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Climate Change and Territorial Effects on Regions and Local Economies

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Final Report

Annex 2

Case Study Tisza River

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Contents

Abbreviations

TRB Tisza river basin
CVM Contingent Valuation Method
WTP Willingness to Pay

List of figures and maps

List of figures

List of maps

0. Introduction

The Tisza river basin is the largest sub-basin of the Danube river basin. The Tisza Catchment area takes almost 20 % of the Danube river basin. It comprise an area of 160 000 square kilometres in South-East Europe and is shared by five countries (Hungary, Romania, Serbia, Slovakia and Ukraine). The catchment area is home to approximately 14 million people. There are only 12 towns in the range of 100 000 -500 000 population. Majority of the municipalities have less than 5000 inhabitants. The case study area comprises 85 % of the river basin, made up of 26 NUTS 3 regions in Hungary, Romania and Slovakia.Before the large-scale river regulatory interventions the length of river Tisza was over 1,400 km. As a result of river regulation in the 19th century, the length of river Tisza decreased by 30 %, and only small parts of the floodplain remained. For the protection of the areas released from regular floods, one of Europe's largest scale flood protection system was constructed. The length of river Tisza is 964 km now. The first 200 km section flows in mountains, the other 760 km section is on plain. The width and depth of the river bed are gradually growing downwards. The river bed is 100 – 200 m wide. The depth of the water – at low ebb – ranges between 1 – 1.5 – 4-5 m, and up to 7-10 m at certain points.

- the mountainous Upper Tisza and the tributaries in Ukraine, Romania and the eastern part of Slovakia and

- the lowland parts mainly in Hungary and Serbia surrounded by the East-Slovak Plain, the Transcarpathian lowland (Ukraine), and the plains on the western fringes of Romania (ICPDR, 2007).

The bulk of the River Tisza catchment area is made by mountains belonging to the Carpathian Mountain Range. The south-western and middle parts of the catchment area (are made up by flat plain. The greatest part of the catchment area is covered by sediments (limestone in the mountains and sand and loess on the plain) and in some parts, for instance in the inner range of the Carpathian mountain, there are volcanic heights too. The geographical differences are determinant for the evolved land-use. In the mountainous areas the forests, on the plains arable land is the dominant land use type. The forest covers 27 % of the catchment area. On the high mountains coniferous woods, on the mountains of medium height deciduous trees are dominant. The majority of grasslands (pastures and meadows) are also on mountains. The plains are predominantly plough lands. Arable land covers 35 % of the catchment area, the greatest part is in Hungary (the Great Hungarian Plain).The climate in the catchment area of the Tisza River is varied and ranges from oceanic to Mediterranean and continental climate zones. The differences are particularly stark in terms of precipitation. In mountainous areas the annual average of precipitation is over 1000 mm, in the lowlands, however, even below 500 mm. Rainfall in the Carpathian Mountains can be substantial and sudden. Extensive runoff, floodplain deforestation and river canalisation reduce the ability of the catchment to attenuate the flood wave. When heavy rains occur, flooding threatens human lives as water levels rise quickly without sufficient retention capacity. (ICPDR, 2007)

According to the results of the exposure analysis of the pan European space (based on the CCLM model) precipitation will decrease in summer and increase in winter month. Both, annual mean number of summer days and annual mean temperature will increase. The sensitivity to climate change also varies according to climatic, geographic and demographic features of the different parts of the Tisza River Basin. In the lowlands increasing drought problems will have serious consequences for agriculture.

Thought here has been a marked decline of agriculture in the Tisza catchment area, both land cultivation and animal husbandry are still significant economic activities, especially in comparison with the European situation. The plain areas are dominated by arable functions and the number of individual farmers is notable.In the mountainous parts climate change will especially impact on valuable protected areas. Due to climate change it is expected that the habitats will alter and biodiversity will decrease. On the other hand in the mountainous areas the increasing erosion also will cause negative impact especially on soils. In the whole territory of the river basin the risk in the built environment (settlements, technical infrastructure) there are a many uncertainties, which needs further researches. Based on a comprehensive assessment of exposure, sensitivity and adaptive capacity in the Tisza River Basin, the case study will focus on river-related (floods) and drought impacts, followed by an analysis or exploration of adaptation strategies suitable for this multi-national river system. Regarding adaptation, the regulation and the change of land use, respectively the alternative strategies of the flood area protection has significant importance.

1. Characterisation of the region

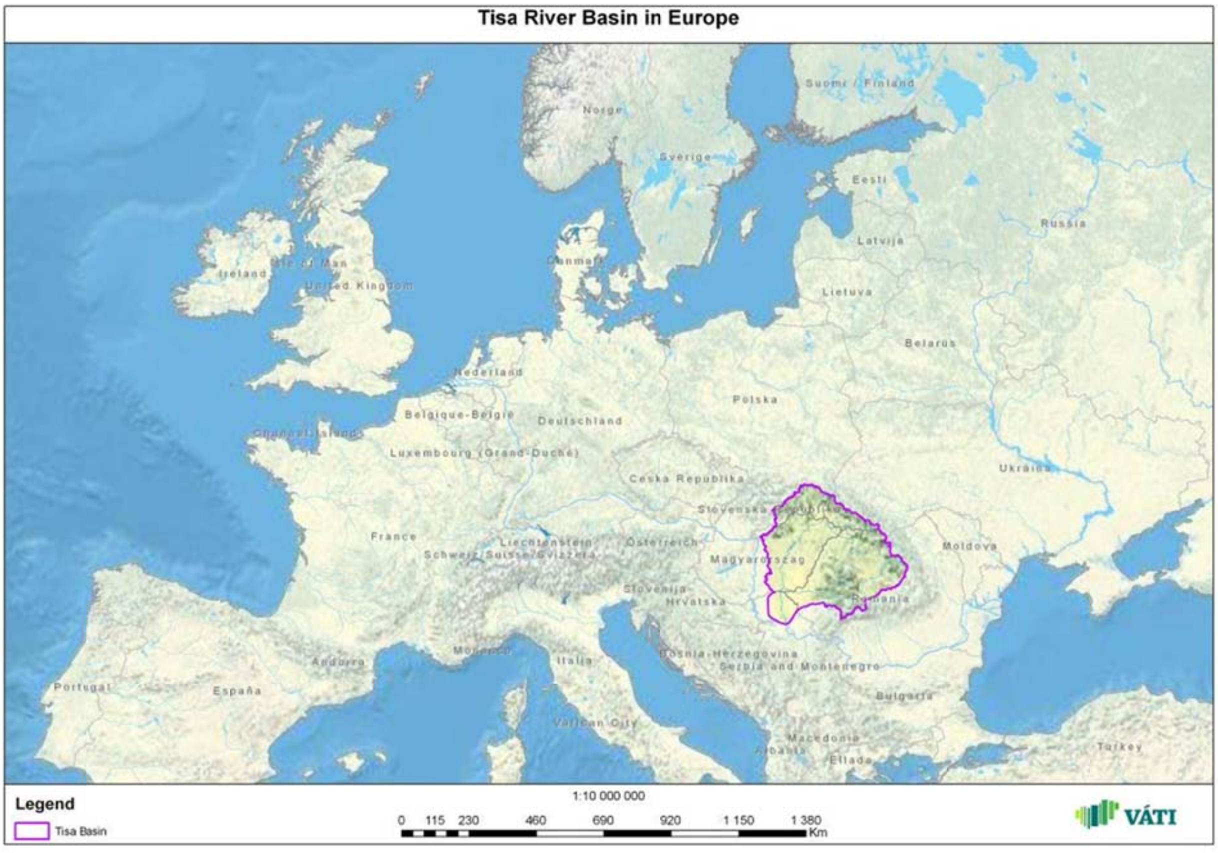
In the water catchment area of River Tisza exposedness to droughts, inland waters and floods are already a serious threat. Droughts trouble agriculture the most, but they have an unfavourable impact on the habitats valuable from the point of view of environmental protection as well. In addition to the damages caused in agriculture, inland waters also jeopardize the settlements. It is not rare that inland waters and droughts hits the same territory in that and the same year. Exposedness to floods is characteristic for the entire region. For the hilly parts short floods of big intensity are characteristic, while on the plains floods that last longer. The frequent heat-waves pose human health at threat, something that is especially true for children and the elderly.

In the European comparison the Water Catchment Area of River Tisza belongs to the areas that are of the most backward and underdeveloped from the economic point of view, something that makes adaptation to extreme weather conditions even more difficult.

1.1. Geographical location of the Tisza river basin

The Tisza River Basin is the largest sub-basin in the Danube River Basin, covering 157 186 km² (19.5% of the Danube Basin), it is home to approximately 14 million people.

Figure 1: Geographical location of the Tisza River Basin



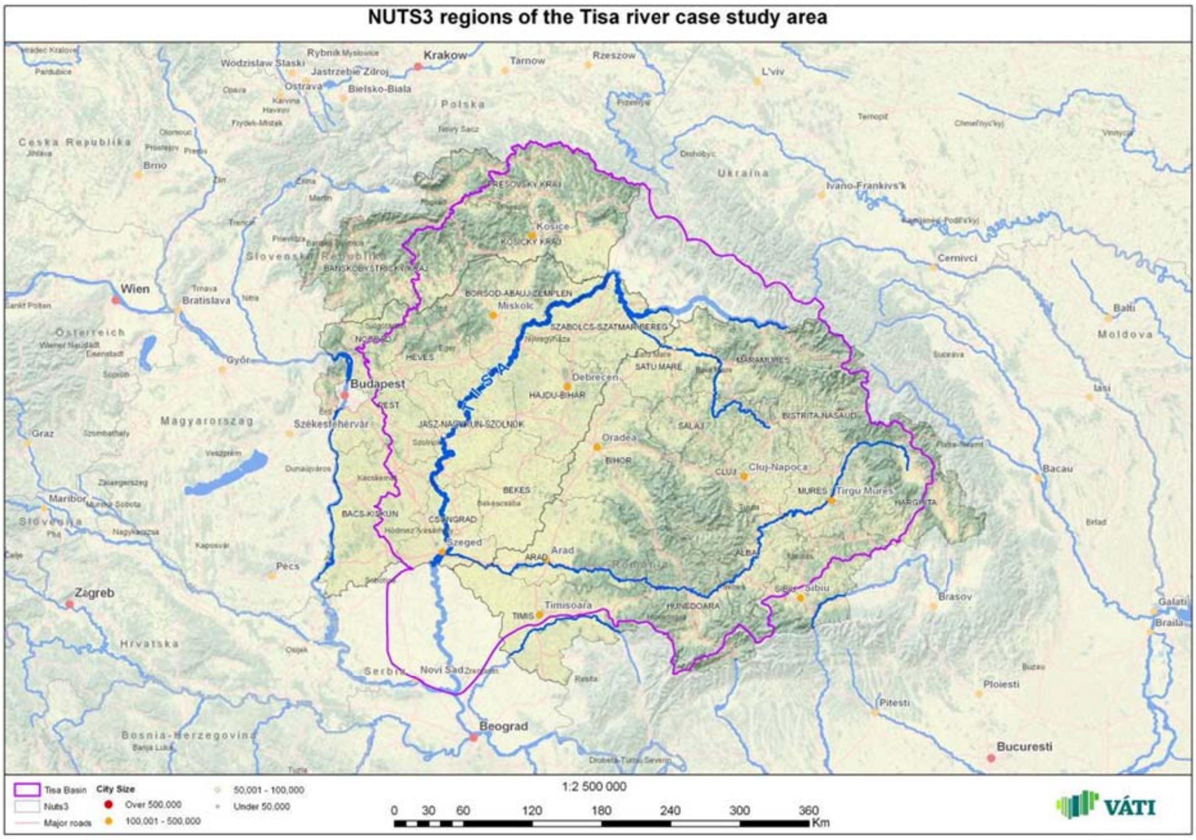
The Tisza River Basin can be divided into two main parts:

- the mountainous Upper Tisza and the tributaries in Ukraine, Romania and the eastern part of Slovakia and
- the lowland parts mainly in Hungary and Serbia surrounded by the East-Slovak Plain, the Transcarpathian lowland (Ukraine), and the plains on the western fringes of Romania. (ICPDR, 2007)

1.2. Delimitation of the case study area

The institutions of three countries (Hungary, Romania, Slovakia) elaborate in cooperation the Case Study on the Tisza River of the ESPON Climate Change Project. The smallest area units of the analysis will be NUTS 3 regions. The catchment area of river Tisza extends to 10 NUTS regions in Hungary, 13 in Romania and 3 in Slovakia. Therefore the Tisza River case study area comprises 28 NUTS 3 regions in Hungary, Romania and Slovakia respectively.

Figure 2: Tisza river case study area



NUTS 3 regions (counties) in Hungary: Bács-Kiskun, Békés, Borsod-Abaúj-Zemplén, Csongrád, Hajdú-Bihar, Heves, Jász-Nagykun-Szolnok, Nógrád, Pest and Szabolcs-Szatmár-Bereg.

NUTS3 regions (counties) in Romania: Alba, Arad, Bihor, Bistriţa-Năsăud, Cluj, Harghita, Hunedoara, Maramureş, Mures, Sălaj, Satu-Mare, Sibiu and Timiş.

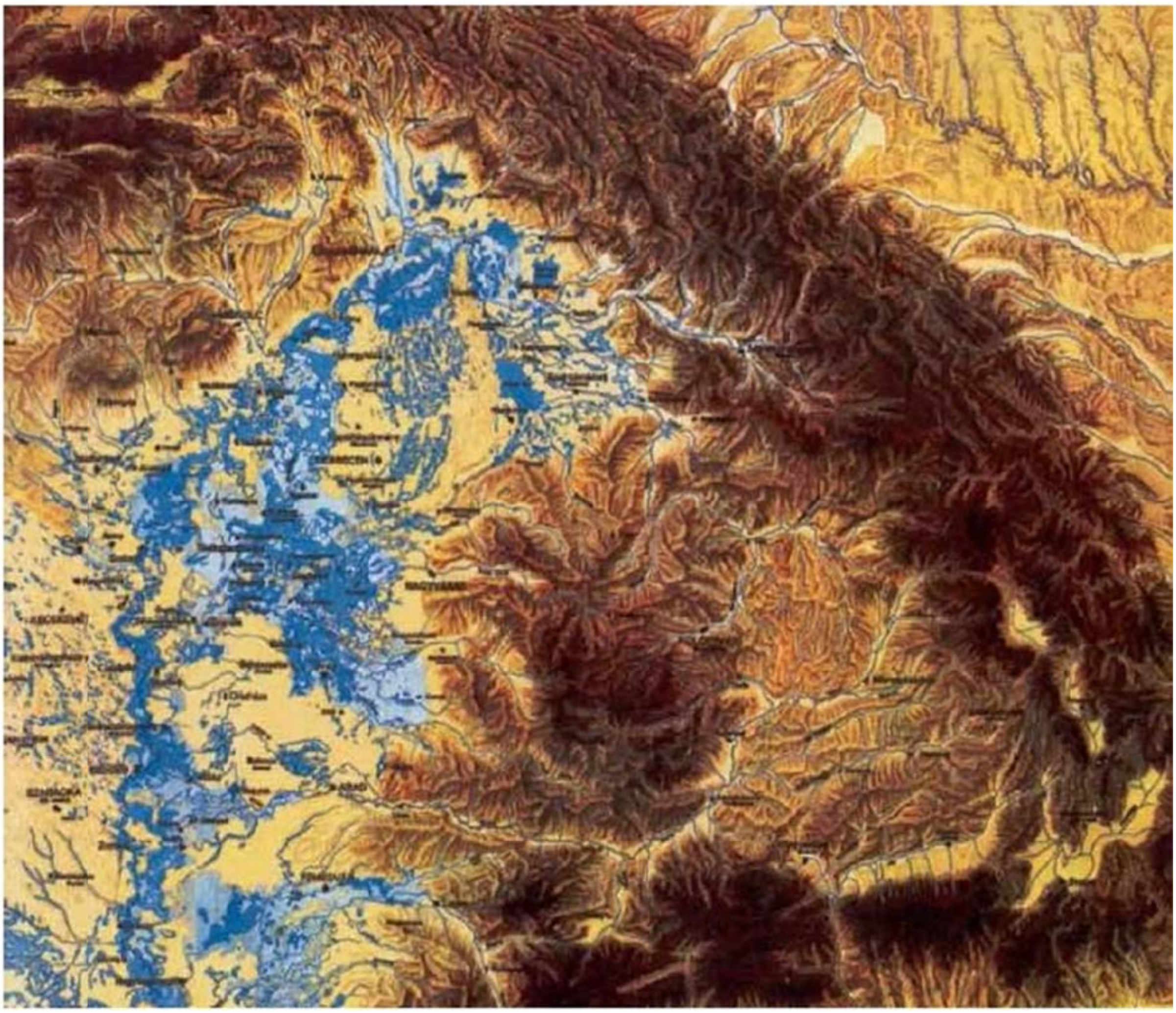
NUTS3 regions (kraj) in the Slovak Republic: Banská Bystrica Region, Košice Region and Prešov Region.

1.3. Brief historical background

Until the eighteenth century land use had conformed to the rhythm of flooding, which meant that water was spread out on the widest possible territory, filled up fish lakes, irrigated meadows and pastures with trees, orchards. In the same time destructive floods was avoided.

During the eighteenth century there was a major decline in forest territory on the hilly areas, bordering the Great Hungarian Plain, while the cultivated areas underwent dynamic growth due to the rise in population and the wheat boom. The growth of the plough land was soon limited more and more by flood danger.

Figure 3: Historical flood map



Source: VITUKI Nonprofit Ltd.

During the second half of the 19th century, extensive measures of river regulation and flood control were undertaken on the river. As a result of these works, the river's total length was shortened by approximately 30% and it is 966 km today. The flood area and its wetland habitat decreased to one tenth of the previous territory. (ICPDR Tisza report, 2007)

1.4. Spatial structure

Settlement pattern

In the catchment area of river Tisza there are two cities only (Cluj and Timisoara) with over 300 thousand population. 26 cities are of the range of 50 000 – 300 000. The municipalities of 10 000 – 50 000 population are for the most part, on the Great Plain of Hungary. The majority of the municipalities of the Tisza river catchment area have less than 10 000 inhabitants. There is a large number of very small communities with less than 1000 population. The majority of these are in the hilly and mountainous areas. (SEE TICAD 2009-2011)

Land use

The geographical differences are determinant for the evolved land-use. In the hilly and mountainous areas the forests, on the plains arable land is the dominant land use. The forest in total cover 4,312 thousand hectares, that is 27 % of the catchment area. On the high mountains coniferous woods, on the mountains of medium height deciduous trees are dominant. The majority of grasslands (pastures and meadows) are also on mountains and hills, and cover large lowland areas too (e.g. Hortobágy in Hungary). The plains are predominantly plough lands. Arable land covers 35 % of the catchment area, the greatest part is in Hungary (the Great Hungarian Plain). (SEE TICAD 2009-2011, ICPDR Tisza report, 2007)

1.5. Relevant economic sectors

Agriculture

During the last 15 – 20 years there has been a marked decline of agriculture in the Tisza catchment area. There was a sharp decrease in agricultural employment and in the share of agriculture in national economic output. Nevertheless, both land cultivation and animal husbandry are still significant economic activities, especially in comparison with the European situation. The plain areas are dominated by arable functions. The main outputs are cereal (autumn wheat, corn, autumn and spring barley, rye) and there has been a growth in oilseed (rape, sunflower) plants. In areas of appropriate soil conditions large estates are dominant with intensive agricultural technologies. The survival of traditional landscape farming is characteristic in areas of poorer soil conditions and in areas where the farming condition vary in a mosaic pattern. (SEE TICAD 2009-2011, ICPDR Tisza report, 2007)

Forestry

The percentage share of forestry in the economic structure has declined, but its importance in the mountainous and hilly parts of the catchment area still prevails. More than half (53 %) of woodland is in the hilly and mountainous areas of Romania. An important challenge of forest management is felling and the decay of forests, involving erosion after logging. (Tisza report, 2007)

Tourism

The region is rich in terms of Tourist assets. The hills and mountains offer excellent conditions for winter sports (skiing, hiking) and for eco-tourism and for the demonstration of natural values. The lowland areas are suitable for soft tourism to the attraction of natural beauties, natural rarities as well as traditional landscape farming activities, whereas the urban areas offer ample possibilities for cultural tourism. The underdevelopment of tourist infrastructure is an obstacle of the utilization of the high tourist potential. (SEE-TICAD, ICPDR Tisza report, 2007)

1.6. Geographic characteristics

Climate

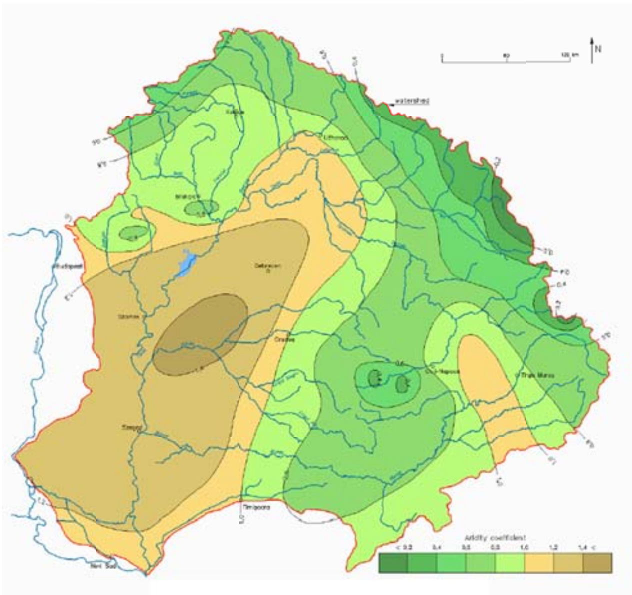
The Tisza River Basin is influenced by the Atlantic, Mediterranean and Continental climates, which impact regional precipitation. About 60% of the Upper Tisza River Basin gets more than 1000 mm of precipitation annually. Warm air masses from the Mediterranean Sea and the Atlantic Ocean cause cyclones with heavy rainfall on the southern and western slopes. In general, two-thirds of the precipitation occurs in the warm half of the year. Furthermore, land surface is subdivided into the Carpathian Mountains (70 % of catchment area) and the wide Tisza Lowlands.

The isotherms of the multi-annual mean air temperature vary from less than 3°C (in the Apuseni Mountains) to more than 11°C (along the middle and lower reach of the Tisza itself). The maximum temperatures are observed in July, the minimum in January (from –1 to –7°C). The annual mean potential evaporation (in RO and HU) is around 700 mm/a and the maximum monthly values (125-145 mm) occur in June and July.

The multi-annual mean values of annual precipitation vary within the Tisza River Basin from 500 to 1600 mm/a. The lowest values (500 mm/a and below) occur in the south-western part of the basin, close to the Tisza River. The highest values (around 1 600 mm/a) occur in the north-western Carpathians and in the Apuseni Mountains. Dry spells (with less than 10 mm/month) are frequent in most areas of the Tisza River Basin in February and March.

The aridity factor (defined as the relation of annual potential evaporation to mean annual precipitation) at the eastern border of the Tisza River Basin (such as in the Carpathian Mountains) is below 0.2 and increases from the northeast to the southwest up to 1.4 in the middle of the Great Hungarian Plain (the mouth of the Körös Rivers).

Figure 4: Aridity factor



Source: ICPDR Tisza Report, 2008

Drought

The Tisza River Basin runoff is highly variable – there are alternate periods of drought and flooding that are difficult to forecast and manage effectively. The droughts of recent years, such as the drought of August 2003, had severe effects in the region, particularly on the Hungarian Plain where agriculture was extremely affected. The lack of water reduces not only agricultural activity, but also the development of industry and urbanisation. Cities and other communities demand more water than the quantity available from rainfall, and it has always been difficult to get enough water for settlements far away from rivers. (ICPDR Tisza report, 2007)

Hydrology

There are two sources of River Tisza - the White and the Black Tisza - in the Northern Carpathian Mountains. The length of the river is measured from the Black Tisza. Before the large-scale river regulatory interventions the length of river Tisza was over 1,400 km. From the medieval times, on the extensive floodplains the land-use structure was adjusted to the functioning of the hydrological system (floodplain landscape management). Later on, during Turkish occupation of the 16-th – 17th centuries this type of management just as all farming activity declined, the floodplain became swampy, the previous sustainable land use declined and was given up at most places. As a result of river regulation in the 19th century, the length of river Tisza decreased by 30 %, and only small parts of the floodplain remained. For the protection of the areas released from regular floods, one of Europe's largest scale flood protection system was constructed.

The length of river Tisza is 964 km now, as a result of regulation. The first 200 km section flows in mountains, the other 760 km section is on plain. Descent in the section in the mountains is considerable: it is 1600 m on the 270 km length between the source and the issue of river Szamos. On the other 700 km long section on the plain descent is no more than 32 m. The average width of the river valley is 3 – 4 km, and this width grows to 10 km at the river delta. The width and depth of the river bed are gradually growing downwards. The river bad is 100 – 200 m wide. The depth of the water – at low ebb – ranges between 1 – 1.5 – 4-5 m, and up to 7-10 m at certain points. (ICPDR Tisza report, 2007)

Floods

Floods in the Tisza River Basin can form at any season as a result of rainstorm, snowmelt or the combination of the two. Snowmelt without rainfall rarely occurs in the Tisza Basin and floods resulting from this account for no more than 10-12% of the total amount. The rise in temperature is almost always accompanied or introduced by some rain. Thus large flood waves are generated more frequently in late winter and early spring.

The warm period from May to October accounts for nearly 65% of total floods, and the cold period from November to April accounts for only 35%. However maximum discharges and the volume of restricted flow of floods in the cold period generally exceed those observed in warm period. The floods generated in Ukraine, Romania and the Slovak Republic are mainly rapid floods and last from 2-20 days. Large floods on the Tisza in Hungary and in Serbia, in contrast, can last for as long as100 days or more (the 1970 flood lasted for 180 days). This is due to the very flat characteristic of the river in this region and multi-peak waves which may catch up on the Middle Tisza causing long flood situations. Also characteristic of the Middle Tisza region is that the Tisza floods often coincide with floods on the tributaries.

Long-observations of level regime and maximum flow provide evidence of the distribution of extremely high severe floods in the Tisza River Basin along the Upper, Middle and Lower Tisza and its tributaries. However, not all high upstream floods cause severe floods along the Middle or Lower Tisza due to attenuation.

Following a relatively dry decade, a succession of abnormal floods has annually set new record water levels on several gauges over the last four years. Over 28 months between November 1998 and March 2001, four extreme floods travelled down the Tisza River. Large areas were simultaneously inundated by runoff and rapid floods of abnormal height on several minor streams. The extreme Tisza flood in April 2006 was preceded by several floods in February and March generated by melting snow and precipitation. (ICPDR Tisza report, 2007)

Flood protection

In the Tisza Valley, organised, systematic flood protection started in the mid 19th century. The backbones of these works are the flood protection dikes along the main river, but also include river training works, bank protections, flood retention reservoirs and polders. Generally, the main dikes are designed for the 'one in hundred year' return period floods. Although this is a general design criterion, there is still a major difference between the approach used in Ukraine, Romania and the Slovak Republic as compared to the method used in Hungary. In upstream countries where reliable discharge intervals are available, the 'Q1%' is used for the design of the structures. On the flat region of the Tisza the rating curves are not single-valued, and the discharge statistics are not reliable and water level statistics are used to provide the 'h1%' design level. This leads to a different degree of protection at border sections, but in the frame of the existing bilateral agreements, this problem is relaxed during negotiations. To provide security against wave actions and to compensate for the uncertainty in the calculation of design flood level and in the dimensioning of dikes, a freeboard of 1 m is generally applied with positive and negative deviances in justified cases. Reservoirs are mainly multi-purpose in mountainous area and are used for water management, fish farming, electricity production, providing ecological flow and some are also used for flood retention. The polders (flood detention basins) on the lowland regions are used for emergency flood detention only. (ICPDR Tisza report, 2007)

Excess water

Another type of inundation in the lowland areas of the Tisza River Basin originate from unfavourable meteorological, hydrological and morphological conditions on saturated or frozen surface layers as a result of sudden melting snow or heavy precipitation, or as a result of groundwater flooding. This undrained runoff or excess water cannot be evacuated from the affected area by gravity and may cause significant damages to agriculture or even to traffic infrastructure and settlements. The appearance of the inundation caused by *excess water* (undrained runoff) is determined together by natural and artificial circumstances. Natural circumstances can be the meteorological conditions (temperature, precipitation), morphological conditions (altitude, geographic structure), soil properties (permeability, physical structure, reservoir ability, type of soil), hydro geological conditions (groundwater level state), geological conditions (soil, rock, impermeable layer). Artificial conditions include drainage networks (the capacity of the network during the excess water's period, its construction, backwater effect), agricultural practice (irrigation, used agricultural technologies, type of cultivated plant) and the increase in urbanised areas. There are more than 50 definitions for this phenomenon in Hungarian alone. The large number of definitions shows that this phenomenon has an effect on several parts of the catchment and several elements of the economy. (ICPDR Tisza report, 2007)

2. Main effects of climate change on case study region

This chapter considers the main effects of climate change on the Tisza river basin and has three main sub-chapters: the first one (2.1) deals with the Hungarian research results related to this theme, the second one (2.2) concentrates on the same subject in Romania and the third one (2.3) focuses on the same effects in Slovakia.

Among the highlighted issues can be found agriculture and horticulture (e.g. land use, irrigation, food supply and security), water management, biodiversity, tourism, infrastructure and disaster recovery and human health.

According to regional and national researches focusing on the Carpathian Basin it can be stated that presumably the warming of the climate, the droughts will be stronger, as well as the seemingly damages, the frequency and intensity of extreme weather events will be increasing. Several examples underpin the phenomena in Hungary that it is not too rare that there is drought, floods, inland inundation and frost damages in the same year, sometimes at the same place as well. Also in Romania the extreme weather events like storms, floods and droughts are expected more often in the future and so the damages coming along with. In Slovakia forests, which are 41% of the whole territory, will be exposed to the growing extreme weather conditions e.g. droughts which will cause increased risk of forest fires or wet periods with significant soil moisture increase which will cause decreased forest stability e.g. wind throw damages in the past. In the TRB agriculture is among the most affected economic sectors because of its addiction to weather condition. Changes in temperature and precipitation patterns will determine modifications in vegetation periods and crossover boundaries between forests and pasture land. Along with flooding periods, extended periods of extreme drought produce serious economic losses in agriculture, but also in transportation, energy providing, water management and households.

2.1. Hungary

As an effect of global climate change, several predictions suggest that weather conditions such as heat, drought and extreme weather patterns will become more frequent; these will last longer, and will be more intensive than ever before. These predictions are confirmed both by the trends observed in Hungary over the last decades, and the environmental phenomena that have taken place in recent years.

In 2003 the Hungarian Ministry for Environment and Water and the Hungarian Academy of Sciences have launched a joint research project of the title of "Global climate changes, Hungarian impacts and responses". It is called "VAHAVA"[1]. This project meant the

[1] The name "VAHAVA" of the above mentioned project is an abbreviation of the first letters of the Hungarian words changes – impacts – responses (VÁltozás – HAtás - VÁlaszadás).

conceptual basics of the Hungarian National Strategy for dealing with climate change. The final report of “VAHAVA” has been published in book format in February 2007. The Hungarian Climate Change Strategy (2008-2025) is focusing on three main areas as mitigation efforts, adaptation possibilities and climate consciousness in the different economic sectors.

The impacts of climate change and possible responses on particularly sensitive area were examined in the publication called “Climate Change in the Hungarian Horticultural Sector” (2006). Furthermore another project, entitled “Environment – Risk – Society” was started as the continuation of the VAHAVA project. The results were published in 2008. The Hungarian Academy of Sciences in the frame of its Strategic Programmes published the “Environmental Foresight – Environment and climate security” in 2010. Its main goal was to summarize the recent knowledge based on the results of different research project related to Hungary and outline three possible socio-economic scenarios.

In relation to the “VAHAVA” Research Programme it is worth mentioning that presumably the warming of the climate, the droughts will be stronger, as well as the seemingly damages, the frequency and intensity of extreme weather events will be increasing in the Carpathian Basin of course in Hungary as well. The climate of Hungary is being affected by impacts arriving from three directions: continental effects arrive from the East, Atlantic from the West and Mediterranean from the South. Owing to these meteorological events various years and seasons are highly variable. It is not too rare that there is drought, floods, inland inundation and frost damages in the same year, sometimes at the same place as well.

The Hungarian settlement structure makes the situation more complicated, in the case of Hungary needs to be underpin the high percentage of small municipalities among the more than 3000 settlements and the problem of boondocks, homesteads in the border of settlements. Nevertheless, in Europe it is unique that the numerous small local governments have so wide range obligatory tasks and responsibility as in Hungary. It can be seen that on one hand the municipalities are overloaded with obligatory tasks and on the other hand they have serious difficulties how to finance their optional development plans. The ratio of rural areas is over the EU average that resulted in higher exposure and vulnerability i.e. from the point of climate than in case of other type of territories. Thus we are mainly focusing on this topic.

Agriculture, horticulture – land use, irrigation, food supply and security

The predicted effects of climate change and the changing weather patterns will affect the agriculture, those whose livelihood depends on it, and their localities in many ways. The activities carried out under the open sky rely on natural resources, which are especially influenced by climatic conditions and weather. The weather patterns influence not only the crop yield and endangering food supplies, but they affect soil quality and growing potential, increase the risks, the costs, the expenditures. Furthermore, they can reduce the groundwater-supply, or indeed, create a surplus, but in any case, they would upset the natural balance of water management. Moreover, this can also affect machinery, and may require the costly modification or upgrade of both farm and residential buildings. Protection against pests and weeds may also be mentioned here. The list of direct, indirect, prolonged or delayed impacts is nearly endless. We will focus a few of these possible impacts and responses.

In 2000, 2003 and 2007 agriculture workers got a sample of the collateral impact of climate change. In 2000 and 2003, frosts followed by floods, inland water and drought that caused problems. In 2007 the warm and early spring was followed by frosts, and a further three heat-waves during the summer, an all-time record in Hungarian history. In 2003, damage was 100% in certain areas, and 2007 saw harvests decrease by 33% for wheat, 32% for sugar beet and 12% for sunflower. The demand-increasing effect of unfavourable weather conditions and the increase of prices is well known.

These were joined by other factors, such as the demand for producing bio fuels, diminishing reserves, depleted warehouses and intervention stock. Inflation expectations were also raised by increased producers' and consumers' prices. The consequences of climate change, the rapidly changing weather patterns do not only affect the quantity of the produce, but they influence the quality as well. This is particularly true to fruits, grapes, and field vegetables.

A sudden increase in pests and infections, and the appearance of formerly unknown types of them further adds to the problems, increasing the costs of integrated defence, not even mentioning the serious questions of sustainability arising from the use of herbicides, fungicides and herbicides.

Taking into consideration that in Hungary, 28 years out of a hundred are dry, arid, and where a sequence of drought-ridden years is frequent, whilst in other year's floods, inland waters and frost damages may also occur, a prospective warming and drying climate raises serious issues concerning domestic food security. In critical years, the price of imported foodstuffs sharply increases.

Field crops play an important role in satisfying the domestic and international demand for food. Thus, it is vitally important to take into consideration the collection and preservation of precipitation, methods of cultivation which take into account droughts as well as abundant rainfall, and the expansion of irrigation. This consideration should extend to technologies, which are adapted to the local properties of the cultivated land and the needs of the crops. New breeds of extreme weather resistant crops, including drought-resistant sorts need to be developed and put into use.

One of the most important natural resources of Hungary is its soil. It is not only the source of raw materials, it is also the largest reservoir of the entire country. Soil quality may be adversely affected by climate change. The prevention of the reduction and degradation of agricultural land is therefore of utmost importance.

Hungarian agricultural and horticultural irrigation has always been dominated by spatially frittered, mosaic-like irrigation technologies, whereas in a historical context it was symbolised by the appearance and subsequent disappearance of various initiatives. The impacts of climate change, the security of food supplies puts the question of irrigation into the spotlight. This could reduce the deviation of crop yields and reduce the associated risks, a solution of which is economical and efficient irrigation. The development of irrigation techniques in a way that takes local topological potentials into account can play a key role in this field. The most important aspect of this method is to focus on areas with a high yield potential, where field crops could be irrigated under various cooperative agreements, through the use of sustainable agricultural systems.

The sensitivity, vulnerability, tolerance and regenerating capacity of agro-ecological areas and zones of Hungary is extremely varied, something to consciously consider in the process of climate change.

Water management

The most serious issue in the field of Hungarian water management is the fact that the significant proportion of Hungary's territory is endangered by floods. Furthermore the one third of the Hungarian lowlands is moderately or heavily endangered by inland water. The Hungarian part of the Tisza river flood prone area is poor in surface water, however the ratio of thermal water is high. 96% of surface water is coming from abroad that can influence both water quantity and quality. The water management tasks are complex.

According to the Hungarian researches it can be stated that the most vulnerable elements of water management is firstly the small-scale reduction of the available water resources. The radical reduction will be peculiar expectedly after 2030 that can endanger the secure satisfying of water demand. It can result conflicts especially in the middle and south part of the Hungarian Great Plain. Important goal is the protection of subsurface drinking water resources, thermal, medicinal and mineral water resources.

Biodiversity

A related UN document (SEG, 2007) indicated Hungary, taking the effect of climate change on biodiversity into consideration, as one of the most vulnerable country in Europe.

More Hungarian researches are focusing on this topic. It is quite difficult to quantify the results of the related researches considering the possible impacts of climate change.

In 2007 a research report was published by the Institute of Ecology and Botany of the Hungarian Academy of Sciences. There were examinations by species and habitats in connection with climate change and biodiversity. The research methods are diverse in case of different species or habitats, thus hardly difficult to compare or summarize the results. However general statements cannot be stated regarding to the effects of climate change in Hungary.

Most significant problems are the large scale spread of invasive species caused by the improvement of survival capability due to increasing percentage of summer droughts and warmer winters.

The damages and degradation of habitats, the isolation of remainder territories especially increase the vulnerability of these areas.

Tourism

Most of the significant tourism types in Hungary are usually related to natural areas or environmental services e.g. water, thermal water etc. The possible impacts of climate change on the natural environment are crucial especially in case of ecotourism.

Tourism is one of the expected take of points – just as building industry and agriculture – in the Hungarian economy. The tourism sector contributions to the national GDP is beyond the average of agriculture, building, financial and real estate sectors. Most regions deal with tourism as a key factor to their economic growth which is influenced by security questions less by terrorism and more both in positive or negative direction by the possible effects of climate change. It is necessary to highlight the importance of climate independent tourism types in Hungary.

It can be stated that the tourism sector is not given due attention both in the VAHAVA project and the Hungarian Climate Change Strategy. Research is in progress related to climate change and tourism in Hungary. The results will be useful to the first review of the Hungarian Climate Change Strategy implemented in 2010.

Infrastructure and disaster recovery

According to the Environmental Foresight 2010 it can be seen that the most vulnerable elements of these sectors include insufficient human resources and the lack of modern technical equipments, optimal resource allocation, prevention and planning, moreover the problematic financial background.

In case this filed cannot increase its capacity to be able to react for the possible effects of climate change, the level of human health related risks can be higher. The consequences of extreme weather events and anomalies can cause dramatically more damages and costs.

With fires ever more frequent, arid fields, pastures, reeds, ditches and hedges, with the devastating fires of the stubble-fields, the size of the damage done in the agrarian sector, to the unharvested crops, the hay and straw, the stables, in animal farms, and even some localities becomes clearly apparent. When it comes to emergencies, several questions arise in areas, where the distance prevents the access of emergency services within 10 minutes, where the water supplies are scarce, or where the equipment leaves a lot to be desired. This is why careful prevention is so vital, that fires are noticed before they come raging, that the available fire engines are suitable for the terrain, that small electronic robotic aeroplanes are available for reconnaissance, that computer software are available to predict the potential spread of a fire, that an accurate and up-to-date inventory is kept about the fire-fighting explosives and equipment, that local voluntary fire services are formed, educated and funded, that schemes are devised for the rescue and relocation of people and livestock.

Human health

The most important problems regarding human health that result from sudden and unusual atmospheric changes are the following: increased mortality rate, embolism, stroke, metabolic disorders, suicides and traffic accidents. The increased frequency of heat waves causes heat stress and psychopathological symptoms to become more common. Increased air pollution increases the incidence of respiratory diseases. As a side effect of climate change, the blooming period of allergens gets longer, new, invasive allergens appear. Flood like heavy rainfalls endanger vulnerable drinking water reservoirs, resulting in an elevated risk of waterborne diseases.

2.2. Romania

Considering the particularities of hydrographical system in Romania and the networking with other European hydro graphic systems, Romania’s authorities has evolved a wide range of strategies, documentation and regulation in order to make a correct policy and to implement actions, taking into consideration international and European agreements and policies regarding climate changes and its projected effects.

It is necessary to mention here The National Strategy for Climate Changes (2005-2007), which is the main strategic document defining our country policies to get international obligations appointed as they are stated within the United Nations Framework Convention on Climate Changes and Kyoto Protocol and also whom establish our national priorities respective to climate changes.

Along with the Strategy was evolved The National Action Plan regarding Climate Change in order to establish real measure of implementation. Those measures aim to cover a midterm time because in a permanently changing economic, social and mostly environmental context this is the most convenient programming period. Other strategies needed to be mentioned concerning climate changes and its effects are:

- The National Strategy to Prevent and Combat the Effects of Drought, Land Damage and Desertification;

- National Strategy regarding Flooding Risk Management;

It has also been evolved a Guide for Adaptation to the Climate Change. The purpose of this guide is the identification of the necessary measures according to the existing economic resources in order to limit the negative effects forecasted by the climate scenarios, estimate for a medium and long term (decades).The measures shall be implemented through cooperation with local authorities and by providing an appropriate technical assistance.

Agriculture, horticulture – land use, irrigation, food supply and security

Extreme meteorological events like storms, floods and droughts are expected more often in the future and so the damages coming along with. Agriculture is among the most affected economic sectors because of its addiction to wheatear condition. Changes in temperature and precipitation patterns will determine modifications in vegetation periods and crossover boundaries between forests and pasture land.

The last years have brought in Romania years of extreme drought (2000 and 2007) and also years well provided with floods (2005). Also, the winter 2006-2007 was considered the warmest winter since there are observational measurements in Romania when, high deviations of the maximum/minimum temperature comparatively to the multiannual average conditions lasted during long periods of time. Along with flooding periods, extended periods of extreme drought produce serious economic lost in agriculture, but also in transportation, energy providing, water management and household.

Drought affects in our country 3.97 million ha of which 2. 87 million ha is arable land located in the main agricultural areas, mostly in south and southeast. Rising of frequency and length of drought periods results not only in diminished favourable areas and location changing but also have an impact over the entire agricultural system and involved technologies, over animal and plants genotypes, assuring life being and environmental protection. In order to minimize negative effects of extreme climatic phenomena (long term alternation of drought and humidity excess periods on the same lands) and prevent land degradation through landslides and soil erosion in Tisza RB, land improvement works - especially drainages (1,230,914 ha) and irrigations on smaller areas (88.583 ha) were executed.

Irrigation works covered a reduced surface (4.3% of the arable surface of the area), by lots: over 1000 ha (43.857 ha), less than 1000 ha (15.331 ha) or local (31.395 ha).

According to data provided by ISPIF Bucharest, most of the works executed on lots over 1000 ha are situated in the counties of Arad (23.059 ha), Timis (7,216 ha) and Cluj (5.955 ha).

The irrigated agricultural surface in Tisza RB is small compared to other areas in Romania. There are areas with water deficit needed for crops and areas with irrigable agricultural potential lacking endowments. Irrigated areas decrease also as a consequence of high costs for maintaining and extending the existing systems.

Problems referring to land improvement works indicate an unsatisfactory state of endowments requiring rehabilitation and modernization, impossibility of economic efficiency of endowed areas, reduced usage of irrigation systems, decreasing interest to extend such works.

Regardless of Tisza River Basin situation, the complex effects of the climate changes on the agriculture substantiate the necessity of the decision making process on the decrease of the risks in order to maintain the appropriate crops standards and to enhance the sustainable agriculture. Thus, the variability and the climate changes have to be approached through the daily agricultural activities, by means of the attenuation strategies and of the adaptation measures.

Water management

Respective of identifying problems and implementing solution concerning water resources, the Ministry has evolved The National Strategy and Policy on Water Management (2008-2015) in accordance with European Parliament and Council Directive 60/2000/EC regarding the creation of a common action framework in water management.

This Strategy aims to:

- Stimulate goods and services production in water management (water demand from households, industry, agriculture, transportation, leisure and others) by maintaining, in the same time, a balance between natural and entropic environment and contributing to rising life quality;

- Prevention and mitigation of floods and droughts effects;

- Adapting to European Union policies for evolving a sustainable water management and aquatic environmental protection.

The main instrument of implementation of the Strategy is The Framework Planning Schemes for Water Management in Hydrographycal Basines. Those includes working and planning proposals in water management in order to obtain susteainable, holistic, balanced and complex water use taking into account important demands of socio-economic development and environmental policies.

Assessment of water resources in Tisza River Basin

In the Tisza River Basin, water resources of the inland rivers have been estimated to 490.8 m^3 /s, which mean a multi-annual average volume of 15.489 million m^3. Knowing the area of the analyzed territory (71.100 km^2), the specific average discharge could be calculated, resulting a value (6.9 1/s.km^2) which exceeds the country's average value (4.6 1/s.km^2).

Water resources of the rivers included in the Romanian part of the Tisza basin represent over one third (38.2 %) out of the ones calculated at the level of the inland rivers. Over one third of these resources are formed in the Mures-Aranca system. The Somes-Crasna (25.3 %), the Cris Rivers with Barcau (19.1 %), the upper Tisza (16.2 %) and Bega (1.3 %) hydrographic systems follow.

Underground water resources have been estimated to 2.149 million m^3, representing 18.4 % out of those calculated at the level of the whole country. The underground waters represent only12.2 % out of the total resources assessed at the level of the Tisza basin. Important resources of underground water are formed in the Cris rivers-Barcau (38.7 % out of total) and Mures-Aranca (36.1 %) hydro graphic systems. The Somes-Crasna hydro graphic system also brings an important contribution to the total quantity of underground water resources (16.9 %). The upper Tisza and Bega systems bring modest contributions (6.1 % and 2.1 %).

Total water resources resulted from summing up the surface and underground waters have been estimated to 17.638 million m^3/year. This value represents 33.7 % out of the total resources calculated at the level of Romania.

The repartition of total water resources on hydrographic systems emphasizes the same territorial contrasts mentioned when analyzing the other categories of water resources. The Mures-Aranca hydrographic system is situated on the first place (37.8 %). It is followed by the Somes-Crasna (24.3 %) and the Cris rivers-Barcau (21.5 %) hydrographic systems. The upper Tisza system holds 14.9 % out of the total water resources, although it stretches over a restricted surface in the Tisza basin (6.4 %). The Bega hydrographic system, with the same basin area as the upper Tisza, contributes with only 1.5 % to the formation of the total water resources.

The risk induced by floods

Floods represent the most widely spread hazard in Tisza River Basin, with numerous losses of human lives and high-proportion material damages.

Floods in TBR take place mostly during the spring high waters and during the high floods of pluvial, plovio-nival, nivo-pluvial and seldom nival origin. An analysis of the years in which high waters occurred (for the interval between 1900 and 2005) indicates that the years characteristic for the maximum flow were the following: 1912, 1932, 1933, 1970, 1972, 1975, 1981, 1995, 1997, 1998, 2000.

The rapid and violent floods cause losses of human lives and important material damages because the water level increases in a very short period of time. They have been recorded in small hydrographic basins. Floods have a high frequency in spring (30-50 %) and a low one in autumn (10-20 %) and winter (15-30%).

On the rivers from the Tisza basin, the natural floods have the maximum frequency. They are caused by the heavy precipitations and by the sudden snowmelt and sometimes by their co-occurrence.

In order to prevent and reduce the impacts induced by floods, a series of structural measures have been taken (damming the main rivers in the plain and hill regions, creating permanent and temporary reservoirs, regularisations of the watercourses etc.).

Non-structural measures refer mainly to: applying a suitable management for the flooded areas (zoning); creating an operational and efficient action plan in case of flooding; exact forecasting and warning in case of flooding, as well as the evacuation of persons from the flood-prone regions; assessing the resistance of buildings in the areas of high risk of flooding; offering help to the affected areas and starting their rehabilitation as soon as possible etc.

All these measures (structural and non-structural) lead, in the case of their application, only to the reduction of the damages produced by floods, but they cannot prevent them totally.

Biodiversity

There is a link between climate change and biodiversity that has been long time established. It is well known that in Earth's history climate changes existed and they have shaped species and ecosystems the way we find them today. However last century climate changes registered such rapidly evolution that nature can no longer adapt to and with seriously bad consequences over biodiversity.

Romania is characterized by a high biological diversity, regarding both the actual number of species, and the number of individuals at each species level, as well as having a notable number of ecosystems and species. However, in the present conditions, mostly as an impact of climate changes, too many plants and animals are endangered and the landscape modifications are the first sign of environmental deterioration. Romania has, among the 27 member states of the EU, the highest biogeographical diversity (with 5 bio geographical regions out of the 11 at European level) and most of these areas are in a good conservation status.

Almost 47% of Romania's national territory is cover with natural and semi-natural ecosystems. There have been identify 783 types of habitats (13 coast habitats, 143 habitats specific for wet areas, 196 habitats specific for pasture and hayfields, 206 forest habitats, 90 habitats specific for dunes and rocky areas and 135 habitats specific for agricultural land) in 261 areas analyzed in the entire country.

The habitats are characterized by a certain composition of flora and fauna, components of the bio-coenosis and are influenced by various clime and soil factors. The clime influences of the drought areas in the Eastern part, up to the oceanic influences in the Western areas, as well as the clime differences between the lowland and mountains due to the relief altitude have determined the appearance of an important number of habitats. The chemical composition of sub layer rocks (soil and under-soil) is another factor that determines the important variety of habitats in Romania. Among the 198 types of European habitat, out of which 65 are priority habitats, 94 types of habitats can be found in Romania, from the above mentioned 23 are priority habitats at EU level and require the designation of Special Areas of Conservation (SAC).

Infrastructure and disaster recovery

Romania policy regarding disaster recovery gathers a National Emergency Management System. The system is evolved, organized and function in order to prevent and handle emergency situations, to assure and coordinate human, material, financial and other resources needed to restore a normal state of facts.

The organizational structure of the mentioned Management System includes the following players:

- A Committee for Emergency Situations;
- A General Inspectorate for Emergency Situations;
- Professional Communitarian Public Services for Emergency Situation;
- Strategic Centres for Emergency Situations;
- Acting Commander.

Along with a good organizational structure, rigorous prevention measures are imperative to be taken knowing that poor planning and other factors may create conditions of vulnerability that result in insufficient capacity or measures to reduce hazards' potentially negative consequences.

Human health

The health status of millions of people is projected to be affected in the Tisza River Basin due to climate changes effects. Some of this expected effects could affect food supply and for so increase malnutrition, increased deaths, diseases; may create injury of humans due to extreme weather events; increase diarrheal diseases; increased frequency of cardio-respiratory situations due to higher concentrations of ground-level ozone in urban areas related to climate change; and the altered spatial distribution of some infectious diseases.

The health sector should embed disaster risk reduction planning and promote the goal of hospitals safe from disaster by ensuring that all new hospitals are built with a level of resilience that strengthens their capacity to remain functional in disaster situations and implement mitigation measures to reinforce existing health facilities, particularly those providing primary health care.

2.3. Slovak Republic

The predicted climate change will have serious consequences for Slovakia in the long term but some effects, such as an increasing frequency of extreme weather events is a reality nowadays. During the last decade the extreme situations have grown. Heavy rains, flash floods, which have suddenly occurred, caused not economical loses on human settlements and infrastructure only, but had taken human lives too. According to the Euro barometer survey 41% of Slovaks think that climate change is the most serious problem the world is currently facing, and 66% of respondents believe that it is very serious and 76% do not believe that it has been exaggerated.

Agriculture, horticulture – land use, irrigation, food supply and security

Changing agro-climatic conditions will have an effect on changing varieties of cereals species. Some of them will find an optimal spreading in longer growing seasons (e.g. maize, soybeans, sunflower etc.) and some will be less favourable to the changed conditions. Expansion and invasion of several agricultural weeds and new animals will be a danger for actually grown agricultural plants.

As regards to the land use, in the Rural Development Programme of the Slovak Republic for the period of 2007 – 2013 several measures have been adopted as:

- afforestation of the low productive soils (1 400 ha)
- grassing of 50 000 ha or arable land by 2015
- afforestation of 23 000 ha by 2020
- elimination of forest fires up to 90% compared the period of 2000 – 2003.

Forests (41% of the whole territory of Slovakia) will be exposed to the growing extreme weather conditions e.g. droughts which will cause increased risk of forest fires or wet periods with significant soil moisture increase which will cause decreased forest stability (e.g. wind throw damages in the past). The forest health is getting worse because of the predominance of the spruce tree in the forest ecosystems and its prone to the bark beetle expansion.

Water management

According the state water management policy of the Slovak republic that expected climate change will have a significant impact on total runoff as well as on its distribution within the year. The number of episodes of heavy rain to the total rainfall will increase and this will have implication for flash floods, development of erosion processes, slope slides etc. Between 1996 and 2002, Slovakia has suffered from 80 major damaging floods, including the catastrophic flash floods. The majority of them have caused victims, the dislocation of hundreds of people and enormous economic losses. Flood disasters in Slovakia are expected to exacerbate this trend and will increase by 19% till 2100 (Aaheim et al. 2008; AEA, 2007).

Contrary to this dry periods are, likely to become more common in summer. Certain adaptation measures have been adopted in the Integrated water management plan (according the EU Water Framework Directive and in the new Flood protection act).

Biodiversity

Because of diverse biotic, abiotic phenomena of lowlands, highlands in Slovakia and the changed ecosystems over the centuries by human population it is hardly explicitly to say the impact of the climate change on biodiversity. But it could be assumed that the predicted climate change - the increase of the air temperature will influence spreading of species of fauna and flora when several native of them will move towards north and several new one will appear.

Tourism

The tourism sector will benefit from the predicted climate change in general. In the lowlands will grow importance of utilization of water resources for sports and recreation, including spa resorts. Not significant negative impact is expected in the mountain areas on active outdoor sports as climbing, cycling, hiking.

Infrastructure and disaster recovery

The transport infrastructure will be endangered by extreme weather conditions such air temperature raising, extreme or long lasting rains and following circumstances as fogs etc. Continuing construction of the highways should be adjusted to the changing climate conditions in summer (draining rain water from the motorways surface into the reservoirs, etc.) and in winter also (snow cover, icing etc.). The infrastructure shall be prepared for increased danger from growing flood situations.

Human health

In Slovakia as in the other Central European countries, climate change will in a short term improve the quality of life over the next 15 years, but from the longer perspective the impact of climate change will have a negative impact (European Commission, 2009). Changing climate conditions are associated with health problems related to the rising heat or cold (rising extremities in air temperature). Extreme rainfalls poses a danger for citizens in the areas where they might be affected by floods. There is an evidence of indirect effects on spreading of some new diseases as malaria, extension of Lime borreliosis and tick-borne encephalitis.

3. Validation of the exposure indicators of pan-European analysis from a regional aspect

Summary

In order to assess the uncertainty of climate change vulnerability in the Tisza river case study area it is essential to verify the exposure indicators. All the seven exposure indicators provided by PIK have qualitatively been compared by the relevant results from regional climate change researches.

1. Change in annual mean temperature. According to our comparisons the annual mean temperature change is less representative than the seasonal changes. It may be important in case of flood-related and heat wave related vulnerability assessments. The quasi homogeneous spatial structure of warming does not allow the proper classification into five classes.

2. Change in annual mean number of frost days. The decrease in number of frost day is a characteristic indicator of regional climate change in Tisza region which is in good coincidence with the results derived from the literature.

3. Change in annual mean number of summer days. The plain spatial pattern in this exposure indicator will bring difficulties in classification into five classes. The situation is similar than is case of annual mean temperature changes.

4. Relative change in annual mean precipitation in winter months. This is a characteristic indicator of regional climate change in Tisza region which is in medium coincidence with the results derived from the literature.

5. Change in annual mean number of days with heavy rainfall. It shows an insignificant changes (less than 1 day) in the Tisza region, therefore this indicator will not contribute to the vulnerability in the case study area.

6. Relative change in annual mean evaporation. This indicator shows a minor (probably insignificant) changes in the Tisza region, therefore this indicator will not significantly contribute to the vulnerability in the case study area.

7. Change in annual mean number of days with snow cover. This is a characteristic indicator of regional climate change in Tisza region which is in medium coincidence with the results derived from the literature.

3.1. Evaluation of exposure indicators

In order to assess the uncertainty of climate change vulnerability in the Tisza river case study area it is essential to verify the exposure indicators. The main objectives of the evaluation of exposure indicators are two-folds:

- "description": brief analysis of the regional characteristics (i.e. spatial structure) of the expected changes derived from exposure indicators literature (labelled by ESPON run)

- "benchmark": qualitative inter comparison of the exposure indicators and related regional climate change research based on relevant literature (labelled by REFERENCE run)

- "conclusions": comments and recommendations on applicability and relevance of the exposure indicators in Tisza river case study

Exposure indicators for the Tisza river case study are provided by PIK and based on latest outputs of the COSMO-CLM model (or CCLM). The model runs have been conducted in conjunction with the global coupled atmosphere ocean model ECHAM5/MPI-OM and based on scenario A1B. , The change indicators always relate the reference time frame (1961-1990) to the climate conditions within the projected periods as calculated by the CCLM model (e.g. 2071-2100).

3.1.1. Change in annual mean temperature

Based on the CCLM parameter 'air temperature in 2 metres above surface average annual temperatures in degrees Celsius for the selected time frames have been calculated. This indicator serves to indicate regional variation of changes in temperature, as the main indicator for climate change.

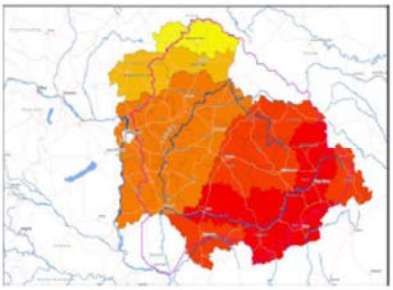
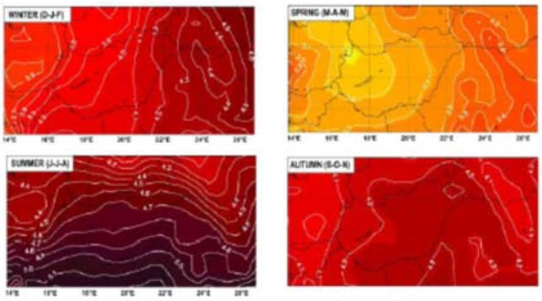
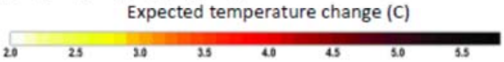
Description of model and experimental design for Reference Run

In order to analyze the expected trends of the extreme climate indices for the Carpathian basin, simulated daily mean, maximum, and minimum temperature, and precipitation amounts are obtained from the regional climate model (RCM) outputs of the Danish

Meteorological Institute (DMI) in the frame of the completed EU-project PRUDENCE (Prediction of Regional scenarios and Uncertainties for Defining EuropeaN Climate change risks and Effects). Results of the project PRUDENCE (Christensen, 2005) are disseminated widely via Internet (http://prudence.dmi. dk/). The primary objective of PRUDENCE was to provide high resolution (50 km × 50 km) climate change scenarios for Europe for 2071-2100 (Christensen and Christensen, 2007) using dynamical downscaling methods with RCMs (using the reference period 1961-1990). Extreme index analysis of the RCM simulation outputs are discussed in Frei et al. (2006) for four regions of Europe, i.e., the Alpine region, Central Europe (which is mainly Germany only), southern Scandinavia, and the Iberian peninsula. DMI used the HIRHAM4 RCM (Christensen et al., 1996) with 50 km horizontal resolution (the RCM has been developed jointly by DMI and the Max-Planck Institute in Hamburg), for which the boundary conditions were provided by the HadAM3H/HadCM3 (Rowell, 2005) global climate model of the UK Met Office. The simulations were accomplished for present day conditions using the reference period 1961-1990 (the model performance of HIRHAM4 is analyzed by Jacob et al., 2007) and for the future conditions in 2071-2100 using scenario A2 and B2 scenarios (Nakicenovic and Swart, 2000). The CO2 concentration under the A2 scenario is projected to reach about 850 ppm by the end of the 21st century (IPCC, 2007), which is about triple of the pre-industrial concentration level (280 ppm). The CO2 concentration under the B2 scenario is projected to exceed 600 ppm (IPCC, 2007), which is somewhat larger than a double concentration level relative to the pre-industrial CO2 conditions. B2 scenario can be considered optimistic among the global emission scenarios while A2 is one of the most pessimistic ones (Nakicenovic and Swart, 2000).

Evaluation of exposure indicator

The projected changes in annual mean temperatures indicate increasing temperatures between 3.4 and 3.7 C for the Tisza Case Study area (see Figure below).

Exposure indicators in Tisza Region: **Annual mean temperature**	
ESPON run *Scenario:* ***A1B****, Period:* ***2071-2100****,* *Model:* ***CCLM***	**REFERENCE run** *Scenario*: ***A1B****, Period:* ***2071-2100*** *Model:* ***PRUDENCE***
 Expected temperature change (C) 3,38 - 3,44 3,45 - 3,50 3,51 - 3,56 3,57 - 3,62 3,63 - 3,69	 Expected temperature change (C) 
Source: Lautenschlager, M.; Keuler, K.; Wunram, C.; Keup-Thiel, E.; Schubert, M.; Will, A.; Rockel, B.; Boehm, U. (2009): Climate Simulation with CLM, Climate of the 20th Century (run no.1 and 2) and Scenarios A1B and B1 (run no.1, 2 and 3),Data Stream 3: European region MPI-M/MaD. World Data Center for Climate – processed by VÁTI	**Source:** Bartholy, J., Pongrácz R., Gelybó Gy. and Szabó P., 2008. Analysis of expected climate change in the Carpathian Basin using the PRUDENCE results. IDŐJÁRÁS Vol. 112, No. 3–4, pp. 249–264

The spatial structure is almost homogeneous, although a slight north-west to south-east gradient is shown in warming. (The South-East regions, such as Hunedoara, Alba and Arad NUTS3 regions in Romania may be attributed by the "highest" expected changes.

The reference run shows similar magnitude of change (3.5 C) in the case study area with a quasi-homogeneous spatial structure. Nevertheless, there are significant differences among the magnitude and spatial structure of seasonal temperature changes.

Main qualitative conclusions

1) It seems that the annual mean temperature change is less representative than the seasonal changes. It may be important in case of flood-related and heat wave related vulnerability assessments, too.

2) The quasi homogeneous spatial structure of warming does not allow the proper classification into five classes. The scores will significantly "magnifies" the spatial differences and lead an unexplainable distortion in estimation of vulnerability.

3.1.2. Change in annual mean number of frost days

Based on the CCLM parameter ‘frost days’ (FD, yearly) average annual number of frost days (days with minimum temperatures below 0°C) for the selected time frames have been calculated. This indicator serves to indicate changes in regional climate extremes with respect to cold temperature.

Description of model and experimental design for Reference Run

In the framework of CLAVIER EU project (Climate ChAnge and Variability: Impact on Central and Eastern EuRope, http://www.claviereu. org) project three regional climate models, namely REMO from the Max Planck Institute for Meteorology (MPIM) in Hamburg, used in Version 5.7 by MPIM (REMOMPI) and REMO5.0 used by the Hungarian Meteorological Service in Budapest (REMOHMS), and the LMDZ model developed at CNRS in Paris were considered in order to provide a small ensemble of regional simulations for the area of interest. All three models have comparable horizontal grid resolution (~30km for LMDZ, ~25km for both REMO versions) and cover a common area over Central and Eastern Europe (mainly the territories of Bulgaria, Hungary, and Romania). All simulations are available for the period 1951 to 2050 using the emission scenario SRES A1B. For each simulation, the climate change signal for the different extreme indices has been derived by subtracting the values for the climate reference period from 1961 to 1990 from those of the target period from 2021 to 2050. The large scale forcings for the regional simulations are provided by the global fields of the ECHAM5/MPI-OM coupled atmosphere-ocean general circulation model.

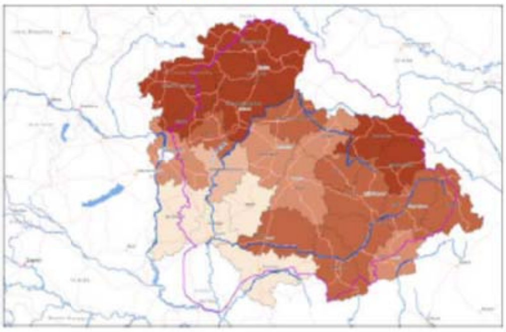
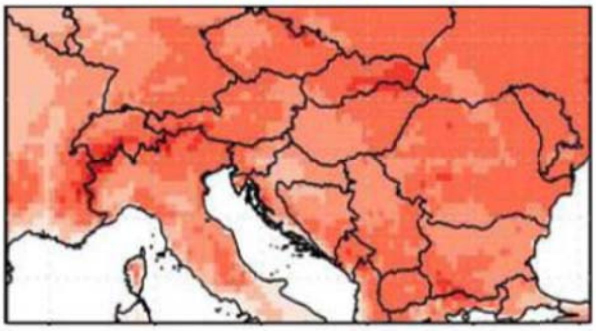
The model domain applied at the Hungarian Meteorological Service covers large part of the continental Europe: it certainly includes the entire Central and Eastern European region of interest with sufficiently large extension towards west (the main direction of flow). Furthermore, care was taken to ensure that the lateral boundaries of the domain are in relatively far distance from the high mountain ranges (especially from the Alps and the Carpathian Mountains). The horizontal resolution of the integration domain is approximately 25 km (exactly 0.22 degree), which allows 2 minutes integration time step. The global fields were coupled to the limited area with 6-hour temporal frequency.

Evaluation of exposure indicator

The decrease in number of frost days indicates a characteristic spatial structure (see figure below). The indicator varies from 41-55 days, the south regions (Bács-Kiskun, Csongrád and Békés in Hungary) exhibit comparatively slight decrease while the mountainous regions (i.e. Banskobystricky kraj, Presovsky kraj in Slovakia) are projected to experience more severe decrease in the number of frost days with regional peaks of 52 days and more.

The reference run refers to simulations for the period of 2021-2050 therefore the magnitude of changes are not comparable. Nevertheless, the spatial structure (higher values in mountaineous area) in reference run shows similar picture than ESPON run.

Main qualitative conclusions
1) The decrease in number of frost day is a characteristic indicator of regional climate change in Tisza region which is in good coincidence with the Reference Run.

Exposure indicators in Tisza Region: **Annual mean number of frost days**	
ESPON run *Scenario:* ***A1B****, Period:* ***2071-2100****,* *Model:* ***CCLM***	**REFERENCE run** *Scenario:* ***A1B****, Period:* ***2021-2050****,* *Model:* ***CLAVIER - REMO 5.0***
	
decrease in number of frost days 40-43 43-46 46-49 49-52 52-55	decrease in number of frost days 
Source: Lautenschlager, M.; Keuler, K.; Wunram, C.; Keup-Thiel, E.; Schubert, M.; Will, A.; Rockel, B.; Boehm, U. (2009): Climate Simulation with CLM, Climate of the 20th Century (run no.1 and 2) and Scenarios A1B and B1 (run no.1, 2 and 3),Data Stream 3: European region MPI-M/MaD. World Data Center for Climate – processed by VÁTI	**Source:** 1. Szépszó, G., A. Horányi, 2008, Transient simulation of the REMO regional climate model and its evaluation over Hungary, Quarterly Journal of the Hungarian Meteorological Service., 112, 3-4, 203-231. 2. CLAVIER (Climate Change and Variability: Impact on Central and Eastern Europe), Results of WP3b: Extremes. http://www.clavier-eu.org/?q=node/876

3.1.3. Change in annual mean number of summer days

Based on the CCLM parameter 'summer days' (SU, yearly) average annual number of summer days (days with maximum temperatures above 25°C) for the selected time frames have been calculated. This indicator serves to indicate changes in regional climate extremes with respect to summer temperatures.

Description of model and experimental design for Reference Run

Same as described in 3.1.2.

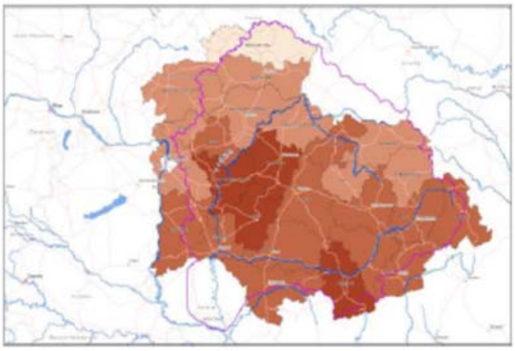
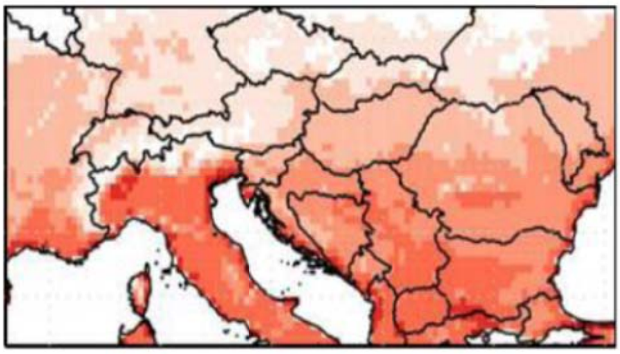
Evaluation of exposure indicator

The increase in number of summer days varies between 28-36 days, with a relatively plain spatial pattern. It seems that low land areas of the region (Hajdú-Bihar, Jász-Nagykun-Szolnok, Békés in Hungary and Bihor and Hargitha in Romania) shows highest increases, while, in case of mountains, slightest increases are predicted. Nevertheless, the spatial differences are insignificant.

The reference run refers to simulations for the period of 2021-2050 therefore the magnitude of changes are not comparable. Nevertheless, the spatial structure differs from the ESPON model run; it shows a definite north-south pattern.

Main qualitative conclusions

1) **It seems that the plain spatial patter in change of annual mean number of summer days will bring difficulties in classification into five classes. The situation is similar than is case of annual mean temperature changes.**

Exposure indicators in Tisza Region: **annual mean number of summer days**	
CCLM model run *Scenario: A1B, Period: 2071-2100*	**Validation model run** *Scenario:* ***A1B****, Period:* ***2021-2050****,* *Model:* ***REMO5.0***
	
Increase in number of days 28-29 29-32 32-34 34-36 36-37	Increase in number of days 
Source: Lautenschlager, M.; Keuler, K.; Wunram, C.; Keup-Thiel, E.; Schubert, M.; Will, A.; Rockel, B.; Boehm, U. (2009): Climate Simulation with CLM, Climate of the 20th Century (run no.1 and 2) and Scenarios A1B and B1 (run no.1, 2 and 3),Data Stream 3: European region MPI-M/MaD. World Data Center for Climate – processed by VÁTI	**Source:** 1. Szépszó, G., A. Horányi, 2008, Transient simulation of the REMO regional climate model and its evaluation over Hungary, Quarterly Journal of the Hungarian Meteorological Service., 112, 3-4, 203-231. 2. CLAVIER (Climate Change and Variability: Impact on Central and Eastern Europe), Results of WP3b: Extremes. http://www.clavier-eu.org/?q=node/876

3.1.4. Relative change in annual mean precipitation in winter months

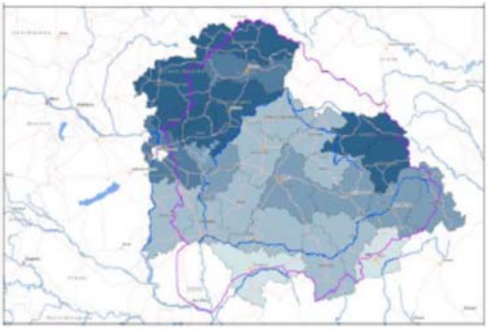
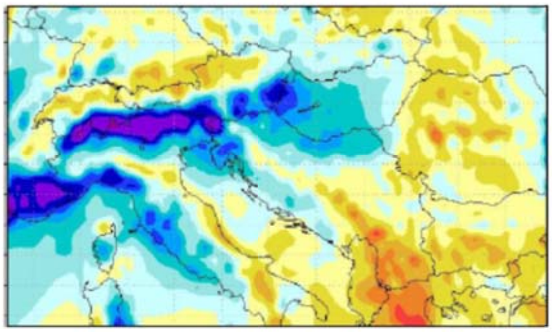
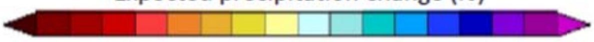
Based on the CCLM parameter 'total precipitation' (PRECIP_TOT, monthly) average precipitation in kg/sqm for the selected time frames has been summed up for the meteorological winter months (December, January and February). This indicator accounts for changes in winter precipitation. Seasonal averages have been calculated to account for the strong intranannual variation of this variable.

Description of model and experimental design for Reference Run

The installation and adaptation of the RCM PRECIS at the Department of Meteorology, Eotvos Lorand University (Budapest, Hungary) was started in 2004. At the beginning of our studies, version 1.3 was used, but the results presented in this paper are from an updated model version (1.4.8). PRECIS is a high-resolution limited-area model with both atmospheric and land surface modules. The model was developed at the Hadley Climate Centre of the UK Met Office (Wilson et al., 2005), and it can be used over any part of the globe (e.g., Hudson and Jones, 2002; Rupa Kumar et al., 2006; Taylor et al., 2007; Akhtar et al., 2008). The PRECIS regional climate model is based on the atmospheric component of HadCM3 (Gordon et al., 2000) with substantial modifications to the model physics (Jones et al., 2004). The atmospheric component of PRECIS is a hydrostatic version of the full primitive equations, and it applies a regular latitude-longitude grid in the horizontal and a hybrid vertical coordinate. The horizontal resolution can be set to 0.44° × 0.44° or 0.22° × 0.22°, which gives a resolution of ~50 km or ~25 km, respectively, at the equator of the rotated grid (Jones et al., 2004). In our studies, we used the finer horizontal resolution for modelling the Central European climate. Hence, the target region contains 123 × 96 grid points, with special emphasis on the Carpathian Basin and its Mediterranean vicinity containing 105 × 49 grid points (Figure 3). There are 19 vertical levels in the model, the lowest at ~50 m and the highest at 0.5 hPa (Cullen, 1993) with terrain-following σ-coordinates (σ = pressure/surface pressure) used for the bottom four levels, pressure coordinates for the top three levels and a combination in between (Simmons and Burridge, 1981). The model equations are solved in spherical polar coordinates and the latitude-longitude grid is rotated so that the equator lies inside the region of interest in order to obtain a quasi uniform grid box area throughout the region. An Arakawa B grid (Arakawa and Lamb, 1977) is used for horizontal discre Tiszation to improve the accuracy of the split-explicit finite difference scheme.

Evaluation of exposure indicator

The changes in precipitation in winter months indicates a characteristic spatial structure (see figure below). The indicator varies from 6-20%, the winter precipitation is projected to increase in mountainous regions (i.e. Banská Bystrica Region, Prešov Region in Slovakia, Borsod-Abaúj-Zemplén in Hungary and Bistriţa-Năsăud, Maramureş in Romania) in ESPON run. The reference run shows similar magnitude of change in lowland areas (0-10% increase) but 10-20% decrease are predicted in mountain and sub-mountain areas in Transylvania.

Exposure indicators in Tisza Region: **Relative change in annual mean precipitation in winter months**	
ESPON run *Scenario:* ***A1B****, Period:* ***2071-2100****,* *Model:* ***CCLM***	**REFERENCE run** *Scenario*: ***A1B****, Period:* ***2071-2100*** *Model:* ***PRECIS***
	
Expected precipitation change (%) 6,55 - 9,30 9,31 - 12,04 12,05 - 14,78 14,79 - 17,53 17,54 - 20,27	Expected precipitation change (%)  -150 -100 -70 -50 -40 -30 -20 -10 0 +10 +20 +30 +40 +50 +70 +100 +150
Source: Lautenschlager, M.; Keuler, K.; Wunram, C.; Keup-Thiel, E.; Schubert, M.; Will, A.; Rockel, B.; Boehm, U. (2009): Climate Simulation with CLM, Climate of the 20th Century (run no.1 and 2) and Scenarios A1B and B1 (run no.1, 2 and 3),Data Stream 3: European region MPI-M/MaD. World Data Center for Climate – processed by VÁTI	**Source:** Bartholy, J., Pongracz, R., Torma, Cs. and Pieczka, I., 2009. Analysis of regional climate change modelling experiments for the Carpathian Basin. Int. J. Global Warming, Vol. 1, Nos. 1/2/3

Main qualitative conclusions

1) The relative change in annual mean precipitation in winter months is a characteristic indicator of regional climate change in Tisza region which is in medium coincidence with the Reference Run.

3.1.5. Relative change in annual mean precipitation in summer months

Based on the CCLM parameter ‘total precipitation’ (PRECIP_TOT, monthly) average precipitation in kg/sqm for the selected time frames has been summed up for the meteorological summer months (June, July and August). This indicator represents regional exposure to changes in summer precipitation. Seasonal averages have been calculated to account for the strong intran annual variation of this variable.

Description of model and experimental design for Reference Run

Same as described in 3.1.4.

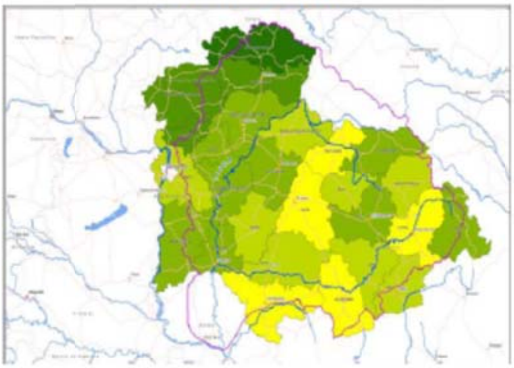
Evaluation of exposure indicator

The decrease in summer precipitation varies from 25-42% and shows a characteristic pattern in ESPON run with a north-west to south-east gradient (see figure below). It is also perceptible that a stronger decrease is predicted in the mountain and sub-mountain areas.

The reference run shows a little bit lower spatial average in the Tisza region (10-30% decrease) than the ESPON run. However, the reference run indicates a very different spatial pattern with a definite west-east gradient, where the eastern regions represent the lower changes.

Exposure indicators in Tisza Region:
Relative change in annual mean precipitation in summer months

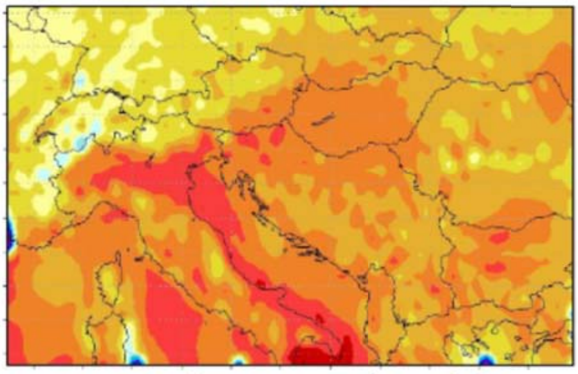
ESPON run
Scenario: ***A1B****, Period:* ***2071-2100****,*
Model: ***CCLM***



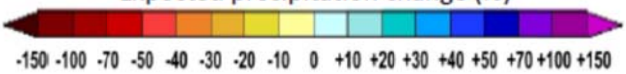
Expected precipitation change (%)
-42,34 - -38,88 | -38,87 - -35,41 | -35,40 - -31,95 | -31,94 - -28,48 | -28,47 - -25,01

Source:
Lautenschlager, M.; Keuler, K.; Wunram, C.; Keup-Thiel, E.; Schubert, M.; Will, A.; Rockel, B.; Boehm, U. (2009): Climate Simulation with CLM, Climate of the 20th Century (run no.1 and 2) and Scenarios A1B and B1 (run no.1, 2 and 3),Data Stream 3: European region MPI-M/MaD. World Data Center for Climate – processed by VÁTI

REFERENCE run
Scenario: ***A1B****, Period:* ***2071-2100***
Model: ***PRECIS***



Expected precipitation change (%)



Source:
Bartholy, J., Pongracz, R., Torma, Cs. and Pieczka, I., 2009. Analysis of regional climate change modelling experiments for the Carpathian Basin. Int. J. Global Warming, Vol. 1, Nos. 1/2/3

Main qualitative conclusions

1) The relative change in annual mean precipitation in summer months is a characteristic indicator of regional climate change in Tisza region which is in low coincidence with the Reference Run.

3.1.6. Change in annual mean number of days with heavy rainfall

Based on the CCLM parameter 'rainfall' (RAIN_TOT, yearly) average annual number of days with heavy rainfall (above 20kg/sqm) for the selected time frames has been calculated. This indicator will illustrate regional exposure to changes in heavy rainfall events and thus indicate hydrologic extremes. This variable has strong relevance for local heavy rainfall event, especially when occurring over highly sealed surface area

Description of model and experimental design for Reference Run

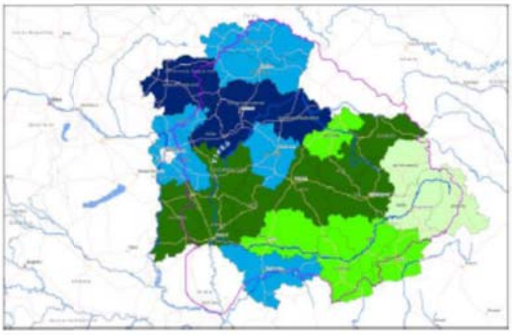
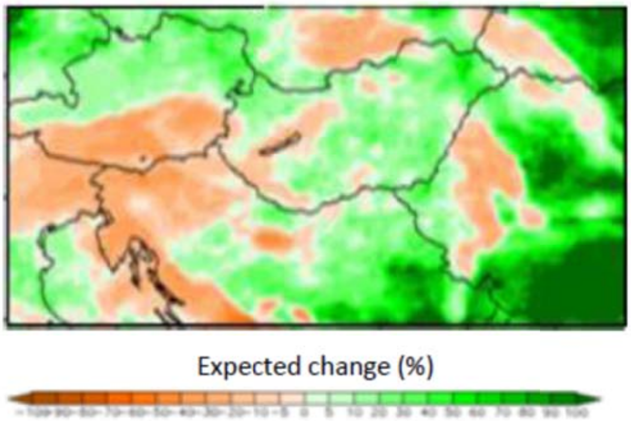
The RegCM model (version 3.1) is currently available from the Abdus Salam International Centre for Theoretical Physics (ICTP). The dynamical core of RegCM3 is fundamentally equivalent to the hydrostatic version of the NCAR/Pennsylvania State University meso scale model MM5. Surface processes are represented in the model using the Biosphere-Atmosphere Transfer Scheme (BATS). The nonlocal vertical diffusion scheme is used to calculate the boundary layer physics. In addition, the physical parameterisation is mostly based on the comprehensive radiative transfer package of the NCAR Community Climate Model, CCM3. The selected model domain covers Central/Eastern Europe centering at 47.5° N, 18.5° E and contains 120 × 100 grid points with 10 km grid spacing. The target region is the Carpathian Basin with the 45.15° N, 13.35° E south western corner and 49.75° N, 23.55° E north eastern corner. The model RegCM may use initial and lateral boundary conditions from a global analysis data set, the output of a GCM or the output of a previous RegCM simulation. In reference experiments these driving data sets are compiled from the Centre for Medium-range Weather Forecasts (ECMWF) ERA-40 reanalysis database using a 1° horizontal resolution, and in the case of scenario runs (for time slices: 1961–1990, 2021–2050) the ECHAM5 GCM using a 1.25° spatial resolution. Several vertical levels (14, 18 and 23) may be used in the RegCM experiments.

Evaluation of exposure indicator

The projected changes in number of days with heavy rainfall is less than 1 day (!) in the Tisza Case Study area (see Figure below). This insignificant value shows a non-characteristic, almost homogeneous pattern. The Reference run shows a significantly higher changes (5-20% increases, which mean 2-8 days). It should also be noted that the Reference run refers to 2021-2050 period, therefore the expected values should be even higher for the ESPON time period of 2071-2100.

Main qualitative conclusions

1) **It seems that change in annual mean number of days with heavy rainfall shows an insignificant changes (less than 1 day) in the Tisza region, therefore this indicator will not contribute to the vulnerability in the case study area.**

Exposure indicators in Tisza Region: **Change in annual mean number of days with heavy rainfall**	
ESPON run *Scenario:* ***A1B****, Period:* ***2071-2100****,* *Model:* ***CCLM***	**REFERENCE run** *Scenario:* ***A1B****, Period:* ***2021-2050*** *Model:* ***RegCM***
	
Increase in number of days 0,01 - 0,22 · 0,23 - 0,43 · 0,44 - 0,65 · 0,66 - 0,86 · 0,87 - 1,07	Expected change (%)
Source: Lautenschlager, M.; Keuler, K.; Wunram, C.; Keup-Thiel, E.; Schubert, M.; Will, A.; Rockel, B.; Boehm, U. (2009): Climate Simulation with CLM, Climate of the 20th Century (run no.1 and 2) and Scenarios A1B and B1 (run no.1, 2 and 3),Data Stream 3: European region MPI-M/MaD. World Data Center for Climate – processed by VÁTI	Source: Bartholy, J., Pongrácz, R. and Torma, Cs., 2010. Regional climate change projected for the Carpathian Basin in 2021-2050 based on RegCM simulations. KLÍMA-21, 2010/60, pp 3-13

3.1.7. Relative change in annual mean evaporation

Based on the CCLM parameter ‘surface evaporation’ (AEVAP_S, yearly) the average annual amount of water evaporating in a distinct area has been calculated. This indicator represents the changes in evaporation, and is from a territorial perspective thus of relevance especially for the natural systems, combining information on temperature and hydrologic conditions.

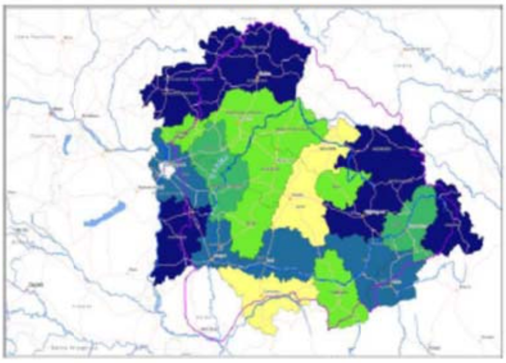
Description of model and experimental design for Reference Run

No source of information in the relevant literature.

Evaluation of exposure indicator

The patterns in the Tisza region on change in annual mean evaporation range from decrease of 4 % to increases up to 1 % (see Figure below). Although the magnitude of changes are less significant, it seems that the evaporation is expected to slightly decrease in lowland regions and increase in mountain areas.

Main qualitative conclusions
1) It seems that change in annual mean evaporation shows a minor (probably insignificant) changes in the Tisza region, therefore this indicator will not significantly contribute to the vulnerability in the case study area.

Exposure indicators in Tisza Region: **Relative change in annual mean evaporation**	
ESPON run *Scenario:* ***A1B****, Period:* ***2071-2100****,* *Model:* ***CCLM***  Relative change (%) -4,40 - -2,48 -2,47 - -1,00 -0,99 - 0,00 0,01 - 1,00 1,01 - 5,21 **Source:** Lautenschlager, M.; Keuler, K.; Wunram, C.; Keup-Thiel, E.; Schubert, M.; Will, A.; Rockel, B.; Boehm, U. (2009): Climate Simulation with CLM, Climate of the 20th Century (run no.1 and 2) and Scenarios A1B and B1 (run no.1, 2 and 3),Data Stream 3: European region MPI-M/MaD. World Data Center for Climate – processed by VÁTI	**REFERENCE run** *Scenario: , Period:* *Model:* *no source of information in the relevant literature*

3.1.8. Change in annual mean number of days with snow cover

Based on the CCLM parameter ‘snow cover’ (SNOW_COV) the average annual number of days with snow covering the surface of the reference area has been calculated. This indicator serves to indicate the change in the number of days with snow cover and indicates changes in the snow condition, from a territorial perspective for example for the winter tourism sector.

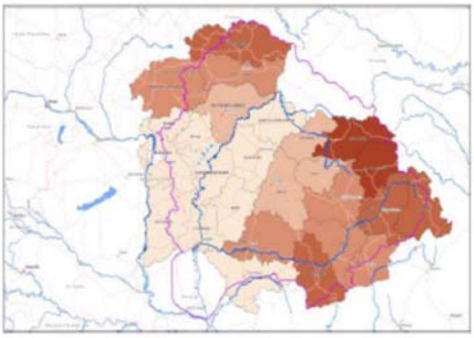
Description of model and experimental design for Reference Run

No source of information in the relevant literature.

Evaluation of exposure indicator

The decrease in number of days with snow cover indicates a characteristic spatial structure (see figure below). The indicator varies from 3-42 days, snow cover is projected to decrease most significantly in the mountain regions (…). The regions in the Great Plain in Hungary will mostly experience decreases of up to 10 days.

Main qualitative conclusions
1) The decrease in annual mean number of days with snow cover a characteristic indicator of regional climate change in Tisza region.

Exposure indicators in Tisza Region: **Change in annual mean number of days with snow cover**	
ESPON run *Scenario:* ***A1B****, Period:* ***2071-2100****,* *Model:* ***CCLM***	**REFERENCE run** *Scenario: , Period:* *Model:*
 Relative change (%) 3-11 11-19 19-27 27-35 35-42 **Source:** Lautenschlager, M.; Keuler, K.; Wunram, C.; Keup-Thiel, E.; Schubert, M.; Will, A.; Rockel, B.; Boehm, U. (2009): Climate Simulation with CLM, Climate of the 20th Century (run no.1 and 2) and Scenarios A1B and B1 (run no.1, 2 and 3),Data Stream 3: European region MPI-M/MaD. World Data Center for Climate – processed by VÁTI	*no source of information in the relevant literature*

3.1.9. Conclusions

	change in annual mean	decrease in number of frost days	increase number of summer days	increase in winter precipitation	summer precipitation	change in days with heavy rainfall	relative change in evaporation	decrease in snow cover days
MAX	3.69	55	36	20.3	42.3	1.01	-5.2	42
MIN	3.38	41	28	6.6	25	0.01	+4.4	3
AVER.	3.57	49	34	13.6	35.4	0.55	-0.3	18
VAR.	0.076	3.9	1.6	3.9	3.8	0.28	2.1	11.9
Representatively	poor	□	□	□	□	□	poor	poor
Problem with classification	!	□	!	□	□	!	!	□
magnitude of change	□	□	□	□	□	≈ 0	≈ 0	□
coincidence with ref. run	□	□	NA	med	poor	NA	poor	NA

4. Climate change impacts on river floods based on national and regional level literatures

While climate variability and climate change sensitivity of flood hazard is evident, the actual flood risk and even the frequency of inundation of a given flood basin are influenced by a number of additional factors causing cumulative impact. This is true in case of investigating tendencies in the past and present and should not be forgotten in climate projections.

Changes in flood hazard

No comprehensive hydrology and flood directed climate change studies are available for the Tisza River Basin. Although sporadic investigations targeted parts of the catchments (Bálint and Gauzer, 1999; Nováky, 1999) the first river basin wide simulations produced results only recently Radvánszky and. Jacob: (2008, 2009) and with complex analyses tools within the CLAVIER (2009) project. Outcome of some Europe wide investigations can also be used for the Tisza River Basin (Dankers et al 2006, 2007; PESETA 2009).

Detailed studies within the CLAVIER project applied the VITUKI NHFS modelling system (Bartha and Gauzer 2001) and the Vidra-Consul Model (Serban et al 2003) to route meteorological input (the (ECHAM5 driven – REMO50 scenario) to produce discharge series at selected gauging stations. Both tools are semi distributed: NHFS model calculates 0.1 degree grid-wise water balance followed by sub-basin wise runoff concentration and channel routing performed for defined river reaches. Vidra-Consul spatial structure is based on small runoff producing sub basins linked by routing modules.

Hydrological impact and water management implications of climate projections in the Tisza Basin concluded that the changes in simulated river discharge under the investigated climate scenarios show a general pattern of change in the discharge regime towards higher runoff in winter and early spring, and lower runoff in summer. This pattern can be seen at all stations and can be explained by less precipitation in summer, more precipitation in winter and spring, and higher temperatures resulting in an earlier snowmelt. Regimes with significant snowmelt component, like the upper Tisza, also show a shift and reduction in the runoff peak in late spring.

Based on the hydrological simulations, the analysis of the mean seasonal and annual discharges simulated time series show the following impact of the A1B climate change scenario (ECHAM5 driven – REMO50):

- Slight increase in Upper Tisza and tributaries (less than 5%));
- No change or general decrease of the mean annual discharges, down to 15 % for Central Tisza and southern basins;
- The mean seasonal discharges are increasing only in winter season, in all the basins but with significant variations (3 ÷ 42 %);

For the spring – autumn period, the hydrological simulations indicate a decrease of the mean discharges for most of the catchments in southern basins between -15 ÷ -20%.

In order to estimate the A1B climate change scenario impact on the hydrological regime the variations of the mean monthly simulated discharges for some selected 30 years periods (1961 – 1990 as reference period and 2001 – 2030, 2011 – 2040, 2021 – 2050 as representative periods for the future) were also analyzed.

The results in most cases indicate slight decrease of annual mean flow throughout the region with significant spatial variability and even some increase for the high elevation zones in the Upper Tisza sub-catchments. The decrease of spring runoff is compensated by the flow resulting from thaw during late winter. An important conclusion of the CLAVIER project was related to the indication of significant variability between different sub basins: increasing trends in the upper Tisza and decrease over the catchments of southern tributaries.

Annual maxima (AM) and peak over threshold series (POT) of hourly and 12-hour discharges resulting from the stream flow simulations have been investigated. No clear picture can be drawn about possible changes in flood conditions. While more frequent winter floods are expected, the decrease of mean flow in some seasons is not followed by the decrease of flood peaks. Fitting of GEV distribution of annual maxima and GPD for POT values for the upper Tisza indicated a rise of the frequency smaller and larger events and a decrease around the median. In one option for Vásárosnamény station extreme discharge levels are higher than int he reference period. Torrential type of flood events may occur even more frequently, while the frequency of floods with long duration and large volume may become lower. Int he central and lower Tisza an increase in discharge level at short return periods is observed, while at most of the stations the control and scenario runs are very close to each other.

Only general regime changes were investigated by Radvánszky and. Jacob: (2008, 2009) for the end of the end of the 21st century, 2071-2100 and similar ECHAM5 driven results received, however the decrease of annual flow occured more intensive.

Similar to the CLAVIER flood analyses approach was followed in the PESETA (2009) project, where estimates of changes in the frequency and severity of river floods are based on simulations with the LISFLOOD model followed by extreme value analysis (Dankers and Feyen, 2008). The LISFLOOD model, which transfers the climate forcing data (temperature, precipitation, radiation, wind-speed, humidity) into river runoff estimates, is a spatially distributed, mixed conceptual-physically based hydrological model developed for flood forecasting and impact assessment studies at the European scale (van der Knijff *et al.*, 2008). Using a planar approximation approach, the simulated discharges with return periods of 2, 5, 10, 20, 50, 100, 250 and 500 years have been converted into flood inundation extents and depths.

The continent wide maps published can be interpreted for the Tisza Basin. River floods: relative change in 100-year return level of river discharge between scenario (2071-2100) and control period (1961-1990) for the 3.9ºC (A2) and 2.5ºC (B2) scenarios indicate small changes and from moderate to significant rise consequently. The regional patterns in flood damage changes in Europe reflect largely those observed in the changes in flood hazard. Moderate rise in Slovak and Romanian parts of the Tisza Basin and mostly in Hungary however significant rise along the upper and central Tisza.

Possibilities for flood vulnerability analyses for the Tisza River Basin

The hydrological regime of the river network is characterised by the sequence of wet spills and low flow periods rivers. Lowland floodplains within the Tisza Basin are protected by a system flood embankments. The existence of these dikes and flood walls prevents the immediate danger of riverine inundation or direct flooding for the lowland part of the catchment by the most frequent flood waves. Over 90% of the nearly 20 000 km^2 area of floodplains (Hungary) is protected where only truncated flood frequency can be considered. The indirect type of flooding linked to the overtopping and failure of the flood protection works remains and even is enhanced by observed rising tendencies of flood crests during the last decades (*Szlávik 2002)*. Flooding is linked rather to the frequency of dike failures than that of the flood peaks. Hilly and mountainous parts of the catchments, smaller streams and creecks are mostly characterised by open floodplains with towns, villages and other land uses under the danger of direct flooding.

Complex integrated investigation of climate change and other impacts is absent for the Tisza catchment as in most extended regions in the world (*IPCC 2007*). Consequently any projection is conditioned on a set of assumptions and boundary conditions and can be evaluated only as a cautious guess.

Even the remaining flood hazard associated with flood waves substantially exceeding the capacity of protection works can hardly be defined owing to methodological difficulties. Failure of the protecting works is possible only in case of flood events with return periods close or longer than 100-year. Projections analysing the expected changes in 1% floods have only limited value, because those still mostly remain the system of flood embankments. Possible failures depend on the height of the dike crests, which is seldom the problem, and mostly on structural strength. Existing transient simulations are usually targeted to define 'climatic' characteristics linked to 30-year periods allowing flood frequency analyses in the range of return periods between 2 to 150 years. Thousand-year floods are already beyond the range of liability and related flood risk cannot be assessed either.

Defence capacity of flood protection structures largely depends on pro-active flood defence measures during flood situations. Unattended dykes often fail while proper emergency measures can constrain even floods with peaks exceeding dike crests. The operation of flood detention reservoirs or polders is also very sensitive.

Adaptation measures

Maintenance and strengthening of flood embankments remains essential along major and medium size of streams where the a number of factors influence the increase of flood hazard beside climate change impact. The possibility to construct new reservoirs to cut floodpeaks is mostly present only in Slovak and Romanian parts of the catchment. Increasing the height of dike crests has its own limits and "space for the rivers" type of approaches should be preferred, narrow flood berms are to be widened, bottle necks to be removed. Generally the conductance of the unprotected floodplain should be preserved and increased. Application of flood detention basins or polders situated on the protected floodplain can be very efficient in case of extreme flood events. The New Vásárhelyi Plan in Hungary with its 2.0 km^3 storage capacity in 14 polders can be an example. The risk associated with flash floods and longer duration torrential floods on smaller streams can be reduced by flood reduction and storm reservoirs. Introduction of proper land use patterns can help to mitigate the situation in very small catchments with rising flood risk.

Flood zoning, limitation of land use and construction on flood plains development of information, early warning, merging of meteorological and hydrologic forecasts, now casting together with efficient emergency services may contribute to the above adding such non-structural measures.

Summary, conclusions

Owing to the specific conditions of lowland parts in the Tisza Basin, flood events causing damage are always related to the overtopping and/or failure of dykes in the region where over 95% of the natural floodplain is protected from inundation by the existing system of flood embankments. Floods having probability equal or higher than 1% in most cases remain between dykes. Climate change induced modification of flood hazard and flood risk are related to the changing frequency of floods endangering protection structures and/or exceeding their crest, however there are several other strong factors influencing flooding. Subsidence certain river reaches, silting up of the flood berm (unprotected floodplain between embankments), formation of bottlenecks by land use changes, expansion of built in area, spreading of dense forest, bushes especially related to invasive elements of the flora all lead to the rise of flood levels. Strengthening existing embankments, construction and operation of flood detention reservoirs ("polders"), intensive defence activity during floods all decrease flood risk. The extent and of inundation and associated damage is mitigated by properly implemented confinement plans limiting the propagation of water spills within the flood basins.

5. Vulnerability assessment

Extreme weather phenomena are already a serious problem in the region. The recurrent and all more frequent droughts and regular inland waters jeopardize the profitability of agriculture, while from the point of view of the built-up environment and the safety of the population exposedness to floods pose the greatest problem. According to the forecasts, the frequency of extreme weather events in the context of droughts and excess waters shall increase as a result of the climate change. There is, on the other hand, a very big uncertainty as regards the impact of the climate on the water discharge of rivers.

5.1. Exposure

In the analysis the quantitative change of summer and winter precipitation were taken as exposure indicators form the Cosmo CLM study. The magnitude and spatial pattern of change of the quantity of winter precipitation are in relatively good coincidence with the earlier scientific literature (e.g. Clavier project). Although, there are significant uncertainties among the climate model's results in terms of the change of summer precipitation over the case study area. In terms of flood the exposure were not assessed separately but the impacts were directly analysed.

Decrease in annual mean precipitation in summer months and increase in annual mean precipitation in winter months

Relevance

The considerable reduction in the volume of summer precipitation on the European scale predicts a probable growth in the frequency of droughts, while the increase in the volume of winter precipitation suggests an unfavourable tendency in the volume and duration of inland waters swamp.

Methodology

We ranged the percentage values into five classes for NUTS3 regions in case of both indices by the method of equal value units.

Map 1: Decrease in annual mean precipitation in summer months

Source COSMO CLM 2010

Map 2: Increase in annual mean precipitation in winter months

Source: COSMO CLM 2010

5.2. Sensitivity

Sensitivity indicators of Tisza river case study area

Sensitivity dimension	Sensitivity indicator	Calculation method	Relevant exposure indicator
Physical sensitivity	Regarding physical dimension the sensitivity indicators were not separately (because it is not necessary) assessed, but the impact were directly analysed according to the definition in the impact indicators table		
Economic (agricultural) sensitivity	*Soil properties in terms of crop production sensitivity to drying climate*	The indicator is based on the categorisation an evaluation of FAO-UNESCO soil map	Decrease in annual mean precipitation in summer mounts
	Soil properties in terms of crop production sensitivity to excess water	The indicator is based on the categorisation an evaluation of FAO-UNESCO soil map	Increase in annual mean precipitation in winter mounts

Italic: Indicators defined in the Tisza river case study

5.2.1. Physical dimension

Regarding physical dimension the sensitivity indicators were not separately assessed, but the impact were directly analysed according to the definition in the impact indicators table (on p. 49)

5.2.2. Economic (agriculture) dimension

Soil properties in terms of crop production sensitivity to drying climate and excess water

Relevance

In the European comparison, the weight and role of agriculture in the Tisza Water Catchment Area is significant. The agricultural GVA various in the range of 5 to 14 % in the countries of the region, while in the European (EU) average agricultural GVA accounts to a mere 2%. This the same is true for those employed in agriculture: in the counties in the Water Catchment Area of Tisza, 3 to 36% of people in employment work in the agricultural sector. On the European (EU) scale this value is around 2 % i.

The economic sensitivity (focused on agriculture) can be well characterized by the water management properties of the various soil types, as the soil types with unfavourable water management properties may considerably strengthen and intensify the climate impacts.

Methodology

The indicators of sensitivity to drought and excess water are based on the soil map of arable land of FAO-UNESCO. The methodology is similar to the one described in the case of erosion indicator. On the basis of FAO soil map (soil type and texture) we developed five categories for sensitivity to excess water and draught. Then we rendered weight to each category. The highest weight was rendered to the highest sensitivity. For each NUTS3 region the area size of the categories were multiplied by the weights and the results were summarized. The sum values were then divided by the area of the arable land of the NUTS3 region, and these values were ranged in five classes.

Map 3: Soil properties in terms of sensitivity to drought

Source: CORINE 2006, FAO Soil map, processed by VÁTI

Map 4: Soil properties in terms of sensitivity to excess water

Source: CORINE 2006, FAO Soil map, processed by VÁTI

5.3. Potential impact

The calculation of potential physical impacts based on the LISFLOOD changing potential flood prone area maps. The exposure and sensitivity indexes were not analysed separately in the course of the analysis, but the potential impacts were assessed directly according to definition shown in the impact indicator table. The impact assessment were performed in physical dimensions, using 4 indices. In addition to the impacts on the settlements, also the impacts on transport networks (existing and planned) have been analysed. The results obtained for each of the indexes have been classified according to a 5 grade scale. As the change is duplex, when making the classification negative and positive impacts were distinguished.

In terms of the economic (agricultural) impacts the indicator values were the result of combination of the appropriate exposure and sensitivity indicators (see on p. 46). During the combination we used the same weight (0,5) for exposure and sensitivity. The results obtained for each of the two indexes have been classified according to a 5 grade scale.

The weighting of dimensions was made on the basis of the opinions of experts.

Impact indicators

Sensitivity/ impact dimension	Name of impact	Definition
Physical dimension	Change of potential impact of 100 year river flood event on settlements	Settlement area on increasing or decreasing flood prone area / settlement area of NUTS3 region
	Change of potential impact of 100 year river flood event on high speed roads	Lengths of high speed roads on increasing or decreasing flood prone area / lengths of high speed roads on NUTS3
	Change of potential impact of 100 year river flood event on main roads	Lengths of main roads on increasing or decreasing flood prone area / lengths of main roads on NUTS3
	Change of potential impact of 100 year river flood event on main (European railway lines, railway lines in national and regional importance) railways	Lengths of high speed roads on increasing or decreasing flood prone area / lengths of high speed roads on NUTS
Economic dimension	*Potential impacts of decreasing summer precipitation on crop production*	Combination of exposure indicator *"Decrease in annual mean precipitation in summer months"* and sensitivity indicator *"Soil properties in terms of crop production sensitivity to drying climate"*
	Potential impacts of increasing winter precipitation on excess water inundation and crop production	Combination of exposure indicator *"Increase in annual mean precipitation in winter months"* and sensitivity indicator *"Soil properties in terms of crop production sensitivity to excess water"*

Italic: Indicators defined in the Tisza river case study

5.3.1. Physical dimension

Change of potential impact of 100 year river flood event on settlements

Relevance

The greatest flood damage is the impact on the settlements (built up areas). In the catchment area of river Tisza the greatest part of settlement areas is protected by dams. The state and stability of the dams are, however, different.

Methodology

The indicator is calculated on the basis of the ratio (%) of settlements on changing (increasing and decreasing) flood-prone area in the total settlement area. The result values were ranged in 5 sensitivity classes (both in negative and positive direction). The state and stability of the dams could not be taken into consideration because of the absence of appropriate data.

Map 5: Change of potential impact of 100 year river flood event on settlements

Sources: LISFLOOD A1B, CCLM2010, Corine 2006

Change of potential impact of 100 year river flood event on transport infrastructures

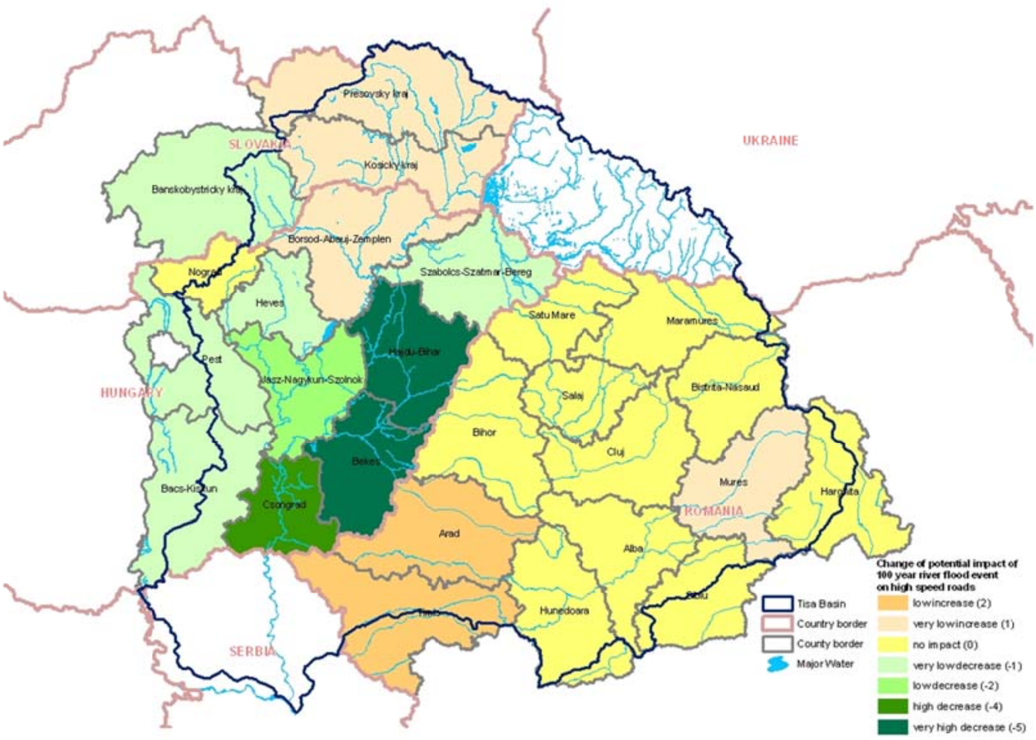
Relevance

In the case study of Tisza catchment area the analysis of infrastructure concentrated on the transport network. The roads and railways are of prime importance in inter-community relations. If the roads and railways are flooded the settlements temporarily lose connectivity which in turn results serious economic damage for the communities in the region.

Methodology

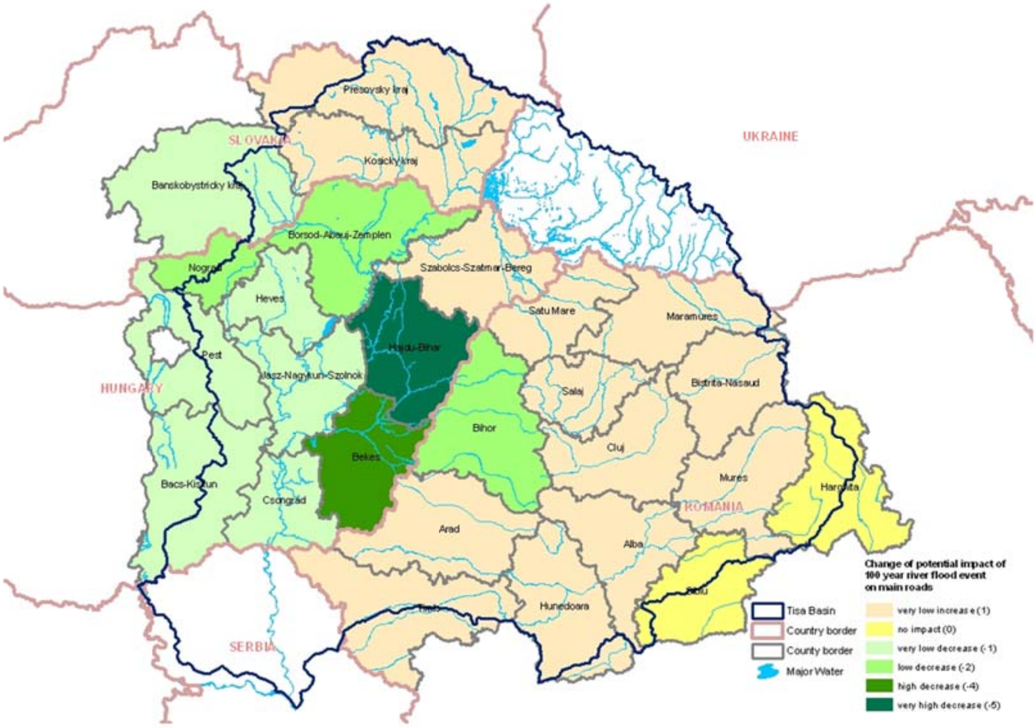
The % ratio of the length of roads on changing flood-prone area was calculated within the total length of roads in the NUTS3 region. The % ratios were ranged in five classes (both negative a positive direction). The state and stability of the dams could not be taken into consideration here either.

Map 6: Change of potential impact of 100 year river flood event on high speed roads



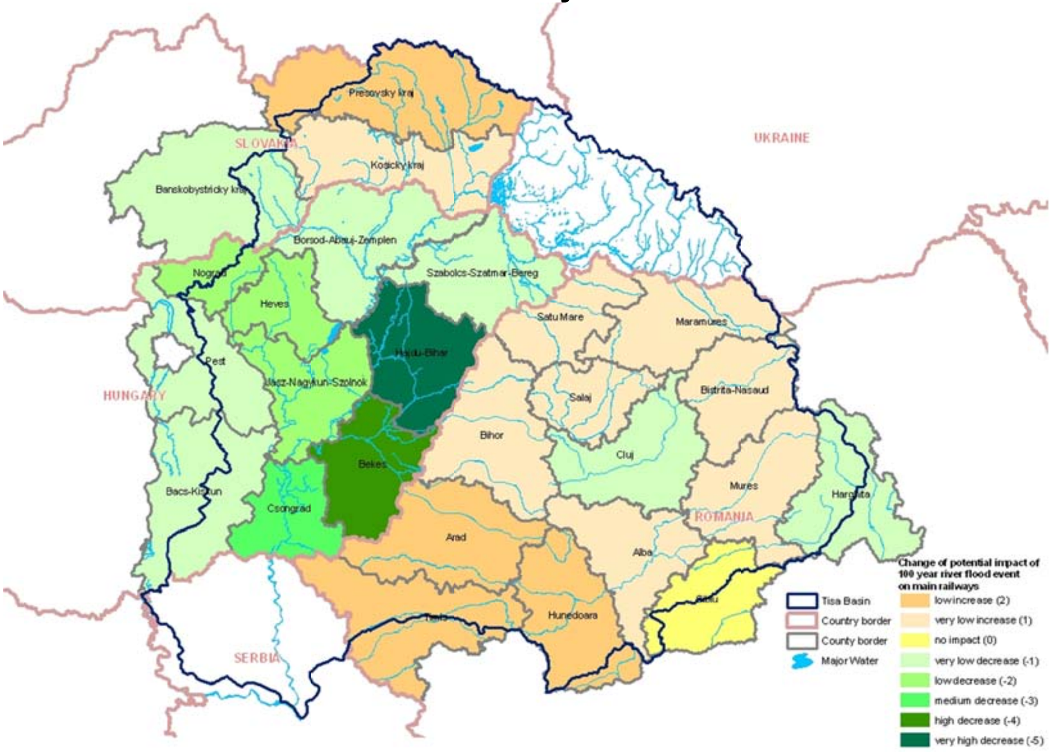
Sources: LISFLOOD A1B, COSMO CLM 2010, SEE TICAD project

Map 7: Change of potential impact of 100 year river flood event on main roads



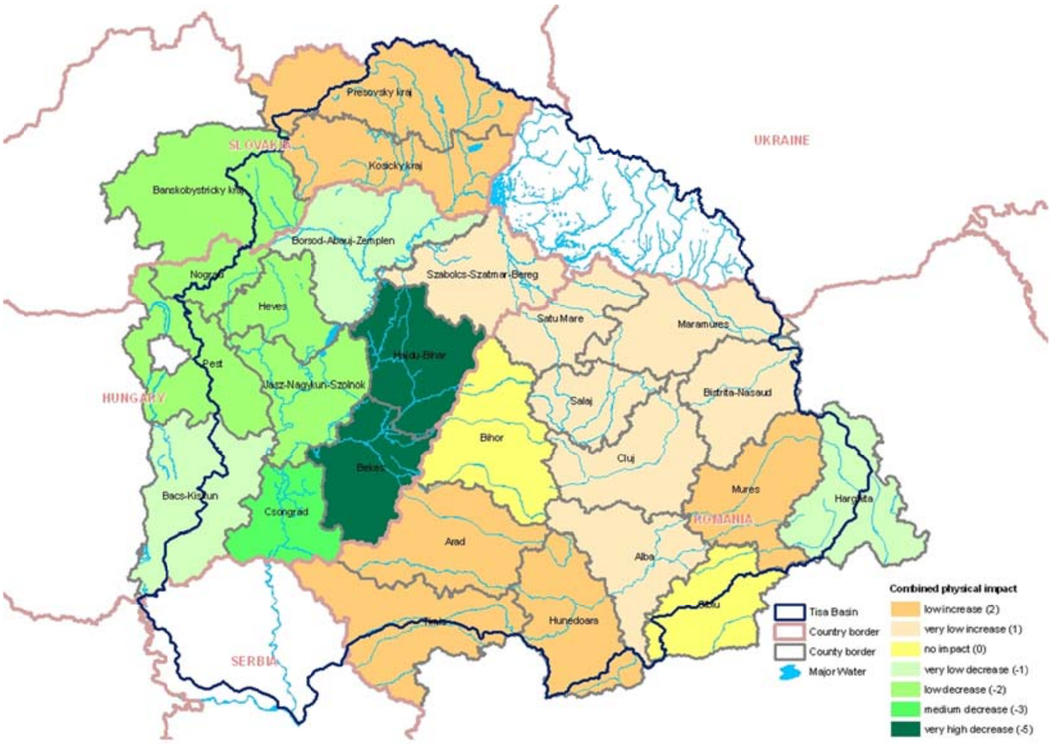
Sources: LISFLOOD A1B, COSMO CLM 2010, SEE TICAD project

Map 8: Change of potential impact of 100 year river flood event on main (trans European railway lines, railway lines in national and regional importance) railways



Sources: LISFLOOD A1B, COSMO CLM 2010, SEE TICAD project

Map 9: Combined physical impact



The highest increase of combined physical impact is predicted mainly in the mountainous and hilly regions, especially in the following regions: Košice and Prešov region. The most significant decreases, on the other hand, can be expected on the plain, and more specifically, in Békés and Hajdú-Bihar counties.

5.3.2. Economic dimension

Potential impacts of decreasing summer precipitation on crop production and

Potential impacts of increasing winter precipitation on excess water inundation and crop production

Relevance

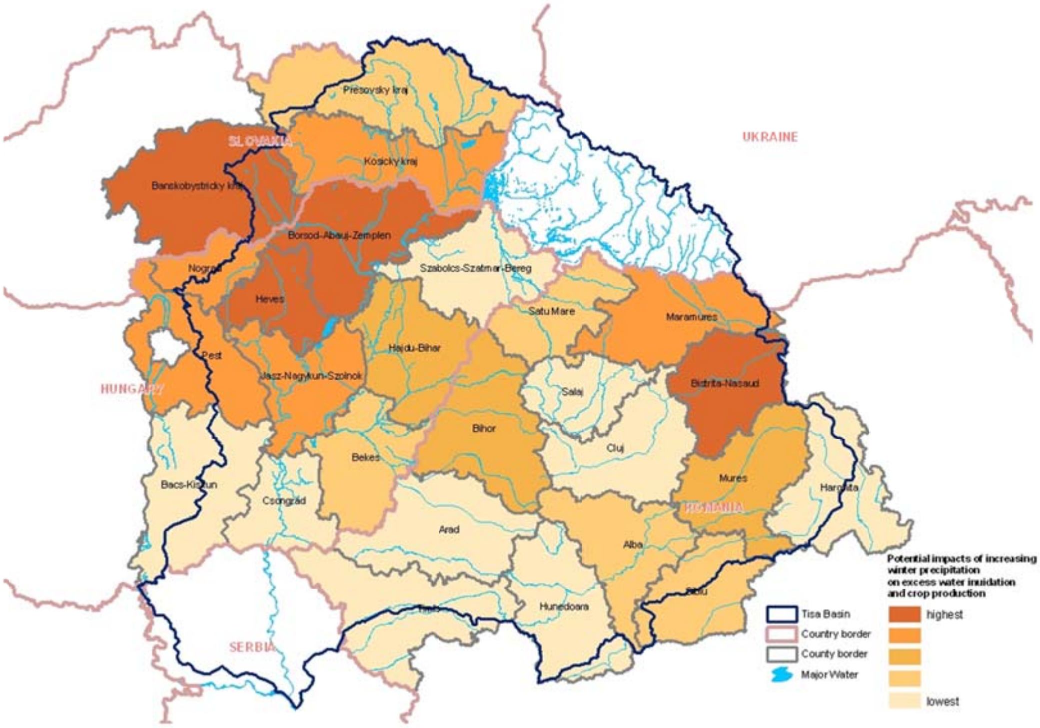
In the European comparison, the weight and role of agriculture in the Tisza Water Catchment Area is significant. The agricultural GVA various in the range of 5 to 14 % in the countries of the region, while in the European (EU) average agricultural GVA accounts to a mere 2%. This the same is true for those employed in agriculture: in the counties in the Water Catchment Area of Tisza, 3 to 36% of people in employment work in the agricultural sector. On the European (EU) scale this value is around 2 % i.

Methodology

In terms of the economic impacts the indicator values were the result of combination of the appropriate exposure and sensitivity indicators. During the combination we used the same weight (0,5) for exposure and sensitivity. The results obtained for each of the two indexes have been classified according to a 5 grade scale.

Map 10: Potential impact of decreasing summer precipitation on crop production

Map 11: Potential impact of increasing winter precipitation on crop production



Map 12: Combined economic (agricultural) impact

The highest increase of combined economic impact is predicted mainly in the NUTS3 region of on the lowland part of Tisza river basin and around the Apuseni mountain, especially in the following regions: Borsod-Abaúj-Zemplén, Bihor, Bistriţa-Năsăud Hajdú-Bihar, Heves Jász-Nagykun-Szolnok Mures and Satu Mare counties and in Košice region . The lowest increase, on the other hand, can be expected in Arad, Bács-Kiskun, Csongrád and in Harghita counties.

Aggregated impact

Aggregated impact was assessed by the weighting of dimensions (see the chart) and, thereafter, by the joint assessment of the dimensions.

The weight of sensitivity dimensions

Dimensions	Weights
Physical	0,4
Economic	0,6

Map 13: Aggregated impact

Aggregated impact represent a mixed picture in the case study area. The increase is the highest in Bistriţa-Năsăud, Mures and Satu Mare counties and in the Košice region. Still, however it is the highest. On the other hand, the lowest increase is probable in Csongrád county.

5.4. Adaptive capacity

Adaptive capacity was characterized by the 6 indices of the four determining adaptive characteristics. They are shown in the following table:

Indicators of adaptive capacity

Adaptive capacity determinant	Adaptive capacity indicator	Calculation methodology
Knowledge and awareness	*Population with higher education*	Number of population 24-X population with higher education / total population
Technology	*Scientist and engineers in R&D*	Number of scientist and engineers/
Infrastructure	*Irrigated area*	Territory of irrigated area / territory of agricultural area
	Share of Natura 2000 area	Territory of Natura 2000 sites / total territory of NUTS3 area
Economic resources	*Income per capita*	GDP / inhabitants
	Employment rate	Number employees / poulatiob15-64

Italic: Indicators defined in the Tisza river case study

Population with higher education

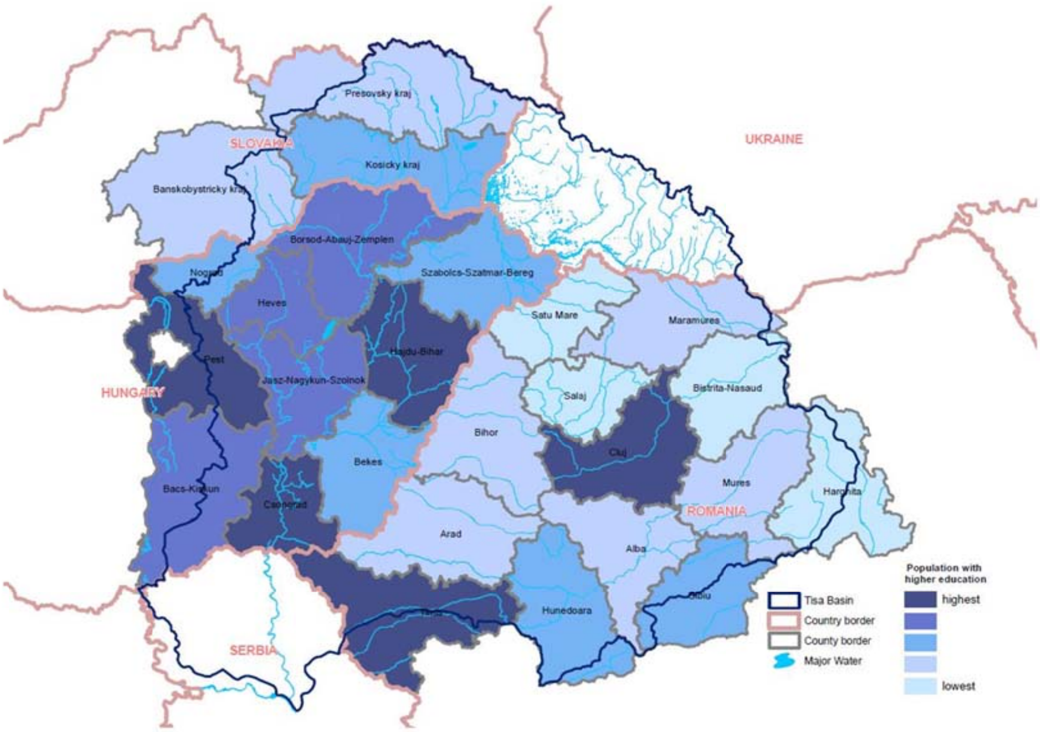
Relevance

As no consistent data for the three countries are available, we characterized the awareness of the population in terms of climate change the determinant was characterised by indices by the population with higher education.

Methodology

The values obtained have been characterized by the method of equal units, according to a five-grade scale.

Map 14: Population with higher education



Source: National Statistical Offices of Hungary, Romania and Slovakia (2007), processed by VÁTI

Scientist and engineers in R&D

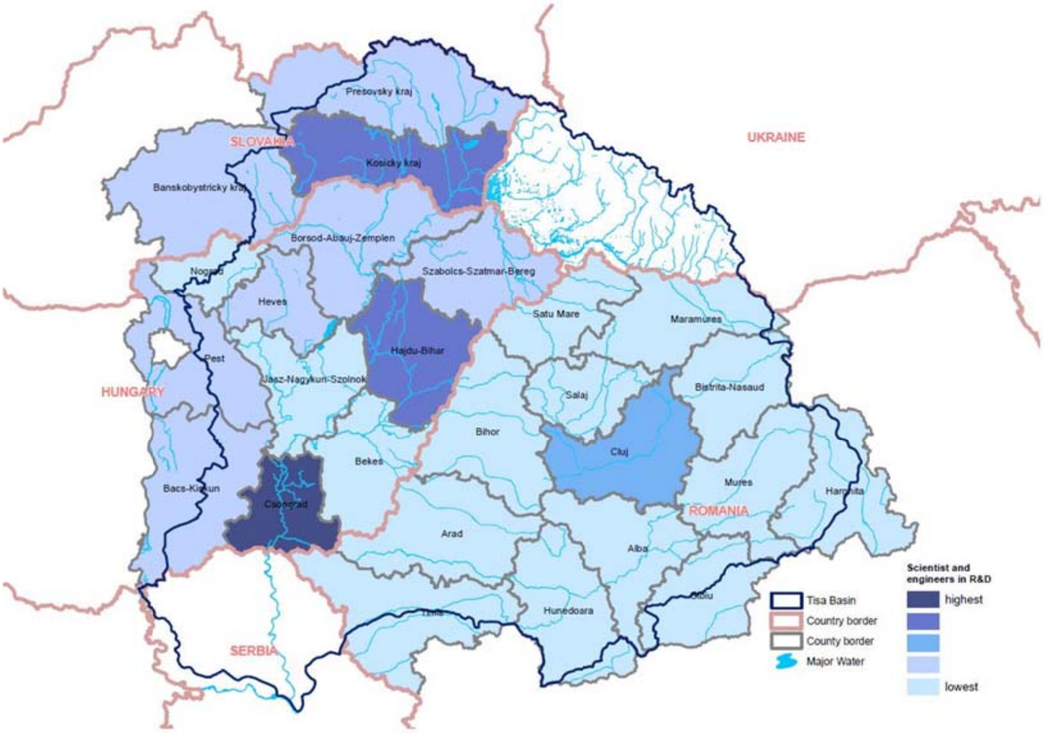
Relevance

The innovative capacity of the region plays a role of utmost importance in adaptation, which, due to the unavailability of data, we express by the number of research workers/1,000 inhabitants.

Methodology

The result values obtained have been characterized by the method of equal units, according to a five-grade scale.

Map 15: Scientist and engineers in R&D



Source: National Statistical Offices of Hungary, Romania and Slovakia (2007), processed by VÁTI

Share of irrigated area

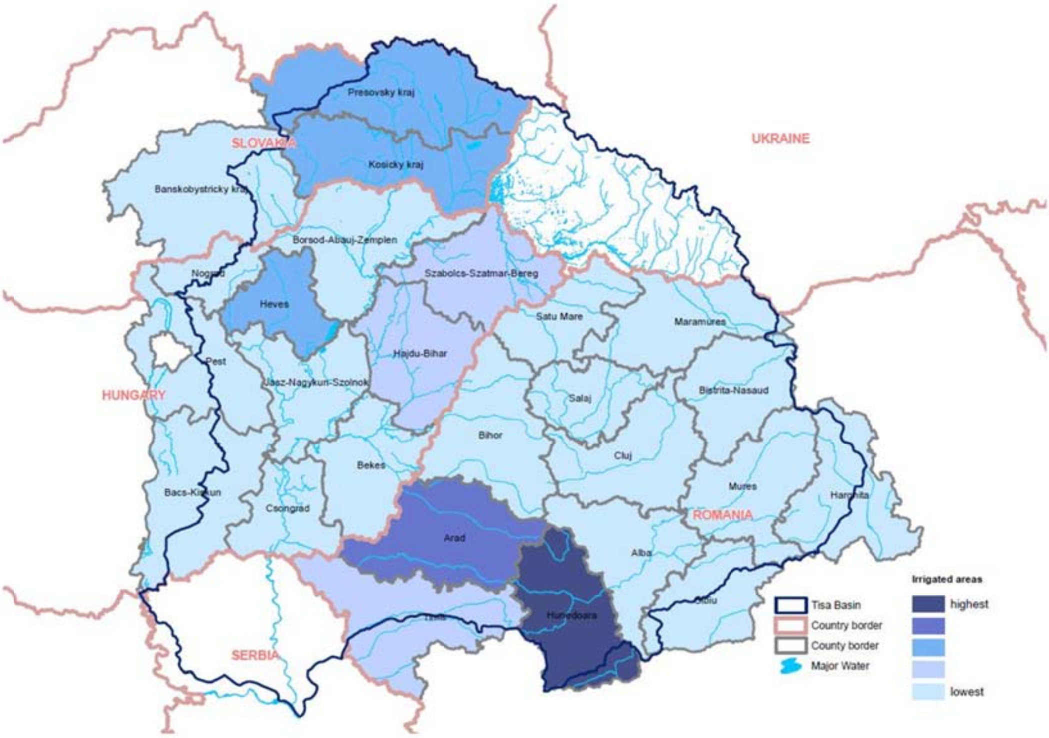
Relevance

The experts are of different opinions on irrigation as a potential adaptive measure, as – a although the results may be favourable - irrigation can contribute to the increase of water shortage and may exert an unfavourable impact on the various soils too. The properly chosen irrigation technology (drop-irrigation), on the other hand, can be a successful adaptation technology in certain agricultural branches. In the Tisza Region the ratio of irrigated territories is used as an index.

Methodology

The values obtained have been characterized by the method of equal units, according to a five-grade scale.

Map 16: Share of irrigated area



Source: National Statistical Offices of Hungary, Romania and Slovakia (2007), processed by VÁTI

Share of Natura 2000 area

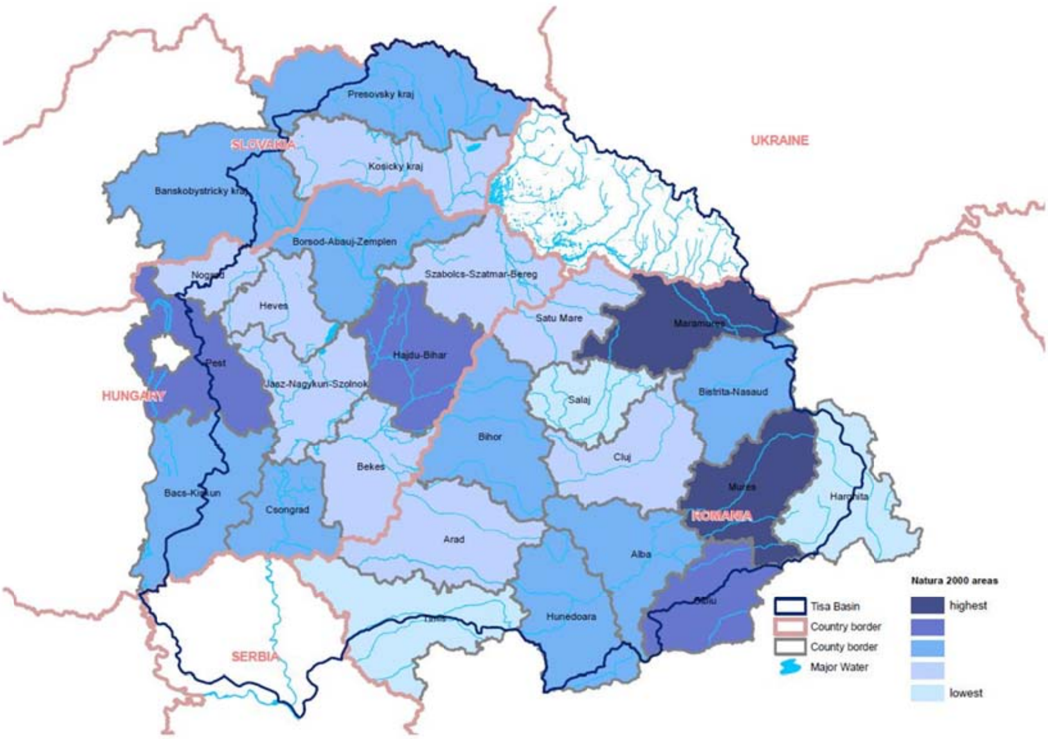
Relevance

The ratio of Nature 2000 sites suggests the ratio of agricultural territories the state of which is close to natural state, territories where a subsidy system elaborated to help sustainable agriculture assists the introduction of adaptive agriculture

Methodology

The values obtained have been characterized by the method of equal units, according to a five-grade scale.

Map 17: Share of Natura 2000 area



Source:

Economic resources (GDP/capita, employment rate)

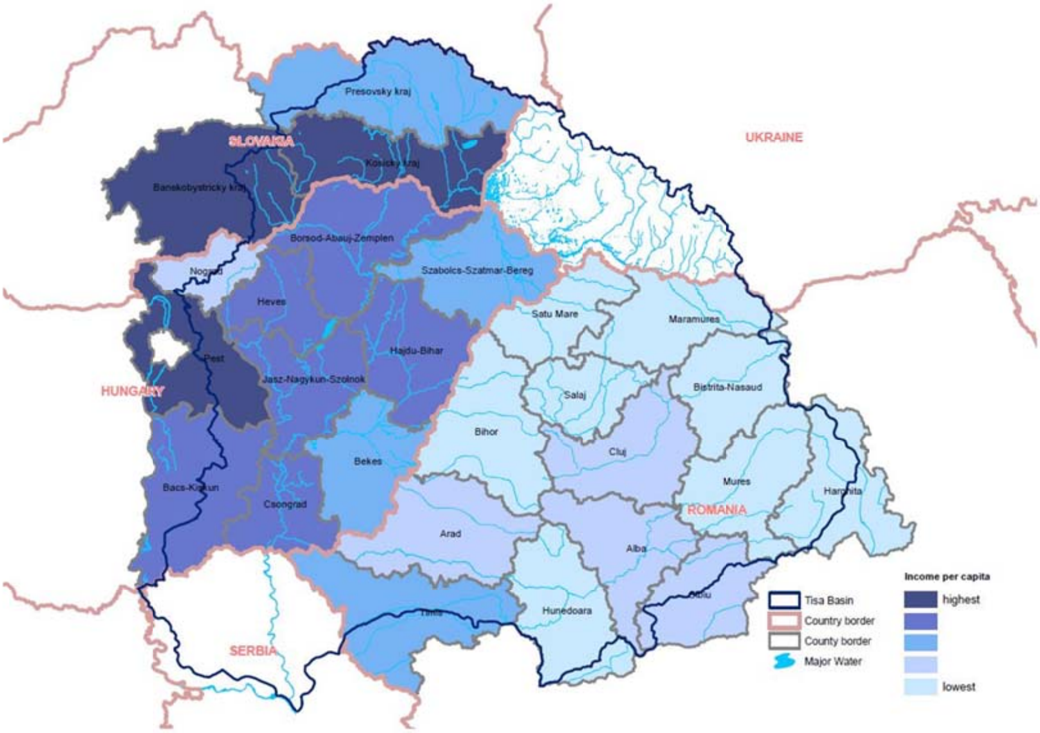
Relevance

As no consistent data for the three countries are available, we characterized the adaptive capacities of the regions by indices that fundamentally influence general economic state, such as GDP per capita and the employment ratio.

Methodology

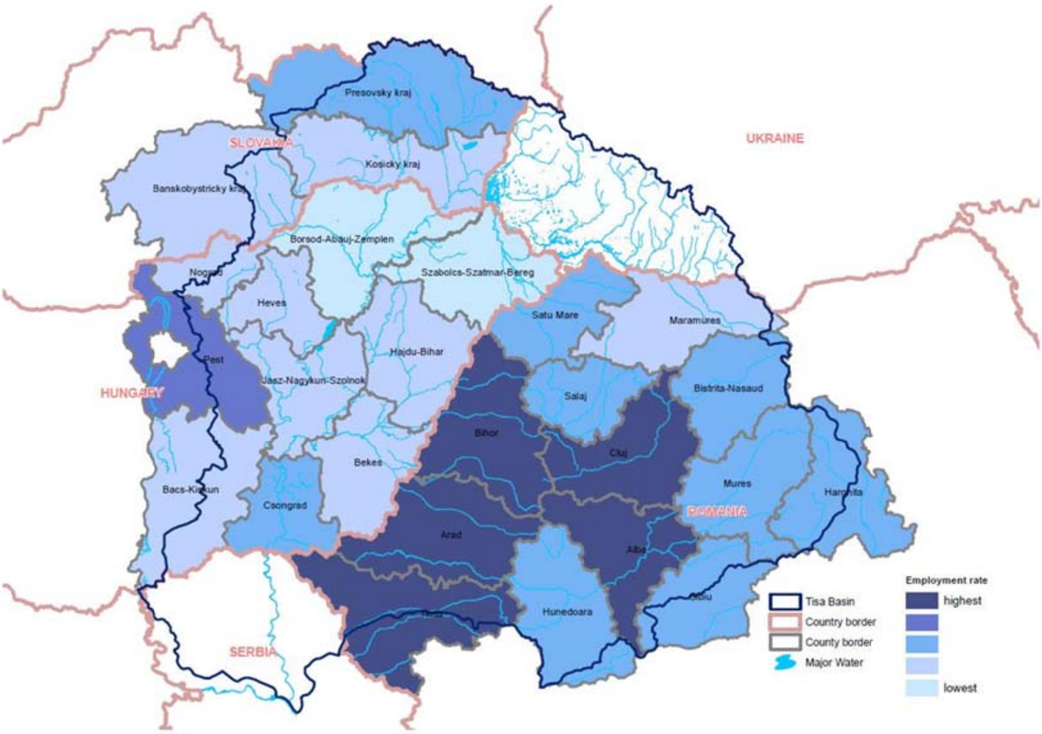
The values obtained have been characterized by the method of equal units, according to a five-grade scale.

Map 18: Income per capita



Source: National Statistical Offices of Hungary, Romania and Slovakia (2007), processed by VÁTI

Map 19: Employment rate



Source: National Statistical Offices of Hungary, Romania and Slovakia (2007), processed by VÁTI

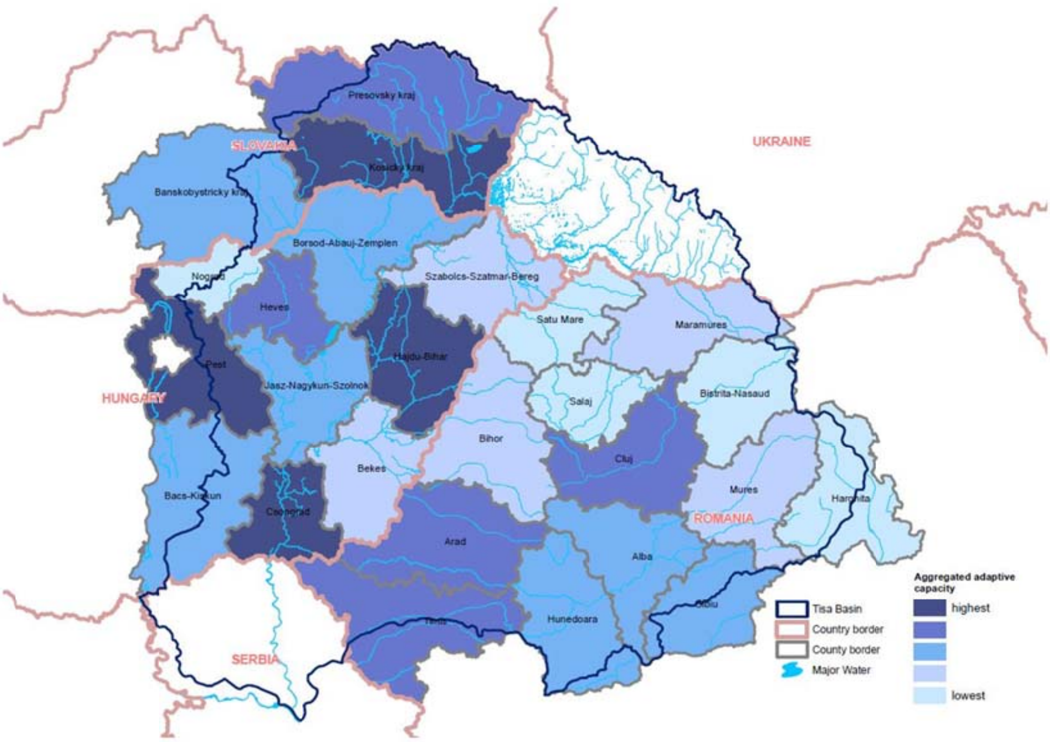
Aggregated adaptive capacity

Aggregated adaptive capacity was estimated by weighting the determining factors (see the table) and then, by the joint evaluation of the determining factors, according to the uniform methodology.

The weight of adaptive capacity determinants

Adaptive capacity determinant	Weight
Knowledge and awareness	0,1
Technology	0,2
Infrastructure	0,3
Economic resources	0,4

Map 20: Aggregated adaptive capacity



The geographical distribution of the aggregated adaptive capacity indices shows a diverse picture. In the NUTS 3 regions of Slovakia, adaptive capacity is medium or high, while in Hungary all degrees of adaptive ability can be experienced: as long as Pest and Csongrád Counties have very favourable values, Nógrád and Békés counties have low and very low adaptive capacity values. The NUTS 3 regions of Romania are characterized by low and very low values. Good adaptive capacities have been defined only for Arad, Timiş and Cluj counties.

Adaptive capacity in the water catchment area of River Tisza is determined by several factors which cannot or can hardly be measured for the time being. As a rule, these factors are related to droughts and floods. As regards floods, adaptive capacity is greatly influenced by the technical skills and knowledge of people responsible for water management, and especially for the elimination of damages caused by water, and for defining the strategic issues of the elimination of damages caused by water (e.g., assessment of the possibility of River discharge on the protected side, etc.) It is also difficult to translate the county-level resources and institutions of regional and town planning into figures. Similarly, the role of transnational co-operation can be the best assessed on the national (NUT0) level.

5.5. Vulnerability

Vulnerability can be calculated on the basis of potential impact and aggregated adaptive capacity, using the weight numbers in the chart.

The importance of potential impacts and adaptive capacity

Elements of vulnerability assessment	Weights
Aggregated impact	*0,5*
Adaptive capacity	*0,5*

Map 21: Vulnerability

The geographical distribution of the vulnerability also shows a diverse picture. The highest increase is predicted in Romania in Bistriţa-Năsăud, Mures and Satu Mare. On the other hand, the lowest increase is probable in Hungary in Csongrád county.

6. Socio-economic assessments related to climate change in the Tisza river Basin

This chapter considers the socio-economic assessment of climate change and has two main sub-chapters: the first one (4.1) deals with socio-economic aspects of climate change at Lake Tisza (Hungary) and the second one (4.2) focuses on a demographic profile related to climate change from the Romanian Tisza River.

Climate change is no longer a theory; it is supported by a wide scientific consensus. In fact, this worldwide problem has made its way from the realm of science to that of political decision makers. The effects of our changing climate cannot be escaped by Hungary, and our analysis has to highlight the possible impacts from the aspect of local stakeholders as well.

According to the Romanian assessment in socio-economic terms, climate change will have a negative impact by decreasing the activity rate, along with an increasing share of unemployment, things that will affect the living standards of people in the examined areas.

6.1 Socio-economic dimension of climate change at Lake Tisza in Hungary

The subject of the analysis was the Lake Tisza region and the 73 settlements in the Regional Development Council of Lake Tisza. This region has been selected because it is rich in environmental values, coupled with economical and social problems and a significant Romani population, making it suitable for the complex evaluation of the interdependences. One focus point of this examination was climate change on local level especially dealing with the opinion of local stakeholders.

Lake Tisza is an important tourism destination with unique natural environment, where in parallel it is possible to satisfy the demand of visitors searching for sport-, conference-, eco-, adventure and other kind tourism. The artificially created lake (Kisköre Aquifer, 1970) is the second largest in Hungary, which has a very important role in flood protection, in water storing, in protection of water quality, recreation, farming systems and in the conservation of biodiversity. Another speciality of this 2262 km^2 area is that one third of it belongs to two different National Parks (Figure 1).

Several methods were used in former examinations, but it has become clear that comparative analysis based on questionnaires is the most suitable. In frame of a PhD dissertation (Csete, M., 2009) 73 questionnaires were distributed for the analyses, of which 38 were processed. These may seem lengthy, but they are quickly completed and include control questions. (Several settlements did not respond, others provided feedback that was unsuitable for processing.) Topics covered by the 26-page questionnaire:

- General data (5 main questions);
- The natural environment, resources and their utilization (31 questions);
- General, social and economic characteristics of the settlement (21 questions);
- Institutional, organizational background (5 questions);
- Main barriers of development (8 questions);
- *Climate change and weather conditions (32 questions);*
- Views on a liveable countryside and settlement (in accordance with the New Hungary Development Programme).

Figure 5: Location of Lake Tisza in Hungary

Source: http://wiki.gtk.uni-pannon.hu/mediawiki_en/index.php/File:Hungary_topographic_map.jpg

The research mainly focused on how sustainability can be implemented for the liveable settlement, environment and countryside. Determining the answer is complicated by the fact that the analysed region is underdeveloped (Lake Tisza region) and a holiday resort of exceptional significance. It is characterized by social tensions and is rich in protected natural values. As contained in the Third Assessment Report (2001) of IPCC, one of the greatest threats to implementing sustainability is global climate change. This statement is confirmed in the latest, Fourth Assessment Report (2007) as well. Further research is needed to determine how this appears on the settlement level and what possible solutions may be.

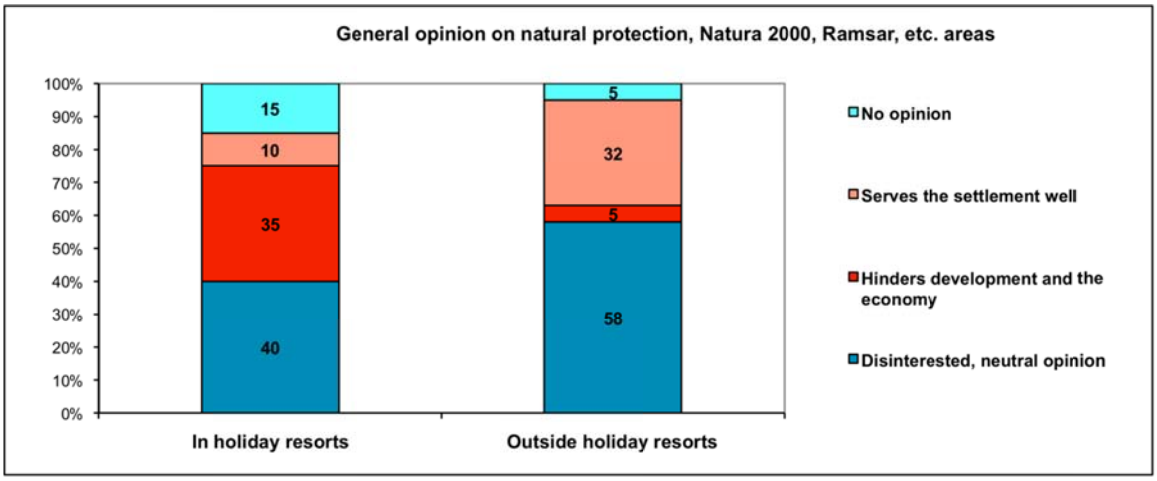
Overall, it can be stated and proposed that although it is important for the locals to understand sustainability, progress can only be made through harmonization with other goals and interests, and translation to action and the „local language". The rational use of natural resources, solving the problems of social tensions and quality of life that hinder development, the solution for the problems of the Romani population, tourism, harmonizing the properties of the settlement and the number of people the settlement can support play an equal role. Since there is no agglomeration centre in the 38 analysed and 73 stakeholder settlements to organize and lead sustainable development with a sense of identity, responsibility, professionalism and a financial background, the activities of the existing – and successful – association must be amplified to prepare for climate change and to offset the effects of globalisation.

The interrelations between tourism and climate change have long been a subject of analysis. Societies have always had to respond to climate variability and extreme weather events. Whilst climate change is a new driver for action, mitigation and adaptation will in many cases be implemented by regulatory modifications of existing policy frameworks for floods, droughts and the management of water quality etc. (Fűr, A., Csete, M., 2010) All these symptoms can lead to significant impacts on the tourism sector as well. The vulnerability of different tourism destinations usually depends on the strengths of the potential impacts and also on the adaptive capacity of the region. Sustainable tourism plays an important role in finding the breakout points for the settlements. The possible impacts of climate change increase the vulnerability of the examined area. For instance in 2003 and 2007 local people got a sample of the collateral effects of climate change: global warming, drying and extremes. In 2003, frosts, then flood, inland water and drought caused problems. In 2007, early warming, then cooling and frost, was followed by the most extreme summer with three heat waves. These phenomena have different effects also on tourism sector and it is especially questionable in case of nature and water based tourism at Lake Tisza.

According to this topic it is worth mentioning that another survey was carried out among tourism suppliers in 2010 by BME. In the frame of this research, Hungarian tourism experts and representatives of different tourism associations were asked about the possible mitigation and adaptation activities and impacts of climate change. As part of a Contingent Valuation Method (CVM) we investigated the Willingness to Pay (WTP) of the stakeholders taking into consideration the possible effects of climate change. (See also the Bergen case study in relation to WTP.) The question was focusing on the percentage of their yearly income related to WTP. Most of the stakeholders (45%) would expend 1% of their yearly income to develop the adaptation activities of their sector. 23% of them would expend 2-5%, 18% would expend 5-10% and 14% would not expend anything for adaptation related development. The results are summarized into an adaptation portfolio that can foster the practical implementation in the research area.

Among the dimensions of sustainability related to climate change, the preservation of natural values and resources is of the utmost importance. This realisation may be controversial in the eyes of the public struggling with day-to-day problems. The results of the analysis show that the public is mostly disinterested in valuable natural areas, even though this is an important dimension of sustainability, a long-term local and social interest. (Figure 2)

Figure 6: General opinion on valuable natural areas



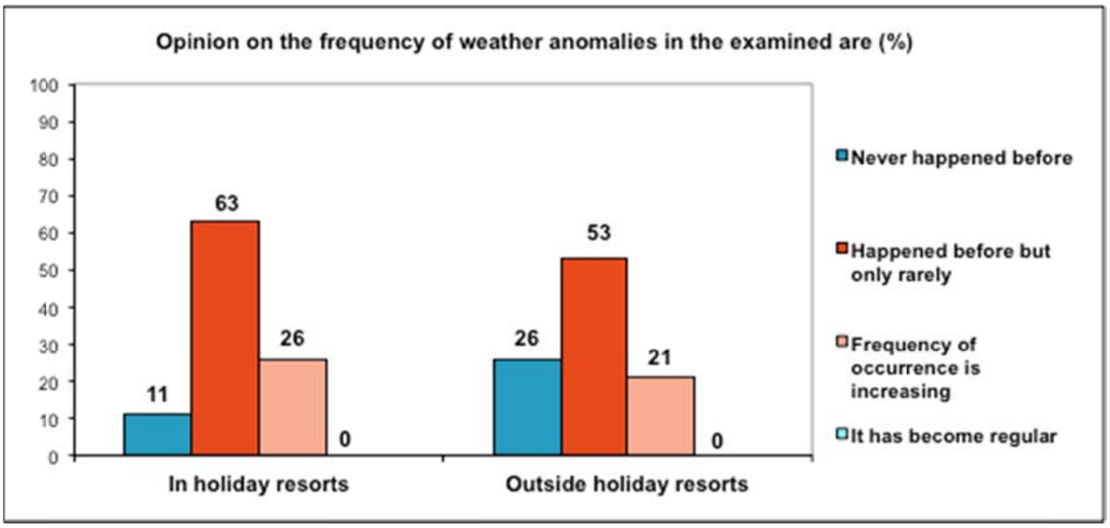
Source: Csete, M. 2009, (n=38)

It is clear that the possibilities in natural resources have done little to help overcoming economical and social problems in the region. This fact, also impacting adaptive capacity and the situation is further complicated by the expected effects of climate change.

As the analysis shows that tourism is supported everywhere, with the exception of four settlements. While activities complementing each other and synergic effects are more secure, it doesn't even occur to stakeholders that especially taking climate change into consideration the water supply of Lake Tisza may become uncertain. Warming increases the danger of evaporation, eutrophication, siltation and the degradation of water quality. This is an important uncertainty and risk factor.

As an effect of global climate change, several predictions suggest that weather conditions such as heat, drought and extreme weather patterns will become more frequent; these will last longer, and will be more intensive than ever before in Hungary. The survey also dealt with this statement. As the results showed (Figure 3) the opinion of local stakeholders are similar in the two of settlement group. Most of them answered to the different extreme weather events that those was happened before but only rarely, although the percentage of new anomalies and the frequency and intensity of other events are increasing.

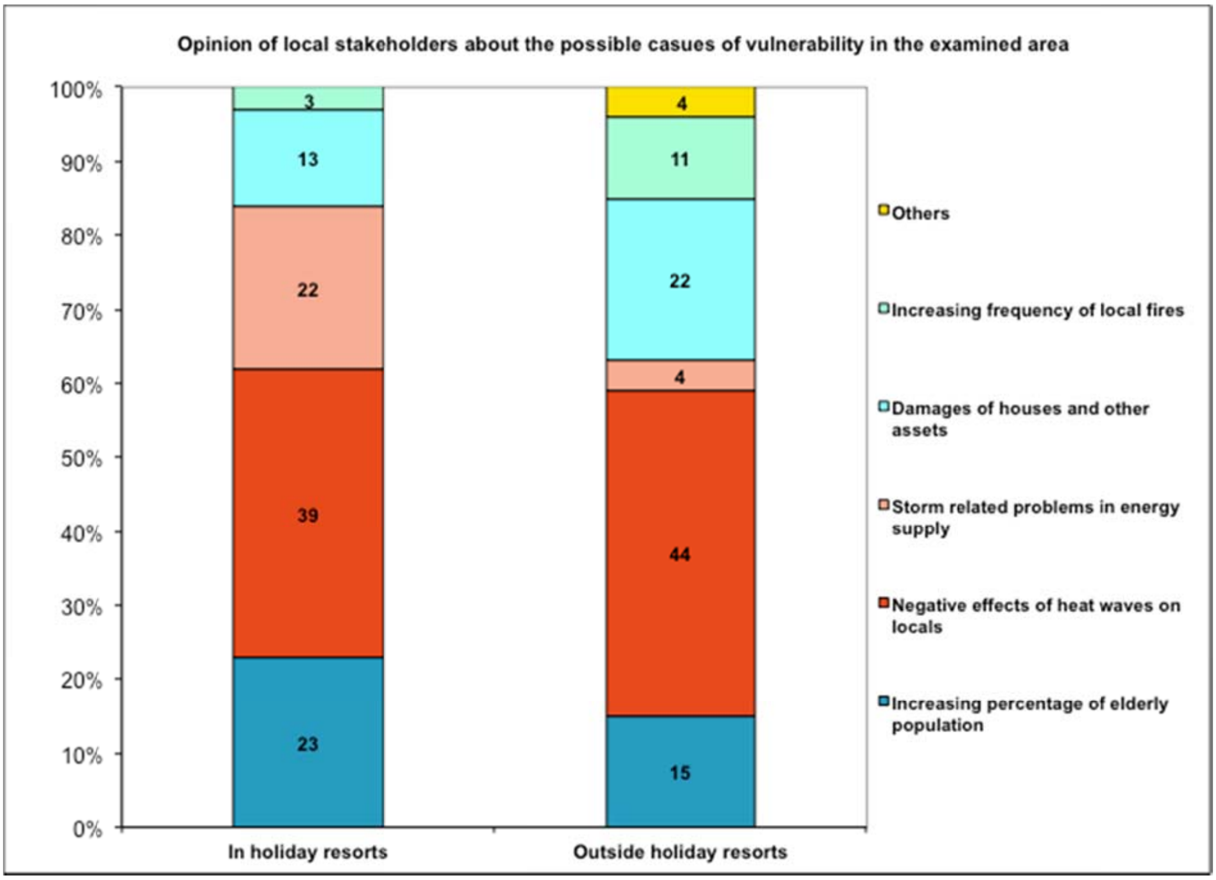
Figure 7: Opinion of local stakeholders on weather anomalies



Source: Csete, M. 2009, (n=38)

The results of the survey also showed according to the importance of mitigation that 76% of the stakeholders in the holiday resort and 65% of the stakeholders located outside of the holiday resorts found only minor opportunity in emission decreasing. Considering adaptation the 67% of the stakeholders in the holiday resort and 61% of the stakeholders located outside of the holiday resort thought important this topic in case of their settlement development. The questionnaire was also focusing on the possible causes of vulnerability in the examined area (Figure 4). In case of both examined settlement area the increasing percentage of the elderly population got the highest rank that was followed by heat waves and damages caused by different extreme weather events etc.

Figure 8: Opinion on the possible causes of vulnerability



Source: Csete, M. 2009, (n=38)

In the interest of preparing for climate change it is expedient to develop an action plan to help preparation, prevention, alleviation and reconstruction so that possible courses of action will be clear to all. Developing local measures for saving energy, increasing efficiency and using alternative energy sources is equally important in preparation and decreasing living costs, with special emphasis on investments and development.

Human health, the security of food supply and water supplies are critical among the effects of climate change. Water is especially important, since the study shows that people in the region are extremely optimistic about water supply and quality perspectives. The existence of Lake Tisza and natural values justifies reviewing the status of and making suggestions for the future of water resources, water protection, alternative solutions and the rational use of groundwater, thermal water and irrigation. A possible source of funding climate protection efforts could be Leader+, which seems to be working well in Hungary as well. With it, synergic effects could be achieved and the financial state of settlements could be improved which can motivate local decision makers towards the practical implementation of adaptation and mitigation strategies.

6.2. The demographic profile related to climate change from the Romanian Tisza river

Comparing indicators of exposure to climate change, temperature and rainfall, it outlines two categories of vulnerable areas on the Romanian territory of the Tisza river basin

The first category, which contains two areas with a high probability of reducing the existing rainfall quantity: in the south-east of the catchment area (a part of the counties of Harghita, Mures and Sibiu) and in its center (the counties of Cluj, Sălaj and Satu Mare)

- The second category, which contains an area with a high probability of increasing the existing temperature, located in the center of the basin, on the north – south axis, including parts of the counties of Sălaj, Cluj, Alba Iulia and Sibiu

By superposing the two categories of territories result two areas with the highest degree of vulnerability to climate changes caused by temperature increase while reducing the volume of rainfall: an area in the south-eastern part of Sibiu County and one in the center of Sălaj County and north of Cluj County.

In socio-demographic terms, the south-eastern part of Sibiu County, is characterized by:

- low population density
- population growth during 2002-2007, based both on natural growth and on migration growth
- decrease in the share of population aged 0-14 years and increasing share of elderly in 1990-2007
- decrease of the dependency ratio by age in the period 2002-2007
- decrease in the activity rate of labor resources in the period 2002-2007
- gross monthly income in 2007 over the average of the studied area, the highest value in services and the lowest in agriculture

The second area, located in the center of Sălaj County and in the north of Cluj county, in socio-demographic terms, is characterized by:

- low population density, except the area around the city of Zalău
- slight decrease in population number during 2002-2007, driven mainly by natural movement
- high value for age dependency ratio in 2007, based on the growing share of elderly population
- increased share of unemployment

- gross monthly income in 2007 below the average in the studied area, with the highest value in construction and the lowest in agriculture

It can be concluded that in areas most vulnerable to climate change the most exposed category of population is the elderly population. In socio-economic terms, climate change will have a negative impact by decreasing the activity rate, along with an increasing share of unemployment, things that will affect the living standards of people in these areas. The most affected branch of the national economy will be agriculture, which in addition to structural dysfunctions; will register a decline caused by environmental changes.

7. Response strategies and policy development

7.1. Response strategies and policy development of Hungary

7.1.1. National Climate Change Strategy of Hungary

The elaboration of the National Climate Change Strategy of Hungary (Hungarian abbreviation: NÉS) was prescribed by Section 3 of Act LX/2007 on the Implementation of the UN Framework Convention on Climate Change and the Kyoto Protocol. In conformity with the international covenants, the climate change strategy for the period between 2008 and 2025 was elaborated first, establishing the framework for the measures planned for this period. With a view to implement the strategy the government approved a National Climate Change Program which contains the concrete measures aiming the fulfilment of the goals set in the National Climate Change Strategy of Hungary. The National Climate Change Program (Hungarian abbreviation: NÉP) covers two years. Within the government the Ministry of Rural Development (now the Ministry for Rural Development, Environmental and Water management) is responsible for the environmental protection aspects. this ministerial body was responsible for guiding the work and involving the ministries affected. The government will revise the National Climate Change Strategy after two years the following its adoption and, then, in every five years. Annual reports are to be submitted to the Parliament on the implementation of the Program and the relevant experiences.

The process of implementation of the strategy is assisted by a body of consultants, the so-called Climate Change Committee, composed of the representatives of the specialized ministries, the Hungarian National Academy of Sciences, the representatives of environmental civil organizations, the Commissioner for the Rights of Future Generations, and the main business stakeholders. The minister of environmental protection is responsible for the comprehensive coordination of the Strategy. To secure successful interdisciplinary coordination and the harmony between the various governmental policies, in the Strategy it is laid down that a Climate Work Team consisting of senior officers of the ministries involved shall be set up, which, if necessity so dictates may set up various sub-groups of experts.

The National Climate Change Strategy fits into the National Strategy of Sustainable Development adopted by the government by Government Decree 1054/2007. (VII.9.).

To support the achievement of the goals the tasks and means the various social partners (governmental bodies, regions, civil organizations, local communities, self governments, churches, business sector) are highlighted too.

Sectors Involved in the National Strategy of Climate Change

- environmental protection
- human environment and human health
- water management
- agriculture and forestry
- spatial and urban planning and development and built-up environment

Territorial dimensions

In the Strategy the harmful impacts of climate change upon the various economic sectors are not clearly linked to geographical areas. It is only in the chapter on agriculture that the strategy designates regions which are most exposed to the impacts of climate change (regions exposed to hail, internal waters, deflation) by name. In the chapter on water management it is emphasized that the plain areas are exposed to drought.

Most of the adaptation tasks cannot be restricted to any spatially defined area unit. In the chapter on water management, the relations between water stock and consumption have been analysed, dividing the country into 9 regions.

In the chapter dealing with regional development and spatial planning the Homokhátság area lying between the rivers Danube and Tisza is given special attention. In addition, the territorial dimensions of the various tasks are clarified by designating “zones” such as, e.g., “areas where construction is to be minimized because of the prevalence of high surface ground water level”.

Correlation between emission reduction and adaptation

In the Strategy it is emphasized that in climate politics mitigation and adaptation measures shall be planned, implemented and supervised in a harmonized way, to achieve mutual enhancement. At the same time attention is drawn to the difficulties of this: as long as a set system of indicators can be well applied for measuring the favourable impacts of the reduction of emission levels, it is much more difficult to measure the effect of the measures aiming adaptation, as it is a task far more comprehensive and far reaching, therefore, it is very difficult to control to what extent adaptation occasionally acts against adaptation goals, and to what extent it is in harmony with them.

It is also emphasized that a data base, information system and institution shall be set up to collect and analyse information on adaptation. This institution should be organised within the Ministry for Environmental Protection.

Targets are set for the reduction of the emission in four sectors, those with the highest amount of emissions. These are: energy, transport, agriculture and waste management. In this respect the most tasks are to facilitate energy efficiency in the community and public sectors, to improve efficiency coefficient, and related energy production, promote the use of renewable energy resources, to control energy demand of manufacturing, and to re-use of heat produced elsewhere, to reduce the electric energy consumption of manufacturing technologies, to transform the structure of transport and reduction thereby of the energy demand and to help the binding of coal by means of afforestation.

The adaptation measures are not addressed to the same activities as those specified for emission reduction. There is overlap in the cases of agriculture and forestry only. In these sectors the designated tasks for emission reduction and adaptation are in harmony and reinforce each other.

Costs and benefits, economic implications

It is assumed that the costs of implementation will be estimated in the action programs, because the accurate costs of the measures cannot be foreseen in advance either in the National Climate Change Strategy or in the National Climate Change Programs.

There are, however, several international studies estimating the arising costs of climate change measures. Two of these are of particular importance. One is the so-called Stern Review according to which the reduction of the emission of greenhouse gases will be regarded as an investment in future, as the benefits offered by efficient and quick emission reduction are far more than its costs. The authors of the Stern Review used various economic models to test how costs will change in function of the emission reduction targets. The other important international study is the cost-benefit analysis prepared by the European Committee to analyse the emission reduction costs. The model used for the analyses simulates the trends to be expected in the reduction of the emission of greenhouse gases and also the impact it will have on the GDP of the EU.

Based on the analyses the conclusion that can be drawn is that the costs incurring if action is postponed would be much higher than those of actions taken in due course and in a harmonized way. The costs involved by emission reduction and adaptation now are far lower then of those that would result from similar actions after 2012 or in case that Hungary was compelled to buy emission units in the future.

It is emphasized in the Strategy that the reduction of emission and progress on the route of a more climate-friendly sustainable development will improve the economic competitiveness of Hungary. By the reduction of emission the so-called “coal intensity” of the country will also decrease, in other words, a national economy of law carbon contents will be created, which in turn will result considerable savings in the years and decades..

The total expenditure of the implementation of the National Strategy on Climate Change will affect the national economy as a whole, including every household. However, the implementation will not involve financial burdens only, but also an excellent opportunity for both the macro-economy and the households to realize savings. A very good example for this is the improvement of energy efficiency resulting considerable savings for the families, increasing the income generating potential and competitiveness of enterprises and also contributing to the creation of new work places.

In order to implement the National Strategy on Climate Change the government will set aside resources for the biannual climate change programs and the long-term activities. In addition to the resources available in the national budget, the state may raise income from the international and EU trade systems for the goals of mitigation (emission reduction) and adaptation. The distribution of these revenues will be defined by the government taking into consideration the recommendations to be made by the Climate Change Committee.

In the Strategy special emphasis laid on the Green Investments Scheme (Hungarian abbreviation: ZBR), and the Environment and Energy Operative Program. Both support the improvement of energy efficiency and promote green (renewable) energy.

Most relevant Measures of the National Strategy on Climate Change for this Study

Agriculture

- speeding up of plant breeding to elaborate the most appropriate choice in view of the adaptability tests,
- setting up the system of shelter-belts and increasing the proportion of wooded pastures,
- maintenance of low-head parkland-type forests in the wooded steppe zone,
- development of economic irrigation technology, multi-purpose cultivation techniques serving the prevention of internal waters and drought hazard, technology of protection against (prevention of) hailstorms and the propagation of these techniques,
- elaboration of an information system serving protection from damages caused by drought, providing for water retention and an uninterrupted, contiguous plant cover and rehabilitation of the aquatic habitats in the most affected regions. Widespread

application of the approaches elaborated in the framework of the agri-environmental protection program, and the implementation of environmental-friendly farming on the sensitive natural areas, the Natura 2000 sites and in our very environment,

- reinforcing the mosaic pattern of land-use (boundary lands, hedges, rows of trees, etc.),
- fundamental reform of the insurance system of agriculture

Water management

- the complex hydrological consequences of the climate change must be understood and identified, and the knowledge basis extended especially as far as the water systems of Rivers Danube and Tisza are concerned. International co-operation is needed in this field,
- plotting of flood risk maps and elaboration of flood risk management plans as prescribed by the EU Flood Directive,
- implementation of the Revised Vásárhelyi Development Plan program,
- water retention should be improved by the complex management and treatment of inland water systems (e.g., loosening of the subsoil, revision, renovation or liquidation of the drainage and canal systems,) on the one hand, and by the preservation and rehabilitation of aquatic habitats, on the other hand.

Spatial planning and territorial development

Several measures are identified in the National Strategy on Climate Change for regional development, spatial planning and building regulations. For example:

- to enforce special building regulations for the protection of river basins (flood plains, foreshores and coastal bands), in order to facilitate drainage, water reserving and water management in general,
- to restrict building on territories where inland waters appear regularly, and thereby to reduce the emergence of conflicts and mitigate damages,
- to maintain the balanced land use intensity and development, so as to contribute to sustainable development (to avoid excessively high or low population densities),
- to protect, maintain and increase the green surfaces and green spaces of settlements,
- to increase or at least to maintain biological activity;

7.1.2. The National Spatial Plan

The National Spatial Plan as enacted by the Parliament is a legally binding national plan with graphic as well as written contents, maps and regulations. It defines broadly (at a scale of 1-500,000) the national spatial structure (land uses and technical infrastructure networks and nodes), lays down general rules as well as specific zoning regulations.

In its regulative function it defines the planning (land use) zones as well as the pertaining land use regulations both at the national level and at the regional level. Thus it defines the zones to be delimited at the subsequent spatial planning level the county spatial plans and the plans of the high priority regions (of which two are defined in the National Spatial Plan: the Budapest Agglomeration and the Balaton Resort Region).

Environmental concern and the account of the continental features of domestic climate – prone to extremes both in terms of temperature and of the annual distribution of precipitation – has always been characteristic for spatial planning both at the national and regional level.

It is a natural course of action that the more recent experience, information and policy requirements following from climate change and its impact on the territory of Hungary have been seriously taken into account in the revision and re-elaboration of the National Spatial Plan. (*Amendment (2008) of Act XXVI/2003 on the National Spatial Plan*) The shift in this direction has involved more and more strict rules and regulations of land use.

Zoning regulations are formulated for the following Planning Zones

Planning zones of the National Spatial Plan	Planning zones of the Spatial Plans of Counties
National Ecological Network	Core Ecological Corridor Buffer zone
High quality plough land	
High quality woodland	
	Area suitable for afforestation
Area zoned for landscape rehabilitation, national importance	
	Area zoned for landscape rehabilitation, regional importance
Landscape protection area, national importance	
	Landscape protection area, regional importance
	Area suitable for waste deposit
Cultural heritage area	World Heritage Site Historic heritage site
Area of highly sensitive subsurface water reserve	
Protected catchment area of surface waters	
Area of subsurface mineral reserves	
Conurbation designated for integrated planning	
	Areas prone to ground water inundation
	Flood basin
	Surface prone to geological hazard
	Area exposed to water erosion
	Area exposed to wind erosion
National military defence area	
	Military defence area

The special protection of the sub-surface water reserves, which are indeed vulnerable to climate change, has been a priority of the earlier planning regulations too. So has been the concern for flood protection and the protection from ground water inundation. The land use regulations of the following zones:

- Area of highly sensitive subsurface water reserve
- Protected catchment area of surface waters
- Areas prone to ground water inundation
- Flood basins
- Area exposed to water erosion

- Area exposed to wind erosion

the regulations serve for the protective restriction particularly of land use change, extension of built-up area, type of farming.

Over and above restrictive measures, in these areas of concern significant change and progress have taken place in the field of regional development promoting pro-active policies and relevant developments.

7.1.3. The Tisza Programme

The Tisza Programme deserves special attention owing to its scale, complexity and innovative operations.

The issue of water management along river Tisza and its tributaries and the need for positive (rather than defensive) action has been recognized for a long time. The floods in spring and summer were ever more devastating.

Following a wide-spread, multi-disciplinary research and a lengthy, laborious and difficult consultation process consensus was attained already in the 1990’s in three main aspects:

- The issue flood control in the region is not limited to Hungary. Coordinated action needs to be undertaken by all affected countries of the catchment area. This is of particular importance for Hungary, as the rivers flow from beyond the national borders.

- The responsibility for flood control is not limited to the water management sector. It needs integrated approach, involving the participation of ecology and nature protection, agriculture, transport and particularly regional and urban development.

- In Hungary a major cause of floods and their devastating impact is the sudden and fast flow of an equally sudden and fast growth of water volume of the rivers, and the deposit results the growth of the volume of sediment in the river bed. The rivers thus build their beds. Therefore flood control can no longer be effective by means of constructing higher and higher dykes. Far more effective and sustainable is to create (or re-install) natural reservoirs in the low lying sections of the river valley.

The relevant studies and comprehensive plans are available. The title of this large-scale planned intervention is “Vásárhelyi Development Plan” referring to the name of the engineer who had elaborated the first river-regulation plan of Tisza during the 19^{th} century.

The implementation of this operation is in progress, in the framework of the current New Hungary Development Plan for 2007 – 2013. The interventions and the relevant resources have been specified in the Environment and Energy Operational Programme under the

Priority Axis “Wise Management of Waters”, intervention entitled “Formation of good flood protection practices”. The costs of the operations are covered from the Cohesion and the Regional Development Funds as well as domestic resources.

An important task in the framework of the Vásárhelyi Development Plan is the restoration of the smooth water flow in the main riverbed of Tisza by means of appropriate flood plain regulation, establishment of a flood-reservoir system, strengthening the critical sections in the flood control, rehabilitation of flood-plain water system and the landscape.

Target state to be achieved is reduction of ice free flood level by at least 1.0 meter on river Tisza. Besides the control of floods the flood plains must be restored too by means of regulated water drainage.

The overall objective of the Vásárhelyi Development Plan includes harmonization with management of the unique ecological systems. Furthermore, the developments serve for the protection of people and assets from natural disasters and ensure new opportunities for rural development in the Tisza Plain.

The Vásárhelyi Development Plan focuses on the establishment of clusters of natural reservoirs at five sites along the Hungarian section of river Tisza. The purpose is to channel and deposit surplus water in flood periods. This operation involves interventions into the existing river control and dyke system. Furthermore it directly affects the riverside land-use, as the reservoirs are established on currently cultivated (though not productive) arable land. The resulting land use will be an alternation of water surface (during and after floods) and marshes, meadows or forests in dry periods, involving the development and restoration of wildlife, various eco-systems.

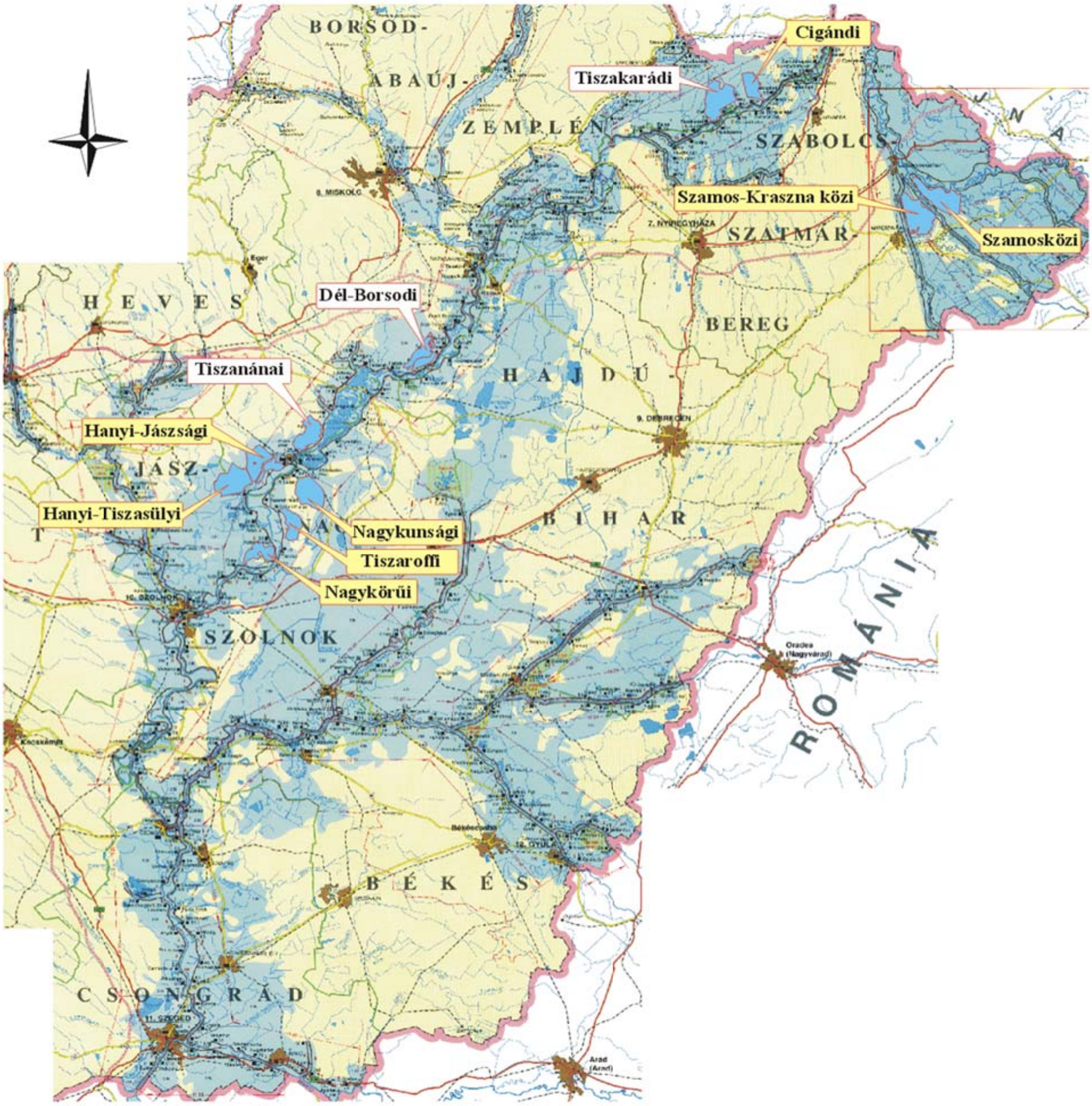
It is assumed that the implementation of these operations will have multiple effects involving widespread changes in land use and local economies. The importance of these latter is underlined by the low economic profile and poverty in this region. Therefore the integrated landscape and water management programme is expected to contribute to broad societal improvements which are targeted by the regional operational programmes of the North and South Plain Regions.

The process which is expected to emerge to a new, higher level phase – owing to the European support and accelerated by the threatening effects of ongoing climate change – began much earlier, and not only by preparatory studies and plans but also by small scale separate actions initiated by municipalities along the river, like the establishment of small, local reservoirs to reduce the hazards and devastating impacts of floods and to restore the riverside ecosystems. Although these actions had but small scale and may be unsustainable results, nevertheless they demonstrated the need and possibility of action.

As the issues and challenges associated with river Tisza and its region are not limited within Hungary's national borders, there have been various attempts to address them at a transnational scale. Earlier steps had been taken to the initiative of the Council of Europe followed by a bi-national agreement between Hungary and Romania. Finally, in 2009 a really transnational project covering the 158,000 km2 of the catchment area could start under the South East Europe Transnational Programme with the support of the European Union and contribution of the participating countries. The title of the project is Tisza / Tisza Catchment Area Development. It addresses the multi-sided environmental, economic, social and infrastructure issues in need of transnational cooperation for sustainable solution. The transnational project with participants from the six directly affected countries will be a contribution to the integrated territorial development of the Tisza area and will help to attain a sustainable economic system, optimum use of pooled natural and cultural resources, balanced distribution of the competitive growth areas and enhancement of the internal and external functional relations in the settlement system of the area.

The main concern of the project is to elaborate a viable common integrated development strategy. The partners work out a common methodology for analysis, strategy building and impact assessment, analyse the relevant aspects, develop pilot programs, build up transnational network for planners and stakeholders, and disseminate the results.

Figure 9: The Tisza flood plain and the planned reservoirs



7.2. Romania

Guide on the Adaptation to the Clime Change Effects

The guide describes different climate change scenarios at global, European, and national levels, and then discusses in detail their impact and the vulnerability for different sectors: agriculture (opportunities, recommendations and adaptation measures), biodiversity, water resources, forests, infrastructure, constructions and urban planning, transportation, tourism, energy, industry, health, recreational activities, and insurances (threats, opportunities, recommendations and adaptation measures). The conclusions include the need for more in-depth research, involvement of research institutions under the coordination of different ministries, identification of previous research performed in Romania, creation of a interdisciplinary scientific group, updating of the scenarios on the climate change, organization of a national campaign for increasing the public awareness, and integration of the aspects on the adaptation to the climate change effects into the legislation. Of particular importance are the issues related to spatial planning, including among the threats landslides, modifications of the materials, damages to buildings, settlements, comfort and welfare of population, while the only opportunity identified is a new market for techniques and materials. The recommendations are promoting systems for the prevention and efficient intervention, resizing of the sewerage, developing appropriate pavements, decreasing the risk, elaborating new standards for construction including novel and "green" technologies and materials, and increasing the public awareness.

National Plan of Action on Clime Change

The document consists of a collection of "fiches" for each required action, including without limiting to: changing the Governmental Decision on the creation of a National Center, strengthening the administrative capacity, improving the National System for estimating the GHG, creation of a National Registry, preparing a communicate for the United Nations Framework Convention on Clime Change, preparing negotiations and actions after 2012, strengthen institutional cooperation, study different scenarios, elaborate the National Plan of Actions for Adaptation, plan a specific research program, identify decisional instruments, elaborate guidelines for J1 projects, establish the framework and prepare the implementation of a GIS-based scheme of green investments, evaluate the needs for transposing Directives 2003/87/CE and 2004/101/CE (approve secondary legislation, elaborate the guidelines and accredit enforcement bodies), present the methodology for elaborating the National Allocation Plan, promote renewable energies, efficient use of energy, co-generation of energy, manage GHG from transportation, close waste deposits, introduce integrated land use systems (land use and its changes), elaborate a Plan of Action for Clime Change and Education, increase public awareness, improve public access to information and public participation.

2005 - 2007 National Strategy on Clime Change

The document is organized in eleven chapters. The first one is an introduction; the second introduces the general objective (fulfill Kyoto obligations, elaborate and implement objectives and measures for adapting to clime change), detailed in more specific objectives; the corresponding actions are detailed subsequently in the following chapters. The third chapter introduces the United Nations Framework Convention on Clime Change, the Kyoto Protocol, the European policy and the position of Romania. Chapter 4 exemplifies actions taken for estimating GHG in Romania and the progress made toward fulfilling the Kyoto objectives. Chapter 5 addresses the vulnerability of Romania to clime change and approaches to possible adaptive actions. Chapter 6 establishes the institutional, juridical and political framework needed to implement the strategy. Chapter 7 details the actions needed to implement Directive 2003/87/CE. Chapter 9 identifies the priorities and measures for reducing CO_2 emissions in the national economy. Chapter 10 describes the activities needed to include clime change issues in education and research, as well as in increasing public awareness and improving public participation to decision making. Chapter 11 estimates the resources needed to implement the strategy, and describes the process of elaborating the National Plan of Action on Clime Change. The conclusions relate the need for actions with respect to climate change to the goals of sustainable development.

The National Strategy on Long-Term Reduction of the Effects of Drought, Prevention and Combat of the Degradation of Lands and Desertification

The document presents the necessity and opportunity of updating the 2000 document (its aim and objectives, actions and measures referring without limiting to international, regional and trans-boundary cooperation, the institutional framework, and sectoral issues: land management, rehabilitation of degraded lands, water and soil management, horticulture, pastures and husbandry, forestry, regeneration of forests, conservation of biodiversity and landscapes, rural communities, research, monitoring, regional development, and energetic security. The second part consists of a presentation of the actions and measures, followed by an appendix. The third and last chapter presents the issue of drought, degradation of lands and desertification in Romania, describing the environment, factors that influence or generate these processes, geomorphology, soils, waters, clime, vegetation and fauna, anthropic influence, statistics and possible correlations of these phenomena (degradation of soils due to drought and desertification, and the adaptation of plants), the national, European and international framework - institutions, legislation, strategies, programs and actions, sectoral issues (agriculture, husbandry, wine and fruit agriculture, water management, forestry, environmental protection and conservation of biodiversity, industry, tourism, commerce, services, rural economy, health, education, civil protection, and social assistance), and concludes with the methodology of elaborating the new strategy: data required, analysis and final presentation.

7.3. Response strategies and policy development of Slovak Republic

Slovak national climate strategy has not been developed so far and it lacks a comprehensive approach to the implementation of the EU's legislative package on climate and energy at national level. Some partial targets are in place – such as reducing CO2 emissions by 8% from 2008 to 2012, as defined by the Kyoto Protocol. However, climate change issue is addressed in National Strategy for Sustainable Development of the Slovak republic. For emphasizing the priorities resulting from the Slovak National Strategy for Sustainable Development the Action Plan for Sustainable Development for the years 2005 - 2010 has been developed and determines the fourteen main aims. As regard climate change, several of these aims are dealing with this topic. For example - main aim No. 6: „Urban reconstruction and territorial regeneration“ promotes of the instruments and processes of landscape regeneration aimed at achieving more efficient and comprehensive territorial development, which includes the Slovakia's water and river basin management plans. Under the waters act, the water management plan is the basic strategic document of water management planning specifying the framework tasks in the protection and improvement of the quality of surface water and water eco-systems, the sustainable and economical use of waters, the improvement of water conditions, the protection of the ecological stability of the landscape, and protection from the harmful effects of waters. The measurable indicators have been set up for this purpose: the draft timetable for the preparation of drafts of river basin management plans and creation of conditions for the protection and improvement of the quality of surface and underground water and water eco-systems. Responsible is central state administration authorities, as Ministry of Environment and other institutions. Funding calculated from the relevant state budget chapter and from EU funds.

Roles of spatial plans in adaptation strategy

Spatial planning in the Slovak Republic is a relatively complex set of instruments and methods at the national, regional and local levels, with the emphasis on applying the decision-making power by the self-government and executive authorities at these levels. It deals with integration of the economic, social and environmental interests that are represented by the sectors (horizontal level) and at the other side by co-ordination of community interests that are the subjects of planning superintendence of the municipalities between the regional and national levels. In this context spatial planning is focused mainly on the land-use plans that are the main instruments for land allocation.

The Strategic Environmental Assessment (SEA) in spatial planning is used as a tool which contributes to a stronger environmental orientation for achieving systematic and transparent assessment of ecological, social and economic aspects. SEA explains the ecological, social and economic context of planning process and can function as a warning in order to protect the environment against already revealed and clearly described dangerous situations and risks coming from the climate change. SEA helps to bring a great number of information on predicted environmental impacts resulting from planning.

The Slovak Spatial development Perspective (KURS)

The Slovak Spatial development Perspective (KURS) is a long term national spatial planning document which has been developed in 2001 and its actualization is under development. The KURS is in line with the European Spatial Development Perspective (ESDP). The KURS is a mandatory document where certain vision of spatial arrangement and functional utilization of the territory of the Slovak republic is expressed. It is important to stress that spatial planning is primarily an instrument of the local government and the KURS is a document where an idea for optimal coherence on national and international level is expressed.

At the regional level the territory of Slovakia is divided among eight regions (NUTS 3) and for all of them the spatial plans of the regions have been developed.

The Tisza River Programme - Slovak part

In Slovakia, Tisza river basin (TRB) covers 19,791 km^2, what is 42,1% of the Slovak Danube basin. The northern part of the river basin is hilly, with the Carpathian Mountains range. Southern part is lowland, the northern edge of the Pannonian Basin. The total length of streams in TRB is about 18,000 km. Geological layers of the upper part of the Tisza river basin are created from flysch – clay sediments, and this is the reason for worsen infiltration of the surface water coming from rainfalls. This creates preconditions for floods events. Floods can have considerable environmental and health consequences, in particular on vulnerability of potable water supplies, on damages caused on citizens properties, on the transport infrastructure in the flood-prone areas.

In an effort to reduce or to prevent food damage, noting that the increase of the heavy rain frequency is caused by the climate change, it has to be admitted that there are some locally or regionally driven accelerators. The increased runoff accelerates very much human actions such as: intensive forest management practices (clearings etc.) in the upper part of the river basin, not proper maintenance of the forest road infrastructure, inadequate drainage practices and an intensive economic activities in flood prone areas. In addition to the current problems of economic activities "old inherited faults" as straightening of rivers and suppression of natural flood plains in the past decades (systematic flood protection started in the mid of 19th century) contribute substantially to the increased danger from flood situations.

"The Water Management Policy Conception of Slovakia until 2015" has declared that current situation in field of mitigation of floods is influenced by reduced natural ability of water retention in particular river basins and accelerated runoff from the territory.

In the Slovak part of Tisza river basin many water management measures for limitation of floods are planned. These measures are contained in Development and Investment Program of River Basin Administrators and are mainly focused on reconstruction of dikes, regulation of stretch and construction of polders. However, as is written above, this problem has to be solved starting from the upper part of the river basin with sophisticated and environmentally friendly approach of management of the whole territory (Kravčík et. all; 2007). The idea of this an inventive approach is build on relatively simple principles “renewal of the small water cycle over an area“ by implementation of comprehensive systematic measures for increasing the water retentiveness and comprehensive anti-erosion measures.

Policy recommendation

The predicted climate change, mainly increasing frequency of extreme weather events is, will have serious consequences for Slovakia. According the state water management policy of the Slovak republic that expected climate change will have a significant impact on total runoff as well as on its distribution within the year.

The number of episodes of heavy rain to the total rainfall will increase and this will have implication for flash floods, development of erosion processes, slope slides etc. Between 1996 and 2002, Slovakia has suffered from 80 major damaging floods, including the catastrophic flash floods. The majority of them have caused victims, the dislocation of hundreds of people and enormous economic losses. Flood disasters in Slovakia are expected to exacerbate this trend and will increase by 19% till 2100 (Aaheim et al. 2008; AEA, 2007).

Contrary to this, dry periods are likely to become more common in summer. Certain adaptation measures have been adopted in the Integrated water management plan (according the EU Water Framework Directive and in the new Flood protection act).

Slovak national climate strategy has not been developed so far and it lacks a comprehensive approach to the implementation of the EU's legislative package on climate and energy at national level. However, climate change issue is addressed in National Strategy for Sustainable Development of the Slovak republic. For emphasizing the priorities resulting from the Slovak National Strategy for Sustainable Development the Action Plan for Sustainable Development for the years 2005 - 2010 has been developed and determines the fourteen main aims.

Under the waters act, the water management plan is the basic strategic document of water management planning specifying the framework tasks in the protection and improvement of the quality of surface water and water eco-systems, the sustainable and economical use of waters, the improvement of water conditions, the protection of the ecological stability of the landscape, and protection from the harmful effects of waters.

According to the Euro barometer survey 41% of Slovaks think that climate change is the most serious problem the world is currently facing, and 66% of respondents believe that it is very serious and 76% do not believe that it has been exaggerated.

In general, the Slovak national climate strategy should have to be developed soon. However, some measures contains Development and Investment Program of River Basin Administrators, e.g. reconstruction of dikes, regulation of stretch and construction of polders. However, as is written above, this problem has to be solved starting from the upper part of the river basin with sophisticated and environmentally friendly approach of management of the whole territory.

Good governance in Slovakia

In Slovakia flood protection measures in the past had been focused mainly at securing citizens, their properties in urban areas by investment activities into serious water works as dams, dike systems etc. just to catch and store water from heavy rains, from spring melting snow and to transport it downstream. With this highly costs consuming technical approach was possible to protect just part of the urban areas which had been exposed to floods and the rest of them are still at danger of flood situation. And because of changing climate patterns, increased intensity of rain the flood risk dramatically increases. Such concepts have proven that do not protect all citizens, all villages.

The new solution which came on scene is a complex integrated water management in the river basin which is based on efficient flood protection approach by the ***spatial optimization*** of the ecosystems and thus to retain water *in situ* - on place. The Government of the Slovak Republic has approved the resolution No. 774/2010 ***The Landscape Revitalization and Integrated River Basin Management Programme for the Slovak Republic*** on October 27, 2010. The new programme is established on to slowing down surface drainage, transforming surface rain water into soil, eliminating soil erosion processes in whole river basins. This will decrease flood flows and flatten flood waves so as to lead to a lower risk of destructive flash floods. A synergetic effect of the programme during its full-scale execution will be a decrease in the impact of extreme rains on river basins/areas/landscapes, thereby lowering the risks of landslides, which are accelerated by concentrations of rain water formed by excessive and high levels of precipitation.

The programme will result in:

- Protection from floods, drought and other risks of extreme natural events
- Construction of effective and complete flood protection and protection against other risks for the entire territory
- Jobs creation for locals mainly during water works and than on their maintenance
- Innovative approach will support innovation of citizens

- safe environment for life.

This new approach is supported by the EU Directive on the Assessment and Management of Flood Risks (2007/60/EC) and the Integrated Water Framework Directive (2000/60/EC).

The execution of the programme will expand the opportunities for locals, for local communities, for their direct involvement in implementation and later on maintenance. To effectively support the optimization of the spatial organization of such management activities in landscapes, in particular within agricultural and forest management and land use planning with respect to this change towards society's approach. This will create an environment where locals will feel as part of their responsibilities to care of management on water resources, to care of river basin management.

8. Adaptation options

To be able to define the adaptation options accurately, the vulnerability study must be further developed. This is especially relevant for the floods. This issue is extremely important as the significance of trans-boundary co-operation among several nations is the greatest here. To describe the issue of floods and vulnerability more accurately, the terminology should be clarified on the one hand, and the missing data bases set up, on the other. It is already apparent that the elaboration of a sustainable regional and land use structure complying with the potentials and opportunities will have a very important role in adaptation. Sustainable land use can contribute to the mitigation of the impacts of floods and droughts alike.

The attainment of future land use objectives can be supported by incentive payments, first and foremost, on the territory of forestry and agriculture, and by regulations in the fields of land use and spatial development.

In the hilly regions sustainable select-cutting forestry should be the goal. Extreme flow conditions would be much rare in case of appropriate forest management. On the plains, adjoining the river discharges on the protected sides, flood zone farming systems could be established, such as flood zone forests, pastures and orchards, etc.. These would, on the one hand, contribute to the mitigation of damages caused by drought and inland waters, on the other, would facilitate the production of special agricultural goods.

It would be reasonable to set the land use targets in a common master plan to be elaborated in common by the countries sharing the water catchment area of River Tisza and would be advisable to model the potential future consequences of the various land use categories jointly as well.

Recommendations by Planners

Spatial planning

- the vulnerability study should be further developed (improved) and extended to cover the entire water catchment area (that is, on the Ukraine and Serbia, too).
- the base data missing for the vulnerability study should be generated or obtained.
- indicators based on the data obtained or generated as aforesaid should be elaborated.
- based on the improved vulnerability study, a new common adaptation strategy should be elaborated and it should be incorporated into the national spatial development tools, and used in their implementation.
- a common spatial development master plan should be elaborated and impact study of the land use interventions prepared,
- according to the land use plan

Agrarian policy

- to put the subsidies for the aquatic habitats, areas affected by inland waters, and the landscape management of flood plains in the forefront within agrarian environmental management
- to elaborate recommendations regarding the various opportunities of breeding drought resistant species
- to inform and prepare the farming society more efficiently for the climate change

Water management

- the synergies between anti flood and internal waters protection and spatial and rural development should be exploited
- river discharge on the protected side and the landscape management of flood plains should be harmonized.

9. Comperision of findings of the case study and pan-European assessment

The overall findings and pictures derived from the case study are, in some cases, different from the ones obtained from assessing the European situation. The differences have, in general, two causes:

1. The multi-scale approach: the Tisza River case study could be considered a product obtained by ‘zooming in’ the overall pattern. While the maps showing the Tisza River area show inner differences, they are lost when the range of values is assessed at a

European level, since the values for Tisza area could cluster in the upper or lower portion of the overall range. To illustrate, the quasi homogeneous spatial structure of the change in annual mean temperature and change in annual mean number of summer days does not allow the classification of Tisza River area into five classes.

2. The cooperation between the countries involved in the Tisza River case study revealed methodological differences, not only in the use of indicators, but also in the methodology used to compute a specific indicator. When differences where visible to an extent suggesting that an entire country had values higher or lower than the others, a common methodology was used. The choice may differ from the European one, and even if it the same, some differences are still expected. To offer an example, the subsistence agriculture, predominant in Romania, provided the overall importance of the sector – also reflected spatially in the share of agricultural lands, results into different values of indices related to this sector when the results are compared to those referring to countries where agriculture is a business.

Considering the two explanations, Table 1 summarizes the key findings of the Tisza River Case Study and the overall pan-European findings. The table discusses exposure, vulnerability, and adaptive capacity overall, and details the particular situation of the three variables common to both the case study and overall assessment (Table 3 of FR Scientific Report). Several differences are noticeable:

1. Exposure: while the case study indicates that the annual mean temperature is less representative than other variables, the entire region appears as a 'hotspot' at the EU level due to its significant projected temperature increase. The explanation consists here of the fact that the Tisza area values situate at the endpoint of the scale, but do not exhibit relevant differences in the regional distribution.

2. Sensitivity: plains and basins on the South-Eastern part of Tisza River area differ very much from the rest of the region. The difference is attributable to the fact that in Romania the economic and social sensitivity of agriculture is extremely high, and that the most important form of agriculture is the subsistence agriculture. In terms of flood the pan-European data were used.

3. Adaptive capacity: awareness, ability and action are lower than in other parts of Europe and significant differences exist between the three different dimensions. This is merely a consequence of the normalization of data: although there are considerable differences in the adaptive capacity among the Tisza river valley, they are relatively small compared with the different performance of all European regions.

In addition, there are several specific conclusions pertaining to the case study, which differ from the European situation:

1. Exposure: a probable growth in the frequency of droughts is expected due to the considerable reduction in the volume of summer precipitation, and also a decrease of the volume and duration of inland waters swamp could occur due to the increase in the volume of winter precipitation

2. Sensitivity and impacts: in the Tisza River area, flood events causing damage are a major issue and appear to be always related to the overtopping and/or failure of dykes in the region where over 95% of the natural floodplain is protected by existing embankments. The modification of flood hazard and flood risk seems to be related to the changing frequency of floods endangering protection structures and/or exceeding their crest. Consequently, the extent of inundation and associated damage can be mitigated by properly implemented confinement plans.

3. Adaptive capacity: appears to be relatively small compared with the different performance of all European region

Table1 Summary of key findings: a comparison between the Tisza River Case Study and overall findings

Research Question	**Tisza River Case Study**	**Overall findings**
Exposure	Probable growth in the frequency of droughts due to the considerable reduction in the volume of summer precipitation Decrease of the volume and duration of inland waters swamp due to the increase in the volume of winter precipitation	“Change in frost days” and “change in days with snow cover” show negative values (decreasing number of days), whereas “temperature change” and “relative change in summer days” show positive values (increasing temperature or days). For other variables, both increases and decreases are projected.
Change in annual mean temperature	Annual mean temperature change less representative than seasonal changes Quasi homogeneous spatial structure of warming does not allow the classification into five classes.	Strong increase in annual mean temperature in ‘Northern Europe’, ‘Southern central Europe and ‘Mediterranean region’ Annual mean temperatures projected to increase between 2 and over 4.1 °C South-Eastern Europe projected to experience the highest temperature changes with absolute changes of more than 3.5 °C

Table1 Summary of key findings: a comparison between the Tisza River Case Study and overall findings

Research Question	Tisza River Case Study	Overall findings
Relative change in annual mean precipitation in winter months	Characteristic indicator of regional climate change in Tisza region	Southern Europe will experience decreases in winter precipitation of 10% and more
Sensitivity and impacts	Flood events causing damage always related to the overtopping and/or failure of dykes in the region where over 95% of the natural floodplain is protected by existing embankments Modification of flood hazard and flood risk related to the changing frequency of floods endangering protection structures and/or exceeding their crest Extent of inundation and associated damage mitigated by properly implemented confinement plans	Physical assets sensitive to extreme weather events mainly concentrated along the coastline Socially sensitive human populations mainly concentrated in Southern European agglomerations and along the coastline Economic sensitivity highlights local economies dependent on tourism, agriculture and forestry in large parts of Eastern Europe Mountain and river delta regions have protected natural areas and/or possess sensitive soils and forests Concentrations of sensitive cultural assets in regions along the coasts and major rivers, as well as particular old cities and historic sites deliberately located along major rivers.
Adaptive capacity	More diverse picture than aggregated sensitivity or aggregated exposure Areas of poor adaptive capacities predominant in the South-Eastern Result almost in line with the pan-European assessment, but a consequence of the normalization of data: although there are considerable	Adaptive capacity of European regions analyzed in terms of the dimensions of adaptive capacity: awareness, ability and action For Eastern Europe, all three dimensions are lower than in other parts of Europe and significant differences exist between the three different dimensions Indicators used for measuring

Table1 Summary of key findings: a comparison between the Tisza River Case Study and overall findings

Research Question	Tisza River Case Study	Overall findings
	differences in the adaptive capacity among the Tisza river valley, they are relatively small compared with the different performance of all European regions.	action are consistently low across the regions within Eastern Europe

10. Conclusion and transferability

The agricultural vulnerability assessment presented in the study can be used in regions where the role of the agriculture and the changes in the climate parameters effecting agriculture change similarly to that in the Tisza region. Such are, e.g., the countries of South-Eastern Europe.

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Basic data sources of vulnerability analysis

Vulnerability of agriculture

Exposure:

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European region MPI-M/MaD. World Data Center for Climate.

Further data Processing: PIK, TU Dortmund

Sensitivity:

<u>Social and economic sensitivity:</u>

Hungary: Hungarian Statistical Office

Slovakia: Office of Statistics of Slovak republic

Romania: Romanian Institute of Statistics

<u>Arable land sensitive to drought:</u>

Soil map FAO-UNESCO

Processed by Centeri Csaba PhD (Szent István University) and

Krisztián Schneller VÁTI Nonprofit Ltd.

Calculation methodology Czira T and Dobozi E. VÁTI Nonprofit Ltd.

Arable lands : Corine Land Cover

<u>Arable land sensitive to excess water:</u>

Soil map FAO-UNESCO

Processed by Centeri Csaba PhD (Szent István University) and

Krisztián Schneller VÁTI Nonprofit Ltd.

Calculation methodology Czira T and Dobozi E. VÁTI Nonprofit Ltd.

Arable lands : Corine Land Cover

Adaptive capacity:

Hungary: Hungarian Statistical Office

Slovakia: Office of Statistics of Slovak republic

Romania: Romanian Institute of Statistics

Ministry of Rural Development Hungary (Natura sites)

Vulnerability in terms of flood

Impacts

Flood prone area (current and predicted) : JRC LISFLOOD, COSMO CLM2010

Settlements: CORINE: 2006

Roads and railways

SEE TICAD project 2009-2011

Hungary: DTA-50 Digital Topography Base Map, 20

Slovakia: SSC (road management authority), basic map, 1:50 000, 2010

Agricultural area: Corine 2006

Adaptive capacity:

Hungary: Hungarian Statistical Office

Slovakia: Office of Statistics of Slovak republic

Romania: Romanian Institute of Statistics

List of indicators

Sensitivity indicators of Tisza river case study area:

Soil properties in terms of crop production sensitivity to drying climate

Soil properties in terms of crop production sensitivity to excess water

Impact indicators:

Change of potential impact of 100 year river flood event on settlements

Change of potential impact of 100 year river flood event on high speed roads

Change of potential impact of 100 year river flood event on main roads

Change of potential impact of 100 year river flood event on main railways

Potential impacts of decreasing summer precipitation on crop production

Potential impacts of increasing winter precipitation on excess water inundation and crop production

Indicators of adaptive capacity:

Population with higher education

Scientist and engineers in R&D

Irrigated area

Share of Natura 2000 area

Income per capita

Employment rate