2016/1–2

# NEWSLETTER

## NATIONAL ADAPTATION GEO-INFORMATION SYSTEM

Table of contents



## Registration is now open for the NAGiS website

From May 1st, 2016 the NAGiS database is available free of charge. The system provides different levels of access in accordance with the relevant regulation (Government Decree No. 94/2014 on the Rules of Operation of NAGiS). Some of the technical content shall only be available to users listed in the decree who have obtained confirmed registration. Registration is a multi-stage administration process, so it is advisable to commence it as soon as possible.

If NAGiS has attracted your interest, please visit the website at http://nagis.hu and find out about logging into the system.

What can be found on the NAGiS website?

The National Adaptation Geo-information System is a tool supporting preparation for climate change. It was established and is being operated by the Geological and Geophysical Institute of Hungary (MFGI). Its purpose is to provide scientific forecasts about the climate vulnerability and adaptive capacity of selected subsystems of the environment and social, economic sectors in Hungary, based on the best quality and highest resolution climate modelling available in the country.

The three main parts of the NAGiS are:

1) a database containing the calculation results based on modelling (exposure, sensitivity, expected impact, adaptive capacity and vulnerability)

2) a meta-database facilitating navigation through different kinds of information (a sort of "data-map" about what to find and where)

3) a map-visualization system (with a resolution of 10×10 km, containing hundreds of layers which show the way different aspects of climate change can affect certain areas of the country)

The meta-database is available at http://nater.mfgi.hu/metaadat. The information available in the system can be searched using this engine.

NAGiS may be a useful tool in the area of strategy-building and legislation. The territorial analyses and vulnerability assessments for Hungarz support decision making both on a national and local (regional and municipal) level. The highlighted topics of the geo-information system include the following:

– regional climate forecasts,
– changes in groundwater levels,
– vulnerability of drinking water sources,
– climate sensitivity of agriculture,
– forestry and natural habitats,
– exposure of mountain and hillside areas to flash floods.

The forecasts provide an outlook for the periods between 2021–2050, and 2071–2100.

The Project is supported by a grant from Iceland, Liechtenstein and Norway.
eea.rec.org | eeagrants.org | norvegalap.hu

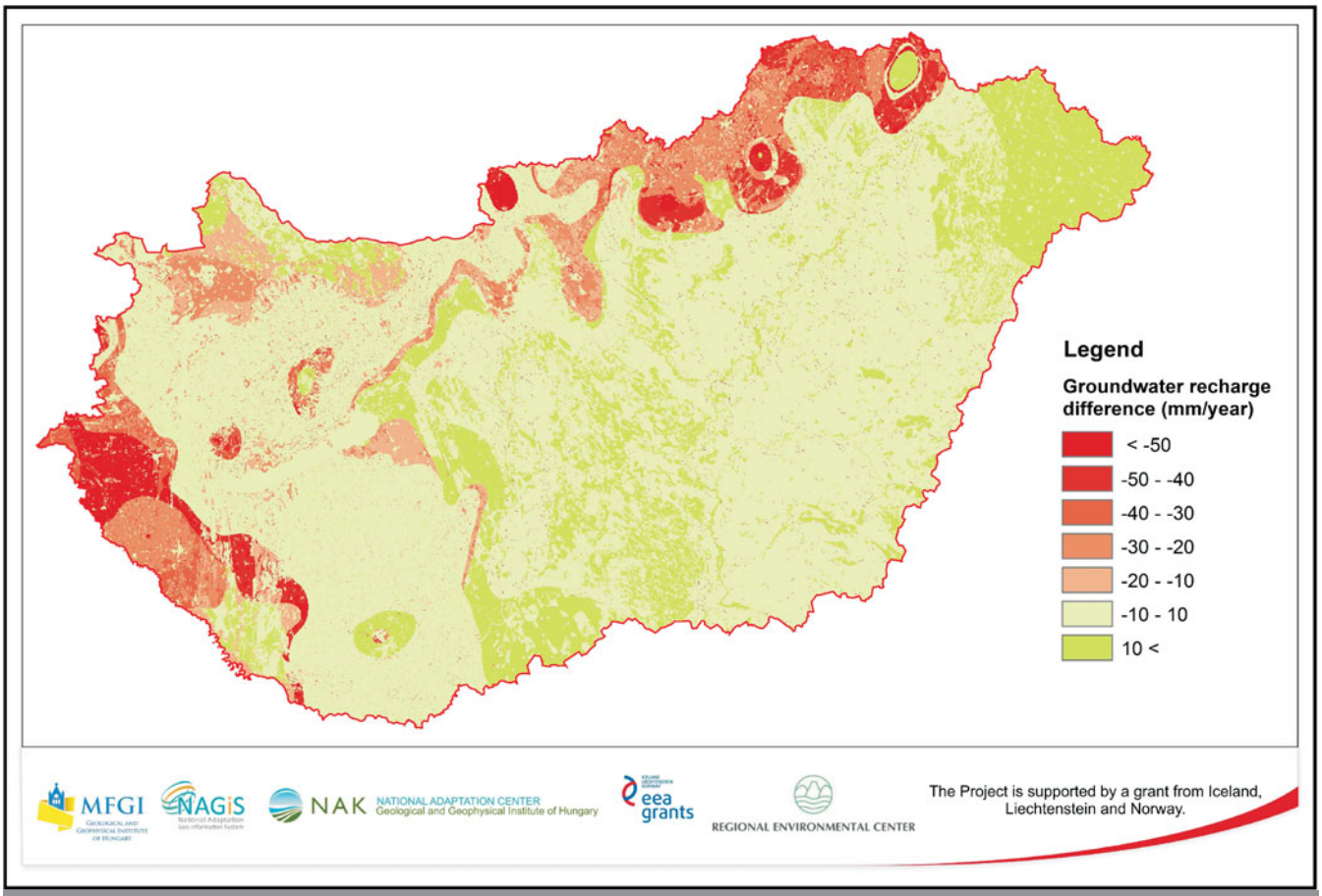
## Methodology for determining the climate sensitivity of groundwater

One of the most important objectives of the NAGiS project was to develop a methodology with which the shallow subsurface water table (hereinafter referred to as "groundwater") can be modelled under different climate conditions.

During the project a dynamic, modular methodology was developed in order to determine the distribution of groundwater under different climate conditions, and this was then applied across the entire country. In doing so, first climate and groundwater recharge zones were demarcated, for which groundwater recharge were determined using one-dimensional hydrologic models. By using modelled groundwater recharges the distribution of groundwater throughout Hungary was determined with the help of numerical hydro-geological models. The methodology establishes a quantitative relationship between the climate parameters, the groundwater recharge and the groundwater table. This methodology was successfully applied to illustrate climate sensitivity.

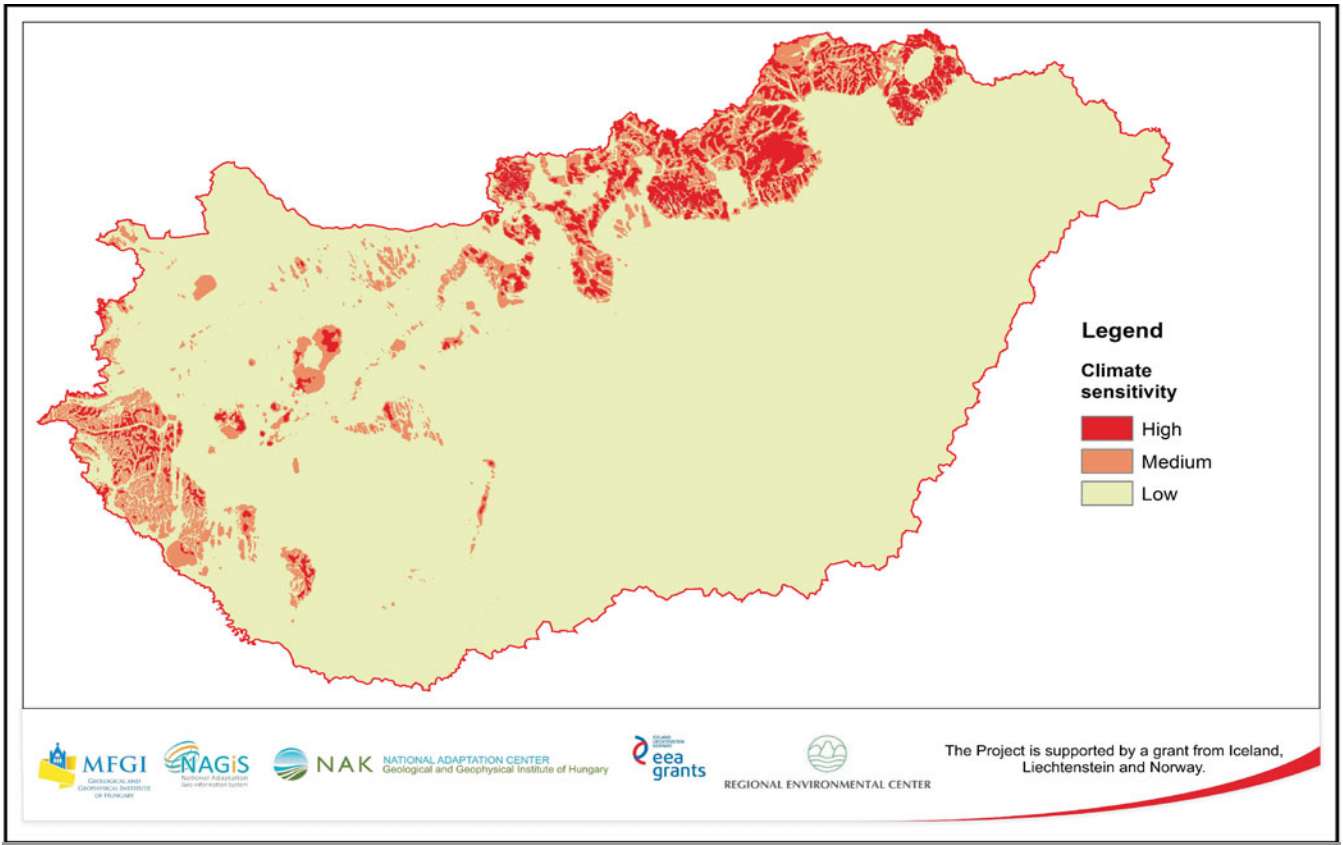
Based on the changes in the calculated groundwater recharges it can be said that a decrease of several tens of mm/year can be traced in the mountain areas (the Pre-Alps, the North-Hungarian Mountains and the Transdanubian Mountains) from the 1960's until the end of the 2000's. This tendency can be shown either based on measured data or based on the simulations derived from the results of the climate models.

The groundwater reservoirs of the country were classified into sensitivity categories based on the extent to which the modelled groundwater levels react to climate change. The sensitivity map was then prepared based both on the simulations founded upon measured data or based on the results of the simulations created from the outputs of the climate models.




Changes in groundwater recharge simulated based on the measured climate parameters from the 1960's until the end of the 2000's

The sensitivity maps indicate that the mountainous areas (the North-Hungarian Mountains and the Transdanubian Mountains) are highly climate-sensitive, while the foothill areas are considered to be moderately sensitive. For the Pre-Alps and the Mecsek Mountains, the simulations derived from the measured climate parameters produced different results from those derived from modelled parameters.




The climate sensitivity map of the shallow groundwater tables of Hungary based on simulations derived from measured climate parameters

The modelled distributions were prepared with precision on a national scale, however the methodology can be applied to assess the climate sensitivity of the shallow subsurface water tables on any scale.

*Attila Kovács, Annamária Marton, Teodóra Szőcs, György Tóth*

## The climate change vulnerability of drinking water sources

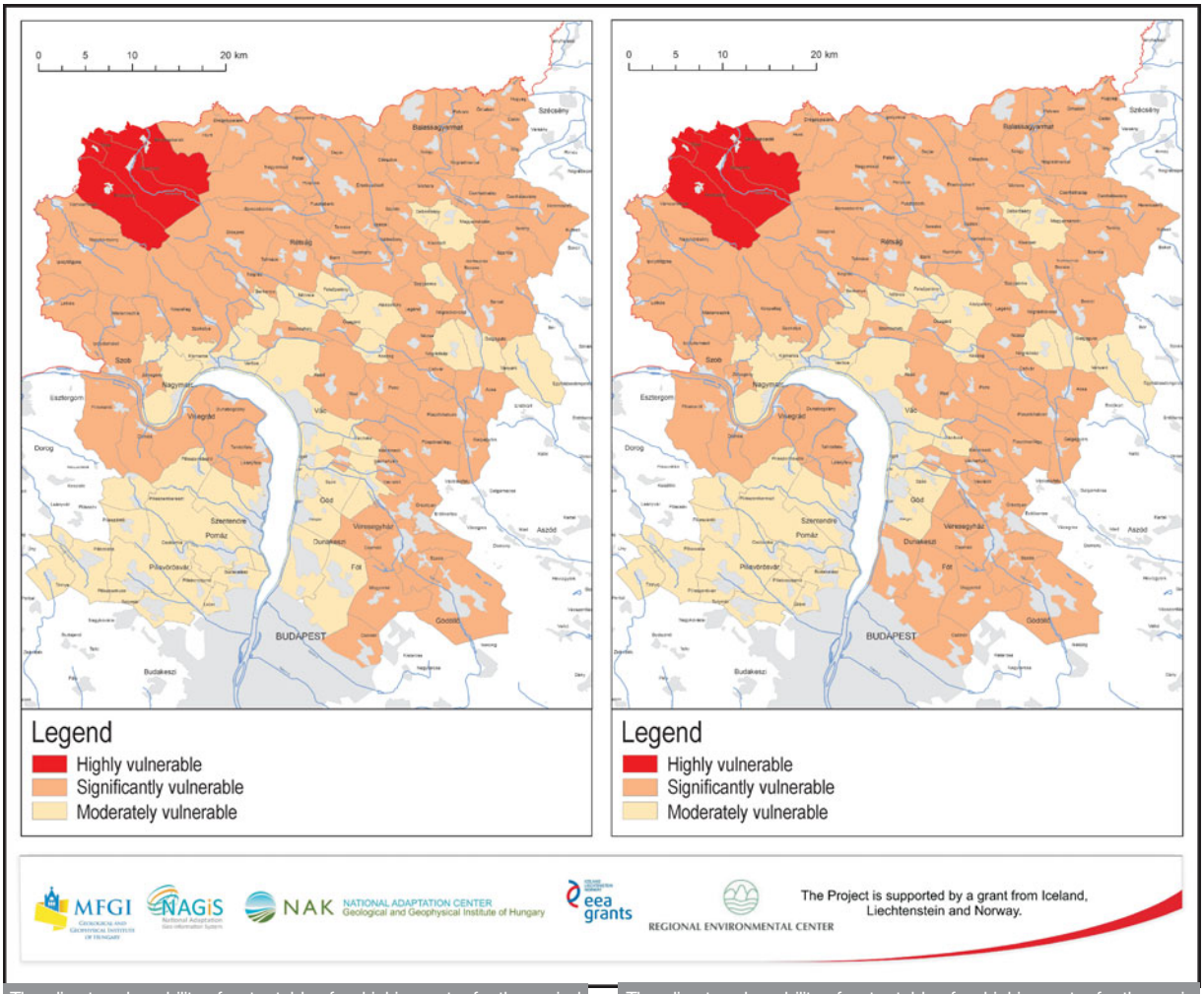
Extreme weather conditions have caused problems in the drinking water supply on several occasions in the past. During dry summer periods water shortages emerged as results of decreasing water resources and the simultaneously increasing demand for water, which has often led to water restrictions. In other cases, due to the floods and karst flash-floods resulting from rainy weather, certain water bases have had to be temporarily switched off from the drinking water supply system in order to prevent the risk of infection.

Generally, the permanent alteration of climatic conditions, and the effects of extreme weather exerted on subsurface waters is not as direct and excessive as in the case of surface waters. Rather commonly, only the results of several years of continuous influence can be observed. These changes, however - apart from a few exceptions - apply for a long time, and when the adverse effect ceases to take place, the previously existing situation can only be restored via very slow processes.

In view of the increasingly frequent occurrence of extreme weather conditions and the further changes to be expected in the future the detailed assessment of the impact of climate change on drinking water bases has become necessary.

The NAGiS project examined the climate elements and their expected future changes alongside with the geological formation particularly characteristic of the vulnerability of drinking water sources, within which the hydrogeological particularities were examined. The examinations were supplemented by illustrating the opportunities of local, socio-economic adaptation to the changing circumstances, alongside the method of illustrating the climatic vulnerability of drinking water sources, and establishing a data system containing geo-information elements which increases the ability to adapt and reduce the impact of adverse effects.

To illustrate the climate vulnerability of water tables the CIVAS-model (Climate Impact and Vulnerability Assessment Scheme) — developed as part of the CLAVIER international




The climate vulnerability of water tables for drinking water for the period 2021–2050 based on the data provided by the ALADIN-Climate model

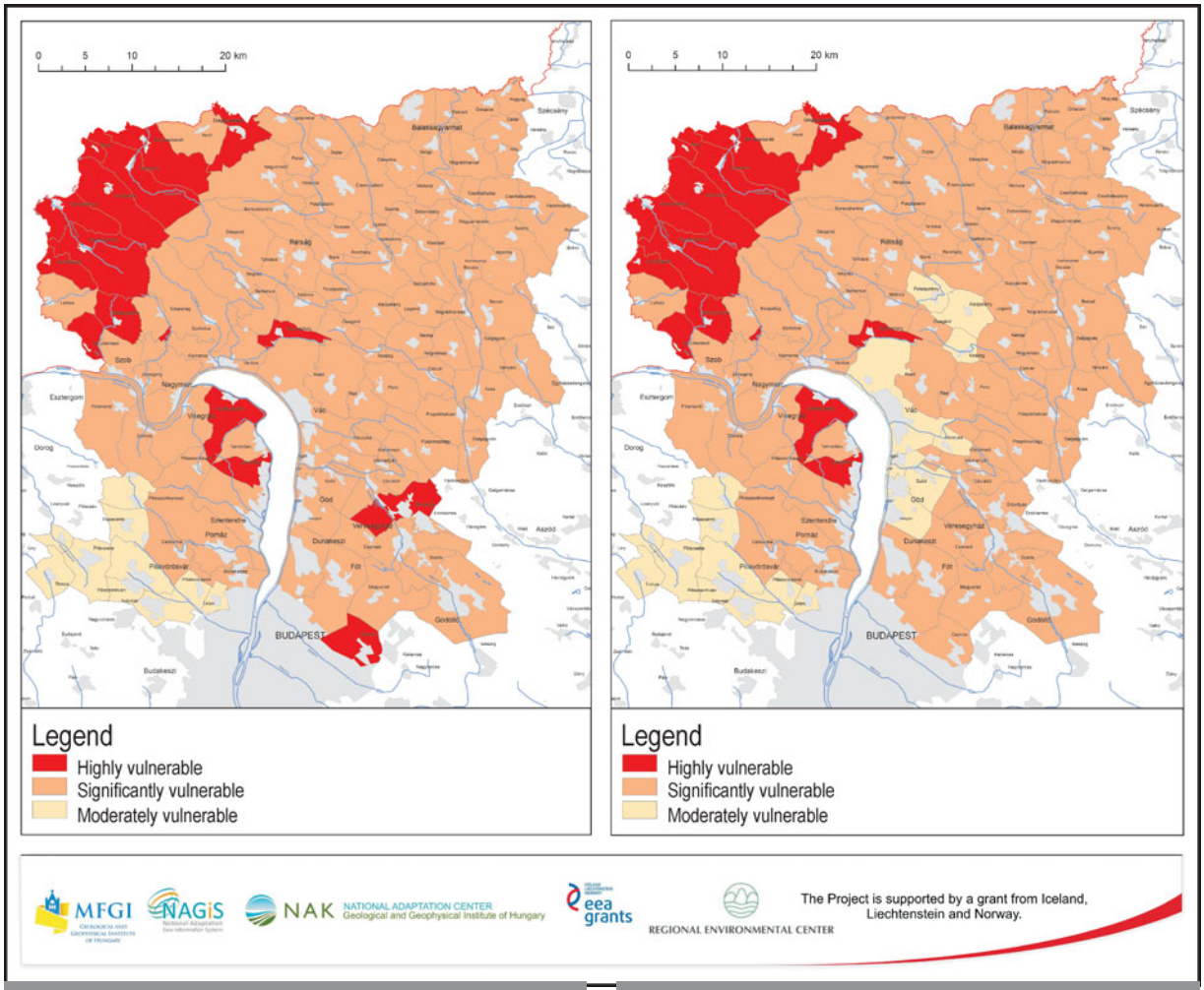
The climate vulnerability of water tables for drinking water for the period 2021–2050 based on the data provided by the RegCM model

climate research project — was applied. The analyses conducted during the development of the methodology were carried out on two different scales: while exposure, climate sensitivity and stress inflicted by water production were examined for the whole country, information obtained directly from the operator of the water tables for drinking water was also required to assess adaptability and determine the adaptation indicators. Adaptability, alongside the vulnerability of the water tables and water supply were assessed based on the basis of the above on the operational area of the Duna Menti Regionális Vízmű Zrt. (Danube Inshore Regional Waterworks, DMRV) as a sample area. The adaptation indicators were determined based on data obtained from the Hungarian Central Statistical Office (KSH), and the data supplied by the Waterworks. The DMRV provided the data for the MFGI based on a co-operation agreement between the company and the Institute.

In order to determine the extent of vulnerability, categories were defined and the factors of exposure, sensitivity, impact and adaptability were taken into consideration with equal importance, with the complex indicators derived from certain indices. The values of the indicators and the categories of vulnerability were determined in a way which allowed them to be used for entire Hungary and allowed the assessment to be extended across to the whole country using the same categories.

As a result of the examination we found that the climate exposure of the water tables is not identical throughout the country, but in fact changes in a relatively narrow range compared to usual European conditions. The recharge rate of the subsurface waters is expected to decrease as a result of climate change. This process is somewhat compensated by the change in the yearly distribution of precipitation, that is the expected increase in the quantity of precipitation during the hydro-geological winter semester.

The climate vulnerability of water tables was determined for both climate windows (2021–2050 and 2071–2100) based on the ALADIN-Climate and RegCM models. According to both models, there are differences in the extent to which certain areas are vulnerable and these




The climate vulnerability of water tables for drinking water for the period 2071–2100 based on the data provided by the ALADIN-Climate model

The climate vulnerability of water tables for drinking water for the period 2071–2100 based on the data provided by the RegCM model

appear as early as during the period of 2021–2050. The extent of vulnerability of water tables for drinking water and water supply increases between 2071 and 2100.

The current climate models are characterised by a rather significant degree of uncertainty, therefore in future research projects it will be important to reduce the extent of such uncertainty by taking further climate projections into consideration and by utilising the results of new climatic models with enhanced resolution. Besides the clarification of climate exposure, further examinations are required in order to illustrate the exposure of the bank-filtered systems.

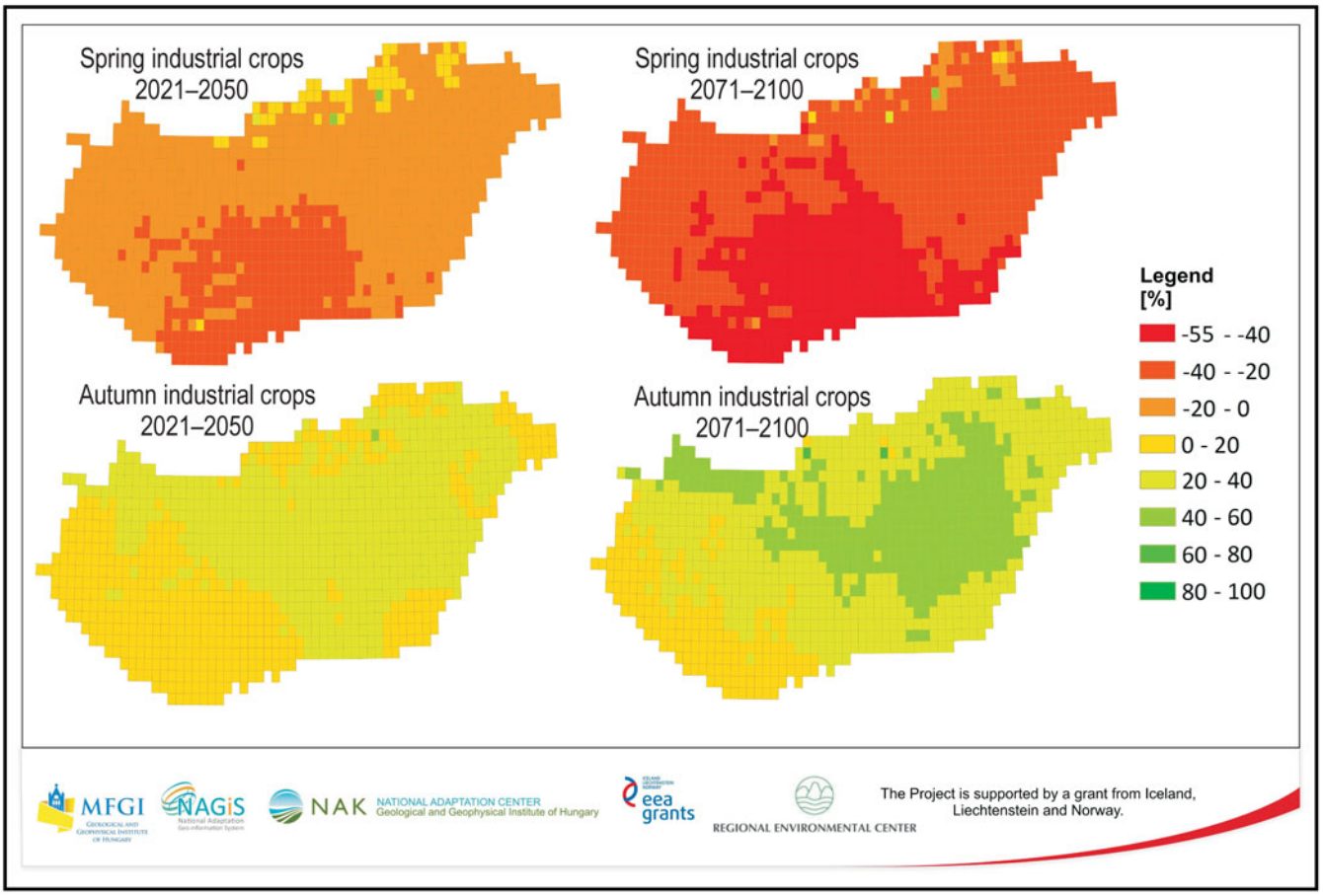
In order to decrease the effects of climate change, greater emphasis must be placed on adaptation. As far as water supply is concerned, regional supply systems may provide additional security, where water flow regulation which is already being applied in several places and water transfer between regions may play a significant role.

In terms of regional development, the climate vulnerability of water tables for drinking water must be taken into consideration, together with the relevant social and economic factors. While planning developments in the drinking water supply infrastructure, it is important to determine the regions where climate change may cause problems in the future, and every effort must be made to implement developments that reduce the vulnerability of the water supply for certain regions by improving adaptability.

*Ágnes Rotár-Szalkai, Emese Homolya, Pál Selmeczi*

## The effects of climate change on crop production

One of the important achievements of NAGiS is the projection of the expected results of climate change in the field of agriculture. The results of this particular part of the project concerning crop production are briefly summarised below.




Expected changes in the yield of spring and autumn crops in different climate windows compared to the present reference value

Crop simulation models are often used for estimating the possible effects of climate change either on local and global scale. In this study the 4M crop model was calibrated and then coupled with two of the latest climate change scenarios as well as with a high-resolution national geodatabase in order to create an impact projection on the biomass production of five major arable crops.

4M is a daily-step deterministic model that simulates the following main processes of the soil-plant system: soil water balance including plant water uptake, soil heat balance, soil nitrogen balance including nitrate leaching and plant N uptake, plant development, growth and senescence. The model was calibrated by using the 10×10 km spatial resolution CarpatClim-Hu meteorological database covering the area of Hungary with 1104 cells, the 0.1×0.1 km resolution DoSoReMi soil database, and FADN (Farm Accountancy Data Network) agromanagement data of 294 representatively selected Hungarian agricultural enterprises from the period of 2001-2010. After calibrating the model the potential impact of climate change on the biomass production has been defined as the difference of model outputs obtained by using future and present (observed) climate data.

Some of the most important findings of the research are listed below. Spring crops (e.g. maize) will suffer serious yield losses especially in the far future (2071–2100) exceeding 50% compared to the present yields at certain locations. At more than 75 and 80% of the crop lands the maize and the sunflower will suffer serious (>30%) yield losses, respectively in the 2071–2100 period. Yield safety of spring crops will decrease in the whole area of Hungary.

Autumn crops (e.g. wheat) will produce more and more yields approaching the end of the 21st century surpassing 50% yield gains at certain locations compared to the present yields. At 62, 58 and 63% of the crop lands the wheat, barley and the rapeseed will produce significantly higher (>30%) yields, respectively in the 2071–2100 period. Yield safety of autumn crops may increase as well at certain locations (e.g. middle part of the Great Plain).

The concentration of $CO_2$ in the atmosphere will be doubled during the investigated period that has a very strong fertilization effect on primary biomass production counterbalancing the negative effects of water shortage to some extent.

Farmers may decrease the harmful effects of climate change by exploiting the potential in agromanagement that could be adapted to the changing environmental conditions: 1) increase the ratio of autumn crops in the crop rotation

system; 2) earlier sowing; 3) choosing early maturing varieties; 4) selecting varieties with higher drought-resistance; 5) cultivate alternative crops.

*Nándor Fodor*

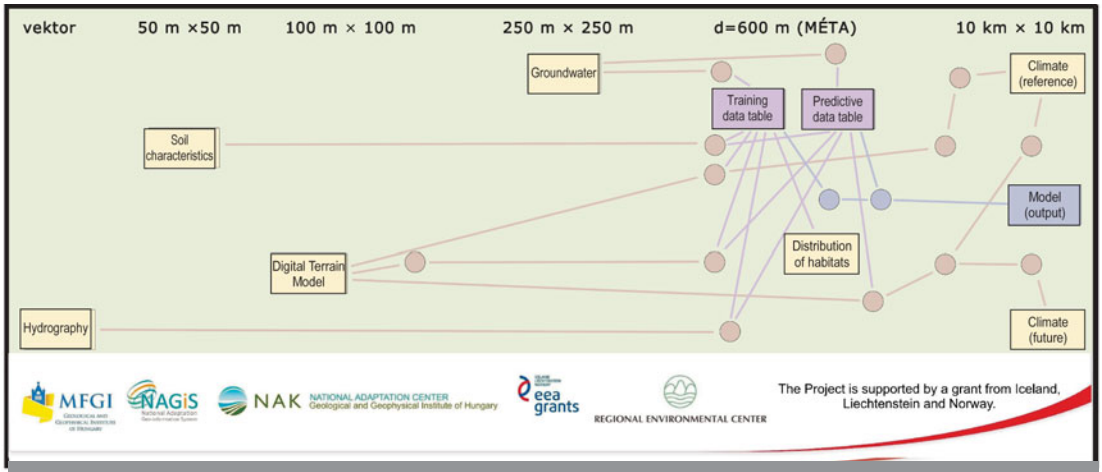
## Modelling the climate sensitivity of semi-natural habitats

The National Adaptation Geo-information System (NAGiS) contains several pieces of environmental data based on which the present (observed) and future possible (potential) prevalence of semi-natural habitats may be estimated. For that purpose, forecasts (so-called predictions) are created by setting up models and then projecting them to the target period in the future while bearing in mind at all times that these models and predictions inevitably contain errors and uncertainties. The uncertainty of input data cannot be eliminated, and is passed on during certain steps of modelling. Later on, as input data becomes more precise (which is the long-term objective of NAGiS), the uncertainty of the final outcome will also decrease. The objective of the work introduced here is to develop the modelling steps and create the forecasts.

Setting up the models requires two databases (a "training" dataset and the database of the observed prevalence of habitats), which describe the currently existing ecosystems and their environment. The training environmental database contains the environmental (climatic, soil capability, topographical) data, with the help of which the model "learns" where (i.e. under what environmental conditions) the examined semi-natural habitats may be encountered. In order to create the forecasts a third database describing future environmental data (the predictive environmental database) is also required, in which climatic data is based on the climate scenarios used by NAGiS. After creating the training environmental database in a uniform format, resolution and structure, we started setting up the model, which in actual fact encompasses one separate model for each habitat, of which there are approximately 40.

Ecological models, including the climate sensitivity model, require high resolution input environmental data that have explanatory power from the aspect of the modelled ecological entity (population, species, habitat). As far as climate variables (precipitation, minimum-, maximum- and average temperature) are concerned, the models run as part of NAGiS rely on two different regional climate models (ALADIN and RegCM), while for the reference period (1977–2006) they use the CarpatClim-Hu data. The vegetation model is based on the GIS Database of the Hungarian Habitats (MÉTA), therefore its approximately 600-meter spatial resolution prevails from the aspect of every environment background variable, so climatic data was also scaled for this resolution.

Our ecological model finds the most significant environment variables for the given habitat, and based on such variables it is able to create forecasts (extrapolate) for another time period. During forecasts it is assumed that if the environmental factors at a certain geographical point in the future are going to be similar to the ones currently observed at the geographical points where the habitat currently exists, then such a habitat may remain in the future as well. Moreover, if the environmental factors at a certain geographical point change, then such a habitat is exposed to the effects of climate change. Overall, if exposure to climate change is generally high across the country, and the habitat in question is climate sensitive, then a significant difference between the current and future prevalence may be observed, which means that the expected effect of climate change on the habitat in question is significant. The assessment of the exposure and sensitivity of semi-natural




The schematic process of setting up the training and the predictive databases

habitats to climate change therefore helps us to understand the vulnerability of natural habitats regarding climate change. The second pillar of quantifying vulnerability is determining the climatic adaptation capacity of habitats, which was introduced by the article titled "Assessment of the adaptability of the Hungarian habitats for the NAGiS" published in Issue 2015/2 of the NAGiS newsletter.

According to the results of the research, habitats may be placed on a wide scale, from habitats entirely determined by the relevant climatic conditions to ones which are entirely impervious to climate change. The most sensitive habitats are the arctophilous forests which are expected to decrease in size as climate change progresses. Besides the above, some wetlands proved to be extremely sensitive and may be affected significantly by the changes in the distribution of precipitation. Rocky and open grasses were classified among habitats which are the least sensitive to climate change.

*Ákos Bede-Fazekas, Imelda Somodi, Nikolett Lepesi, Bálint Czúcz*

## Project workshops

### Bilateral workshop to discuss the interim results of the NAGiS project

On October 19th 2015 a workshop was organised in the REC Conference Centre, Szentendre, Hungary as part of the NAGiS project. The main objective of the event organised for Hungarian and foreign – primarily Norwegian – experts was to present the interim results of the NAGiS project to discuss the observations which may facilitate further development of the system. The workshop also aimed to consider the possibilities of forming long-term co-operation between institutes.

The event provided an opportunity to introduce good practices and to exchange experiences obtained in the modelling of climate change, the collection and processing of data and other relevant topics.

During the event the associates of the Geological and Geophysical Institute of Hungary introduced the results achieved so far in the EEA-C11-1 NAGiS project, supported by the EEA. They reported on the research processes regarding the effects of climate change on groundwater, drinking water sources, natural habitats and the risk of flash floods, and on the results of the examinations as well.

The experts of the RCMGiS, CRIGiS, AGRAGiS projects and those of the project named Long-term Socio-economic Forecasting for Hungary also presented the current status of their developments. The representatives of the Norwegian partner institutions reported on projects which are relevant to NAGiS in connection with climate change and adaptation.

The participants at the bilateral workshop (Photo: Zsolt Bauer, REC)

In the final stage of the workshop the participants had the opportunity to exchange their views. While doing so the experts could gain a deeper insight into the topics discussed during the day, and had an opportunity to connect with other researchers with similar interests in order to determine the areas of possible future co-operation. Several participants emphasised that the Norwegian examples focus attention on the significance of the intensive dialogue between scientific researchers and decision-makers and the expected positive effects of this.


The participants at the NAGiS workshop (Photo: Zsolt Bauer, REC)

On the day following the event the participants were able to take part in a field survey in Tard and in Cserépváralja. This field survey, accompanied by an expert allowed the participants, to visit one of the plots providing information for the ecological research of the project with the changes that occurred during the past decades and focusing on the expected future direction of the transformation.

*Péter Kajner*

## Workshop about the preliminary results of the examinations concerning climate vulnerability

The Geological and Geophysical Institute of Hungary organised a workshop of the NAGiS Project for November 3rd 2015. The event took place at the seat of the institution on Stefánia Road in Budapest, Hungary.

The participants at the workshop titled *"The Different Applications and Limitations of NAGiS, the Preliminary Results of Climate Vulnerability Assessment"* were the associates of the Centre for Ecological Research of the Hungarian Academy of Sciences (MTA), Institute for Soil Sciences and Agricultural Chemistry of the MTA, the Forest Research Institute of the National Agricultural Research and Innovation Centre, the Hungarian Meteorological Service, the University of West Hungary, Faculty of Forestry, the Research Institute of Agricultural Economics, the Regional Environmental Centre for Central and Eastern Europe and the Geological and Geophysical Institute of Hungary.

The experts at the one-day workshop reported on the results of the project achieved so far in a total number of seven professional presentations divided between the morning and the afternoon sessions, thus providing a basis for the round-table debates discussing the presentations.

While summarising the morning session *Dr. Tamás Pálvölgyi* (Head of the NAC and Deputy Director of the Geological and Geophysical Institute of Hungary) emphasised that during the application of the vulnerability assessment methodologies developed as part of the NAGiS project they must ensure that they bridge the "gap" between the requirements of the decision-makers and scientific uncertainty, which at the same time may also indicate the direction of further application-oriented research-development activities.

As a conclusion of the workshop *Dr. Zsuzsanna Iványi,* senior expert of the Regional Environmental Centre for Central and Eastern Europe, stated that the scientific results of NAGiS achieved so far are a good basis for continuing and developing the research. She added that besides producing scientific results another similarly important task of the project is to present the results to the decision-makers in a way that is easy to understand.

*Mariann Sziráki*

## Promotion: presentations and publications

NAGiS and the results of the Project achieved so far have been presented by the experts participating in the work at several conferences and professional events since the newsletter 2015/2 of NAGiS was published. A significant number of them were international events.

Turczi, G., Mattányi, Zs., Vikor, Zs.: Flashflood – a layer of the NAGIS. The 13th International Symposium on Geo-disaster Reduction in Prague, 9–11 August 2015, Prague.

Bede-Fazekas, Á., Somodi, I.: Statistical downscaling of climate data for the ecological model set up within the framework of the National Adaptation Geo-information System (NAGiS), 10th Congress of Hungarian Ecologists, 12-14 August 2015, Veszprém.

Kajner, P.: Establishing the National Adaptation Geo-information System (NAGiS) in Hungary. Session No. 21 of the European Environment Agency Interest Group Climate Change and Adaptation (EPA IG CCA), 11th September 2015, Budapest.

Kovács, A., Szőcs, T., Tóth, Gy., Marton, A.: Assessment of Climate Change Impact on Shallow Groundwater Conditions in Hungary. The 42nd Annual Conference of the International Association of Hydro-geologists (IAH), 14 September 2015, Rome, Italy.

Turczi, G.: NAGiS – first results. – ESRI Hungary User Conference, 8 October 2015, Budapest.

Kovács, A., Tóth, Gy., Szőcs, T., Marton, A., Kun, É.: Assessment of Climate Change Impact on Shallow Groundwater Conditions in Hungary. International Association of Hydro-geologists – 2nd Central European Groundwater Conference, 14-15 October 2015, Constanta, Romania.

Kovács, A.: Quantitatve assessment of climate impact on shallow groundwater conditions in Hungary. Climate-KIC Short Course on Spatial

The participants at the climate vulnerability workshop (Photo: Mariann Sziráki)


The presentation of Gábor Turczi at the ESRI conference (Photo: www.esri.hu)

Group photograph of the participants at the conference in Constanta (Photo: www.ahgr.ro)


Sustainable Innovation Forum at the Climate Change Conference in Paris (Photo: www.rec.org, www.azertag.az)

Planning Challenges in Sustainable Urban Water Management, 26 November 2015, Budapest.

Bálint, J., Iványi, Zs.: Innovative tool supporting adaptation-related decision making in Hungary – National Adaptation Geo-information System. Innovative decision making tools for low carbon development and climate resilience in Europe and Central Asia – REC/CAREC Joint Side Event at the UN Climate Change Conference December 2015 (COP 21/CMP 11). The presentation was given by the representative of REC from the materials compiled by the MFGI. 4 December 2015, Paris, France.

Closing event of the project titled 'Long-term Socio-economic Forecasting for Hungary' (C12-11). 7 December, 2015 Budapest.

Kajner, P.: The 'Establishing the National Adaptation Geo-information System (NAGiS)' Project. Closing event of the AGRAGiS Project, 21 December, 2015, Budapest.

In addition to the presentations listed above, a wide range of experts and stakeholders could become acquainted with the project via publications, online appearances, interviews with NAGiS experts, and the articles published on the official website of the Project. The following are the most significant:

Kovács, A., Marton, A., Szőcs, T., Tóth, Gy. 2015: A sekély felszín alatti vizek klíma-érzékenységének országos léptékű kvantitatív vizsgálata. [Quantitative assessment of climate-sensitivity of shallow groundwater in Hungary.]. – Hidrológiai Közlöny, 2015/4.

Kovács, A., Marton, A., Szőcs, T., Tóth, Gy. 2016: Climate change impact on shallow groundwater conditions in Hungary: Conclusions from a regional modelling study. EGU General Assembly, 17-22 April 2016, Vienna, Austria, Abstracts.

Rotárné Szalkai, Á., Homolya, E., Selmeczi, P. 2016: Ivóvízbázisok klímasérülékenysége. [Climate Change Vulnerability of Drinking Water Sources in Hungary.]. – Hidrológiai Közlöny, 2016/1.

Rotárné Szalkai, Á., Selmeczi, P., Homolya, E. 2016: Climate Vulnerability of Drinking Water Supplies. EGU General Assembly, 17-22 April 2016, Vienna, Austria, Abstracts.

Selmeczi, P. 2016: Application of geographic information systems in the field of strategic planning in climate policy through the example of the drinking water service. EGU General Assembly, 17-22 April 2016, Vienna, Austria, Abstracts.

*Mariann Sziráki*

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NAGiS

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