving the useful biological properties of the soil, by the harmony of the appropriate sequence of crop and nutrient supply.
- Integrated plant protection with soil conservation techniques, mulching and appropriate crop rotation.

# 7. SOIL FUNCTIONS, SOIL MANAGEMENT AND THE CLIMATIC FACTORS

Soil represents a considerable part of the natural resources, consequently, rational land use and soil management – guaranteeing normal soil functions – are important elements of sustainable development, having special importance both in the national economy (rural development, agriculture) and in environment protection. Soils are the most important conditionally renewable natural resources in the Carpathian Basin, with three specific/unique characteristics:

- fertility/productivity: soils can satisfy, to a certain extent, the main ecological requirement of living organisms (biota, natural vegetation, cultivated crops);
- resilience: soil may recover (renew) from various disturbances, natural or human-induced stresses;
- multifunctionality: ability of multipurpose.

The main soil functions are as follows[20]:

- Soils are the most significant – conditionally renewable – natural resources. During *rational* biomass production they do not change irreversibly, their quality does not decrease unavoidably and fundamentally, but their "renewal", based on *soil resilience* does not happen automatically. Soil conservation, the maintenance and increase of soil fertility require permanent activities, such as rational land use, proper agro-technique, and in some cases remediation, reclamation or amelioration.
- Soil is a reactor and transformer. It integrates the influences of other natural resources, such as solar radiation, atmosphere, surface and subsurface waters, deeper geological strata and biological resources. Their biogeochemical cycles develop a "life medium" for microbiological activities, and create ecological environment (standort, landsite) for natural vegetation and cultivated crops.
- Soil is the most important medium for biomass production (food, fodder, industrial raw material, alternative energy). Soil, as a four-dimensional [*spatial* (horizontal and vertical) variability and *temporal* dynamism], three- (or four-) phase, polydisperse system can simultaneously satisfy – to a certain extent – the ecological requirements (air, water and nutrient supply) of living organisms, the natural vegetation and cultivated crops. This special ability is the unique soil property: *soil fertility,* which varies greatly and has changed considerably depending on natural factors and human activities. Soil is the primary food source of the biosphere, the starting point of the food chain.
- Soils represent a major natural storage capacity of heat, water, plant nutrients and – in some special, well-controlled cases – wastes and other compounds. The stored water and plant nutrients ensure the continuous water and nutrient supply of plants (satisfying their uptake dynamics) for shorter or longer periods without any additional supply (rain, irrigation, nutrient application). This soil function is the basis of favourable soil moisture regime (preventing or moderating extreme hydrological situations as flood, water-logging, over-moistening vs. drought) and sustainable plant.

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[20] Várallyay Gy., 2003: Role of soil multifunctionality in future sustainable agricultural development. Acta Agronomica Hung. 51(1) 109-124

- Soils represent a high capacity buffer medium of the biosphere, which, within certain limits, may moderate the various stresses caused by environmental factors[21] (extreme temperature and atmospheric precipitation pattern; extreme hydrological events: floods, waterlogging – droughts) and/or human activities (high input, fully-mechanized and chemically controlled crop production; liquid manure from large-scale livestock farms; wastes and waste waters originating from industry, transport, urban and rural development, etc.). Buffer systems have strict limits and boundary conditions. Sometimes this is forgotten by the "users", which leads to serious environmental problems. To prevent and avoid unfavourable side-effects, the *tolerance limits* must be identified, precisely determined, quantified and evaluated. This requires comprehensive sensitivity (susceptibility, vulnerability) studies and impact analyses.
- Soil is an efficient "natural filter" and detoxication system that may prevent the deeper horizons and the subsurface waters from becoming contaminated by various pollutants deposited on the soil surface or put into the soil.
- Soil is a significant gene reservoir of the biosphere and thus an important element of biodiversity. A considerable proportion of living organisms live in or on the soil or are closely related to (sometimes depending on) the soil.
- Soil is the conservator of natural and human heritages.

These functions are all equally important, but society has used them in different ways (rate, method, efficiency) throughout history, depending on the given natural conditions and socio-economic circumstances. In many cases the character (territorial and temporal variabilities, changeability–stability–controllability, boundary conditions, limitations) of a certain function was not (properly or adequately) taken into consideration during the utilization of soil resources. In such cases the misguided management resulted in over-exploitation, decreasing the efficiency of one or more soil functions, and – above a certain limit – causing serious environmental deterioration or even catastrophic events.

**Limited water resources – extreme moisture regime**

The natural conditions of the Carpathian Basin are generally favourable for rainfed biomass production. These conditions, however, show extremely high, irregular, consequently hardly predictable spatial and temporal variability, often extremes, and sensitively react to various natural or human-induced stresses. According to the meteorological-hydrological-ecological forecasts the risk, probability, frequency, duration and intensity of extreme meteorological (thunderstorms, high intensity rains, hail) and hydrological (floods, waterlogging, over-moistening vs. droughts) events will be increasing in the future and their unfavourable economical, ecological and social consequences will be more and more serious, sometimes catastrophic.

The frequent, serious, irregular and hardly predictable extreme meteorological events are and will be the most influential consequences of climate change. The annual precipitation will not be more in the future and its unfavourable high spatial and time variability is expected to increase. The growing risk and frequency of high intensity rains is also forecasted.

Under such environmental conditions it is an important fact that soil is the largest potential natural water reservoir (water storage capacity). The 0–100 cm soil layer potentially may store more than half of the average annual 500–600 mm precipitation. About 50% of it is "available moisture content".

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21 Várallyay Gy., 2008: A talaj szerepe a csapadék-szélsőségek kedvezőtlen hatásainak mérséklésében. "KLÍMA-21" Füzetek. 52. 57–72.

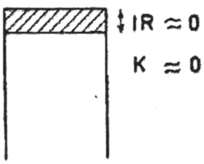
This favourable fact is quite contrary with the high and increasing risk, hazard, frequency and duration of extreme hydrological events (flood, waterlogging, over-moistening vs. drought) sometimes in the same place in the same year.

What are the main reasons of this "huge water storage capacity" – "extreme moisture situation" contradiction? The huge potential water storage capacity is not (or only partly) utilized because of the following reasons (these factors are illustrated on *Fig. 1*):

- The pore space is not "empty": it is filled up to a certain extent by a previous source of water (rain, melted snow, capillary transport from groundwater, irrigation etc.): "filled bottle effect".
- The infiltration of water (rain, melted snow) into the soil is prevented by the frozen topsoil: "frozen bottle effect".
- The infiltration is prevented or reduced by a nearly impermeable soil layer on, or near to the soil surface: "closed bottle effect".
- The water retention of soil is poor and the infiltrated water is not stored in the soil, it only percolates through the soil profile: "leaking bottle effect".

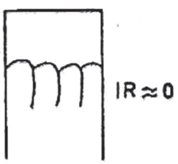
1. Limited infiltration

A. Impermeable layer (crust ) on the soil surface




a) cemented by salts
– Na salts
– gypsum
b) compacted by improper soil management
over-tillage, heavy machinery
– improper irrigation methods

B. Shallow wetting zones (low water storage capacity)

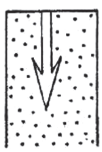



impermeable layer near to the soil surface
a) solid rock
b) hardpans (fragipans, duripans, orstein, ironpan etc.)
c) layer cemented by exch. Na+, clay, CaCO3 and other factors (clay-pan, concretionary horizons, petrocalcic horizons, etc.)
d) layer compacted by improper soil management (plough pans, etc.)

↓

extreme water regime

→ oversaturation (aeration problems)
waterlogging problems
surface runoff – water erosion
→ drought sensitivity



2. Limited water retention
IR, HC > FC → drought sensitivity

*Fig. 1.* **Main reasons of extreme moisture regime**

Under the given and forecasted future conditions soil moisture control is an important element of sustainable development. The more efficient use of the water storage function of soil has special significance in the adaptation to and the mitigation of the economical, ecological, environmental and social consequences of climate change.

The main objective of an efficient soil moisture management is to increase the water storage within the soil in plant available form without any unfavourable environmental consequences[22]:

- to reduce evaporation, surface runoff and filtration losses;
- to increase the available moisture content of the soil: to help infiltration into the soil; increase the water storage capacity; reduce the immobile moisture content;
- to improve the vertical and horizontal drainage condition of the soil profile or the given area (prevention of over-saturation and waterlogging).

## Conclusions

All climate change prognoses forecast the increasing risk, frequency, duration and intensity (seriousness) of irregular, extreme climatic and – as a consequence – hydrological events and moisture situations. In their prevention, elimination or reduction the water storage function of soil has special significance. Consequently, all efforts have to be taken for its more efficient use: helping the infiltration and storage of water in soils. Permanent soil moisture control may help to prevent, eliminate or at least reduce undesirable soil processes and their harmful economical/ecological/environmental/social consequences; and may satisfy the conditions for the “quality maintenance” of soil, this “conditionally renewable” natural resource, which is an important element of sustainable development, including the adaptation to or mitigation of climate changes.

[22] Várallyay Gy., 2010: Increasing importance of the water storage function of soils under climate change. Agrokémia és Talajtan. 59(1) 7-18

# 8. FORESTRY AND CLIMATE CHANGE

Climate change has substantial impact on the composition and stability of the forest cover. Forestry is based almost exclusively on the given ecological conditions and therefore the composition of forest stands, the multiple functions of forests and the profitability of forest management are very sensitive to changes in the meteorological conditions.

Extreme weather events of the near past have caused damages to the natural environment. For example frosts and windstorms resulted in smaller and larger scale adverse impacts on forest stands, but the natural regeneration and resilience capacity of the ecosystem have mostly rehabilitated the forests.

In Hungary the foreseen potential changes of the climate will create warmer and drier weather conditions. The increasing dryness of the air and soil will be caused by the rise of temperature, mostly in the summer periods, and by the modification of the distribution of precipitation within the year. These will have an impact on the growth and yield of forests, which in turn will affect the composition of tree species and the generation rates of organic matter. Recently climate became the most dynamically changing factor of the forest habitat. This variability will delineate the area of propagation of various tree species and with this the generation rates of organic matter of the forest ecosystems.

There are several climate categories used in forestry practice for the evaluation of the habitat (forest site). The various sites (beech, hornbeam-oak, turkey-oak sessile-oak forests and forest steppe) have different productivity and there is a need for different growing techniques due to their different ecological conditions. The profitability of forest management is also different for these forest categories. The potential transposition or shifting of the vegetation zones is mostly expectable at the boundary of closed forest cover and forest-steppe. Nevertheless, climate changes will certainly have impacts also on the cooler zones of higher precipitation (beech, hornbeam-oak climate zones).

Effects of decreasing precipitation, drought and extreme weather phenomena can unambiguously be traced in the Hungarian forests.

Hungary is characterized by relatively low forest cover ratio and the high ratio of deciduous trees. Macro-climatic conditions have already created a critical situation for the stand-forming tree species over a substantial part of the country (mainly in the great lowland plains, called the 'Alföld'). A relatively small rise of the temperature and small decrease of precipitation can induce changes that are having an impact on the forest biocoenosis. Decisively degrading impacts are expected, which cannot be rectified by the natural self-regulating mechanisms and neither by the human interventions.

All plant communities generate organic matter of high energy content from the inorganic carbon, while using the radiation energy of the sun. Therefore, in biological sense, the value of autotrophic plant communities is defined by their carbon sequestration and carbon cycling. Among plant communities the forest has the largest carbon sequestration capacity and therefore forests are of high ecological value and their multiple role in the household processes of nature will gain higher values. While forests cover about 28% of the continents the forest-soils contain nearly 40% of the total carbon stock stored in the soils of continents. The carbon content of the plants of the forests amounts to 70% of the total stock of carbon of the continental vegetation cover of the Earth.

In the process of climate change the forests play three different roles through affecting the carbon cycle. Namely, it is generating the changes, suffers from them and provides the mechanism for alleviating the changes.

Destruction of tropical forests and other land use changes contribute by 15% to the total annual $CO_2$-loads of the atmosphere. This type of activities in many developing countries (in South America, Africa and Asia) causes a substantial release of carbon dioxide. It is less known, however, that proper forest management can contribute to the mitigation of carbon dioxide accumulation. Therefore the value and the global ecological importance of the organic matter generation of forests should be better recognized, that is the mitigation of greenhouse gas effects by the lasting fixation of $CO_2$. Since carbon is the ’building element’ of plants and especially of the organic matter of trees, a forest management that is also aimed at an appropriate carbon fixation, may efficiently contribute to the mitigation of greenhouse gas impacts.

The carbon, which is fixed in the forests of Hungary, is accumulating partly in the dendromass and partly in the soil. In the Hungarian forests the annually fixed carbon mass amounts nearly to 7 Mt of which about 5 Mt will be released (via respiration and decomposition), but the remaining 2 M-tonnes will be lastingly fixed in the growing tree stock and in products of the wood industry. (In the USA 91% of the total fixed $CO_2$ is considered as that of the forests.) Therefore it is extremely important to increase forest coverage, either owned by the state or privately, along with that of all other green zones of urban and rural land and with care taken to the management and maintenance of them with due concern to multipurpose uses that provide protection for the atmosphere and the environment. This is a highly complex task, which requires new conditions and substantial financial support. In this process a new light is thrown to the selection of the site and the tree and brush species, requesting novel approaches of forest and wild-game management, wood processing, and also to green areas in general (including ’green roofs’, etc.).

Knowledge gained in this issue and the concerns induced require the supporting of all such forest management and wood processing activities that can, by fixating atmospheric carbon dioxide, alleviate the regional changes of the climate. Consequently:

- There is a need for improving the quality of the forest crop by professionally appropriate management. As a result of these measures the ratio of trees suitable for durable wood products (for furniture and construction) to the total yield can be increased. The forest left alone, that is forest free of professional silvicultural treatment, will maintain a carbon balance where the fixed carbon is in balance with the carbon released by respiration and decomposition, and no excess fixed carbon can be observed. The general propagation of the adherence to the principles ’PRO SILVA’ is an urgently needed task in all such sites where the ecological conditions allow this approach. In this approach the silviculture is based, in an increasing way, on the natural processes of succession, avoiding rough intrusion to nature.
- Structural transformation is needed for the increasing of the production potential (the growth) of the forests and this also can result in the decreasing of the carbon dioxide level of the atmosphere. Presently there is a realistic chance for establishing forest stands of optimal structural composition of tree species that are capable for the better utilisation of the growth potential of the site over nearly 30% of the total forest land of Hungary.
- Planting of new forests is the most effective means of contributing to the lowering of the carbon dioxide level of the atmosphere. In this case one can also count with the increasing of carbon accumulation in the earlier mostly agricultural plough-land fields

that have soils, which are poor in organic matter, in addition to the carbon lastingly sequestrated in the tissues of the trees. In the next 50-100 years there will be a possibility for planting new forests on about 600 thousand hectares area of plough-lands, which were non-economically utilised earlier, thus promoting the achievement of the above named objectives.

- Carbon dioxide emission can also be decreased by substituting products (for example plastic and metal products) that were made by utilising large quantities of power, which originated from non-renewable natural resources, by wood-products stemming from professionally cultivated forests. Consequently the development of wood processing industry is an unavoidable and urgent task.
- As opposed to the use of fossil fuels, the combustion of firewood produced by sustainable forest management will result in a neutral carbon balance, since the amount of carbon emitted into the atmosphere by wood-combustion will be equal to the quantity that had been fixed by the forest via photosynthesis. The use of wood for power generation is of growing importance also in Hungary. Presently 72% of the renewable power production stems from wood. In order to enhance Hungary's reaching the EU level in this context it would be highly desirable to urgently start the selection of sites suitable for energy plantation along with the selection of suitable tree species and the upgrading of the respective machinery (for harvesting forest, making chips, barking and for waste-wood briquetting and for suitable furnaces, etc.).

A key task of getting prepared for climate change is the preservation of the existing forest stands. This can be done by the widespread propagation of near-natural forest management strategies, thus securing the maintenance of forest microclimate. (It is a proven fact that the preservation of 30-50% of the aged forest stands will result in substantially smaller damages and losses and in smaller plantation expenditures and renewal difficulties than in other cases and sometimes such losses and expenditures are not encountered at all. The forming and maintenance of unevenly aged and mixed stands might be of great help.)

Further adaptation strategies might include: the mycorrhizal inoculation of seedlings; the further increase of tree species diversity with dryness-tolerant endemic Hungarian species (by *Quercus pendunculiflora* Koch.; *Quercus virgiliana* Ten.; cluster-fruited oak, *Quercus polycarpa* Shur.; Hungarian oak; Italian oak, *Quercus frainetto* Ten.); the protection of groundwater; halting of harmful anthropogenic strategies (such as drainage and stream regulation; and most importantly the careful exploration of the sites selected for forestation; and the selection of tree species that are suitable for all these purposes.

Forest plantation, forest regeneration, interrow cropping, grove planting, park planting, tree planting, wood utilisation, etc. are forestry techniques, which are likely to gain much importance on the long term and therefore it is desirable to assure the technical conditions that are needed for these approaches. The most urgent tasks are the provision of appropriate machinery for seedling production and for the forest planting and tending techniques.

Avoidance of forest and wildland fires and the establishment of the options of efficient defence action are especially important tasks in nature-protected and nature conservation sites, also contributing to the protection of the atmosphere. The extinguishing of fires and the halting of the propagation of fire require off road vehicles and machinery and the on site availability of fire-extinguishing materials. Nevertheless the most important and least expensive means are the coherent precautionary measures and regulations, including the prohibition of open-burning.

Private forests play an increasing role in Hungary in the protection and expansion of forests (presently about 40% of the forests are owned privately and it is expected that those agricultural land owners who terminate plough-land cultivation will turn towards forestry).

The more so, since the budget available for the maintenance and expansion of state owned forests are much limited in Hungary. Therefore it is important to provide advisory services for private forest owners and to curtail the bureaucracy of the respective state administration.

In supporting climate change preparedness and the propagation of private forests it is desirable to mobilise civil organisations such as the Hungarian Forestry Association and its Forest School Department and also the Association of Hungarian Private Forest Owners.

The matter of forest expansion would gain a new impetus if larger subsidies were given to the installation and maintenance of game fences, so as to decrease game-damages. Further it would be important to compensate forest owners for the losses stemming from their adherence to nature conservation restrictions. Protection and renewal of forests and the planting of new ones could be highly enhanced if the members of the corporations of joint forest owners were supported in their activities (with some percentages of the profit, etc.).

To promote adaptation the “rejoining” of agricultural production and forestry would be justifiable. This could partly provide incentives for the forestation and partly contribute to the security of long-term employment, thus supporting farmers and the countryside as a whole.

State owned joint-stock forestry companies that use unified forest management procedures over large areas will have a decisive role in the forestry based protection of the atmosphere and in the $CO_2$ fixation. Therefore it is an urgent task to improve operational and development conditions of forest management along with the improvement of the supervisory and financial management systems of state forests, aiming at the multipurpose (wood production, nature conservation, environmental protection, recreational forest uses) utilisation of the forests.

The National Forest Database of the State Forest Service and the knowledge base of the Forest Research Institute and its ecological and forest-protection monitoring network have outstanding importance in the tasks of preparedness and adaptation and also in the support of private forest owners. It would be desirable to expand both systems to make them more suitable for performing the tasks of adaptation to climate changes and the prevention of damages.

Owing to the high carbon fixing potential forests play a substantial role in mitigating the regional impacts of climate changes and the same is true for forest management, which defines the carbon fixing capability of the forests.

Hungary can contribute to the alleviation of the regional effects of global greenhouse impacts by expanding the area of forests and by improving the quality of the wood yield of existing forests, that is by establishing forest stands that can optimally utilise the yield/growth potential of a given site. Nevertheless the professional guiding principles to species choice and forest tending should be reviewed in the light of considering the carbon fixing potentials of the species as well.

The importance of the role of green areas is increasing in Hungary due to the substantial damages to tree stands that can be caused by the likely warming and drying of the climate and by the extreme weather events. Due to their multiple capacities forests and the green zones in general are such elements of the protection of the atmosphere and climate change adaptation that cannot be substituted by any other elements. These capacities include $CO_2$ fixing, oxygen emission, shading, vapour and moisture protection, control of wind forces and also their aesthetic effects. All these remain important even if one considers the expectable loss of $CO_2$ fixing capacities of green areas due to the decrease of production. (This is also indicated by the results of Hungarian investigations but in the USA it was numerically defined; that $CO_2$ fixation has been decreased by 23% in the period of 1990-2001.)

Upon the impacts of climate change the role of wild game management and hunting also changes. The importance of protecting forests and new plantations is increasing along with the importance of forestation, tree planting and in the increase of the green areas in general.

Presently game overpopulation causes serious damages to forests and this damage is 2-10 fold larger than that of the year 1971. The game stock might amplify the impacts of climate changes and therefore the populations of deer and wild boar should be decreased to 80,000 and 56,000 respectively, while it is also justifiable to decrease the fallow deer- and mouflon population of 20,000. The small game stock of Hungary is of good quality but its population is smaller than desirable (the size of predator population causes serious problems).

In among the first ten of the list of world-record trophies of red deer (*Cervus Elaphus*), fallow-deer (*Dama dama*) and roe deer (*Capreolus caprea*) 5 for each stem from Hungary. It is likely that climate changes will deteriorate the quality of trophies.

Wild game management may, when adhering to the principles of balance-keeping, much enhance the production of forest propagation material, the plantation and regeneration of forests and the establishment of various tree plantations. The balance in agriculture, forest and game management should be achieved *inter alia* by means of the following elements: (i) game population and the ecosystem supporting capability of the habitats; (ii) the benefits and damages of games, so as to decrease the latter; (iii) in among the interests of game, hunter, forest, nature, nature conservation and environmental protection, agriculture, country-side development and traffic.

The game stock is unfavourably affected by the changes of the climate. The process of drying might decrease the quality and number of offsprings and thus both the small and big game population will suffer from the changes. The habitat of waterfowls is shrinking and the nesting places are especially endangered. Uncertainties stemming from this situation might induces the changes of the behaviour of bird species causing the shifting of migration routes and overwintering places from Pannonia (the Carpathian Basin) to elsewhere. Warming up of shallow waters might cause mass botulism and avian botulism. Field games will tend to leave the extremely dry areas.

Forest management should be prepared for securing appropriate watering and feeding of games and for avoiding game damages on both forested and agricultural land. Adaptation strategies of forest management must include the careful and sparing use of all available water resources of forest sites, with the main objective of the storage of water for watering of plants and animals and for water-game habitat preservation purposes. The habitat of small games can be favourably affected by grassing and the planting of forest strips, mosaic woodlots and groves, while forestation will increase the habitat of big games.

# 9. ENERGY AND CLIMATE CHANGE

It is generally acknowledged that the present climate change hazard is caused primarily by the energy industry. Consequently, in this chapter we shall present the energy sector basically from this point of view.

The radiation conditions of the atmosphere significantly affect the equilibrium temperature of the flow of energy between the Sun, the Earth and the outer space. Within these conditions the major factor in this energy flow system is the global average temperature of the surface of the Earth including its changes. The adsorption-emission capability of selectively radiating gases depends on the temperature of the body that radiates on them. These gases (water-vapour, carbon dioxide, methane, NOx, CFC-s, SF6) do not adsorb the short wave radiation that arrive from a body of high temperature (the Sun with 4000 K temperature) but let them through. Nevertheless they partially adsorb and reflect back the radiation that arrives from the body of low temperature (the Earth of 287 K). This system adapts to the increase of the concentration of these selectively radiating gases in the atmosphere in such a way that the average temperature of the Earth surface increases, so that it could continue to radiate the energy quantity that arrives from the sun towards the outer space. This phenomenon is called the greenhouse effect. Many bad words are said about the greenhouse effect, although so far we have only enjoyed its positive effects. Namely if there were no greenhouse gas effect then instead of about 287 K (13.7°C) that assures the present life conditions on Earth, the global average surface temperature would be only 254 K (-19.2°C).

The industrial revolution was nothing else – when we consider the subject of this publication only – than the very rapid exploitation, combustion, of the (carbon containing) fossil fuels, which have been accumulated during millions of years. This activity actually turns the carbon into $CO_2$ and this $CO_2$ is emitted into the atmosphere of the Earth. The result is the rapid growth of the concentration of greenhouse gases in the atmosphere. So this way the greenhouse gases, which enable life on Earth, gets an excessive input that can be harmful to the life on Earth.

Greenhouse gases (GHG) are present in the atmosphere partly due to natural processes and partly to anthropogenic impacts. With the onset of the industrial revolution there was a substantial change in the accelerating use of fossil fuels. Combustion of fossil fuels results in carbon dioxide emission, which is much higher than the adsorbing capacity of natural systems. The concentration of carbon dioxide in the atmosphere is continuously increasing. Since the onset of the increasing use of fossil fuels (1750) the carbon dioxide concentration has grown from 280 ppm to 379 ppm of our days. Simultaneously the average temperature of the atmosphere of Earth has grown from 137°C to 14.4°C. Other human technical activities also resulted in the emission of other greenhouse gases (methane, $NO_x$, $SF_6$, freons, etc.) increasing the respective concentrations of the atmosphere. Evidently there is a cause and effect relationship between the two processes. It must also be stated that the rate of the geological processes that generate fossil fuels is much slower than that of the human consumption of these resources and this comparison means that the process is not sustainable. However, climate changes might create a catastrophic situation far before the run out of fossil fuel resources.

*Table 1.* **Hungary’s primary energy mix 2000–2020 (Mtoe/a)**

| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2010 | 2020 |
|---|---|---|---|---|---|---|---|
| TPES* | 25.01 | 25.42 | 25.81 | 26.34 | 25.87 | 28.47 | 33.21 |
| Coal | 3.97 | 3.62 | 3.62 | 3.75 | 3.50 | 2.72 | 2.52 |
| Oil | 6.87 | 6.62 | 6.64 | 6.30 | 6.05 | 6.74 | 7.54 |
| Gas | 9.65 | 10.71 | 10.81 | 11.88 | 11.63 | 12.98 | 16.93 |
| RES&waste | 0.42 | 0.40 | 0.80 | 0.82 | 0.74 | 1.50 | 3.30 |
| Nuclear | 3.71 | 3.70 | 3.65 | 2.89 | 3.10 | 3.79 | 3.79 |
| Hydro | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| Geothermal | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.20 | 0.20 |

Source: OECD-IEA 2006. (Organisation for Economic Co-operation and Development – International Energy Agency)
* TPES - Total Primary Energy Supply

*Table 2.* **Primary energy mix of the Hungarian electric power industry 1990–2006 (TJ/a)**

| Year | 1990 | 1995 | 2000 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|
| Coal | 124,395 | 113,963 | 114,711 | 112,299 | 103,000 | 83,519 | 79,524 |
| Oil | 18,573 | 60,975 | 43,046 | 19,274 | 10,191 | 6,244 | 5,850 |
| Gas | 73,047 | 68,342 | 76,989 | 129,367 | 129,170 | 132,215 | 137,456 |
| Nuclear | 148,366 | 152,304 | 151,904 | 118,555 | 127,423 | 147,370 | 143,619 |
| Hydro | 641 | 587 | 641 | 614 | 755 | 751 | 670 |
| Wind | | | | | 19 | 36 | 156 |
| Other renewables, waste | 1,599 | 2,215 | 2,556 | 8,200 | 18,579 | 31,496 | 29,487 |
| Total | 366,620 | 398,386 | 389,847 | 388,310 | 389,138 | 401,631 | 396,762 |

Source: Hungarian Energy Office 2006.

*Table 3.* **Greenhouse gas emission of Hungary**

| Category | Base year (1985-87) | 1995 | 2000 | 2001 |
|---|---|---|---|---|
| 1 Emissions of the energy industry | 84,006.31 | 61,925.63 | 58,665.82 | 60,142.75 |
| 2 Emissions of the industrial production | 10,724.97 | 4,905.03 | 5,755.88 | 5,855.76 |
| 3 Emissions from the use of solvents and other products | 384.46 | 250.38 | 235.84 | 263.38 |
| 4 Emissions of agriculture | 17,495.73 | 8,486.79 | 8,829.94 | 9,022.18 |
| 5 Emissions and sinks due to land use and its changes | -3,117.37 | -7,917.60 | -1,868.85 | -3,483.78 |
| 6 Emissions of waste management | 3,070.34 | 3,649.14 | 3,822.77 | 3,798.81 |
| Total | 112,564.44 | 71,299.37 | 75,441.40 | 75,599.10 |
| **Category** | **2002** | **2003** | **2004** | **2005** |
| 1 Emissions of the energy industry | 58,845.33 | 62,038.33 | 60,082.99 | 61,454.90 |
| 2 Emissions of the industrial production | 5,079.15 | 5,337.66 | 5,947.37 | 6,209.42 |
| 3 Emissions from the use of solvents and other products | 208.31 | 274.58 | 336.64 | 148.24 |
| 4 Emissions of agriculture | 9,125.96 | 8,874.86 | 9,054.97 | 8,464.48 |
| 5 Emissions and sinks due to land use and its changes | -3,099.46 | -4,775.45 | -4,441.10 | -4,475.56 |
| 6 Emissions of waste management | 3,766.78 | 3,730.04 | 3,753.66 | 3,941.81 |
| Total | 73,926.07 | 75,480.02 | 74,734.53 | 75,743.29 |

*Table 4.* **Electricity from renewable energy sources in Hungary (GWh/a)**

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|
| Hydro | 186 | 194 | 171 | 206 | 203 | 186 |
| Biogas | 7.6 | 11.2 | 15.6 | 15.0 | 27.0 | 32.0 |
| Wind | 0.9 | 1.1 | 3.3 | 5.4 | 10.0 | 43.0 |
| Biomass | 0 | 0 | 74.8 | 655 | 1612 | 1278 |
| **Total** | **194.5** | **206.3** | **164.7** | **881.4** | **1852** | **1539** |

Source: Hungarian Energy Office 2006.

To illustrate the concrete climate vs. energy relationships of Hungary, the structure of power production of the country is presented by *Table 1.*

It is worth noting that in the last years of the "socialist" planned economy (1988-89) the total energy consumption was round 29.5 Mtoe, while after the turn to the market economy and after the shift to more favourable structure of products this value was reduced to 25 Mtoe and ever since it increases at a slow rate only, while the GDP was increased by about 20%. The values referring to the years 2010 and 2020 are the estimates of the OECD-IEA. These numbers may be lower if the climate policy of the EU will be fully adhered to in the coming decades. Evidently, Hungary as a Member country of the EU will comply with the requirements of the energy policy of the EU *(Table 2).*

GHG emissions of Hungary are shown in *Table 3* since the base-period 1985–87 until 2005 expressed in tonnes $CO_2$ equivalent. It is worth noting that GHG emission was significantly decreased form the 112.5 million tonnes of 1985/84 to the 75.7 Mt of 2005. It is also worth mentioning that the emission of the agriculture was reduced to 50% while the performance of the GHG sinks (sink capacity) produced by the changes in the land use was increased by 50%.

Tables 1 and 2 indicate that Hungary has relatively good GHG emission parameters since in its power budget natural gas based and nuclear energy production is significant. In respect to renewable energy the topographic and weather conditions do not offer very good options (e.g. hydro and wind power). However, the biomass based energy resources of Hungary are encouraging, if properly utilized *(Table 4).*

In Hungary electrical energy production from biomass started in 2003 and had a steep increase utilising mainly carbon based power plants with the joint combustion of wood and coal (co-combustion). This is the simplest method of producing electrical energy from biomass and in Hungary this method could save a few power stations that were to be closed down due to violating emission limits. However, although this solution is attractive, it is not really good and cannot be considered as a final version. Namely, the power stations which presently operate partially with wood combustion are old ones and of low efficiency. Preparations are being made for really good, long-lasting power stations of high efficiency. They are being planned and/or constructed mainly based on by-products of the agriculture (mostly straw) as fuels. There are even more favourable solutions: smaller heat generating stations that are based on local sources of biomass. In this way the costs (and emissions. e.g. environmental loads) of road and rail transport are reduced. There are facilities of very good efficiency already available for the heating oriented utilisation of biomass.

Regarding hydropower the topographic conditions of the country do not offer too many options. The theoretical hydroelectric potential of the country is 110,000 kWh/km$^2$ and only the Netherlands has potentials lower than this in whole Europe. In spite of this, there is very little hydropower utilisation in Hungary; 31 small and dwarf power stations provide a total of

55 MW capacities having produced (depending of river discharge) annual 195 GWh electrical energy in the past years.

In Hungary, the conditions for utilizing geothermal energy are theoretically favourable because the geothermal gradient (ºC/m. along the depth of the borehole) is larger than the global average (which is 3 ºC/m temperature rise downwards). This however means only that thermal waters of 40-70ºC can be obtained from the not too deep boreholes. This temperature can well serve the needs of heating the homes, greenhouses, hatcheries, etc. Thermal pumped heating could also be supported by this temperature range, but this option has not yet been utilised so far, although there are some initiatives in that direction. Nevertheless one should be very careful with the utilisation of the thermal groundwater resources of Hungary because these waters are of much higher value as medicinal waters than sources of energy and the exploitation rate of these resources is already in a balanced but critical state.

Electrical power generation with these water temperatures is not possible or could be done with “prohibitive” efficiency only. To our present knowledge there is only one geothermal source that can be rationally utilised and this is Fábiánsebestyén with its 64 MWe potential capacity.

In utilising wind energy there are growing stresses in Hungary between the operators of the electrical network and the representatives of the marketing of wind turbines. Namely, a control problem occurs due to the unpredictable energy input of the wind turbines and the 40% share of the Paks Nuclear Power Plant in the electrical energy production of Hungary also adds to this problem. Presently (2008) the Hungarian electrical energy system cannot receive more than 330 MW “non-predictable” energy inputs. Consequently the Hungarian Bureau of Energy has limited the total capacity of wind turbines that can be connected to the network to 330 MW. This limit violates the profit interests of the companies of wind-turbine production and marketing. This profit of the wind-turbine industry stems from price of electrical energy produced with renewable resources, which is compulsory for the electrical network and much higher than the cost of production.

Evidently, there is no obstacle against (it is rather welcomed) the construction and operation of a facility of any kind, which produces electrical energy of any quantity and operates this in “island” manner – i.e. without connecting to the network – for local purposes covering all the costs and utilising all the energy produced.

Supporting the use of renewable resources for energy production is a good approach, but the ways and means it is done presently in Hungary are obscure as they put heavy loads on both the consumers and the national budget that is it is not sustainable. The profitability of investors into wind-energy utilisation is that “green” electricity has an outstanding support, which means that the network is obliged to receive this green energy at much higher and fixed prices than the cost of production. In addition to this the extra costs stemming from the irregular energy input to the network has to be covered by the consumers and the national budget. The solution would be the storage of electrical energy.

For the integration of the periodically changing (predictable or unpredictable) electrical energy producers into network, that is harmonizing with the need of the consumers, the establishment of substantial energy storage capacities are unconditionally required. One of the means to provide such storage capacity is the pumped-storage hydropower systems, however, there is not easy to find proper sites and/or methods for this purpose, which would also meet all the criteria required by regulations and by various stakeholders.

Coming to international comparisons it can be stated that in respect to GHG emission Hungary belongs to the lower medium category. The annual Hungarian emission is 7.4 t $CO_{2eq}$/capita, while the annual average of the Annex I countries (in the UN convention on

*Table 5.*
**Per capita TPES (Total Primary Energy Supply) toe/cap.year (ton of oil equivalent = 42 GJ)**

| Country | Toe/cap.year |
|---|---|
| Hungary | 2.2 |
| Poland | 1.9 |
| Austria | 3.6 |
| Germany | 3.3 |
| Belgium | 4.0 |

Source: Hungarian Energy Office, 2006

*Table 6.*
**Per capita energy consumption (kWh/cap.year)**

| Country | kWh/cap.year |
|---|---|
| Hungary | 4800 |
| Poland | 4600 |
| Austria | 7000 |
| Germany | 6500 |
| Belgium | 7500 |

Source: Hungarian Energy Office 2006

*Table 7.*
**Energy intensity of the national economy (toe/MUSD. where MUSD: million US dollar)**

| Country | Toe/MUSD* |
|---|---|
| Hungary | 132 |
| Poland | 141 |
| Austria | 121 |
| Germany | 120 |
| Belgium | 147 |

Source: Hungarian Energy Office, 2006

climate change) is 4.6 t $CO_{2eq}$/capita (for comparison: the annual average of the non-Annex I countries is 4.2 t $CO_{2eq}$/capita).

The position of Hungary in using electrical energy in the international comparison can be illustrated by the data on the Table 5-6 of the Total Primary Energy Supply (TPES):

Thus, Hungary is in the lower third part of the European range in respect to both total energy supply and electrical energy consumption *(Table 7).*

The energy intensity of the Hungarian economy stems from the improperness of energy technologies to a smaller part only, while the larger part stems from the low values of the products generated. To reduce the energy intensity (e.g. to secure the same income with lower use of energy) one should increase the ratio of products, which represent higher added value. This is a process under way at the present.

Hungarian energy policy pays a special attention to increasing the energy efficiency. Namely, the consumer shall use the lowest possible energy for meeting his/her demands (e.g. to heat or cool a room. to fabricate a spare part. to light a work-site or to make a cup of coffee). This endeavour does not mean the curtailing of supplies or reduction of comfort, but it means the provision of the same supply in the same quality, but with the reduced use of energy. This is what one shortly names the increase of energy efficiency.

A special weight is given to this endeavour by the recognition (which is rather evident though) that in the major part of the energy systems of the world, and thus also in the Hungarian one, the ratio of TPES to the TFC (Total Final Consumption): the ratio TFC/TPES is about round 0.7. This means that only 70% of the total primer energy input to the system reaches and is consumed by the consumers and 30% is lost owing to the improper technologies of the energy industry. This also means that 700 kg GHG out of each 1000 kg GHG emission is caused by the consumers, while usually the energy sector is blamed for all the emissions. If someone consumes less energy (or nothing at all) then he/she decreases the GHG emission at a ratio of 1000/700, because in addition to his/her not consuming the 700 units also saves the other 300 unit, which would stem from the improperness of the energy industry. Those who save 1000 unit TFC (by not consuming it) will reduce the emission by a value that belongs to 1428 unit TPES.

The need for increasing energy efficiency is emphasized in all international documents, which deal with climate change and it is also a major topic in the highest level international political forums (G8, WSSD). In addition to this when the distribution of financial resources to be devoted to the decrease of emissions is discussed, then the choice is to select from the increase of efficiency and the subsidence of renewable sources and the alternative that wins is the one, which results in the larger decrease of emissions.

Hungary makes all efforts (dependent on the available resources and natural conditions) to reduce emissions and to support the alleviation of climate change and also wishes to comply with all international and EU obligations in this context.

As far as the response and adaptation policies and measures, Hungary considers the following actions as necessary ones:

- increase of energy efficiency by considering externalities and economic efficiency with special regard to the buildings and traffic/transportation.
- To enhance the best use of the project based flexible mechanisms of the Kyoto Protocol to the United Nations Framework Convention on Climate Change (Joint Implementation, Clear Development Mechanism).
- To make use in a correct manner of the options of the trade of $CO_2$ contingencies (quotas).
- The utilisation of renewable energy resources in an optimised manner as to serve the interests of the protection of the climate (e.g. the cost of the emission reduction should be optimised and not the profit of the manufacturers of the relevant equipment).
- To construct pumped hydropower storage systems and other means of storing energy (e.g. Hydrogen production) in order to match the energy offered by the renewable sources to the needs of the consumers (e.g. to reduce the asynchrony).
- To consider all possible sources of energy as options (no sources to be sacred and no sources demonised).
- Consider the options to comply with the rules related to CCS (Carbon Capture & Storage).
- To make sure that the organs and institutions of the state show a good example in climate-concerned behaviour.
- To decrease the weather vulnerability of the energy supply system.
- To construct power supply networks in such a way that the consumer may get their energy from several directions.
- To make preparations for the reliable meeting of energy demand also in emergency situations caused by extreme weather events.
- To get prepared for supplying the extra energy in the summer period, which will likely be demanded by the air conditioners.
- To meet local power demand with the use of local sources of energy.
- To decrease the water demand of the energy industry.
- Expansion of the options of Combined Heat and Power production at small and large scale.
- To develop the safety and security systems of new technologies (e.g. the use of hydrogen) and to increase the general acceptance of new technologies.
- To get prepared for the tasks of the energy industry, which will stem from the decrease of fossil fuel consumption of traffic/transportation.
- To develop options for enhancing “teleworking” (working at home).
- To support the reduction of the use of materials, their reuse and recycling.
- To increase the market-share of long lasting (non-disposable) products and to support the social acceptance of these products.
- To shift the handling of social problems from the subsidence of energy prices to the social-care sector.
- To enhance energy-saving and environment-aware education starting with that in kindergarten.

# 10. ARCHITECTURE: CLIMATIC IMPACTS AND RESPONSE MEASURES

## General considerations

According to statistics an average man spends 70-90% of her/his life in buildings in a given microenvironment. It follows from this statement that buildings and their quality play a major role in the life of the people living in them, both in physical and psychical sense.

Hungarian building of dwellings is being presently characterised by the growing need for quality, thus replacing the earlier (20 years ago) technocratic approach. Namely, earlier we were building flats (in the possible largest quantity) and now the objective is to build homes, which can serve the needs of human beings giving a prime role to make them comfortable. It follows from the former statement that there are two major factors, which affect the design of buildings:

- Effects due to internal and external functions (in a broader sense from the usefulness to the aesthetic appearance); and
- external macro- and micro-climatic effects that influence the usefulness of the built environment.

A planner architect considers objectively these two parameters and defines them nominally or sometimes verbally only and all factors together provide the basis for shaping the desired building.

It can be unambiguously stated that in the planning process of the establishment of a building all those activities of the architect are necessary and useful, which are focussed at optimal balancing of the requirements of these two groups of factors. On the other hand those works that do not serve the achieving of these objectives have no value for the society.

The values of these requirements are given and a part of them can be obtained from the functions of the building and is some cases they are fixed in standards or regulations. Similar is the case with climatic effects, which have also been defined on the basis of several years of experiences.

Consequently, from the point of view of constructing and establishing buildings the changes of external affecting factors, incl. the climatic factors are of decisive importance and determine at least 50% of the parameters, which are used for the planning of the buildings and their structures. Buildings and establishments are not made for short-term use and their expected-requested lifetime is about 50-100 years. Consequently, the benefits or potential harms of the buildings that we create today will be enjoyed or suffered by our descendants.

Therefore it is absolutely necessary that appropriate climatic design parameters be provided for the planner-architect for both the short- and long-term future for designing the external enveloping structures in an objective manner.

In our era the building science (including load bearing structures, building machinery, thermal-physics, acoustics, fire protection, etc.) has reached the stage of development where one can nearly optimally create buildings or structures of continuous human use, which are suitable for all kinds of possible design parameters (construction of space ships can be mentioned as an example, for which one needed only reliable design parameters).

What is the situation today with the forecasts of the climate? It is an important question since as mentioned earlier it has deterministic impact on the design of buildings.

In respect to Hungary the most repeated information is the “global warming” and desertification with peak weather parameters that are much more extreme than the present values. Nevertheless some more rarely given information indicate a significant cooling-down process in a time horizon of fifty years. This means that the expectable climate shows a varying picture and therefore it is difficult to assess the design parameters of building construction.

Nevertheless we must step forward, since the built environment will affect the life of people on the long run. The seemingly logical estimate is to select design parameters that suit increased peak-stress conditions (both in the summer and the winter periods).

This conclusion is also supported by the rapidly accelerating rise of energy prices, which excludes the earlier mass practices (e.g. when it is cold one should heat more and when it is warm ones should cool more by appropriate climate-devices).

Therefore we must design such groups of buildings that are suitable for both the changes of the climate and the energy availability in the coming decades.

## Interrelations of construction processes and the environment

Effects of construction and buildings on the environment:

- All intrusion into the environment and thus construction too has a harmful effect on it disrupting the earlier balanced state of the ecosystem (affecting the vegetation, heat-conditions, precipitation and runoff-water, groundwater levels, etc.).
- The energy consumption used for the construction operation and maintenance and of buildings (amounting to more than 40% of the total energy consumption of the country) also damages the environment.
- Urban land is excessively harmful to the microenvironment with its “heat islands” (obstructing air flows, precipitation-runoff, traffic and transportation, thermal conditions and causing pollution, etc.).
- Other damages to the environment are caused by ever increasing construction activities, growing rates of the production of construction materials, and also by the waste depositions originating form the demolition of outdated buildings.

Each of these impacts and also their cumulative effect; disrupt the balance of the environment and this has an increasing impact on the buildings to be constructed in the future, that is environmental destruction by construction has a feed-back loop affecting the construction of buildings.

Impact of deteriorated environment on the buildings:

- Buildings are increasingly suffering from the deteriorating conditions of their environment, partly caused by themselves, which is a self-generating process.
- Extreme impacts need a design method that has reserves and these is the so called “peak- stress design” of buildings.
- Increasing heating-cooling demands turn our buildings to “energy consumer machines”.
- Increasing traffic and transportation (with its noise and gas emissions) obstructs natural ventilation and therefore artificial ventilation must be applied.

**Possibilities for reducing unfavourable impacts**

Changing environmental impacts of increasing intensity—including the outcomes of climate changes—make the transformation of the process of building design a must.

Considering the concrete tasks of the architecture, which stem from the changing climatic conditions and the energy crisis as discussed above, the following solutions can be proposed for individual buildings, building structures and groups of buildings.

*External structures of buildings*

In changing climatic conditions and in pressures caused by energy crisis two basically important affecting factors should be considered when designing the structures of building and the external facilities (external enveloping structures):

- intensified solar radiation in the summer, resulting in heat impacts (global warming); and
- the cooling effect of winters (also considering the sparing use of energy and peak stress on the energy supply system).

In both cases one should differentiate between: the design of the reconstruction of old buildings and the design of new buildings.

In the case of reconstructing old buildings (which amount to 70% of our stock of buildings) the use of the “sandwich” principle is desirable, which means that auxiliary structural elements and layers are used for improving the efficiency of external enveloping structures, i.e. – walls, roofs, floors – in such a way as to suit to the modified requirements.

For these structures it is necessary to provide an additional heat insulation layer in such a way that external layers are to be applied when the configuration makes this possible and internal heat insulation is required for historic buildings.

In case of the renewal of old buildings another important task is the reduction of air filtration, because 40% of the heat-loss of these old buildings stems from undesirable exchange of air volumes. Consequently the replacement of doors and windows is desirable along with the application of air- and vapour-proof layers on the walls so as to decrease the unwanted heat intrusion. Installation of shades (such as Venetian shades) to the external facade may also improve the cooling effect.

In the case of new buildings: appropriate orientation of the buildings and the provision of options to increase heat income (in the transitional seasons); caring for the mass-design of buildings – decreasing of surfaces available for the loss of heat; energy-saving concerning the design of the external enveloping structures of the buildings.

Basically important factors are as follows:

- decreasing the loss of heat, increasing heat-insulation values; in our days this means the use of 14-20 cm thick active heat-insulation layer;
- decreasing of the summer-time heat income with the help of ventilated and shaded wall and roof structures, which enable the diversion of about 30% of the heat flux, caused by solar radiation from the building;
- eliminating the unwanted effects of “thermal-bridges”;
- installation of air-tight, heat-insulating and shaded doors and windows;
- enhancing the wide spread propagation of green roofs and green walls.

Assuming changing climatic conditions the implementation of these modifications may (in the case of specifying the concrete parameter values) considerably improve the comfort feeling of the users of these buildings and dwellings without any specific building-machinery alterations (e.g. without the use of excess energy).

*Load-bearing structures and external linings of buildings*

An outcome of the global warning can be the change in wind characteristics, including the intensity and frequency of events with extreme wind pressures. This would mean increasing loads on the buildings, affecting their stability and also the way of fixing of the external lining materials and the complete reconsideration of their structure might be needed (e.g. the well-known windstorm damages of our days).

Consequently the review of the relevant regulations and structural requirements becomes unambiguously justified.

*Impacts of precipitation and changing groundwater conditions*

Extreme weather conditions result in short-time rainfalls of high intensity and they have an impact on the buildings. Consequently the applicability of various watertight insulating facilities should be reviewed in conjunction with the sinks, drains and water conveying facilities.

Rainfalls of high intensity have their impact also on the paved spaces around the buildings and will considerably affect the design of rainwater drainage and sewer systems including the shafts of the sinks.

The design of foundation and other underground structures of buildings are also affected by high intensity rainfall. Namely, the periodically occurring soaking-drying process causes (especially in clay soil) the “lifting of buildings” (e.g. rising and sinking of buildings). The hydraulic pressure of groundwater levels means an extra load on subsurface structures (cellar, basement), which also need altered design requirements.

*Cities: “heat islands”*

The expectable warming is especially unfavourable for the urban dwellers. The forecasted average temperature rise in the summer months will cause a significant warming of the inner and external parts of the buildings due to the heat-storage capability of the walls of the buildings, that will upon solar radiation result in secondary heat radiation. A considerable part of precipitation water is drained away in the storm-water sewers and this amplifies the “desertification”.

Natural green areas are replaced by the masses of buildings, the cleaning and cooling effect of wind is attenuated by the blocks of the buildings. This harmfully affects the health and comfort feeling of the citizens.

Proposed protection strategy: (i) what we have taken from nature should at least partially be returned in the forms of green roofs, green facades; (ii) the unfavourable impact of the drainage of precipitation water can partially be counteracted by fountain wells the release vapour.

These proposals help counterbalancing the unfavourable impacts of the changing environment by aiding the changing of the attitude of people and also by modifying the relevant legal regulations.

## Conclusions

The design of building needs the simultaneous consideration of all affecting factors in a near-optimum manner and this in turn needs a good team of professionals.

The difficulty of this task is amplified in our days by: the forecasted changes of climatic conditions and the continuous increase of energy prices.

These effects are of opposite direction, namely, one cannot counterbalance the climatic changes purely by building-machinery solutions (by increased heating and cooling) and therefore one must design and construct the buildings and their structures by considering all the changes of all affecting factors.

In solving these tasks one needs to

- change the attitude of both the people who have the buildings built and of the professionals who design and build the buildings;
- develop reliable methods for assessing the parameter values also considering the expectable peak-stress conditions, which will be the basis of the planning/designing process;
- develop new design guidelines; these new guidelines should reach a stage of wide spread application in the planning of buildings;
- educate and train experts and professionals for the required special knowledge, so as they would be able to solve the tasks that come along with the changing climate.

Implementation of the proposed changes is not an especially difficult task in the field of architecture, but those must be unconditionally done. No very large expenditures are encountered; basically the attitudes should be changed. No damages will be made to the existing stock of buildings, but only their quality will be improved to suit the needs of the future generations, who will use the buildings that are refurbished, constructed or planned today.

# 11. TRAFFIC, TRANSPORTATION AND THE CLIMATIC FACTORS

### Interaction of traffic and the environment

In addition to its favourable social and economic effects, traffic/transportation is one of the major sources of atmospheric pollutants, which cause serious environmental pressure. Simultaneously, various environmental factors (including the climatic factors) substantially affect the traffic and transportation. The strong and mutual interaction between this sector and the climatic conditions will be dealt with in this chapter.

The critical conditions of urban public traffic, transportation and cargo shipping of Hungary are well known to the local population. These unfavourable conditions are further aggravated by extreme weather events and the changes of the climate.

The conditions of public roads are bad. Very hot weather contributes to deformation of the road pavements. Large and very intensive rainfall deteriorates the road structures, the road pavements etc. Intensive snowfall and frost makes winter traffic very difficult and increase the operation and maintenance tasks (removal of snow, spreading de-icing agents, repair of frost damages of pavements, protective barriers against snow drift). The risk of road accidents is amplified by pavement damages, also hindering the uniform flow of traffic and increase the frequency of traffic jams. Extreme weather events, windstorms and high temperature fluctuations occurring within short periods of time cause large damages to highways and railways.

In air traffic the increasing frequency of extreme weather situations increases congestion and cancellation of flights and decreases the security of landings and takeoffs. The shifting of the hydraulic regime of rivers towards the extremes hinders navigation and contributes to the increase of ship accidents. The frequent traffic jams of urban traffic peak hours increase the risk of town dwellers to get asthmatic illnesses, especially in conjunction with unfavourable weather conditions.

The identification of damages to traffic due to climate changes is a main subject of research in Hungary and abroad[23] along with the research into the contribution of traffic and transportation to global warming and including the exploration of the impact mechanisms, the tracking of the changing conditions and the identification of the efficient options of counter strategies.

Among the harmful environmental impacts of traffic and transportation it is desirable to differentiate between locally identifiable impacts, especially when they refer to unfavourable effects that act on the short term, and the global impacts. The latter means impacts, which induce unfavourable changes that will be identifiable only on the long run ($CO_2$ emission). The reactions aimed at "handling" the phenomena, which was brought along with the changes of the climate, should be in proportion to social-economic weight and dangerousness of these phenomena. This means that "strategy packages" of appropriate efficiency should be made available for the responses of the society ("AGRO-21". 2005).[24]

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[23] Tánczos K., Török Á., 2007: The linkage of climate change and energy consumption of Hungary in the road transportation sector, Transport Journal (ISSN 1648-4142) Year XXII, 2007/2, (pp 134–138)

[24] "AGRO-21", 2005: Agro-21 Füzetek Változás-Hatások-Válaszok (*Booklets "AGRO-21", Changes-Impacts-Responses*), 2005/44

Emissions of traffic and transportation amount to 22% of the $CO_2$ emission of the world. This ratio is growing year by year and exceeds several times the industrial emissions. Consequently in protecting the atmosphere traffic and transportation form one of the subjects where the impacts of climate change should be explored and analysed to the possible greatest extent. Nevertheless, this is the segment of the economy where a relatively wide choice of potential counter measures and strategies is available for protecting people and the atmosphere and this offers favourable options for reducing the emissions of greenhouse gases as well.

The ’operation’ of the society and the economy cannot be maintained without traffic and transportation. Namely, transportation and traffic has to provide not only the physical conditions but the right regulation as well, at which the society and the economy can be operated, assuring the efficient ’transposition’ of people and cargo, assuring also the conditions for blood-circulation of the society. Transportation of people and goods is done by vehicles in a ’space’ defined by the natural, social and economic environment and therefore the system of the transportation should be formed and operated in such a way as to ensure the mobility of the society in an economically, efficient and environmentally acceptable manner.

In order to establish the conditions briefly sketched above one should know the technological, organisational, economic, financial, institutional and social characteristics of the sub-systems of traffic and transportation (e.g. infrastructure, traffic control of vehicles and the human factors) along with their ecological impacts and implications. Then in selecting the appropriate strategies all options of control and modification should be considered with due concern to the efficiency of the means and tools involved.

### Critical sub-sectors of traffic and transportation in the light of climate changes

International research results (ETA 2008)[25] have verified upon careful surveys that among the activities related to the transport sector the road traffic of motor vehicles and the air traffic are the elements that play a deterministic role in the emission of greenhouse gases and thus in the altering of the climate. Investigations and the making of an account of the impacts should thus be focussed at these segments of traffic and transportation.

Among the potential responses of the society to climate changes the efforts to select the most appropriate strategies shall focus on road and air traffic and transportation not only because the rate of increase of transfer rates (expressed in tonne-kilometre or passenger-kilometre) was the highest and most dynamic in these sectors, but also because they have the most harmful environmental impact per unit performance. Having the social impacts analysed comparative international studies have proven this numerically. This was made by expressing the external impacts of transportation in monetary terms that is by the possible widest internalisation of the external impacts.

### Measures aimed at mitigating the harmful impacts of traffic and transportation on climate

The first option is to curtail the causes that result in climate changes that is to globally reduce the loads to the environment. Nevertheless the result of this strategy would be seen only after longer period of time. Motor vehicles combust fossil fuels. If there were a perfect combustion then only water and $CO_2$ would be generated. $CO_2$ is a greenhouse gas; it can only be reduced

[25] ETA, 2008: European Technology Assessment Group: Report on the Future of European Long Distance Transport (2008) Copenhagen

either by reducing the quantity of combusted fuel, or by strengthening the sinks of $CO_2$. The only solution could be if fuels of no carbon content were combusted. Nevertheless, the use of fuels of lower carbon content, such as methanol or hydrogen would not provide a solution, as with them only the location of greenhouse gas emission will be changed; namely, environmental pollution would occur when producing the fuel instead of when operating the vehicle. The real solution would be to reduce the quantity of fuel combusted.

This can be facilitated and enhanced with a rich choice of tools and means that are available for those who can set the regulations of the vehicle owners, vehicle users and of the state management of traffic and transportation or for those who can affect the habits of the participants of the traffic. At global scale, however, the reduction of emission of harmful substances can only be achieved on the long term and only as the result of the joint action of the societies of larger regions. In the case of decisions of that scale it is not a simple task to identify the responsible persons or groups, because of the highly complex routes of the propagation of effects. It is similarly difficult to force them to act with the means that are acceptable in a market-based society. Consequently the objectives shall also include in addition to the strategies of improving efficiency (such as the use of vehicles of lower fuel consumption) the strengthening of efficient strategies (e.g. reduction of the use of motor vehicles by single individuals).

The second possibility is the local adaptation. In Hungary, according to the climate change scenarios, there will be milder winters with more precipitation and drier and warmer summers and this will also substantially affect traffic/transportation, like the decreasing of frost damages in the winter and the increasing of problems due to the heat of the summer. The prognoses also indicate the decreasing of springtime flood damages.

It is likely that the frequency, extent and duration of extreme weather events will be increasing and the unfavourable impacts of them on the environment, economy and the ecosystem will be aggravated. Damages to the environment and the society cause social problems[26]. Although it is a difficult task to forecast storms that were not characteristic to the climate of Hungary before, but we will still need such services in order to prevent the occurrence of damages and plan defence actions. Storms may damage the roads, tracks and other equipment of transport and traffic, thus having a serious impact on them and on a significant part of the population. The avoidance of damages is difficult and therefore efforts should be made for the decreasing of the extent of such damages. Earlier experiences indicate that action plans need to be frequently updated and this requires the co-operation of the social groups in concern.

It is not likely that in Hungary the impacts of climate change will considerably change the presently existing regional, economic and social inequalities, but we anyhow must count with the further strengthening of the migration of people and this may amplify the above sketched unfavourable changes. These occasionally synergetic impacts may, however, amplify the regional and social segregating processes. The lastingly unfavourable downtown climate of certain seasons may, in association with the permanently occurring traffic jams, accelerate the process of sub-urbanisation.

In making decisions for avoiding the occurrence of unfavourable future processes the various elements of the society, the individuals and the state face, as a panel manifesting the decision makers, different tasks. The society and the people forming the traffic must change their attitude. The establishment of an environmentally concerned life style is our

[26] ”AGRO-21”, 2005: “Agro-21” Füzetek Változás-Hatások-Válaszok (*Booklets “AGRO-21”, Changes-Impacts-Responses*), 2005/44

common interest for saving the habitat of the next generations to come. The role of the state in this process is directly deterministic through education and training (including the rising of awareness and the spreading popular science materials). In addition to adaptation more and more tasks are related to the survey of the climate-sensitivity of the society and to the keeping of the population informed with updated knowledge. The climate-sensitivity of the population is rising with the growing average life span of people and with the increasing number of urban dwellers.

The state has also other means for reducing the traffic-born pressures on the environment. International experiences indicate that the introduction of various fees can reduce the attractiveness of traffic on public roads and this will reduce the extent of traffic. The use of private cars (and not the ownership of them) can be reasonably curtailed with the help of road usage fees, zone-entrance fees, parking charges, P+R parking lots, and with the establishment of B+R stops and stations. It is important to note, however, that road usage fees must not be used for increasing incomes only, but shall primarily be used for the efficient influencing of the means and ways of traffic/transportation.

Although in an economist’s approach the strategic elements of improving adaptation and reducing environmental pressure are inter exchangeable, their effects cannot be compared due to the difference in action time scales. The strategic means of mitigation consider the environmental pressure as a common good and therefore the extent of mitigation will be smaller than the optimum[27]. Consequently the climate-sensitivity and market conditions of the transport sector should be analysed very carefully and in a complex way, according to the above mentioned aspects in order to succeed in selecting the optimum strategy as a response to the impacts of climate changes.

[27] Török Á., 2008: A közúti személyközlekedés klímára gyakorolt hatása. (*Impact of road transport on the climate*), “Klíma-21” Füzetek

# 12. HEALTH, HEALTH PROTECTION AND THE CLIMATIC FACTORS

In the early 1990s the health-deteriorating impacts of climate change was not of major concern, as it was reflected in the first report of the IPCC (Intergovernmental Panel on Climate Change) in 1991. This situation has been changed. The second report of IPCC devoted a whole chapter to the harmful health effects of climate change. In the declaration of the Third Conference of European Environment and Health Ministerial Conference (1999, London) the chapter dealing with the early health impacts of climate change and the decrease of the ozone in the stratosphere in Europe has five paragraphs (39-43) that summarise the proposals. In the declaration of the Conference the ministers acknowledged the need for studying the global climate system and the health hazards of the changes of the ozone layer of the stratosphere along with the potential unfavourable impacts on economic development and economic-social stability.

In Hungary the investigations into the health-deteriorating effects of climate change have started in the year 2000. The voluminous programme carried out within the "National Action Programme of Environmental Health" was focusing primarily on surveying the health-deteriorating effects of the ever more frequent heat waves. Within the action programme the comparison of meteorological and mortality data of Budapest was carried out for the period of 1970-2000. Influences of allergenic pollen producing plant species were analysed in function of weather factors along with the spatial distribution of morbidity incidents caused by encephalitis and Lyme disease, which are spread by ticks. The effects of UV-B radiation on melanoma morbidity and the occurrence of cataract were also investigated together with the health-deteriorating effects of heat waves.

The statistical analysis of weather variables, daily morbidity and daily emergency ambulance calls were carried out by the joint study of the Public-health Institute of the Fodor József National Public-health Centre and the National Service for Public Health and Medical Officers[28,29,30]. It was found that 5°C increase of the daily average temperature results in:

- 10% increase of the risk of death due to all possible causes;
- 12% increase of the risk of death due to cardio-vascular diseases;
- 15% increase of the number of emergency ambulance calls for heart complains and "general indisposition".

**Study of heat waves and related features in Budapest in 1992-2000**

There is no generally accepted definition for 'heat wave' in the relevant literature. For Budapest we have defined the criteria of heat wave on the basis of analysing the meteorological and

[28] Páldy A., Erdei E., Bobvos J., Ferenczi E., Nádor G., Szabó J., 2003: A klímaváltozás egészségi hatásai (Health impacts of climate change). "Agro-21" Füzetek; 32; 62-76.

[29] Páldy A., Erdei E., Bobvos J., Ferenczi E., Nádor G., Szabó J., 2004: A klímaváltozás egészségi hatásainak vizsgálata: nemzeti egészségügyi hatásbecslés (*Investigation of the health impacts of climate change: assessment of national health impact*). Egészségtudomány(48) 2-3.230-236.

[30] Páldy A., Bobvos J., Vámos A., Gorove L., Buranszki-Sallai M., 2007: Effect of Elevated Temperature on Daily Emergency Ambulance Calls: A Time Series Analysis in Budapest, Hungary 1998-2004. *Central European Journal of Occupational and Environmental Medicine 13 (2) 159-169. 2007*

mortality data of the period 1992-2000. Namely, we consider a period as that of heat wave when the 26.5°C daily mean temperature of 98% probability is exceeded during at least three subsequent days. According to this definition there were 6 heat waves in Budapest in the period 1992-2000[31]. Excess mortality occurred shows the *Table 1.*

*Table 1.* **Excess mortality in Budapest during the heat waves of 1994-2000**

| **Age group** | | **1994. VI*.** | **1994 VIII.** | **1998. VII.** | **1998. VIII.** | **2000. VII.** | **2000. VIII.** |
|---|---|---|---|---|---|---|---|
| Cardio-vascular | 15-64 | - 4 | 2 | - 1 | - 1 | 8 | 0 |
| | 65-74 | 14 | 6 | 14 | - 4 | 8 | 0 |
| | 75+ | 51 | 36 | 22 | 25 | 39 | 27 |
| | total | 61 | 44 | 35 | 20 | 55 | 27 |
| | | | | | | | |
| Due to all causes | 15-64 | 11 | 32 | 2 | 3 | 31 | -3 |
| | 65-74 | 10 | 12 | 18 | - 4 | 14 | 8 |
| | 75+ | 49 | 50 | 48 | 33 | 57 | 33 |
| | total | 70 | 94 | 68 | 32 | 102 | 38 |

* Roman numbers mark the month of the year

In the period 2001-2007 there were 13 further heat waves in Budapest with the total duration of 80 days[32,33] *(Table 2).*

*Table 2.* **Heat waves in Hungary, 2001-2007**

| | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** |
|---|---|---|---|---|---|---|---|
| Number of heat waves | 1 | 2 | 2 | 1 | 1 | 5 | 3 |
| Number of days with heat wave | 3 | 8 | 11 | 4 | 5 | 30 | 19 |

In 2007 – in the most extreme summer so far experienced – there were three heat waves in Hungary. In the period of the first and third ones of these waves excess mortality was less than 5%. In the second and heaviest heat wave record breaking daily mean temperatures of higher than 30°C were measured for five days in the period 16-24 July. The unfavourable impact of high temperatures on the daily mortality can be unambiguously determined and this impact is even larger in the cycle of hospital patients. The excess mortality rate (33%) of the ten-day heat wave was lower in Middle Hungary than in France during the heat wave of 2003. Nevertheless, during the five hottest days the excess mortality was 57%. At a national scale the estimated total excess death cases were calculated by the respective relationships as likely falling into the range of 600-800.

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31 Páldy A., Bobvos J., Vámos A., Kishonti K., 2005: Többlethalálozás a nyári hőhullámok idején Budapesten 2001-2003. során (*Excess mortality during the summer heat waves of Budapest in the period 2001-2003*) Egészségtudomány, 49:4 299-310.

32 Páldy A., Kishonti K., Molnár K., Vámos A., Szedresi I., Gramantik P., Csaba K., Bobvos J., Gorove L., Buránszkyné S. M., 2006: A hőségriasztás hazai tapasztalatai (*Experiences with heat warning in Hungary*) *Budapesti Népegészségügy 37(2)99-105.*

33 Páldy A., Bobvos J., 2008: A 2007. évi magyarországi hőhullámok halálozásra gyakorolt hatásai (*Impacts of the heat waves of 2007 in Hungary on the mortality*). "Klíma-21" Füzetek

## Establishment of the heat alertness and warning system

In developing the system of heat warning the results and practices established during the European Union supported programme PHEWE, which was launched in 2004 has been utilised. The professional principles of heat-warning were developed firstly for Budapest and then for the whole country[34]. The action plans of heat wave periods were defined for the National Service for Public Health and Medical Officers (ANTSZ) on the basis of the EC supported *EuroHEA*T programme and making use of the proposal of the Rome office of WHO-ECEH by the National Institute for Public Health. Level 3 (Third Grade) heat warning was first time released in 2007, while in the earlier years the daily average temperature reached the second level (grade).

The heat warning threshold levels are defined on the basis of the weather forecasts of the National Meteorological Service in the following way *(Fig. 1, Fig. 2):*

- *Level 1:* when forecasts indicate that the daily mean temperature exceeds 25°C for one day. The internal information system of the Service of Medical Officers is involved.
- *Level 2:* when forecasts indicate that the daily mean temperature exceeds 25°C for at leas 3 days. The National Chief Medical Officer alerts the health institutions, the emergency ambulance service, the local governments and the population through the regional chief medical officers and orders the performing of preventive actions to protect our health.
- *Level 3:* when forecasts indicate that the daily mean temperature exceeds 27°C for at least 3 days. Involves the strict control of the actions and measures of level 2. The National Chief Medical Officer notifies the Secretariat of the Central Co-ordinating Committee requesting the taking over of the co-ordination of actions and measures of the various economic sectors when so required.

## Further tasks

Considering the health impacts of climate change, the objectives of the Climate-Health Prevention Strategy as part of the National Climate Change Strategy are as follows:

- To survey and identify all features and characteristics of climate-change induced illnesses that are presently known or could be encountered in the future, including the provision of the accessibility of all vulnerable people concerned with the appropriate preventive measures and taking the expectable widening of the range of involved people into account.
- To increase the weight of prevention and avoidance (timely preparedness) in defence activities with the aim of putting the major weight to such actions in the future in comparison to that of the basic emergency activities (emergency rescue. health care and rehabilitation).
- To establish and further develop a climate-health-care network on the basis of the principle of “minimum structures” with the meaning that the existing system should be modified with the minimum needed but sufficiently effective alterations only.
- Practical approaches should be given priority in each decision and measures and therefore the implementation of strategic tasks should be aimed strictly at achieving concrete daily practical objectives.

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[34] Bujdosó L., Páldy A., 2006: Az ÁNTSZ feladatai a klímaváltozás egészségi hatásainak megelőzése érdekében (*Tasks of the National Service for Public Health and Medical Officers in preventing the harmful health impacts of climate change*). “AGRO-21” füzetek,48. 60-67

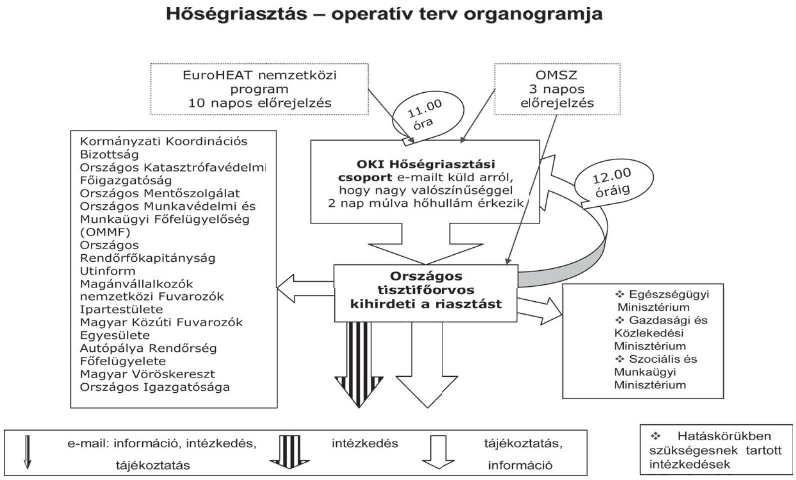


*Fig. 1.* **Organisational chart of heat warning**
(boxes: International Programme EuroHEAT, 10 day forecast, 11:00 h; 3 days forecast OMSZ; Central Co-ordinating Committee, National Head Office of Catastrophe Prevention, National Emergency Ambulance Service, National Chief-inspectorate for Labour and Labour-safety, Police Headquarter, road information 'Útinform', Association of Private Entrepreneurs and International Transport Companies, Association of Hungarian Trucking Companies, Motorway Police Headquarter, National Headquarter of Red Cross; Heat-warning Group of OKI sends e-mails that heat-wave arrives in 2 days with high probability - by 12:00 h; The National Chief Medical Officer declares alertness; Ministry of Health, Ministry for Economy and Traffic, Ministry of Social and Labour Affairs; e-mail: information, measures, action; measures; information; Measures falling into the competence of these ministries)

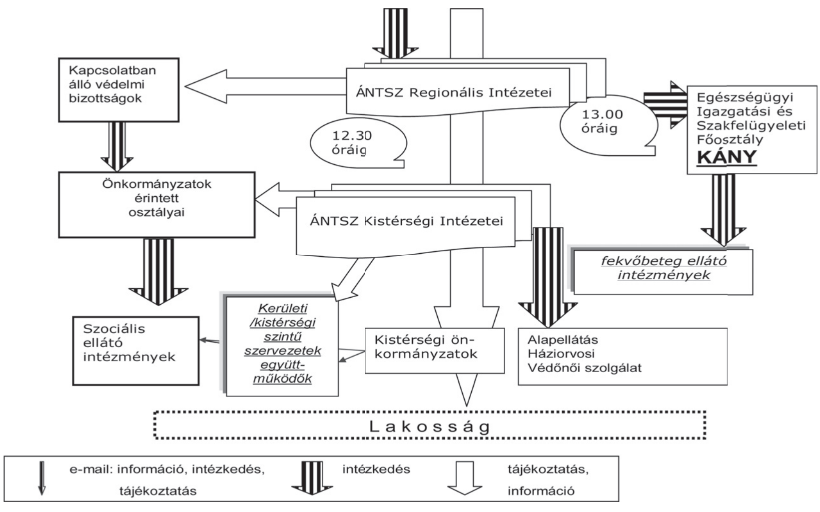


*Fig. 2.* **Flow of information in heat-wave warning, 2007**
(boxes: Defence Committees in connection; Regional Institutes of ANTSZ; Department for public health management and inspection; Departments of local governments involved; Small-regional Institutes of ANTSZ; Institutions of in-patients; Social (welfare) institutions; District/small-regional organs and co-operative agencies; Local governments at small-regional level; Basic health care. services of family doctors and district nurses; Lakosság = Population. Bottom boxes: as on Fig.1.)

## Conclusions

1. The human organism is sensitive to the impacts of climate change and to the increasing frequencies of extreme weather events. Apart from old people and people suffering from chronic diseases, healthy people are also impacted as these extremities induce – especially in hot days- vulnerable and sensitive status. In Hungary detailed research work has been carried out since several years by the institutions of the Public Health Service to aid the process of getting prepared and adapted to the impacts of climate change.

2. The research topics so far concerned the health deteriorating effects of heat waves (heat stress, heat stroke, premature mortality), the impacts of plants that release allergenic pollens, the diseases of encephalitis and Lyme, which are spread by ticks; new virus infections, such as those of the viruses West Nile and the Hanta; and the melanoma and non melanoma type malignant diseases caused by UVB radiation. The largest challenge is created by the process of warming up, which has been proven by both international and Hungarian experiences.

The concern with the harmful health effects of rising temperatures were launched by the heat wave of 2003 in France, which resulted in the excess mortality of 15 thousand people. Occasionally high temperatures especially endanger the urban population due to the so-called ’urban heat-island’ effect. Vector borne diseases (such as those spread by ticks and mosquitoes) are becoming more frequent with the rise of the temperature and the propagation and spreading of vectors are also changing, which result in the increase of the number of illnesses that were not so frequent before in the area in concern. The start of the blooming time of allergenic plant species is also changing along with its duration and this results in increased pollen load. Climate change also results in the need for evacuating people (prone to floods, deluge type rainstorms, land-slides, etc.) and this frequently comes along with injuries, infections, food and drinking water shortages and psychological impacts. There is a significant relationship between global radiation and the increase of melanoma cases. The increasing of skin cancer cases was also detected in Hungary, when the number of new cases was increased in the period of 2001-2005 from 1300 to 1800. We do not have such precise data for the number of winter frost- or down-cooling deaths but it is estimated that 200-250 such causalities occur in the colder winters. In large heat the human organism attempts to keep the body-temperature in a balanced state. Sweating is the counter action of our body. In extreme heat it is especially important to supplement the water losses. Sweating might cause two health problems: drying-out and loss of sodium. Heat-stroke causalities occur mostly upon intensive physical activity made in open air and in large heat (during work or lasting sport activity). Symptoms and illnesses due to high temperature (skin-pimples, tiredness, cramps, sudden fainting, exhausting, heat-stroke, etc.) can generally be traced back to the disturbances of the temperature regulation system. The need for more water is marked in the healthy human body by a feeling of sadness. The over-heating or drying-out of human body is especially dangerous for people suffering in chronic cardio-vascular, metabolite, kidney and mental diseases. Appropriate clothing can also help to avoid the overheating of our body. In days of heat wave the bright sunshine radiates more UVB onto the surface than in normal days and this increases the risk of melanoma. Medical doctors propose the use of light-protecting creams and the avoidance of being exposed to direct sunshine. WHO reported that excessive sunbathing causes at least 60,000 deaths in a year mostly due to melanoma. 90% of these casualties are caused by UV radiation.

3. The procedure of ordering heat alertness/alarm needs special attention and the performing of organisational tasks. In hospitals, social-homes and in work-sites requiring increased concentration on actions the number of air conditioned premises should be increased.

On the other hand the status of ‘over conditioned’ buildings should be reviewed since the appropriate labour organisation. In designing new buildings the principles of ‘rational air conditioning’ should be considered. In forming urban development concepts it is desirable to consider the avoidance of creating ‘urban heat islands’. Medical-meteorological forecasts should be improved along with the respective information strategies and with the involvement of public health experts.

4. In order to prevent the harmful impacts of the changing climate and to decrease their magnitude there is a need for creating a ’Climate-health Preventive Strategy’ in harmony with the existing National Climate Change Strategy. This Strategy would include: (i) the tasks and steps to be taken to create the climate-health network; (ii) the identification of the options of avoiding and preventing climate-change related illnesses; (iii) giving of priority to prevention along with priorities of rescue, health-care and rehabilitation; (iv) performing of usual daily services. The implementation of the Climate-health Preventive Strategy would require 7-10 years.

5. New approaches are needed for mitigating the harmful health impacts of climate change in several sectors of the public health service. These sectors include for example the emergency health-care, the units dealing with chronic diseases, social welfare institutions and the adapting of the services of the “catastrophe-health-care” to the altered weather conditions. Activities of the Public-Health and Epidemiological Service should be adapted, including the creation of a surveillance system of new illnesses. To aid the performing of these changes the international relationships of the Red Cross and other organisations such as WHO and CDC (European Centre for Disease Control) should be utilized.

6. It is likely that the process of warming will have an impact on hygienic conditions making them more vulnerable. Increased attention should be paid to the compliance with food safety regulations that should bring along increasing forced-control. Drinking water safety must have high priority as the water quality is highly impacted by both the dryness and drought and by the deluge-type rainstorms.

Serious drinking water born epidemics were launched in Hungary by abrupt and large rainstorms: In the period of 2-15 June 2006 a serious water-born epidemic was launched by storm-runoff in the City of Miskolc, causing 2890 identified illnesses, including 212 clients needing hospital treatment. The epidemiological survey and investigation found relationship between the consumption of drinking water and the illnesses of people served by the Tapolca Waterworks.

7. Climate change also has a bearing on labour-health and labour-safety. Special areas of this include the establishment of health-protecting working-conditions and especially the required changes in the timing of the daily work shift of outdoor labourers (changing the ratio of resting time to working time, or introducing noon-time siesta). This especially concerns construction sites and the processes of labour-safety. Climate-specific expansion of the activities of labour-health services will be needed. Safety requirements of certain industrial works must be strengthened with special regard to chemical safety. Regulation of working and resting times should be reconsidered, changing the respective regulations and specifying the type of works where the working conditions must be adapted to changing climatic conditions.

8. Climate changes have an impact on the ways of living and on the services protecting consumer’s rights. Public information and awareness rising is needed for supporting adaptation of the population to climate change in their clothing, eating, in- and outdoor recreational and sporting activities and the becoming acquainted with the risk of these activities. Risks of organising gatherings of masses of people are also changing. Measures to protect the rights of consumers should also be modified in order to lessen the harmful effects of climate change.

# 13. CLIMATE CHANGE AND TOURISM

### Tourism and environment

At global scale tourism faces three basic challenges: the realisation of sustainability, security in a broader sense with due concern to terrorism, the provision of conditions that the tourist gets what he/she had paid for, and the handling of the lasting or sudden impacts of the changes of the climate Evidently the three challenges are interrelated, but the recognition of this seems to be delayed. For example the devastation of visited places, terrorist actions, and the weather-induced and other natural catastrophes had a cumulating impact on tourism, in the last years. The latter called the attention to the expectable impacts of climate changes.

In the past decade tourism became a dynamically developing industry at global scale. More and more people travel to further and further places due to the spreading of air traffic. In tourism the main attractions include pristine natural environment and cultural values, while mass-tourism often causes harmful environmental impacts, especial in the peak-tourism periods. What pollution is or can be caused by tourism? Increasing road traffic of vehicles causes air pollution, while air traffic contributes to this substantially. Air traffic is considered the most polluting one, especially in the case of short-distance (less than 1000 km) flights, because take off and landing requires increased fuel consumption and therefore air traffic causes twice-higher pollution than private vehicles. Based on the research results of the European Federation for Transport and Environment, T&E the carbon dioxide emission of air flights was increased in Europe by 85% in the period of 1990 and 2004. High number of tourists causes increased water consumption and higher sewage loads in recreational places. Similarly serious problems can be caused by the increase of solid wastes, as the capacities of disposal sites often cannot follow the increase of waste generation. Not properly controlled movement of tourists may cause the deterioration of the flora, the fauna and the soil. In order to decrease the harmful impacts of tourism several proposals were made in the past decades for creating the conditions of sustainable tourism.

The World Tourism Organisation (WTO) defined the concept of sustainable tourism in the following way: The tourism that can be kept (sustainable) under control may satisfy the needs of today's tourists and of the target places of tourism, but shall simultaneously preserve the presently available conditions for the future generations to come, and make effort to improve these conditions. This type of tourism is the result of a development process, in which the resources are utilised in a controlled manner for meeting the needs of the economy, the society and aesthetics in such a way as not to harm cultural values, basic ecological processes, economic systems, biodiversity and other systems that need to be preserved for sustaining life on Earth.

### Focusing on impacts of and response policies to the climate change

In the past decade the tourism industry have recognised the potential impacts of climate changes on tourism and therefore WTO held several conferences on the relations between climate changes and tourism. The first international conference of this kind was held in 2003 in Djerba and the topics included not only theoretical themes but also practical issues and had invited the representatives of the organisations dealing with these issues. The so-called Djerba Declaration adopted in this conference included the following statements:

- To urge all governments concerned with the contribution of tourism to sustainable development, to subscribe to all relevant intergovernmental and multilateral agreements, especially the Kyoto Protocol, and other conventions and similar declarations concerning climate change and related resolutions that prevent the impacts of this phenomenon from spreading further or accelerating.
- To encourage international organisations to further the study and research of the reciprocal implications between tourism and climate change, including in the case of cultural and archaeological sites, in co-operation with public authorities, academic institutions, NGOs, and local people; in particular, to encourage the Intergovernmental Panel on Climate Change to pay special attention to tourism in cooperation with WTO and to include tourism specifically in its Fourth Assessment Report.
- To call upon UN, international, financial and bilateral agencies to support the governments of developing, and in particular of least developed countries, for which tourism represents a key economic sector, in their efforts to address and to adapt to the adverse effects of climate change and to formulate appropriate action plans.
- To request international organisations, governments, NGOs and academic institutions to support local governments and destination management organisations in implementing adaptation and mitigation measures that respond to the specific climate change impacts at local destinations.
- To encourage the tourism industry, including transport companies, hoteliers, tour operators, travel agents and tourist guides, to adjust their activities, using more energy efficient and cleaner technologies and logistics, in order to minimise as much as possible their contribution to climate change.
- To call upon governments, bilateral and multilateral institutions to conceive and implement sustainable management policies for water resources, and for the conservation of wetlands and other freshwater ecosystems.
- To call upon governments to encourage the use of renewable energy sources in tourism and transport companies and activities, by facilitating technical assistance and using fiscal and other incentives.
- To encourage consumer associations, tourism companies and the media to raise consumers’ awareness at destinations and in generating markets, in order to change consumption behaviour and make more climate friendly tourism choices.
- To invite public, private and non-governmental stakeholders and other institutions to inform WTO about the results of any research study relevant to climate change and tourism, in order for WTO to act as a clearing house and to create a database on the subject and disseminate know-how internationally.
- To consider this Declaration as a framework for international, regional and governmental agencies for the monitoring of their activities and of the above mentioned action plans in this field.

As a follow up of the Djerba Conference the second climate-change-and-tourism conference was held in October 2007 in Davos also focussing on the interrelations of tourism and climate changes. The importance of the conference was marked by the facts that it was organised with the support of the World Economic Forum (WEF) and the 450 participants of the conference represented 80 countries. The so-called Davos Declaration indicates that the basic principles adopted at the Djerba conference are still valid and unfortunately there were no such changes that would question the timeliness of any of the paragraphs of the earlier declaration.

Proposals of the Davos Declaration can be listed into four groups:

- For governmental and international organisations the most important proposals concern; the practical implementation of the guidelines of the Millennium Declaration of the United Nations, the financing of relevant research work, the transfer of information and the possible closest co-operation of the parties involved.
- In respect to the tourist industry and the target places of tourism firstly the enhancing of the security of travellers are mentioned along with the improvement of the energy-efficiency of the tourist-sector in order ensure sustainable development and the preservation of cultural values and that of the landscape.
- The attention of tourists was called to the consideration of the options of reducing their "carbon-footprint" when selecting their target places and to enhance the preservation of the environment and the cultural heritage.
- The most important recommendation for science was to initiate multidisciplinary research into the impacts of climate changes and to study the role of tourism in inducing climate changes and to develop guidelines for establishing sustainable tourism.

Numerous international research projects deal with climate changes and their impact on tourism. Some of these projects were commissioned by tourist and travel companies (such as the Holiday 2003 report of the Halifax travel agency). Others are research projects of the European Union (such as the Project CLAVIER). In this latter the Middle-East-European region appears as a planning unit and it includes Hungary. Since the Project CLAVIER was started in 2006 and therefore no detailed information on its results are yet available.

According to the forecast of the Halifax Travel Insurance the number of days with the highest temperature over the hardly tolerable 40°C will in the next decades rise in the southern parts of Europe, which include the most favoured tourist target places. This will most probably be associated with decreasing precipitation sums and water shortage, which will further deteriorate the conditions of tourists. As indicated by the events of the summer of 2007 the frequency of forest fires increases in dry and hot summers. Due to the water usage restrictions, which are expectable upon water shortage, the rooms of the hotels having swimming pools might remain empty. Maintenance of golf courses, favoured by so many tourists, may become ever more expensive, due to the dryness of the climate.

Climate changes might redraw the tourist map of the world, as stated in the forecast of the Halifax agency: The climate of the southern countries (Greece, Italy, Spain, Tunisia, Cyprus, etc.), which are traditional tourist target places, is turning hotter and drier and may thus become intolerable for the tourists in the summer periods. The countries having so far cooler and wetter climate (Germany, Ireland, Great Britain, Scandinavia), which are also the most important tourist "sending countries" may be turned into tourist target countries, when their climate becomes milder. It is expectable that tourism remains intensive in the southern countries, but the peak tourist period will be shifted from the summer into the milder spring or fall periods.

It is likely that the impact of rising sea level on the favoured tourist paradises will be substantial; a large part of numerous south-sea islands will be inundated even upon a few centimetre rise of the sea level. Rising seawater temperature and the changes of the pH of the seawater may drastically reduce the number of corals and therefore it is likely that the diving and goggle-fishing oriented tourism will be reduced.

In addition to the changes in seacoast destinations serious changes are expectable in ski-tourism in the traditional target places. Snow-limit elevation moves upward by about 100 m in each decade and the length of the skiing season is also shortened. Upward shifted skiing activities may have a serious impact on the ecosystems of higher mountains and this could bring along erosion and the devastation of rocky areas.

The impact of climate change on the important recreational sites of Hungary will be varying. Results of numerous international research projects indicate that drier climate will have serious impact on shallow lakes to where Lake Balaton, the largest lake of Hungary, also belongs: water depth may be drastically reduced and this will deteriorate water quality and thus also tourism. Similar impacts may be expected in other shallow Hungarian lakes, such as Lake Fertő and Lake Velence. The inflow to Lake Tisza may remain undisturbed, but this also depends on the changes of the discharge of the River Tisza. In the recreational area of the Danube Bend the main attractions are the cultural values and therefore the preservation of these are important tasks from the viewpoint of tourism.

## Conclusions

1. *Tourism is one of the expected break-through points of the economic policy of Hungary.* It is expected that tourism will contribute to the development of the Country more significantly, including the increase of the employment and the improvement of the budget. The realisation of these expectations can directly or indirectly be affected by climate changes to both positive and negative directions. Control of environmental pollution, potentially associated with tourism, becomes ever more important, along with the protection of natural values and the regeneration of deteriorated ecosystems. Fortunately terrorism has so far avoided Hungary, but vandalism associated with internal political events may also harmfully affect tourism, as it was well indicated by the decrease of the number of tourists after the attack of the headquarters of the Hungarian television.

2. In a global sense climate changes of the northern hemisphere affect mostly the *tourism of the seasides and high mountains*. Upon the warming of the climate the recreational season may be shifted in Europe, along with the direction of the flow of tourists: On the Mediterranean seaside resorts the summer heat may become intolerable for many tourists and they will choose other destinations towards the north. In the mountains the snow limit is being shifted upward, the winter becomes shorter and the demand for winter sports will be decreased. These impacts may, although indirectly, favourably affect the tourism in Hungary, if the relevant sector will be prepared for that with appropriate marketing.

The likely warming up of the climate and the related drier seasons may have some advantages. For example; less cloud cover, wind, rain and cool days will make the tourist life miserable at Lake Balaton and other Hungarian resources. The recreational season may be broadened, the milder spring and autumn months and milder winters may increase the visitor days of the recreational resorts. At Lake Balaton the main season that was dwarfed to 4-5 weeks of today may become longer. Nevertheless, higher temperatures will accelerate algae growth and drier years may cause serious decrease of the water depth. To counterbalance these impacts alternative tourist attractions should be developed at the lake. At Lake Balaton these could include tourist attractions of sites further away from the lake, as these would create less direct pressure on the lakeside and may offer less season-dependent recreational activities. Eventually these recommended changes refer not only to Lake Balaton but to all recreational sites of the country, such as those related to *medicinal and thermal waters, cultural heritages, village tourism, special protected natural values and to their combinations*. In planning these new tourist attractions their sustainable operation must be born in mind.

Global warming cannot be halted, even if one would not believe it during some very cool summer days. The geological department of the University of Innsbruck warn the relevant decision makers that the routing of the mountain tourist tracks should be urgently reconsidered with due concern to their research results. One should (and probably also can) avoid those routes where rock fall (avalanches?) might soon happen, as it was indicated by the results of the research into the composition of the geological formations of the mountains.

This phenomenon is inseparably related to the melting of the glaciers: loose stone formations, which were kept frozen before by the ice, appear from below the disappearing glacier. The same refers to the melting of the upper soil layer that was so far frozen. The movement of these newly appearing formations, which are looser than the earlier surface cover, cannot be predicted. The melting of glaciers is not a new phenomenon, but has been started 150 years ago. Nevertheless, the process has been accelerated since 1990 and its rate exceeded in the past year all expert's predictions.

Accepting the warning of the experts Austria started the displacing of mountainous tourist tracks in the fall of 2006. They have taken special care for those tracks that routed between glaciers and to those where rock fall from the mountains endanger tourists.

3. Future tourism of Hungary may be much enhanced, when one would more concisely emphasise the country's favourable climatic conditions, with facts and numerical data and by well-designed advertisement. In comparison to the Mediterranean the main advantages are; the lower UV radiation, the good state of the natural environment, the medicinal and wellness tourism that can be based on the outstanding thermal and medicinal groundwater resources of Hungary. Further on such factors include; good public and environmental security, good quality of food and food-quality control and the broad offer of restaurants and accommodations. Medicinal and wellness tourism is relatively independent of the weather and gains thus new significance. Therefore it is decisively important to protect these water resources and the environment and to improve the level, variety and quality of services, with due concern to the broad ranges of the paying-willingness of tourists.

Simultaneously one must get prepared for counterbalancing the negative impacts of climate changes (drying vegetation, decrease of water depth and flow in lakes and water courses, dust, and the invasion of flies and mosquitoes, etc.), which will require various strategies of differing expenditure. On the other hand one should urge the entrepreneurs of the tourist industry to adopt the concept of "*sustainable tourism*" in which the options offered by the industry take into account the effects of climate change and considers the chances of reducing environmental pressures and that of regenerating the environment. One must take much more care, than before, of causing the least possible damage by traffic and transportation, littering, destruction of special natural values (by the collection of such items), etc. Preparations for such preventive actions need time and expenditure and the establishing of appropriate technical conditions, and these also consist parts of the process of getting prepared for climate changes.

4. Experiences of the near past call the attention to the *increasing foreign tourism of Budapest and of some other larger cities of Hungary*. In this context the weak points of these cities could be converted into a critical state in the future. Consequently the urgent tasks include, for example, the installation of drinking-refreshing wells on the streets, elimination of the lack of sufficient number and area of parks, green zones, alleys, flowers, public utilities for refreshing and the hygienic conditions of the existing ones. Sparsely located waste bins, excrements of our favoured pets, stinking side streets, trams with windows that cannot be opened, shortcomings of shading, ventilation and resting places, lack of natural air flows, open air "green" restaurants, low number of open air beaches and lidos, their hygienic problems all wait for improvement, while the significance of "baths and spas" is increasing. The low choice of non alcoholic drinks, light food, etc. also mean challenges that should be dealt with, needing the launching of an *action programme,* in which the education and training programmes should focus on *human infrastructures* with special emphasis. Security and well-being of tourists demand the availability of seasonally appointed police staff, which

speak foreign languages, as well as the easily accessible medical night duty, especially in frequently visited sites.

5. *Village and country tourism,* associated with the miracles of a peaceful landscape and other local specialities, may become the main attraction of foreign tourism in Hungary. A special feature of countryside tourism, in contrast to the urban environment, is that heat-days will be better tolerable in the country.

*In the camp sites and in the river- and lake-side recreational areas* adaptation strategies include the elimination of flies, mosquitoes and ticks, dust reduction, noise protection and evidently the cooling of dwellings, either artificially or by natural means.

Extreme weather events appear also in tourism as risk factors. For example at Lake Balaton the tasks of water-police (rescue teams, life-guards) will be amplified. In the eighties of the last century the number of deaths caused by the windstorms was about 50 in a year. In 2004 this was reduced to 10 causalities per year. The number of people rescued from the lake in the near past was in the range of 200–300 persons per year! It would be desirable to keep this ratio also in the future and for this the 6 police water-police stations offer a staff of 60 and 18 motorboats.

On the beaches the conditions of accident preparedness do not, in many sites, include facilities to handle serious cases and loss of conscience (black-outs).

Tourists and to be travellers (as almost everybody) demand more and more and ever more accurate information on the expectable weather. With the help of such information they can select the destinations and the time of travel, which are best suited to their person (for example to their health condition). Accurate knowledge of climate and bio-climatic conditions, and the relevant well-understandable public information could significantly contribute to the advertising of the natural conditions of various destinations, thus providing help to travel organisers.

# 14. TASKS OF CATASTROPHE DEFENCE IN LIGHT OF GLOBAL CLIMATE CHANGE

### Basic climate change issues for catastrophe defence

The role of the catastrophe defence, as an organisation is to ensure the safety of life and work conditions and this is done in a unified framework of the tasks of prevention, defence and rehabilitation, integrating it into the national security system. These tasks can be effectively fulfilled in close cooperation with other organisations (state administration, police, etc.) and the population, the relevant companies, the charity organisations and practically with all actors of the society. It is especially relevant for the protection against natural and civilisation-induced catastrophes.

It has become clear that security is not just a simple technical task, but also a complex social issue. Furthermore it is not the problem for a single professional discipline, but it can be tackled only in a multidisciplinary approach, moreover, and we must not consider only short-term solutions but long term responses.

The fact that security substantially defines the social and economic state of the country makes the maintenance of the safe and secure life- and working conditions a task of the state management, and is called the “sustainable security”. Sustainable security basically means a functional sustainability, which means – from the point of view of the Catastrophe Defence Organisation – the management of dysfunctions.

The catastrophe defence related to global climate change and its impacts from the point of view of the defence of crucial infrastructure needs a specific approach based on existing national catastrophe defence experiences and the international co-operative in this field. The basic factors and issues in this context were recently studied (particularly in the framework of the VAHAVA project) and the most important findings of this research are as follows:

- Because of some foreseen critical impacts of climate change the organisation of catastrophe defence/prevention will face very serious challenges in addition to the traditional tasks of fire-fighting, civil defence and catastrophe prevention. Among these new, anticipated challenges the most outstanding ones will be the security and catastrophe defence issues related to climate change.
- Further important finding for the catastrophe defence is that the most pressing problems expected due to the climate change is the increase of the intensity and frequency of extreme weather events.
- Much more attention should be paid to the development and operation of defence, adaptation and tolerability strategies in handling the impacts of climate change.

### Contributions of the catastrophe defence to national preparations to climate change

The results of the Project VAHAVA are put into three so-called baskets:

- The integration of the data and knowledge accumulated so far by the large synthesising effort of the contributors to the project.
- Proposals and suggestions for measures and research subjects for short-, medium-, and long-term and also for local, regional and national levels.

- Laying down the scientific basis of the development of a national climate change strategy.

The national catastrophe defence can profoundly contribute to the tasks belonging to each basket.

Firstly, all data and information on extreme weather events are collected and analysed, and the most important experiences during such events (including the direct and indirect damages caused by the events) and the defence operations.

Secondly, proposals have been formulated, such as the tasks and field of competence of the local governments in combating extreme events, updating of technical equipment (such as pumps), along with the programmes of rising public awareness and the ways and means of developing the preparedness plans and the methods to be used.

Thirdly, a National Catastrophe Defence Strategy was elaborated together with the Documents of Security Strategy and these also address the problem of the climate change. Moreover, the National Climate Change Strategy refers to the national tasks of catastrophe defence.

From the point of view of catastrophe defence the changes of the climate are viewed mostly as physical changes, distinguishing direct primary and secondary impacts. Primary impacts are those, which are directly induced by the changing climate, such as:

- extremely low or high temperatures;
- extreme precipitation (lasting rainfall, rainstorm, hail or snow storm creating lastingly thick snow cover and snowdrift);
- windstorm, hurricanes, tornados, etc.

Secondary impacts – stemming also form the primary ones, frequently in a cumulating or combined manner – are the followings:

- floods and inland excess waters;
- mudflows and landslides;
- drought and desertification;
- intensive fires, extra danger of blasts.

## Further research tasks

Research priorities, related to climate change are ranking as follows in terms of catastrophe defence:

- collection of Hungarian and international experiences, legal regulations and methods, which are related to catastrophe defence in the field of climate changes, preliminary evaluation and processing these information;
- investigation of professional terms of climate change and the related catastrophe defence tasks, proposals of unifying and standardisation;
- identification and definition of the critical sectors of catastrophe protection in relation to climate changes;
- development of indicators related to climate change and the tasks of catastrophe defence;
- investigation of technical development issues related to the new strategic methods of catastrophe defence;
- investigation of the economic efficiency of carrying out the tasks of catastrophe defence in relation to climate changes;
- development of public information techniques in the field of crisis commutation;
- development of risk analysis methods in climate change related catastrophe defence;

- investigation of the reaction-ability of the organisation of catastrophe defence, along with the development of planning aspects;
- investigation of the regulatory, organisational and management aspects of catastrophe defence and the making of relevant proposals;
- design of pilot programmes and the monitoring of effectiveness.

The basic principle of for these research activities is to prepare a practical and scientifically based method for the numerical determination of risk properties of a given region in order to aid the risk related decision-making. Such This method enables the exact numerical determination of the catastrophe risks of the various regions of the country. Based on these quantified risk assessments, measures and interventions can be developed, which will increase the level of safety and tolerability throughout the country.

# 15. CREATING RESERVES

The provision of reserves forms an organic part in the process of getting prepared to face the impacts of global climate changes, including the provision of the means of prevention, damage avoidance and mitigation. Not only standby tools, materials and equipment are included in these reserves, but also the plans for handling various changes of the weather and climate. The scope of creating reserves should also include public information; namely that there must be people in each settlement who know that where are these reserves, how to get them, who can use them under what conditions and how and when they should be replaced in the stock. Without the standby assets and without having people trained on their use the risk of increased damage is growing, due to the unexpectedness of the event and due to the idleness and panic so created.

Eventually the provision of reserves needs financial means the extent of which can be reduced if the standby tools, materials, medicines, food, etc., are such as one uses in the "normal", daily routine, without violating their availability of the reserve in emergency situation. This means that after a certain period of standby-stocking these reserves (medicines, water, and food) can be sold. The costs of providing reserves can be rationalised by multipurpose utilisation of the stock.

1. In extreme situation the *food and drinking water reserves* are of the highest priority, as they are the essential life-support means. It is an ancient human behaviour to stock reserves for the "time of the lean kine" for the years of shortage or for the times of war. Safety food and drinking water reserves are formed also in our era in all developed countries. Nevertheless climate change will put a new light on this issue, as the reserves correspond not to faraway future event of low probability, but to events that might happen in any day. Climate change is not only 'knocking on the door' but has opened it, as it happened in 2007 in Europe and also elsewhere. This situation is further aggravated by the growing needs of the developing countries, by the decreasing extent and degrading quality of fertile soils, by the interest in bio-fuels and by the damages done by extreme weather events.

The actors of the social-economic life of Hungary were coddled by the per capita abundance of good quality arable land, which has assured the safe supply of food for the population and the income from export. The first task of forming reserves follows directly from this situation and it is the protection and guarding of the quality and quantity of arable land and the halting of the accelerating process of converting arable-land to other land uses. In hard times always those countries are in better situation, which have "superfluous" food production capacities. Consequently in considering the changes of the climate, one of the most important reserves-stocking tasks is to *maintain the food-production capacity.* Events of the year 2007 have proven that economic policies aimed at the reduction and "freezing" of food production rates are shortsighted.

In the concrete physical forms of stocking reserves *cereals, conserved food and livestock* are of the main importance. Cereals can be well stored with only smaller loss of the quality, can be used in multiple ways and are essentials of human food. Therefore they form an important standby stock in adapting to climate changes. The provision of livestock reserves is not a new invention. In the not too far past village housewives practised the keeping of animals on foot around the house and using them when needed, this way was the term live-stock born. We also may mention the ancient Hungarians migrating towards the Carpathian Basin, driving their cattle and carrying meet and barley for food supply. Eventually there are, in addition to cereals, other important well stock-able food staffs, such as salt, sugar, pastry and frozen or canned food.

Although in *drinking water supply* Hungary is in a favourable state, but taking into account the long recharge times of groundwater resources, which form most of the drinking water resources in Hungary, one must consider strict stocking rules already in the near future. In this regard, the first step should be the sparing use of water and the reduction of the wastage of water. The provision of water ’stock’ is a multilateral task: firstly it includes the protection of surface and subsurface water resources, the prevention of their pollution. It is especially important to protect the quality of water of the deep confined aquifers and the sparing and rational use of these deep groundwaters. Bottled mineral waters play an important role in forming reserves. Hungary is in a favourable position in this respect, being very rich in mineral waters. Rising water prices gain an important role in the sparing use of waters, throwing new light on the reuse of spent waters and on water treatment. The issue of recharging spent subsurface waters into the aquifers also need consideration.

2. Considering the impacts of climate change on human health the provision of reserves gain new and widening aspects. Complex measures are needed in handling this issue:

Upon the impact of heat waves the harmful effects of allergenic *pollen producing plants* are increasing and therefore the standby stocking of the tools of the rapid elimination of weeds (sprayers, motor lawn movers, etc.) is needed, in addition to preventive measures.

In providing protection against *ticks* the stocking of (the expensive) insecticides, spraying equipment and preventive substances are especially needed in the vicinities of schools, kindergartens, public green zones and parks, arboretums and in the garden homes. Stocking of vaccines for protective springtime vaccination is also needed.

Distribution of bottled drinking water can provide protection against *drying-out* and disturbances of blood circulation and oxygen supply.

Information is the major means of protection against *Melanoma* but the provision of standby stocks of spectacles, light-protection sheets, shading devices and sun-oils can also support the fight. It is also important to assure that these products be inexpensive and “fashionable”.

A similar solution is to make fans fashionable, distributing them on the street. The provision of support to the production, stocking and selling of windows with venetian blinds and sunshades can also be good means of tolerating heat days.

Although *air-conditioning* is a whip-saw, consuming much energy, creating peak-consumption of electricity and emitting heat to the outer environment, the use of air conditioners cannot be avoided in hospitals, department stores, public institutions, etc. Alternative solution might be the provision of cooled escape/refuge rooms in such sites. Standby spare parts and repair capacities should be also provided for the days of heat alarm.

Impacts, loads and exposures are increasing in all issues of hygiene and therefore the appropriate standby assets should be determined and stocked.

Provision of standby assets is essential in *labour-health and protection*. The standby stock should include skin-protective creams and lotions, spectacles, other personal protective clothing and drinking water of 14-16°C.

For the *cooling of the asphalt pavements* of 60-70°C it is important to provide water and vehicle reserves, as the latter tend to break down in the heat.

Upon the impact of extreme weather events the increased need for *accident emergency* and rescue vehicles, first aid kits and for standby stock of various tools, equipment and medicines must be taken into account (to handle injuries, indisposition, fainting and other accidents).

3. In the hot and dry periods it is especially important to provide sufficient *watering for animals*, both in the barns or stables and in the pastures. The importance of the techniques of shower cooling, spraying or bathing of animals is rapidly growing. Lacks of drinking water for animals will not only decrease their capacities for smaller-larger periods of time, but also may cause their death or the need for forced-butchering.

In addition to meet watering needs the close environment of animal farms (the caddy and the floor of barns and stables) might also need cooling and the maintenance of shade providing vegetation becomes also important, along with the water reserves.

The need for breeding animal species and hybrids of low specific (per body weight) water consumption will be increasing, demanding the promotion of their stocking and breeding.

4. In Hungary the floods of the rivers Danube and Tisza caused tremendous damages in the past, devastating whole cities and destruction of transportation lines over huge areas and keeping villages and valuable natural areas under water for longer periods of time. Recently the occurrences of fierce floods of small streams are encountered, upon the impact of extreme rainstorms concentrating on small areas.

In Hungary there is a well established and operating flood defence system supported by an excellent guard of water engineers. Nevertheless this system can only fulfil its duties in emergency situations when sufficient reserves are stocked and these stocks can be rapidly reached. This stock should be completed by the availability of staff, materials, tools and equipment and the means of their rapid transportation. The standby assets of flood control and defence include sand, sandbags, wood-stock, brushwood, plastic sheets, lamps and torches and mobile buildings and tents for providing rest for the staff. Availability of defence plans and a staff of acknowledged managing professionals and well trained workers is also very important along with the list of volunteers who can be called in emergency situation.

5. The increasing frequency of “novel” *mud avalanches*, induced by high rainstorms concentrating on small areas or by rapid thaw and snowmelt, needs new considerations. This can be handled by rapidly site-transported slurry-pumps and machinery for hauling-scraping-transporting mud. Standby equipment is needed firstly for cleaning the jammed and silted-up sewers.

6. The basin-bottom geographic location of the country and the impermeable upper soil layers create favourable situation for the occurrence of excess waters (e.g. naturally non-draining precipitation waters that fill shallow depressions of flat-land areas) and this phenomenon can occur over even larger areas upon extreme weather events. In the near past the handling of these excess water were focussed at the rapid drainage of the inundated areas in concern into the nearest stream. Nevertheless this practice is unfavourable from several points of view. Before the 90-ies there was a correct approach to the solution of this problem, when the waters were drained into the soil and stored in it. Based on these earlier experiences it is highly desirable to use deep-soil loosing equipment to solve this problem. Multiple problems (excess water, floods and drought) can be handled in this way and therefore these equipments should also be made available as standby reserve. High performance tractors of good all-terrain driving ability and of low specific on-soil axis pressure should also be made available as standby stock.

7. The frequency of occurrence of *wind- and rainstorms* has also been increased in the near past, marked by fallen trees, poles, alleys, torn off roofs and disturbances in traffic and energy supply. Standby stocking of ladders, chain-sows, plastic sheets and vehicles equipped with lifting equipment can aid the rapid solution of such problems.

8. In the past decades Hungary was frequently ridden by drought and longer dry and warm periods. Taking into account the expectable warming and increase of dryness in this region,

the adaptation strategy demands storage and sparing use of *irrigation waters.* This is very important since in the lack of sufficient irrigation dry periods are associated with reduced food production – that might also be coupled with deteriorating quality – and this can result in the accelerated rise of food prices. Irrigation water becomes especially important in the case of highly valuable cultures or in that of crops high dryness sensitivity value. Therefore preparations must be made for the provision of irrigation water. Storage of water can be made in various ways: storage of winter and spring high flows in reservoirs; storage of excess waters in the depressions of the terrain; and most importantly storage of infiltrated precipitation water in the soil (as the largest water reservoir in Hungary is the soil of the arable land). All these need programmed preparedness both at national and local scale.

9. Extreme weather events may cause tremendous damages to *orchards and wine-yards* of high economic value. To aid preventive action (such as: smoke-protection, frost-protection by spraying, use of materials to protect against sun-burn, hail and frost, etc.) standby stocking of the respective materials are needed. Stocking of pesticides is also needed to provide protection against the pests that show up after extreme weather events. Eventually the stocking of propagation substances (seeds, cuttings, etc.) may also accelerate the remedial action.

10. In Hungary catastrophe-prevention is a well-established organisation that also deals with the stocking of standby assets. Nevertheless, in the case of climate changes new solutions are needed in providing reserves for the solution of recently encountered new problems, so as to enhance adaptability and tolerability. The existing reserve capacities are insufficient and very rapid access time, within ten minutes, to damage-sites might be needed. The protection of the 13 most important infrastructures also creates new aspects of the provision of standby stocks.

This organisation, mostly equipped for fire fighting only, should be provided with new material and technical standby reserves, so as to enhance their action in fighting weather events. It would be expedient to consider the new system of conditions that are required for rescue, repair and other contingency action upon weather impacts. Fighting of forest, meadow, bush and reed fires require substantial standby assets, considering also the increasing hazards. The timely observation of fires is of special importance and the standby stock shall include electrically driven small robotic aeroplanes, softwares that forecast the propagation of the fires, and materials and tools that are needed for fire extinguishing by blasting.

The unexpected character and rapid occurrence of extreme weather events require extra standby stocking capacities for the organisation of catastrophe prevention, for rescuing and evacuating people and also for the provision of supply of goods for the feeding and protection, with due concern to the facts that these weather events differ from those so far encountered in their impact type and magnitude and in their speed and duration.

# 16. INSURANCE IMPLICATIONS OF CLIMATE CHANGE

Looking on the topographic map of the Carpathian Basin, it is unambiguously recognized that it forms a drainage basin of rivers and the lower part is an enormous sedimentation zone. The lower parts of the rivers draining the basin are of meandering type, have large floodplains and potentially inundated flood basins.

In the Hungarian lower part of the Carpathian Basin these characteristics appear as abrupt changes of hill and channel slopes at around the rim of the foot of the mountains, where the vast flatland of the great planes start. This situation is prone to the development of serious floods. The nearly 2000 km long ridges of the Carpathian Mountains is of decisive importance in forming the special climate of the basin and the morphological features define the routes of surface runoff, the sediment loads and sedimentation rates. The weather of the basin is characterised by extreme events and this forms a lastingly unfavourable condition for both economic activities and human life. A part of these anomalies is, however, due to anthropogenic impacts. Investigations of the European Environmental Agency (EEA) in 2006 indicated that 9.2% of the greenhouse gas emission stems from the agriculture.

This very specific "basin character", with the Dévény "gate" between the Alps and the Low Carpaths and the protective barrier of the Dinári Mountains on the South, created a system of micro climates that have large differences even within Hungary. Extremes of precipitation and other weather elements cause potentially high erosion damages, wind and hail storms, floods and sedimentation rates (mud avalanches) over the whole Carpathian Basin, but the geographic distribution of these impacts and the frequencies of damage events show marked differences.

The given special natural and geographic conditions create challenges for the security of crop yield of various cultivation branches, affecting also the security of animal husbandry. The security and protection of private and industrial wealth and of the environment are also critical challenges when elemental damages (for example flood and hail damages) happen in a concentrated way in a given area.

Elemental damages of the agriculture are listed below according to the type of damage and in the light of the conditions that insurance companies prescribe for the acceptance of an insurance case. The agricultural insurance market is reviewed from the point of view of those taking the risk (the risk holders) and thus defining the market.

On the basis of the questionnaires of a survey of MABISZ (Federation of Hungarian Insurance Companies) the main findings can be summarized as follows:

- The market share of Allianz Hungaria Insurance Company (AHBRT) is 45.6% and this means in comparison to the competitors the followings (for agricultural insurances): provides the widest coverage of risks for both crop and animal insurances; provides special coverage for pests (e.g. for Cleonus fasciatus).
- Income of the companies is slightly increasing and this is recently 1,752.4 M-HUF per annum for AHBRT, while only the company ARGOSZ had a recession of 10 M-HUF.
- The newly organized non-profit insurance companies of the farmers have only 2.7% share of the market, which is a very weak position.
- It is to be noted that medium and small agricultural farming units, which will hopefully be substantially strengthening in the future, are going to establish non-profit

farmer-insurance companies based on producer-trader-consumer type associations and professional bodies protecting their interests (similarly to the non-profit farmer insurance companies of the other EU Member States).

- In Hungary there are 29 insurance companies and most of them deal with life insurance only. Only 4 of the largest joint-stock insurance companies are undertaking agricultural insurances (most likely due to the high risk and low profit involved in such insurances).

Agricultural types of damages belonging to the category of elementary damage are as follows:

- Drought damage 42.35%.
- Hail damage (caused by hail storms) 20.52%.
- Water damages (caused by flooding of surface waters, by inland excess waters – precipitation water accumulating in the large shallow depressions of flat land not infiltrating into the soil- and by the rise of the groundwater table) 18.44%.
- Storm damage (mechanical injuries of the crop at wind speed higher than 15 m/sec, 54 km/h, including deflation damages caused by sandstorms, 2.65%.

Observations of 35 years length indicate that the concrete damages show large differences from each other in the type and frequency of occurrence of the damage.

As the data above shows the “traditionally” largest damage of the agriculture is caused by the drought (42.35%). The geographical location of drought-prone areas indicates that the largest agricultural regions of the country are involved most frequently.

It is a fact which needs serious consideration, that compensation of drought-damage is not undertaken by any insurance company, namely there is no risk-coverage due to the high frequency of events (out of 10 years 6-7 year are drought ridden) and to the large areas involved. It is to be noted that the Hungarian Great Plain and the southern part of Trans-Danubia will fall into semi-arid zone (the zone to where Sicily and Southern Spain falls presently), according to the scenarios provided by the climate models for the time period of 2030-2050. These facts put a warning question mark to the successfulness of future agricultural activities in Hungary. Activities of national scale preparedness and prevention, involving several sectors of the national economy, need substantial financial resources, which are much exceeding that available in the agricultural sector. For this reason it is expectable that the whole insurance system must be restructured, involving new multi-partner type non-profit insurance companies to take the risks and cover expenditures.

Among other damage types hail damage is also of considerable magnitude (20.52%). Hail damage, as an insurance term, is defined as “precipitation water falling in the form of ice, causing such injuries to crop, which substantially alters the quantity and quality of the harvest.

Very high hail damage occurs frequently in Baranya County, where wine-grape and fruit cultivation is of special importance (the historic wine yards of the region Mecsek-Villány), forming also decisive agricultural factors. The high frequency and large extent of hail damage justified the establishment of NEFLA, the Hail Prevention Association of South Hungary, to replace the former hail-rocket prevention system. This Association was established in 1991 on 650,000 hectares land area of the large farms of Baranya, Somogy and Tolna counties with the financial support of the insurance companies AB AEGON and Allianz Hungária and with the assets offered by the National Meteorological Service. The operation of this system is a good example of preventive action and of the joint work of different institutions and organisations of different profit sensitivity. The dense network of power generator units assures the appropriate protection of the so-called ’standing cultures’ against hail. This positive example would be worth adopting in other valuable agricultural regions of the country instead of the termination of the existing systems (like the termination of the hail-prevention system of the area between the rivers Danube and Tisza). Long records of hail events starting in 1896 are available as the results of damage surveys made for the insurance companies to assess compensation.

According to the national survey of elemental damages the third largest damage-type is the water-damage, which involves several damage causes. The relatively high share (18.44%) of this damage type in the total damage stems from the jointly considering of the flood damages of streams, the excess water damage and groundwater emergence (or return flow) damage.

The definition of water damage as an insurance item is when the cultivated stand (the crop) is destructed, or its harvest yield is nil, due to water coverage originating from precipitation water, or from water overflowing the banks of natural streams, artificial canals and of natural or man made lakes (water reservoirs).

In Hungary all the flood basins and flood plains of river valleys are prone to such damages (flood damages) but the insurance companies strictly limit the conditions of damage compensation for losses on cultivated land.

For plant (crop) cultivation and gardening the conditions of the insurance companies exclude the following:

- The crop harvested or taken out of ground.
- Damages to the secondary harvest (straw, stem).
- Damages caused by erosion and snowmelt.
- Losses in seed or seed quality.
- Water damages of crop grown in floodplains and emergency flood reservoirs.
- Damages done by seepage water originating from high water levels of streams not overtopping their banks or from the high water levels of excess water drainage canals.
- Flood damages on land not included in the area protected by the flood control system. (Not protected flood basin is defined as a part of the flood basin specified by the water authority, which is located between the stream channel and a road (of maximum second order numbering) that runs approximately parallel to the stream or a railway embankment of similar arrangement and the area between a high-river-bank and the border of the inner part of a settlement).

Other elemental damage (wind-storm and sand-storm damage) is defined by the insurance companies as loss of harvest due to mechanical damage made by wind of higher than 15 m/s speed, to be verified by the National Meteorological Service. This damage can be characterized by the followings: broken ear of crop, loss of grain from ear; broken/tilted stem or loss of head of sunflower; damage to leguminous plants; beating down of apples and pears.

It is to be noted that damages done by runoff water or snowmelt are excluded from the insurance, although one of the largest damaging-factor is storm damage combined with water damage. This is true for crop production and gardening (horticulture) and about 40% of the total arable land of the country, 2.3 million ha, is involved.

Splash- and runoff-damage of torrent like rainfall of higher than 20 mm/24h intensity is not covered by insurance, unless it happens simultaneously with windstorm (of higher than 15 m/s or 54 km/h wind speed. Namely, such events are not insurance events when they happen separately.

Erosion damages of floodplains, flood basins or hill slopes are not covered by insurances, although they are also water-caused damages.

Taking these factors into consideration the security of the farmers in crop production or gardening (horticulture) can only be provided by establishing new non-profit farmer-insurance companies, based on producer-trader-consumer type associations (similarly to the non-profit farmer insurance companies of the other EU Member States).

AHBRT has also developed the frost-damage insurance method separately for the horticulture sector. In this insurance the frost damage is the freezing of the bloom of orchards and the loss of harvest yield stemming from it and for green plants freezing of the stump and stock is also considered a damage item. Harvest loss of especially temperature dependent cultures (green pepper, tomato, melon, cucumber, etc.) due to springtime frost is not covered by insurances either. Plants grown in culturing-equipment (in green houses and folia tents, etc.) are similarly excluded from risk coverage. The low share (2.5%) in total damage is a bit surprising since frost can practically occur over the whole country.

Forest insurances have a special role in this scheme, dealing with elemental damages of forests, forest plantations and the wood stock. Risk coverage of weather events is similar to those of the agricultural and horticultural insurances.

Evaluating the 35 years long records of the Chamber of Agriculture and the MABISZ it can be stated that in annual average elemental damages to agriculture amount to 3-10% of the total value of annual production (800-900 billion HUF). This value, however, refers to the insured land area, which is be substantially lower than the total area to which elemental damage is done in agriculture. The ratios covered by insurance are as follows: cereals, industrial plants, protein plants (these three together are covered by insurance for 38.2% of their land area, for animal husbandry the share, within agricultural insurances, is 17.6% (on the basis of an EU questionnaire survey).

According to the available assessments on climate change and risk for agriculture management from the point of view of the insurance sector, the weather risk will be amplified in the near future, unfavourably affecting the crop yield and its security, and also the environmental security in a broader sense.

Taking the unfavourable tendencies into consideration the following remedial actions can be proposed for the compensation of potential damage and to reach a better level of “insurance coverage” of the country:

- Involving areas not covered for risk by insurances in non-profit forester’s organisations based on counter-insuring.
- Development of new insurance strategies for including floodplain, flood-basin and sloping-land areas, that are presently excluded from insurance, and thus providing better security for the harvest.
- Provision of a fund (catastrophe fund) from the state budget for insuring harvests and establishing environmental security in the endangered regions (e.g. for drought damage).
- In addition to export sensitive crops (cereals, oil-, protein-, filament- containing plants) it would be expedient to broaden the product-security of special cultivated fields, such as those for firstling vegetables. If insurance companies see too high risk in the insurances of such special agricultural fields and activities, then non-profit farmer’s organisations could be established also in such regions. Examples include historic wine-grape regions, orchards and market-gardening regions. The insurance coverage of such special fields is less than 10% in national scale.

Investments into preventive strategies should be acknowledged in the form of bonus-malus type insurances, which are effective means of reducing damages.

Agricultural insurances involve larger regions, due to the agricultural character of the whole country. Consequently potential damages can be substantially reduced by agricultural cultivation techniques of the preventive type that are also tailored to the given agro-ecological conditions, along with the appropriate insurance systems.

However, the achieving of this objective depends not only on a “good” insurance construction.

Unavoidable damages, which exceed the burden-bearing capability of a given sector, (such as torrent type rainfall events causing catastrophes, wind-storm damages of larger regions, floods, etc.) must be compensated by the state and by the economic units involved. The events referred to above also endanger the infrastructure of the agriculture, in addition to the security of the crop yield. It must be also taken into consideration that the mentioned climate anomalies concern the wealth of the citizens as well as that of the industries and this will require the creation of a state-controlled catastrophe fund, with the involvement of all interested parties, all stakeholders. In Hungary the first steps have already been made towards such solution with the establishment of the National Agro-Insurance Fund and the National Catastrophe Prevention Fund.

Better adaptation to changing agro-ecological conditions and the broadening social basis of risk-holders, along with the preventive strategies supported by bonus-malus type insurances, will in the future form the basic piers of the successful management.

# 17. CLIMATE-CONSCIOUS THINKING AND THE HUNGARIAN SOCIETY

Scientific debates and many uncertainties characterized the issue of global warning for a long time. However, the latest findings and developments resulted in substantial changes. Increasing number of observations and scientific results has verified the existence of this problem. Intergovernmental and civil organisations played an outstanding role in inducing these changes. Strengthening the climate awareness of the international public was a deterministic factor in the changes. According to the reports of large international public-opinion surveys of the past years the number of European citizens who are worried about the changes of the climate is increasing, along with the number of those who are unfavourably affected by the already perceivable impacts of the changing climate[35]. Increasing public concern was accelerated by human causalities of the warming of the climate[36], and also by more frequent occurrences of economic and environmental damages and losses that were caused by extreme weather events.

According to recent research results changes occurred in the climate-consciousness of the Hungarian society and increasing number of people accept the changing climate as a fact, considering it a serous problem. This is an important finding, because results of similar researches done in the 1990s revealed opposite notions. A survey of environmental consciousness, made in 1992 by the Gallup International Institute in 22 countries of the world, found that 10-30% of the people of the total sample considers environmental problems as the main critical issue of their country. Hungary was the only country where the ecological problems were not mentioned in the first place. Hungarians ranked to the first place unemployment, followed by poverty and the increasing crime[37]. In the survey of 1992 it was Hungary where the lowest fraction of the interviewed persons (33%) considered global warming a serious problem (while 73% of the interviewed Germans considered global warming a serious problem). Answers of the rest of the countries ranged between 36% and 73%. The ozone hole hazard was considered by a bit larger percent (47%) of the Hungarians a serious problem, (while the rest of the countries were in the range 54-84%). The survey made in 1994 by the Hungarian Gallup Institute yielded similar result. A Hungarian research found similar trends in 1996; opinion of the people interviewed was that the least serious environmental problem is the warming of the climate[38].

Regional scale surveys made in the same period yielded a bit wider scene: The climate sensitivity of urban dwellers was higher than that of the average people[39]. Structural changes

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[35] Gallup International Institute, Millenium Survey 2000. www.gallupinternational.net/ survey1.htm

[36] Páldy A., Erdei E., Bobvos J., Ferenczi E., Nádor G., Szabó J., 2003: A klímaváltozás egészségügyi hatásai. (*Public health effects of climate changes*) “Agro-21” Füzetek, Klímaváltozás – Hatások – Válaszok (VAHAVA), 32. szám. pp. 62-77.

[37] Gallup International Institute: Health of the Planet Survey, 1992

[38] Mészáros J., 1996: Vélemények a környezetről (*Opinions about the environment*). In: Társadalmi riport (*Social report*) 1996. Szerk.: Andorka R., Kolosi T., Vukovich Gy. Budapest, TÁRKI. pp. 121-152.

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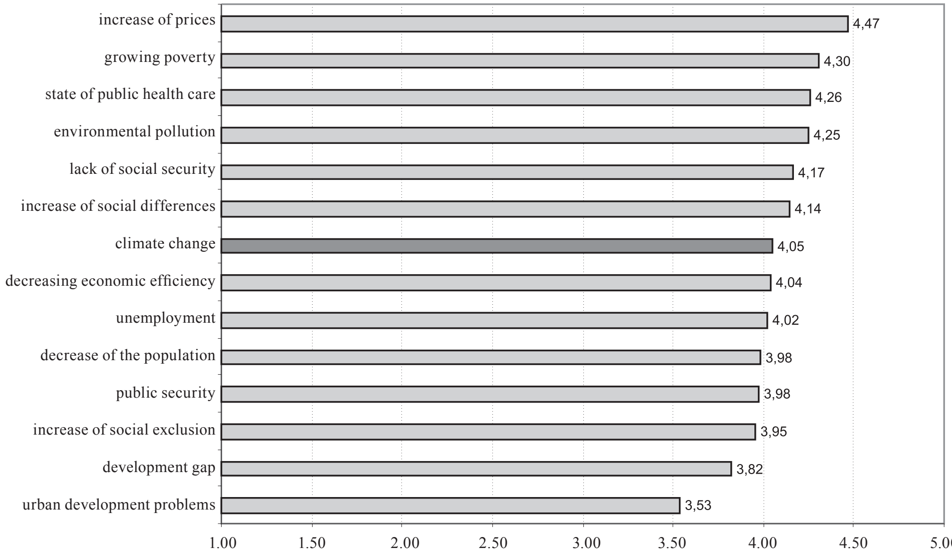


*Fig. 1.* **"Do you consider the following problems timely ones?"**
(On a scale of 1-5: 1 marks the least actual problem, while 5 the most actual/timely one.)
Results show the average values of the whole sampled area

of the urban economy, made at the time of changing the political regime, also contributed to the increase of environmental sensitivity of urban citizens, with the dynamism of the economy and the process of the achievement of middle-class status and with the creation of the institutional system of the protection of the environment. Several urban surveys found that urban citizens consider, in addition to the safety of their job, the issues of protecting the natural and built environment, of the prevention of damages and of the protection of health very important ones and that they should be included in the urban environmental policies.[40,41]

A sociological study made in the vicinity of Budapest reported strengthening of climate-sensitivity, in addition to environmental concerns.[42] According to the results of this survey the larger part of the people interviewed thinks that the *problem of climate change exists.* 52% of the people responding fully agreed that we are subject to climate changes, while 32% thinks that it is rather probable. Only 3% of the interviewed people did not agree that the phenomenon of climate change exists and 12% thought that it is rather improbable. People with low level education and those of the low and medium income range are much more

[40] Marelyin Kiss J., Dénes A., 2001: Aréna és otthon. Írások az önkormányzati rendszerről I. (*Arena and home, studies on the system of local governments No.I)* Jelenkutató Alapítvány és Intézet, Budapest.

[41] Szirmai V., A.Gergely A., Baráth G., Molnár B., Szépvölgyi Á., 2003: The city and its environment (Competition and/or cooperation?) Centre for Regional Studies of Hungarian Academy of Sciences, Discussion Papers No.41., Pécs, 33. p.

[42] *"Social impacts of climate changes; Spatial and social mechanisms that define the, vulnerability and adaptation of people living in the vicinity of Budapest"* (In Hungarian) Budapest, 2007, p 183. Study supported by the Hungarian Academy of Sciences. Theme leader Szirmai V., Contributors: Ferencz Z., Molnár B., Szépvölgyi Á., Schuchmann J., Váradi Z. and Vág A.

willing to accept the existence of the phenomena of climate changes than those of medium and high level education and of the high income ranges, a they do not agree with this statement.

Citizens of Budapest interviewed think that not the climate issues are the most significant ones, but the rising of prices, increasing poverty and the state of public health. Environmental pollution got a high score, higher than the climate issues as shown in *Fig. 1.* Importance of the issue of climate changes is located, on *Fig. 1,* just beyond the increase of social differences and the lack of social security. These are important findings; since they show the increase of the climate sensitivity of the population, as people consider the problem of climate changes in among their social and environmental problems and they also score climate problems in among the most characteristic present problems of the country, the decrease of economic efficiency and the growing unemployment. The growing gap between the development levels of the regions of the country and the strengthening of the social exclusion were considered as the least important problems. (The reason is that the investigated group of Budapest citizens are rather the beneficiaries than the losers of the spatial development problems of country.)

Some of the social problems – the state of public health care, rising prices, social security, unemployment – are considered heavier ones by those of low level education and of low and medium income, than by those of higher level education and income. Labourers also consider some of the problems heavier ones than those of the management level. In respect to climate changes the trends are similar: Those of low level education and of lowest or medium income range and the labourers consider climate change problems heavier ones, than people of their own income, the intellectuals, those of the high education and of high income, and of high position. This indicates that people of lower social status are more sensitive to various social and economic problems and also to climate change issues. This is because they feel more exposed to the various social and environmental impacts and to their cumulative effects. Another explanation is that those of the medium social classes, being more interested in acceptance of consumption models that contribute to the reproduction of environmental and climate problems, more readily accept the uncertainties of some of the climatic statements than the factual reasoning.

*Table 1.* **“How endangered you feel yourself by the changes of the climate?” (on a scale of 1-5)**

| | **Score of endangeredness** |
|---|---|
| **on the basis of income level** | |
| <70 thousand HUF | 3.05 |
| 71-90 thousand HUF | 2.93 |
| 91-120 thousand HUF | 3.53 |
| 121-150 thousand HUF | 2.93 |
| 151-200 thousand HUF | 2.91 |
| >201 thousand HUF | 2.18 |
| **on the basis of education level** | |
| Basic | 4.89 |
| Medium | 3.11 |
| High | 2.78 |
| **Mean** | **3.04** |

They consider the air pollution due to the increasing number of cars the heaviest environmental problem (as this decisively contribute to the changes of the climate). The increasing solid waste quantity is considered a similarly serious problem. The warming of the climate is considered in the third place, and they think that it is a heavier problem than floods or the operation of factories that pollute the environment. People of the lowest education and income considered these problems heavier than those of higher education.

The survey was also dealing with the exposure and endangeredness of various social groups. The people interviewed think that they are endangered by the changes of the climate to a medium level only (*mean value 3.04).* However those with lower education and income consider themselves more endangered (*Table 1*).

In order to assess the adaptation ability we carried out a survey of what the people think of the probability of changes in their own way of living and conditions of life due to bearing the pressures that are related to the changes of the climate and of their options to act. As indicated by *Fig. 2* below they expect changes mainly in energy use and in conscious environmental protection actions. Less changes are expected in their individual way of living (especially by those of basic education, while those of medium and high level education consider the worsening of their health). The individuals interviewed (mostly those of basic education) think that the distribution of burdens within the society becomes more unjust than that of the present.

The steps that citizens are willing to take in order to reduce the impacts have also been explored in this study (*see Fig. 3*). The results indicate that 36% of the interviewed persons think that he/she cannot make any steps since he/she already uses minimum resources to satisfy his/her needs, while 5% of them do not wish to make any steps, as this is not their obligation. Another 36% of the responding persons are willing to make steps, but only such ones, which do not cost any money. Only somewhat more than 19% of the people, those with higher income and education, are willing to make certain changes even if it means extra

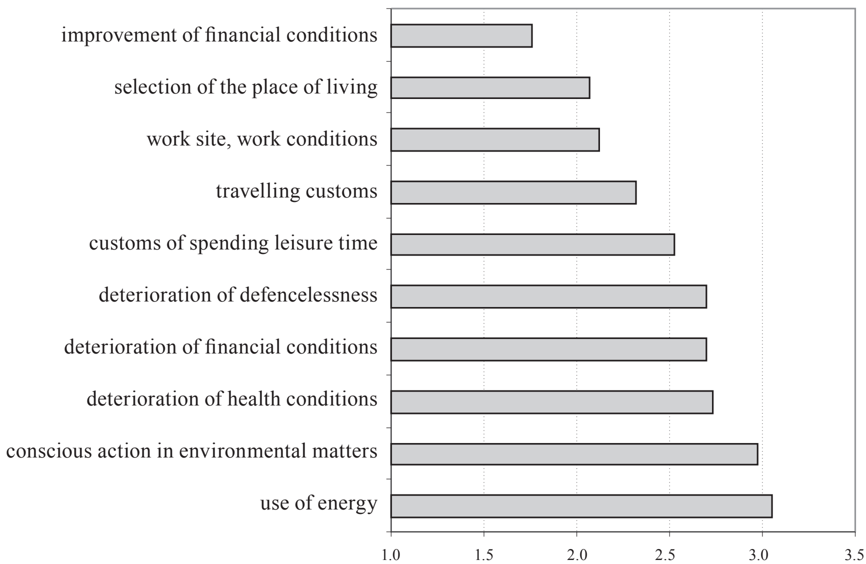


*Fig. 2.* **Impact of warming on the way of living and conditions of life**

expenditure. All these indicate moderate willingness of the population, which lives in the vicinity of Budapest, to do something for reducing the impacts of the changing climate (*Table 2*).

The population thinks that measures should be made at multiple level and both in the micro- and macro-environment. However the latter is considered more important one *(Fig. 4)*.

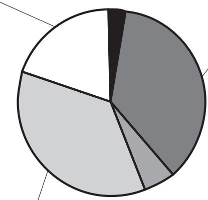


*Fig. 3.* **“What steps are you willing to take?” (in % of the people responding)**

*Table 2.* **Responders stating that “I will make certain decisions even at extra costs” (in percentage of the total number of responders)**

| | |
|---|---|
| **On the basis of education level** | |
| Basic | 9.60 |
| Medium | 19.40 |
| High | 29.60 |
| **On the basis of income** | |
| <70 thousand HUF | 21.00 |
| 71-90 thousand HUF | 14.40 |
| 91-120 thousand HUF | 18.80 |
| 121-150 thousand HUF | 16.40 |
| >151 thousand HUF | 41.80 |
| **On the basis of work position** | |
| Labourer | 6.35 |
| Light physical work | 16.07 |
| Entrepreneur, manager | 27.27 |
| Diploma holder, employee | 34.48 |
| Office employee | 37.50 |
| Independent intellectual | 44.44 |
| Mean | 19.58 |

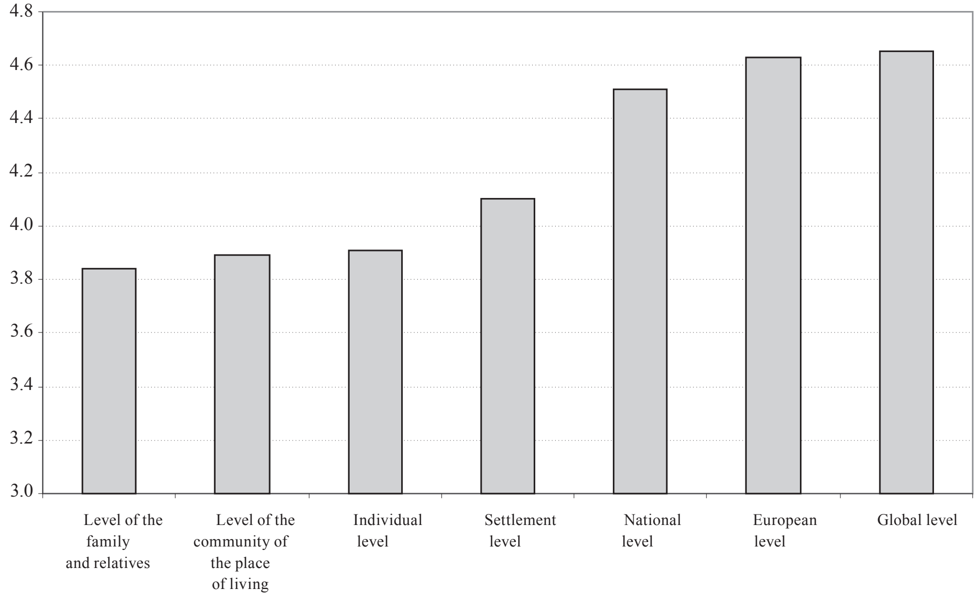


*Fig. 4.* **Possible levels of handling climate changes (on a scale 1-5)**

## Summary

On the basis of the survey of Budapest and other similar studies it can be stated that there was a substantial shift in the processes in comparison to those of the earlier years and the climate sensitivity of Budapest citizens and other urban dwellers seem to be strengthening. Groups of lower social state (people of low education and of income level of low and medium category and physical workers, labourers) are unambiguously more sensitive to the social and economic problems relating to climate changes. Investigated groups of higher social status (those of high education and income level, intellectuals, employee of high position) are less sensitive to the risks of climate change. Most of the people see only limited options to actively participate in applying strategies. To this contribute a fact that a part of the interviewed persons (mostly those of higher social status) the way of living of people plays a lesser role in inducing climate changes, are less responsible. Further on they think that macro level is responsible for casing the problems and climate change is rather a global than local issue. There are only few people who would be willing to financially contribute to solutions. Most of the people cannot or do not want to actively participate. While most of the people clearly see the responsibility of individuals in causing the changes of the climate, they rather want the solution to be made by some central regulation via environmentally friendly production and by the spreading of climate-protecting services and by applying global strategies. The feeling of individual responsibility is growing with the levels of education and the income.

# 18. CLIMATE CHANGE AND THE TASKS IN RESEARCH AND DEVELOPMENT

Research and development projects are focussing on two main lines of climate policy: the mitigation of the emission of greenhouse gases and the adaptation strategies (including prevention, defence and damage-reduction i.e. contingency planning and reconstruction).

### Energy management and GHG-emissions

In respect to the use of energy three well known strategies have been identified: sparing use of energy; increasing energy efficiency; increased use of renewable sources of energy (solar-, wind-, geothermal- and biomass energy).

The scope of research and development themes is very wide in relation to adaptation methods and strategies:

- Taking account of the lack of knowledge in the field of adaptation to the impacts of climate change.
- Increasing support to hydrological research, which is closely related to studying the climate change and its impacts, in order to become able to give assessments of higher reliability and better probability to enhance the scientific background of decision support in the future.
- To identify irreversible consequences of climate changes on human, biological and physical systems, so as to better understand the mechanisms behind such consequences.
- Carrying out economic analysis, in relation to the analysis of vulnerability and risk, for calculating the losses that would stem from the do-nothing scenario and also calculating the benefits of preventing such losses for all professional fields concerned (e.g. human health, water management, agricultural cultivation, infrastructure, etc.).
- Identification of positive interactions (such as synergy and complementarities) between adaptation and sustainable development) and exploring them to the necessary depth.
- Exploration and analysis of the close relationship between mitigation and adaptation in order to select and apply options, which are favourable or beneficial for both type of action.
- Research themes and action plans that are aiming at utilisation of the new research and innovation results of international organisations and other European countries in Hungary on the adaptation methods to the impacts of climate change. Special attention should be paid to the identification of the conditions of applying those flexible adaptation alternatives, which will in the future help tolerating the ever rising climate-shocks and the effective handling of unexpected events.

The matter of renewable energy resources is not only an issue of energy policy but also of: environmental protection, the development of agriculture and countryside, enhancing sustainable development, reducing energy import to Hungary, enhancing the utilisation of agricultural areas, improving local life conditions, assuring that people stay where they live now, etc.

The Sub-committee on Renewable Energy Technologies of the Hungarian Academy of Science has prepared the strategic concept of renewable energy sources and in this strategy the priority is given to the following themes:

- Expanding the use of solar energy in architecture (in building design).
- Expansion of the active utilisation of solar energy in building machinery.
- Expansion of the photo-electrical utilisation of solar energy.
- Introduction of hydrogen as fuel and the fuel-cell energy systems in Hungary.
- Expansion of the use of biomass for energy production in Hungary.
- Expansion of the utilisation of wind energy.
- Expansion of the utilisation of hydropower.
- Increasing the utilisation of geothermal energy in Hungary.
- Use of renewable sources of energy in agriculture.
- Economic evaluation of renewable energy utilisation technologies.
- Development of concepts and programme for education, demonstration, and for rising public awareness.
- Expansion of the options for tenders on the use of renewable energy sources.
- Management of the programme on the expansion of the use of technologies based on renewable sources of energy.

Evaluation of the future role of nuclear energy in Hungary needs a detailed analysis. Presently in Hungary there is a single atomic power plant in Paks, having four blocks, each with around 400 megawatts capacity. Around 40 % of Hungary’s electrical energy production stems from this power plant. There is no public social movement of the population against this plant but the green organisations are opposed to its operation. The essence of continuing further disputes will be whether Hungary should build a new plant or not.

### Adaptation to changing climatic factors: research tasks

In this context he following tasks can be mentioned:

- Participation in the international network of institutions related to adaptation and the exchange of experiences and information.
- Analysis of the institutional obstacles of adaptation and of the (social-scale) learning of new knowledge and the identification of management options and the development of the relevant solutions.
- Studying the Mediterranean techniques of urban planning, social services and life-styles, so as to adopt and apply the relevant “know-how” in Hungary.
- Studying the complex impacts of climate change on the urban environment (urban planning, mortality related to heat waves, the state of green zones, streets and buildings, impacts on water quality, water storage and waste management).

The development of monitoring systems and databases represent a special new task.

- It is important to create a Hungarian network of open knowledge base on adapting to climate changes with full public accessibility. The information and data stored in these facilities should contain the continuously updated climate data and their forecasts, the regulation system related to adaptation, the practical ways and means of adaptation and the details of the international experiences for each economic sector and social activities. Additional tasks are the collection and exchange of Hungarian experiences and, having this knowledge, the development of measures to be applied for the solution of the identified problems.

- Data base development: (a) data on costs and damages that could be used in the future for the development of indices, which will facilitate decision-making. (b) identification and storage of data belonging to natural systems and the related auxiliary information, along with the development of databases and the gradual improvement of data collection and processing with due concern to the interconnection of existing other databases.
- Development of monitoring: Gradual development of the instrument-based monitoring systems of the economic sectors, aimed at the supporting of decision making of that sector, with special concern to the need of inter-sector co-operation and the aspects of professional co-ordination. Development and expansion of existing monitoring systems to measure/observe direct and indirect impacts that are related to climate change.
- Adaptation requires the rapid co-operation of a number of central state organs and local/regional institutions. There are several institutions working in the field of adapting to the impacts of climate change. Nevertheless, the development of rapid and direct connection between the relevant databases is an urgent task, due to the expectable increase of the number of extreme weather events. It is important to improve the exchange of information between various authorities so as to strengthen the chance of joint action of those authorities.
- The role of insurance companies must be revised. The weather that becomes more and more extreme will not only increase the loss of the insurance sector, but also represents a direct pressure on wide ranges of the society, depending on the type of the damages. Therefore it is necessary to assure a more just pressure-bearing of the society by developing a new system of the risk-taking of the government and of the financing of the losses caused by damages. This system shall take the strengthening impacts of the changes of the climate into account and broaden the scope of risks to be covered by insurance.

## Adaptation and security

A new field of research is the exploration of the connections between the changes of the climate and the provision of security.

Issues of climate security appear on national, regional and global level. In case of a given country the issue of security covers mainly the following three themes:

- Protection of the natural or near-natural ecosystems and habitats and the protection of biodiversity in general.
- Preserving the quality of life of the population.
- Protection of the so-called "critical infrastructures" that are needed for the normal operation of the production and service systems of the society.

The basic objective is to protect the life conditions and critical infrastructures of living beings (plants, animals, humans) against natural disasters (floods, excess water, drought, wind storms, heat waves, etc.)

Only the stabilization of the quantity of greenhouse gases in the atmosphere can create the long-term safety of living beings and critical infrastructures.

The guarantee for short- and medium-term security is born with the adaptation and immediate defence action. The two systems of action will not substitute each other but they are of complementary character and they together can assure the sustainable development and the realisation of the interests of future generations to come.

In Hungary the relations of climate and security are of main concern in the following issues:

- Water management (flood, excess water, ground water, drinking water, water shortage, desertification).

- Safety of fertile soils and geological formations.
- The natural environment (biodiversity, habitats, ecosystems).
- Agriculture and forestry (land use, food-security, fodder, biomass utilisation).
- Economy and infrastructure: power generation (fossil-based, renewable and nuclear.
- Energy utilisation (sparing use and efficiency increase) in industry, transportation, construction and in settlements.
- Human and animal health (protection of life and health against heat, UV radiation, pathogens, stemming from extreme weather events.
- Vulnerability of individuals and social groups, social welfare, life styles, migration.

The important factors, which strengthen climate security are:

- Meteorological services, monitoring of greenhouse gases.
- Catastrophe defence, ambulance services, damage fighting at local government and company level.
- Economic and legal regulations (incentives, constrains, forbidden actions, fines, etc.).
- Rising climate-awareness by education, training, popular sciences, professional advisory systems.

The above listed issues and actions need interdisciplinary research and innovation. In this approach the mitigation of the emission of greenhouse gases and the actions of adaptations (prevention, defence, damage fighting, contingency planning, etc.) should be analysed in a unified system.

# 19. CLIMATE CHANGE AND RISK

In analysing climate changes one of the basic problems is related to the ways of occurrence, namely: as the result of a simple process when the individual meteorological parameters change in a predictable way, or as a process where the frequency and severity of weather anomalies are increasing.

Several climate experts think that the latter is the case and this seems to be justified by the events of the past years both in Hungary and elsewhere. Climate models cannot describe the variability of the weather and therefore the expectable occurrence of major event groups can only be assessed.

According to the report of IPCC in 2007 the expected changes of extreme weather events will be as follows by the end of the 21st century:

| | |
|---|---|
| Higher maximum temperature, more heat-days | High probability (90-99%) |
| Increasing drying of the continent, danger of drought | Likely in the inner part of the Continent (66-90%) |
| More intensive rainfalls | High probability (90-99%) |
| Wind storms | Probability of 66-90% |

These tendencies must be considered as warnings, since the damages caused by these four weather phenomena have been significantly increasing in the past few decades both in Hungary and abroad. The following statistics support this statement:

- WHO reported that in the summer of 2003 more than 20,000 people died in Western and South Europe due to the impact of heat waves.
- In July 2007 10-day heat-alertness had to be declared, temperature records were broken and the estimated number of human deaths (excess mortality) due to heat-wave was more than 600 in Budapest.
- In Hungary the frequency of drought years have been increasing since the 80-ies of the past century. There were especially serious droughts in 1983, 2003 and 2007. In 2007 the estimated loss originating from the decreased harvest of maize only was more than 80 billion HUF.
- The number of higher floods, due to more intensive rainfalls and altered rainfall distribution, were increased four times in Europe since the 70-ies, calculating with the 10-year averages of flood numbers. The damage caused by floods was higher than 58 billion Euros in the past one and half decade.
- In Hungary there were several record-breaking floods in the past years. Examples are the floods of the Upper Tisza River region in March 2001, the Danube and Tisza Floods of 2005 and the rainstorm of April 2005 in the catchment of a small creek crossing Mátrakeresztes that caused tremendous flood damages in this village.
- Frequencies of larger windstorms have also been increasing in Europe and thus also in Hungary, along with the increase of the damage caused. An especially remarkable windstorm was that of the 20th of August 2006 (National holiday in Hungary), causing the death of several people.

The joint losses of the damages caused by unfavourable weather events and the costs of defence actions are estimated to amount to annual 150-180 billion HUF. In 2007 the damages of the agriculture reached this sum.

If the magnitude of losses is so high then one must consider the options of avoiding, preventing and mitigating the damages.

There were weather anomalies and extreme weather events also in the past, as there are in the present too, and consequently defence and control organisations and systems have been developed to fight and combat such events.

Such organisations include those of the flood defence and catastrophe prevention and the various insurance systems. These systems and organisations were modified taking into account the experiences of the near past. The major question is how long these systems can provide appropriate safety under growing risks.

One can already see that flood-defence works at the margins of its capabilities, the agricultural insurance system is not satisfactory and the hospital services are fitful during the heat waves.

The methods of risk analysis can help exploring emergency situations, creating preparedness and in managing the contingency work and defence actions.

## Risk and uncertainty

Before dealing with the estimation and analysis of risks let us define what are their meaning of these terms in relation to climate change.

*The risk* is the probability of occurrence of an extreme meteorological event. More precisely:

Risk is the combination of the probability of a consequence and its magnitude. Therefore risk considers the frequency or likelihood of occurrence of certain states or events (often termed 'hazards') and the magnitude of the likely consequences associated with those exposed to these hazardous states or events.

Risks can be characterised by a stochastic process and therefore it involves serious uncertainties. Nevertheless in relation to climate change the term uncertainty is used with a different meaning.

Uncertainty describes the quality of our knowledge concerning risk. Uncertainty may affect both the probability and consequence components of the risk.

Uncertainty exists where there is a lack of knowledge concerning outcomes. Uncertainty may result from an imprecise knowledge of the risk i.e. where the probabilities and magnitude of either the hazards and/or their associated consequences are uncertain. Even there is a precise knowledge of these components there is still uncertainty because outcomes are determined probabilistically.

As knowledge on climate change and its consequences is still rather restricted, the major means of reducing the risk is the gathering of knowledge, research and the adaptation of the results.

As it follows from the definition of risk the following steps are needed for the handling of risk:

| | | |
|---|---|---|
| Scenarios of climate change | - | Climate parameters (Temperature, wind, precipitation, etc.) |
| ↓ | | |
| Changes in climate parameters | - | Determination of critical values heat days, dry periods, etc.) |
| ↓ | | |
| Impacts | - | Illness, changes in mortality rates, increasing energy consumption, drought, etc. |
| ↓ | | |
| Risk | - | Number of hospital beds is insufficient, failure of electricity supply, problems with food supply |
| ↓ | | |
| Risk management | - | Series of preventive and post-event measures |

As indicated above risk analysis is a highly complex process. The major steps are demonstrated below.

(a) *Identification of an area in space, time and in respect to social implications.*
The following features justify this: climate changes in time and space, various climatic conditions results in different impacts, climate impact might affect several economic processes. Examples for the latter are: increased incidence of death and serious illness, particularly in older age groups; increased heat stress in livestock and wildlife; increased risk of damage to some crops; increased forest fire danger (frequency and intensity); increased electric cooling demand and reduced reliability of energy supply.
Identification also means the selection of those parameters that will be involved in the investigations.

(b) *Three interconnected terms should be introduced for analysing climate impacts and for the determination of the critical values of climate parameters, these are: climate sensitivity, adaptive capacity and vulnerability.*
*Sensitivity.* Sensitivity is the degree to which a system, receptor or exposure unit would be affected, either adversely or beneficially, by a particular change in climate or climate-related variable. (E.g. a change in agricultural crop yield in response to a change in the mean, range or variability of temperature.) Different systems may differ in their sensitivity to climate change, resulting in different levels of impact.
*Adaptive capacity.* It is the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, take advantage of opportunities, or cope with the consequences. Adaptive capacity can be an inherent property of the system, i.e. it can be a spontaneous or autonomous response. Alternatively, adaptive capacity may depend upon policy, planning and design decisions carried out in response to, or in anticipation of, changes in climatic conditions.
*Vulnerability.* Vulnerability defines the extent to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. It depends not only on a system's sensitivity but also on its adaptive capacity.
Knowing sensitivity and vulnerability the critical domain of climate parameters or parameter groups can be determined.

(c) *Selection of climate scenarios to be considered and the statistical characterisation of the selected climate parameters.*
This means the determination of the critical values of climate indicators selected for the analysis and the calculation of the probabilities of occurrence (relative frequencies). Probabilities are many times given in a simplified form, such as those of the IPCC reports: highly probable, probable, less probable, rare.
Steps 1 – 3 above described the essentials of selecting climate indicators, description of their impacts, and the statistical characterisation of the probability of occurrence. Climate indicators can be investigated separately but to aid the better understanding of impacts it is sometimes desirable to form indicator groups.
A heat wave has different health-deteriorating effects at high and low vapour content of the air. Similarly a long dry period will have different impact on the agriculture at mild temperature and at high temperature and with- or without wind.
The threshold values of climate indicators should be defined in terms of their impacts, taking into account sensitivity and vulnerability and the various grades of these latter.

It is important to note that climate indicators have their simultaneous impact on the environment, economy and on various components of the society. Therefore in defining the potential damage (to be avoided) these should be handled together.

According to the definition risk is the distribution of the magnitude of the impact. The determination of this is a nearly impossible task because: we have relatively few knowledge of the processes involved; observations relate to short periods only; climate projections have large uncertainties and this especially refers to the features of extreme climatic events.

Owing to the above reasons the statements relating to risk are highly uncertain, irrespectively to whether it is based on statistical analysis or experts judgement. Consequently in the future it is expedient to carry out objective oriented observations and to develop monitoring systems, so as to enable the upgrading of risk analysis.

*(d) Economic and infrastructural conditions of risk management.*

Finally all risks concern the members of the society and therefore the limits of taking a risk can, in principle, be connected to the tolerability of the people (of social groups) in bearing a certain impact. Eventually the handling of this problem is far not that simple. Occurrence of certain events cannot be avoided, while in other cases the cost of 'defence' means unbearable loads for those involved. In order to be able to create an acceptable 'defence system' one needs to know each climatic effect and the chain of their consequences, the points of exercising defence action, etc.

In agricultural crop cultivation one of the most significant risk elements is the loss of harvest yield. The extent and probability of this can be relatively well determined on the basis of the statistics of available records.

The task is to determine where are the critical thresholds at regional and national scale. What further impacts are generated by the loss of crop yield in: food supply, livestock breeding, supply of industrial resources (stock) and in other fields?

How can one reduce the risk of the loss of crop yield by: irrigation and by applying up-to-date agro-techniques (is the appropriate infrastructure available?); diversified production (securing choice of crop species)?

The impact of a given loss of crop yield can be alleviated by: provision of standby stock (forming reserves); import; insurance.

The relationship between risk and the conditions of the economy and infrastructure can in many cases be expressed in quantitative terms. However, in many cases the risk cannot be expressed in monetary terms. Social impacts are in many cases heavier than the economic ones.

*(e) Risk treatment.*

Risk treatment (management) consists of determining the most cost-effective actions to be undertaken in response to the identified risks and implementation of those actions. This will usually result in the modification of existing strategies and plans, the development of new plans, allocation of resources and responsibilities for the plans and their implementation. The formulation and implementation of actions is a matter for the routine operating practices of the organisation.

It is often the case that one treatment/management action will have an effect on several risks and one risk will be affected by more than one treatment. Some consideration of natural groupings among the risks and strategic combinations of treatments will be beneficial in completing this stage of the process.

The treatment of risk assumes a complex work of systems analysis. Nevertheless, as there are several factors of uncertainty and unknown relationships the factors of risk should be ranked in many cases. Irrespectively of this one shall, in strategic design, make efforts to follow the principles of integration and long-term applicability.

Well-balanced insurance systems must gain an important role, although they will not reduce the risk, but can provide better tolerability of the consequences.

(f) *Actors of risk treatment (management).*

The risks of the climate can only be handled with joint efforts of the society and there are international and regional tasks. The EU is dealing with the establishment of the so-called solidarity fund to aid the poorer and more climate-change exposed regions (the Green Paper of the EU[43]).

In the Carpathian Basin the regional approach cannot be avoided. This primarily means the selection of regions on the basis of catchment basins and water systems.

The state must assume a decisive role in several issues: in catastrophe prevention, in health care and in the insurance systems, etc.

Nevertheless, the problems have to be generally solved at local scale and in this the local governments, the social and economic organisations and the citizens as a whole have to play the key roles.

**Research and knowledge dissemination**

As it was mentioned also above our knowledge on the processes of climate changes and the expectable variation of risk is rather restricted.

It is extremely difficult to fight the risks in such a way that we do not know its nature and therefore the best way of reducing the risk is to gain knowledge on the relationship between risk and climate changes. Within this the most important tasks are to perform research in the following fields: identification of relationships between climate and the natural, social and economic systems; research into the regional impacts of climate change, and studying of the weight and distribution of extreme climatic events.

The society must bear the risk of the climate change and therefore only joint efforts of the society as a whole can result in the avoidance of risk and in the mitigation of the impacts.

Consequently education, training and the forming of awareness are basically important tasks at all levels of the society. If the people do not see the essence and importance of the changes of the climate then they will not take share in the decisions and will not accept the decision makers and thus the most up-to-date risk management strategy will fail.

[43] Green Paper from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions - Adapting to climate change in Europe – options for EU action {SEC(2007) 849} Brussels 2007

# 20. CLIMATE CHANGE AND ECONOMICS OF REHABILITATION AND RECONSTRUCTION

It is expedient to investigate international and national climate strategies and rehabilitation strategies serving short-term climate programmes in terms of their relation to sustainable development. The means and expenditures serving the implementation of the climate strategy can only form parts of the economy and policy when viewed in terms of sustainability. The steps of short-term climate policy should be confronted with the interests of economic development, employment, economic balance and of the standard of living.

If one hopes to get real support from the actors of the economy and politics for the steps aimed at the reduction of climate risk, these steps must be harmonized with the elements of the market. However, the mechanisms of the market should be tailored to suit the structure of economic development so as to serve sustainability.

Most of the resources, products and services have their price in the market, since this is the only way to distribute limited resources in a rational way. Nevertheless, it is a basic problem that we still handle certain natural resources as free goods or quasi-free goods and calculate with them at zero or near zero price. The result is that society overexploits and uses these resources. Such resources include the air and the multiple services of nature (such as the recreational services of waters, forests, etc.).

### Rehabilitation of natural resources

From the point of view of sustainability it is a serious source of debate whether natural capital can be substituted by artificial capital, and if so, to what extent. (It is to be noted that this debate is fuelled the different interpretations of the relationship between the biosphere and the economy.)

According to the concept of weak sustainability, natural capital can be converted to artificial capital without any limitations. According to the concept of strong sustainability, the replacement of natural resources by economic capital is highly restricted. (This can be partly explained by the fact that our presently available technical knowledge is insufficient for replacing the difficult and complex systems of nature. However, when the technical means are suitable, this can generally be done at very high expenses and with negative externalities, which result in a very low economic efficiency.)

In relation to climate change the above statements apply to both mitigation and adaptation.

For the implementation of the climate strategy, or in a wider sense the strategy of sustainability, it is necessary to ensure the sustainability of both flow and stock. This relationship is defined by the concept of environmental sustainability. Namely, a climate strategy in harmony with sustainability receives the support of society only if stakeholders receive their share from the yield of protected natural stock after implementing the strategy.

In the case of a wetland habitat or a park forest this means for example that the conservation strategy shall not only focus on the value of natural capital but also on the yield of the ecological function of the wetland (forest). (A separate research topic is to answer the question that whether yield from natural capital is different from artificial capital yield and the changes raise the question of the implementation of sustainable consumption.)

From the point of view of strong sustainability, forests and wetland habitats shall be considered "recreational stock" and therefore ecotourism development can be based on their recreational yield. Simultaneously natural values, as $CO_2$ sinks, contribute to the mitigation of the greenhouse effect. On the other hand they form the leisure and recreational resorts for people in the summer heat.

Analysing the above situation from an economic point of view, the relationships are very complex. Services (cleaner and cooler air than in other places of the urban area and higher biodiversity) of a natural or near natural area (park-forest, park, wetland) are considered by society to be free goods and are used as public goods. The market price of free goods is zero, and if they are available to someone, then they must be available to all, free of cost.

These are not free goods in reality though, since the establishment and maintenance of a park or forest requires expenditures, but the presently accepted situation is that no services are offered in return.

In most of the cases the population considers these services to be free goods and provides neither economic nor other – e.g. political – counter services. In the present financing conditions of Hungary there is a strong pressure on the operators (the local governments in the case of parks) to decide on the termination of such natural or near natural areas instead of spending on their reconstruction or rehabilitation. (They are sold for building parking places or shopping centres, etc.)

Creating financing constructions (with the involvement of the state budget, the local government, banks and the citizens) for the green areas similar to that of the investments made for improving the energy efficiency of buildings would be a step forward. As a result of this reconstruction, green areas would no longer be public goods and they would act like private goods or limited public goods.

In Hungary such limitations could not be made in the case of public parks and would not be desirable either. However, the inner gardens and courtyards of buildings could be involved in such a reconstruction procedure. In this case the direct user interest in the reconstruction and maintenance could be secured.

Applying the system of compensatory mitigation used in the USA could contribute to the reconstruction of natural habitats and especially of wetlands. (Wetlands have outstanding importance in the conservation of biodiversity but can also directly or indirectly - e.g. through irrigation – contribute to combating climate change.) This system is similar to that of the 'tradable permit' of the Clean Air Act, which forms the basis of the quota system that regulates the trading of greenhouse gas emissions.

In the case of saving and reconstructing wetlands the priorities of actions are (i) avoidance, (ii) minimization and (iii) compensation.

When a wetland is unavoidably destroyed or injured by an economic activity then compensation must be provided. However, this compensation cannot be purely financial, the wetland, the natural capital should be reconstructed instead.

The basic principle is "no net loss of wetlands". It is very important to note that his principle and related actions and solutions strictly serve the principle of sustainability. Natural capital cannot be replaced by artificial capital. Simultaneously, however, environmental protection also creates options of economic development and this points to environmental sustainability. In Hungary, compensation is generally financial and this will not be used for the reconstruction of the natural resource.

The system of compensatory mitigation (which the author considers expedient and implementable for regulating the reconstruction of the natural capital) contains the following reconstruction approaches: establishment of new wetlands; restoration and rehabilitation of degraded wetlands; enhancement and expansion of the functions of existing wetland habitats; protection and maintenance of ecologically important wetland habitats on a continuous basis and the securing of the operation of the entire system. (On the last item, it is to be noted that wetlands nowadays exist mainly in a man-made environment and therefore should be maintained. An example is the need for dredging the mud from Lake Tisza – a large reservoir on the river Tisza – to avoid upsilting.

In the case of reconstructing natural capital, it is desirable to carry out a cost-benefit or cost efficiency analysis. There are several methods to track the changes of the value of the capital, following the different characters of the value elements of capital.[44]

While one might use market evaluation or quasi market evaluation systems for those elements of the natural capital that are related to personal usage, evaluation methods based on identified preferences are used for investigating existence value.

Climate change might have an impact on biodiversity in Hungary as well. The expressed preference methods can be used for evaluation (for example the Contingent Valuation Method – CVM). However, when changes have their effect on tourism, specifically on eco-tourism, then the economic evaluation of these changes can be made based on the travel cost method. In the case of the reconstruction of an ecologically valuable area (like Kis-Balaton), the reconstruction cost method can be used.

Some programmes of the protection of the agricultural environment can also be related to climate change and thus should be subject to economic analysis. Similarly, the Hungarian climate change strategy might include the construction of emergency flood storage reservoirs aimed at decreasing the risk of flooding. The so-called Alföld Programme can also be part of the climate strategy as this is aimed at a joint segment of the agro-environmental and water-risk decreasing programmes.

## Rehabilitation of human resources

In Hungary, health problems related to climate change already occurred in the hot summers of past decades. The most endangered group of the population are the elderly living in housing estates in large cities. However, no adaptation or prevention programme has been launched yet as the risk is not as catastrophically high as in other places, like in France.

In Hungary several attempts were made for the calculation of health damage due to environmental pollution.[45] In this study the environmental economic damage was calculated as the sum of medical and remedial expenditures and the damage done by loss of work time. This study was dealing with the economic consequences of the health impacts of air pollution.

These damages were increasing in the period of 1986-1987 from 0.38 % of the GDP to 0.59%. No health damages due to increased heat resulting from climate change were calculated or recorded in this period. The same applies to the economic implications of accidents, illnesses and deaths caused by extreme weather events, although they would have unambiguously increased the above numbers.

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[44] Szlávik J., 2005: Fenntartható környezet- és erőforrás gazdálkodás, Kjk-Kerszöv, Budapest, 2. fejezet

[45] Szlávik J., Várkonyi T., 2002: Egészségügyi hatások közgazdasági értékelése. (*Economic evaluation of health impacts*) In. A légszennyezés környezeti hatásainak elemezése – elméleti háttér. (*In:Analysis of the environmental impacts of air pollution-theoretical background*) Eds: Flachner B.; Németh T.; Tóth R. MTA TAKI-KÖM Bp. 2002. (2007-2013. o.)

Since the economic analysis of health impacts cannot even be started without health statistics, the statistical tracking (tracing) of illness types that could be related to climate change must be performed in addition to the identification of those illnesses.

As mentioned above, the termination and elimination of urban green zones is under way in Hungary, disregarding the related health and economic risks. In this context, it is very important to make a health survey of affected citizens as soon as possible. Knowing the impacts the health damages can be calculated. These calculations are absolutely necessary for taking cost-efficient measures.

What can an analyst of environmental economics do until these surveys are made? The method of “benefit transfer” used in environmental assessment can be applied for estimating the costs of health damages and of the recovery of human health (the reconstruction of human capital). The essence of this method is that after making the appropriate corrections of damage calculations made in other countries, data relevant to Hungary can be obtained. This data can then be used as part of our own database when making calculations as control data. The method of benefit transfer can be used in the compliance with the following conditions: (i) the problem to be investigated is similar to that for which the original investigation was made; (ii) the study to be utilized was made with appropriate accuracy and in professional quality; (iii) there are no appropriate conditions for carrying out an original investigation (lack of data, financial constrains, shortage of time, etc.).

This method can be used for the damage and cost calculation of other climate change impacts as well, in addition to the assessment of health damages.

## Reconstruction of the built environment

In calculating damages related to climate change and the cost of recreation, the types of damages are different in urban and rural environments. In the rural environment damages to nature, built environment and to human health might equally occur. In urban and highly urban environments, human health and the built environment are damaged. In an industrial environment the negative external economic losses of the entrepreneurs should also be taken into account. A special approach is needed for calculating the economic damages done to linear infrastructures (transport systems). In this latter case road traffic is of deterministic character.

The mitigation of the emissions of greenhouse gases is feasible both technically and economically with the implementation of new developments. A significant emission reduction can be implemented in power generator and supply systems with the implementation of the technological reconstruction of these systems. These especially refer to the district heating system and the generation of CHP (Combined Heat and Energy).

Increasing energy efficiency and reducing greenhouse gas emissions require the establishment of a service line that connects power generation to consumers. To achieve an efficient reduction of emissions the critical factor is to improve energy efficiency, along with a substantial support to the respective research and development activities, and with the development and spreading of alternative energy generation technologies. It is expedient to subsidise technologies under development to establish their competitiveness and help them enter the market.

Protecting and strengthening carbon assimilation is an essential and mostly cost-efficient element of preventive strategies. Although the cost of fixing carbon dioxide with the help of photosynthesising forest biomass could change in a broader range, it is usually competitive in comparison to other preventive strategies. The direct and indirect benefits of forest plantation could counterbalance the related costs.

One of the most efficient means of preventing climate change is the improvement of energy efficiency (considering both production and consumption). Presently there are very high losses of energy encountered and therefore cost efficiency could result in considerable savings in increasing the efficiency of energy consumption. In Hungary "win-win" solutions sometimes cannot be implemented mostly due to the low income of citizens that will not allow the investment of the initial capital even into the most advantageous construction. (In this case one could propose securing bank credit with the support of state guarantee or other means of capital allowance.) In the next two-three decades 10-30% improvement of energy efficiency could be achieved with minimum cost to society. On the long run the potential energy efficiency could be even higher. In Hungary there are several options for decreasing energy consumption in a cost-efficient way. Nevertheless, the implementation of the respective measures depends highly on the trends of economic policy and technical development, and also on the inflow of operative capital, which will be needed for these developments. If coal or coal-based energy were taxed as a strategy of emission-reduction policy, a substantial increase of the tax-income of the state and the redistribution of this extra income could be expected. The redistribution of these funds would determine the costs of prevention.

The increasing share of renewable energy sources could result in socially economic solution only along with the improvement of cost-efficiency.

If the above-mentioned strategies were applied (and our calculations have proven that they can be economically implemented) then global sustainability would be served by greenhouse gas emission-reduction in such a way that it might also increase the potential living standards of the present generation.

# 21. THE NATIONAL STRATEGY ON CLIMATE CHANGE

In May 2004 the Scientific Committee of the Project VAHAVA has adopted the proposal for the development of a National Climate Change Strategy (NCCS) for Hungary. This proposal was incorporated into the programme of the Government in the spring of 2006 and the scientists of the Project VAHAVA have formulated the scientific concept of NCCS. In May 2007 the Hungarian Parliament adopted a law (called the LX/2007, the Kyoto law), which provides for the creation of NCCS. The working document of the Strategy was prepared in the Ministry of Environment and Water (KvVM) and has been released to be subject of public debates in the summer of 2007. Taking the experiences of this public debate into account the Ministry produced the final form of the document, and the Government accepted in February 2008 and subsequently the Parliament unanimously adopted the law on the strategy. The Law LX of 2007 also provides for the implementation of the tasks of NCSS and this should be done by the National Climate Change Programmes to be provided in each second year. The Government is requested to submit a biannual report to the Parliament on the state of the implementation of NCCS.

### Essential elements of the strategy

The Strategy gives the following main action lines for climate policy of Hungary:

- Measures aimed at the reduction of the emissions of gases (GHG) that are causing climate changes should be made, in compliance with the respective requirements of the EU and other international forums. These measures should also ensure the halting of further increase of the emissions of GHG. The mitigation of the emission of GHG should be made along with the reduction of the total use energy in such a way as to transform the structure of consumption and production towards the less energy-demanding direction.
- In order to enhance the defence against the unfavourable ecological and social impacts of those changes of the climate that cannot be anymore avoided the Strategy should include the most important elements of improving the adaptive capacity to handle the consequences of climate change.
- The climate awareness of the society must be ensured and strengthened.

NCCS is a frame system, which is especially intersectoral and concerns the society as a whole, involving all branches of the economy and all interest groups. Therefore the respective strategic objectives and tasks should be incorporated in the activities of all economic sectors (and their Ministries), defining separately the tasks of the government and of the society. NCCS defines the parties involved as follows: state organs, regions, the public, NGOs, local communities and governments, churches, the business sector, and the media.

### The objective and basic principles of the Strategy

It should express a deep concern towards future generations, the global, EU Member State, and national responsibility of Hungary in the combat against the impacts of climate changes; Should contribute to the transition of the country to the state of climate-friendly sustainable development and to the improvement of economic competitiveness, to the upgrading of the security and quality of life of the population, taking into account the country's social and economic conditions, and the challenges of approaching the standards of more developed (EU) countries.

NCCS was prepared on the basis of the following basic principles:

- The principle of sustainability: Measures of the strategy consider the life conditions of future generations and the conditions of meeting their needs.
- Systems approach: The Strategy interprets the changes of the climate in the dynamic system of drivers, pressures, states, impacts and responses.
- The precautionary principle: In dealing with the impacts of the climate changes the strategy provides for appropriate protective measures to handle situation even in the cases of the potential occurrence of human, natural and social-economic losses. And this is done even in such cases when the cause and effect relationships and the expectable extent of such losses have not yet been scientifically identified.
- The principle of common but distinguished responsibility: The global character of the changes of the climate requires the possible most wide spreading co-operation of all countries. This means the participation of all countries in the efficient and appropriate international actions in proportion to their possibilities, to their social and economic conditions.
- The principle of solidarity: An individual and the society are, as of their essence, depending mutually and actively on each other and therefore the mutual acceptance of obligations and helping each other are the essentials of survival.
- The principle of prevention: It is a well proven and general principle that the costs of preventing (avoiding) changes that have the risk of large losses and damages may, by orders of magnitude, be smaller than the costs of reconstruction or compensation of the occurred damages.
- The principle of decentralisation and regionalism: The implementation of measures related to the changes of the climate and the allocation of workload and fields of competence must be based on the principle of subsidiarity.
- The principle of environmental justice: The accessibility of the public goods of the environment and the healthy environment should be equally secured for everybody, disregarding their age, gender, race and social-economic state. Similarly, the disadvantages and pressures of environmental damages should be equitably born with all the parties concerned.
- Avoiding the translocation of environmental pressures: Only such measures may be accepted that will not cause similar environmental pressures in other environmental or natural systems and in other regions.
- The principle of integration: The protection of the environment is an organic part of the policy of all economic sectors. In accordance with this the guidelines and instructions of the climate change strategy should also be built into all those strategies, plans and programmes of the Government, which are directly or indirectly related to the changes of the climate.

According to the principle of integration:

- The climate policy should be integrated with the development policy.
- The combat against the impacts of climate changes should be turned into the core and organizing power of the cohesion policy.
- Measures of prevention and adaptation should be organically integrated with the ongoing legal activities and into the legal regulations being prepare, along with the

integration with development projects, operative programmes and action plans financed by the communities.
- Ongoing development projects should be subjected to climate-sensitivity studies (the development be in harmony with the requirements of emission mitigation and the strategies of adaptation).
- Climate research programmes should be integrated with other scientific research programmes and studies.
- The society and business world should be involved in forming the climate policy.
- Efforts should be made to identify new social, economic, and technological development trends.
- The principles of decentralisation and regionalism must be followed when implementing development programmes, which concern climate policy.

**Priorities of the Strategy**

The following priorities were defined:
- Strict compliance with the national obligations.
- Combat against the drivers of climate changes (including not only technological drivers but also those of the social behaviours and the scale of values, which require the forming of attitudes and the strengthening of the acceptance of the mentality that complies with sustainability.
- Decreasing the emissions of greenhouse gases.
- Adaptation to the impacts of climate changes.

*Decreasing of emissions*

The Strategy provides a complete review of the present state of emissions in Hungary. It describes the present state and past changes of the emissions of various economic sectors for each greenhouse gas. These sectors are: Energy industry, other industries, traffic and transportation, agriculture and forestry, waste and sewage handling; population and public organs. Future emission images for “business-as-usual” and in comparing to this for decreased emissions corresponding to various strategic objectives are formulated for each of these sectors. The decreasing (mitigation) potential of each of these sectors are identified along with the tools needed for the realisation of these potentials. Whenever possible costs and benefits are rendered to strategic objectives. It is stated that in Hungary the sector-priorities of the Strategy in decreasing emissions are as follows:
- Enhancing energy-efficiency in the sector of the population and public organs, with special regard to renovating doors and windows, insulating the walls of buildings, upgrading heating facilities, regulating remote-heating, replacing the facilities of heating, lighting, air-conditioning and other of facilities with energy saving type devices.
- Increasing of efficiency of power generation and coupled energy production.
- Renewable sources of energy (biomass, geothermal energy, wind, and solar energy).
- Switching to other fuels from fossil ones.
- Reshaping the structure of traffic and transportation, favouring public transport.
- Storage of carbon dioxide.
- Fixing carbon dioxide by planting forests.

### Adapting to the changes of the climate

This task concerns the total area of the country, practically all layers of the society that is all citizens of Hungary and all enterprises. NCCS takes mainly the following subjects of climate impacts into account:

- Nature and the biota (nature conservation and ecosystems).
- Human environment and the health of the population (heat waves, spreading of viruses, bacteria, pathogens, allergy, pollens and the safety of food).
- Agricultural production (drought, extreme water budgets, irrigation, soil erosion, safety of harvest, selection and improving of species, insurance systems).
- Water management (flood control, drinking water supply, water quality and quantity, drying of shallow lakes and small watercourses; low water stage problems of rivers).
- Forestry (forest plantations, regional problems).
- The built environment (new developments, land use, landscape management, construction standards, development of settlements).

### Implementation of the Strategy

Tasks of the Government and the means of the state: Elimination of “market failures”; supporting competition in the energy market; releasing constrains on the flow of information; development of credit constructions; new subsidence policy and incentive systems; reforming professional policies; new green taxation reform; “greening” of public procurement procedures; Green Investment Scheme; education-training and the forming of attitudes; research & development; data bases and the expansion of monitoring systems; monitoring-reviewing the implementation of NCCS and of the actual National Climate Change Programmes (NCCP) and the preparation of annual reports to the Government.

Tasks of the society: New tasks of the population, business world, civil organisations, local governments, churches and of the media.

The Government adopts National Climate Change Programmes (NCCP) of two years duration aimed at the implementation of NCCS. Development of this programme is the task of the Ministry of Environment (KvVM) and this ministry is obliged to involve and co-ordinate the work of the other ministries.

The Government reports annually to the Parliament on the implementation and experiences of the programme.

Steps of the implementation of the Strategy are supported by an advisory board, the Committee on Climate Changes, formed by the representatives of the ministries involved, by those of the Hungarian Academy of Science, the civil environmentalist organisations, the person protecting the rights of future generations (“green ombudsman”), and also by the deterministic actors of the national economy, the business world.

In order to ensure an effective intersectoral co-ordination and the harmonisation of the various professional policies of the government a Climate Policy Working Group should be formed, consisting of the representatives of the high level professionals of the ministries involved, and this working group may create professional sub groups for solving special tasks.

# 22. CONCLUSIONS AND PROPOSALS

1. It can be stated that it was a correct decision when in 2003 it was agreed in the framework of the Project, in compliance with the *precautionary principle*, to accelerate actions in the process of *getting prepared to climate change*, instead of trying to find further proofs of changes and impacts. To do so intensive and offensive communication strategies were implemented by the experts of the Project. This action was firstly focussed at securing the recognition of the risks and dangers of climate change by the society and especially by the decision makers and opinion leaders, with due concern to the acceptance of their responsibility, also encouraging them to initiate the process of preparedness by reviewing the options of preventive measures. In doing so the Project suggested the sticking to simple solutions and decisions, which can be coupled with developments and investments that are anyway needed and timely and could open new markets and create jobs in such a way that in addition to mitigating harmful impacts they would also offer advantages.

2. One of the important findings – if not the most important one – was that the attention of the Society was drawn to the fact of the changing climate, to the likely consequences and to the options of preparedness, prevention, damage mitigation and recovery. The solution-finding abilities of the politicians, experts, leading managers were successfully activated along with the rising of the awareness of the citizens and the securing of their willingness to act.

3. Endeavours of the Project to introduce and propagate new concepts and to recognise the importance of avoiding the risk of sustainability and to create a national climate-policy have been justified. The urging of the Parliament to adopt decision on the *creation of a National Climate Change Strategy* for 20-25 years time-span with shorter periods of actions of 2-6 years has proved to be a correct approach. Implementation of the initiatives and proposals of the Project is under way involving the scopes of the protection of the atmosphere, the strategic elements of adaptation, the relevant conditions, the options of integration, the tasks of securing sustainability and the international obligations.

4. The major lead line of the Project was that *the strategy is made for the people and will be implemented by the people*. The strategy that was initiated from the top meets local voluntary, self-propelling and self-supporting preparedness actions. *The sensitivity and vulnerability* of people and of the various layers of the society are highly varying and so are their abilities to getting prepared and regenerated. Consequently social policies should be supplemented with measures that help overcome these differences. In order to achieve this the creating of preparedness plans of the smaller-larger settlements is needed and these plans should specify that when an event occurs in a given place and at a specified time who should do what, with whom together and with what means and tools. It is expedient to make such procedures well known and well practised with the help of local pilot programmes that should be developed and propagated within broad cycles. It is justified to propagate the *differentiated approach*, which takes into account sensitivity and vulnerability, also in the fields of the protection of *biodiversity, landscapes and regions, and the determination of critical infrastructures.*

5. In the field of *public health* the most important topics include impacts relating to heat waves, plants producing allergic pollens, illnesses propagated by ticks and caused by UVB radiation, dangerous cooling-down in the winter and frost-death. The relevant tasks are the identification/monitoring of such incidents, preventive actions, preparedness and curing the

illnesses. Measures and regulations related to this are included in the chapter that deals with public health issues. In public information the changes occurring in the way of living, eating, clothing, recreation, sports and entertainment have growing importance. Changes needed in various fields of hygiene (those of the persons, food, other products, buildings, community contacts etc) are also of growing importance. To facilitate such changes there is an urgent need for finalising the ’Preventive Strategy for Climate-health’, for having it adopted and for starting the organisation of its implementation, because they form an important part of the climate-policy.

6. In critical situations drinking water is, in addition to the needed preparedness of public health agencies, of deterministic importance in the tolerability of the situation and in reducing the losses of the population. A key issue in such situations is the protection of the natural resources of *agricultural production* that secures the safe supply of food for the population and indirectly also the supply of water. The safeguarding of production capacities can be a long-term advantage of Hungary owing to the expectable increase in the shortage of food and water resources at international scale. The protection and preservation of the per capita high quality agricultural land area is a decisive factor in utilising this advantage.

In open field crop production the primary task is to make arrangements for securing the infiltration and storage of precipitation water into respectively in the fertile soil layer, along with that of the sparing utilisation of water. Knowledge on the means, tools and technologies of such production should be subject to widespread dissemination. Related tasks are the compliance with the changed needs for new nutrient supply and the transformation of the composition, quantity and quality of agricultural machinery. In solving these tasks the breeding of dryness-tolerant and flexibly adaptable crop species. This process could be much enhanced by an appropriate tendering frame, the result of which may raise international interests, similarly to that of the seed-corn production in Hungary.

The conditions of life-stock breading in Hungary, being in a jeopardised state already, will be worsened by the increase of breading expenditures (e.g. that of providing better shades and ventilation). This could be counteracted by improving the breeding parameters and by sparing-saving techniques. Where the climate turns drier, life-stock breading based on cereals and mass-fodder supply will have better chances and the development of pilot breading farms will be necessary.

Climate change might bring the horticultural sectors of Hungary (sectors of fruit, wine grape, medicinal-, aromatic-, and ornamental-plant growing) into a more exposed state to weather conditions. Adaptation techniques are already available in a book that has been written by a high number of the most relevant experts of this field.

7. *Forested land areas* should be protected and increased in size, as they have a direct and indirect atmosphere-protecting and adaptation-enhancing role. A complex forestry approach is needed for these saving-improving tasks. The main task is the protection of existing forests including their sustainable, multi-purpose long-term utilisation, focussing on the protection of the microclimate of the forests, with the caring for the possible best protection of water resources and supporting all kinds of water supplementation options. Propagation of wood-based products should also be supported thus enhancing carbon fixation.

Increasing utilisation of dendromass for energy production also brings the issue of forest renewal into the forefront. Both in the renewal and planting of the forests a key issue is the production of saplings of climate-change tolerant species. At the same time complex sustainability criteria should be taken into account in the species selection, in the multifunctionality of the forests and in general, in the full cycle of forest management.

In planting forests an increasing need might be encountered by the number of people shifting from agriculture to forestry and also by the afforestation of sloping grasslands and other areas. Therefore, in addition to state forestry, the role of private forest owners-managers will be increased, needing better subsidies and organisation of their activities. Consequently it would be expedient to develop a national programme on forest management by companies and private entrepreneurs, including the appropriate subsidy of state forestry as well.

In wild-game management there is an urgent need for decreasing the damages caused by over-kept wild-stock and one should establish a balance of forest plantation expenditures, tourism and hunting incomes and the expenditures for establishing wild-game parks.

Amendments of the National Forest Strategy are urgently needed to take account of climate change.

8. *Green areas* deserve special attention due to their multilateral effects ($CO_2$ uptake and storage, oxygen emission, aesthetic effects, etc.) both in settlements and in the outlands and in all forms (alleys, parks, groves, groups of trees, roadside trees, gallery forests, meadows, stream bank ecotones, planted forests, arboretums, wooded pastures, rooftop gardens and house gardens, etc). In order to keep and increase green covered surfaces awareness rising and advisory services are needed, pointing out the types of trees, brushes and other plants that tolerate urban climates and conditions of rooftop and terrace gardens, providing also lists of places where these plants can be bought. It would be desirable to have it acknowledged by the lay public that agricultural fields are also green areas from sowing to harvest. Here again the objective is to have the least amount of fixed carbon emitted back to the atmosphere.

9. Climate change in Hungary increases the danger of *flooding, drought and inland excess waters*. The extent of damages caused is expected to increase and therefore the tasks of the water management in fighting floods, excess waters and droughts must be defined in their interaction and joint causes, putting the main emphasis on supporting multiple effect measures, such as the creation of multipurpose reservoirs or the breaking through the semi-impermeable upper soil layer with various ploughing techniques so as to avoid inland excess water, which is generated mostly due to the lack of appropriate infiltration capacity of the soil.

It is important that the actors of flood and excess water control and defence shall have appropriate plans, and possess the financial and technical means needed for action and maintenance of the respective works. It is also important to provide appropriate monetary resources for the investments needed for development of control and defence systems, bearing in mind the principle of tolerable damages.

*Water management* – the protection and sparingly reasonable and purposeful utilisation of water resources of ever increasing value – becomes a so far never experienced task of extreme importance. Consequently a programme should be developed for the protection of drinking water resources and for that of all the surface and subsurface water bodies, with due concern to the importance of mineral, thermal and medicinal waters in Hungary and to the need for international co-operation in protecting and utilising transboundary waters.

10. Impacts of the changing climate are especially endangering the unique *natural landscapes and irreplaceable natural values* of Hungary, as well as the nature preserves and the biodiversity of the ecosystem. Consequently an appropriate action programme is needed for the protection of these resources and for getting prepared to handle the impacts. Within this special attention is due to the implementation of the EU policies relating to the ecological network of the Natura 2000 sites and to other sensitive areas, which latter coincide with the Natura 2000 sites to a 30% extent only.

The spreading of the techniques of sustainable agricultural production is of high importance from the nature conservation's point of view as well, as this supports the protection of the biota, the natural ecosystem.

It is necessary to develop sensitivity indicators or indices for the evaluation of the results of the continuous observation of protected and non-protected natural resources. These indices would allow the tracing of the impacts of the weather events, thus allowing the organisation of timely preparedness. It would be desirable to involve in this work university and college teachers, researchers, the staff of plant-and-soil protection stations, village farming advisors, the staff of the local nature conservation, environmental protection and water management agencies, other experts of relevant fields, NGOs and voluntary helpers.

11. Climate change can affect the various sectors of the national economy and the various companies in different ways. Therefore it is advisable to prepare separate programmes for the *various economic sectors* and pilot preparation programmes for at least the larger company groups. Such programmes are needed for the sectors of: health, energy, food, water supply, nature conservation and natural resources, flood and excess water control, water management, drought management, agriculture, traffic and transportation, insurance systems, catastrophe prevention, research and education. The results of this project may contribute to the development of such programmes.

12. The economy and the society as a whole will be seriously impacted when *critical infrastructures* are damaged. For example when weather events cause problems in traffic, energy supply or in telecommunication. Multilateral interventions are needed for the prevention of such impacts, including the updating of the techniques of system-repair, the provision of local standby equipment and the expansion of the stock of alternative solutions.

13. Positive and negative impacts and consequences of the changing climate should be taken into account in sites involved in *tourism* (medicinal and wellness resorts, natural waters, unique natural sites, towns favoured by visitors, ecotouristic sites, etc.). Resources of tourism should be regenerated and its environmental impact reduced so as to secure sustainability.

14. The issues of *energy production, traffic and transportation* are of high importance from the point of view of protecting the atmosphere and adapting to the changes of the climate. Adaptation techniques include the improving of the efficiency of both power production and energy utilisation, the sparing use of energy, the expansion of alternative energy resources, the strengthening of institutional background, the provision of standby assets, and the making of all the respective urgently needed government decisions.

In agriculture, forestry, in the settlements and in the households the sparing use of energy and the utilisation of alternative sources could contribute to the lessening of energy dependency of the given locality, to reduction of costs and to the simultaneous and timely creation adaptation to climate change and to the protection of the climate. There are already some good national examples in utilisation of renewable energy sources; therefore it is justifiable to initiate more local programmes, project and to speed up their implementation by subsidies.

We were also dealing with the present state and future of traffic and transportation in details that are appropriate to the weight and importance of this issue, offering a detailed concept for handling the related problems.

15. Urban citizens have badly tolerated the *heat waves* of the near past. There is a strong need for adapting to such heat with appropriate changes in the buildings and their machinery. Building technologies should also be changed. Man and animals cannot have sufficient rest in the heated buildings and shelters, stored crop, food and many other products get damaged and the night-radiation of the heated buildings lessen the chance of cooling in the environment, etc. Consequently the importance of providing appropriate shading and compass directions

and ventilation for the *buildings* and also for barns and stables is growing along with the need for green areas that enhance heat-loss and white surfaces to reflect sun radiation. Re-invention of traditional insulation and lining techniques has also a future. Air conditioners will not provide long-term solution, neither for buildings nor for live-stock breeding constructions as they are large energy consumers and emit hot air when in operation.

Building materials of larger strength will be needed for both all kind of buildings (homes, commercial and farming buildings) and their supporting frames, while the role of insulation of the outer surfaces is increasing. One must take into account the damaging movement of soil in foundations, firstly in clayey soils, due to the increased desiccation, the loss of moisture. In the case of large storms wind pressures and suction pressure differences should be taken into account along with the effects of off-spinning vortices. A general rule will be the consideration of the loss of strength and tiring of building materials due to climatic impacts and this can result in earlier than usual destruction of the buildings. It is desirable to follow advises and adapt the rules and measures of the EU’s Energy Performance of Building Directive.

In the settlements the first task is to prepare guidance materials for aiding the establishment of preparedness of the citizens, have them known to the population and to organise practices. The general framework of actions is to make efforts to create sustainable settlements and the respective requirements must be defined for each settlement in course of public hearings, discussions and debates, so as to reach commonly supported decisions.

16. In changing climatic conditions the following measures should be made, in addition to those described above:

In order to lessen the severity and damages of weather events caused by the climate change one should provide *reserves* of food, drinking water, medicines and spare parts for repairing damaged infrastructures. These reserves should be appropriately stored and regularly renewed. Such standby stocks and the rules of their storage and utilisation should be provided in the near future, as the nation’s attention was drawn to the importance of this by the impacts of the extreme storms and other weather events of the near past.

Prevention, damage recovery and mitigation require different approaches in the various economic sectors, in different regions of the country and in different settlement types. This means that different technical equipment, logistic and information systems are needed in their capacities and composition and therefore sample stocks and systems should be developed for them and then they should be summarised and generalised at country scale, thus providing an important part of the national climate strategy and its measures.

In making long-term programmes, plans, concepts and development plans for *infrastructures* (such as building power stations, or investments in traffic-and-transportation) the preparation of climate-impact studies, as parts of the strategic environmental impact assessment, should be carried out.

In the framework of the National Climate Change Strategy a methodology should be developed for “atmosphere-protection rapid testing”, which could, already in the early phases of planning, allow the consideration of alternative solutions and techniques in the light of climate-change oriented evaluation.

17. In the field of *insurance systems* the objective is to reach a multiple approach as soon as possible, in which the joint means of market- and non-market based insurance systems are coupled with local, professional, sectoral and government supported endeavours, thus securing the climate-impact damage compensation, alleviation and mitigation of those impacted. There is an urgent need for enhancing self-aiding public participation in both prevention and damage mitigation, for which the identification of potential institutions is the first task to be followed by the harmonisation of their operation.

Any initiated future changes in insurance systems aimed at solidarity, equity and security first the subjects should be precisely identified (e.g. who are involved, the insured ones) followed by that of the type of the damage events concerned along with the institutions involved (state supported, profit oriented, non-profit one, or public foundation), as they will together ensure the efficient and objective oriented operation of the insurance system.

The operation of the National Agricultural-damage Compensation system is extremely important in countries, which are exposed to extreme climate-change impacts and where agriculture is facing an ever-sharpening competitive international agricultural market.

In shaping the climate-change policy of Hungary the objectives, operation conditions, task distribution and interconnection of the National Climate Change Strategy, the National Catastrophe Prevention Strategy, and of the National Agricultural-damage Compensation Fund should be reviewed and harmonised and then be fitted into the Hungarian insurance systems with due concern to their connection with the international ones.

18. The National Catastrophe Prevention Strategy has been prepared on appointment with the Government. This Strategy considers all kinds of *catastrophes* and takes into account the increasing frequencies of extreme meteorological events. Nevertheless measures are needed to harmonise this Strategy with the National Climate Change Strategy and this needs the development of the respective forecasting and logistic systems, so as to ensure that the tools and means of prevention and defence be available when and where they are needed.

19. The significance of obtaining *meteorological and climatological information*, forecasts and analyses is growing, along with that of the modelling research in general. In order to be able to fulfil the requirements and perform the tasks discussed in this Project measures are needed that would enhance and promote the activities of the National Meteorological Service, university departments and of other professional and research institutions, so as to ensure appropriate upgrading of innovation in this field.

Collection of relevant statistical data is needed along with the data of weather impacts, damages caused, and of the costs of prevention and recovery. In this the Central Office of Statistics plays the main role with its Programme for Collecting National Statistical Data. In order to support this data collection activity novel data needs and terms should be specified as soon as possible, identifying the cycle of data suppliers and the needed financing sources.

20. In *education and training* it is important to ensure the appropriate knowledge of the expectable impacts of climate change of the ways and means of securing sustainability, of the ways of living that can handle these impacts and of the long-term social importance of this knowledge. The present teaching/learning system of Hungary – from the cradle to the post gradual education – should be reviewed from this point of view, acknowledging also the urgency of novel initiatives and measures as they could, with relatively small endeavour, result in solutions that are effective also on the long-term.

In the field of research priority should be given to the protection of the atmosphere and to innovation in the issues of adaptation and to the protection and sparing use of all natural resources. Innovative programmes and tenders aimed at these topics require subsidies and priority.

21. Preparatory activities to face climate change and to prevent the occurrence of damages need *financial resources*. Part of these should be contained in the state budget, but the other part is to be provided by companies and the citizens. An appropriately large budget can, however, only be created during several years and solidarity and equity must play an important role in it.

22. In order to counter balance the expectable unfavourable impacts of climate change one needs to critically evaluate the respective *legal framework* and modify it as might be required. This legal framework includes regulations by the authorities, standards, means of providing incentives and the institutional system behind them. Routine human behaviour

should also be changed and the options of strengthening the interest of various parties should be found.

The role of the State is increasing in the process of getting prepared to climate change and in the procedures of handling various related events. The tasks and duties of the relevant state agencies should be reviewed and modified as required, with due concern to the information level of the society and the transparency of the acts of state organs.