Climate Strategy for the Upper-Tisza Region

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"CLIMATE CHANGE IS URGENT, AND IF WE DELAY, WE WILL BE IN MORE TROUBLE. BUT LET'S NOT COMPLAIN ABOUT THE PROBLEM, LET'S START TO DO SOMETHING ABOUT IT, LET'S NOT WAIT FOR OTHERS TO DO SOMETHING ABOUT IT, AND LET'S NOT SHIFT THE RESPONSIBILITY ONTO OTHERS. AS PART OF THE SEVEN BILLION OF HUMANITY, WE ALL HAVE AN IMPACT, AND THAT'S NO SMALL THING, BUT IF WE LOOK AT IT FROM OUR OWN PERSPECTIVE, WE CAN SEE THAT WE ARE A WORLD OF OUR OWN. LET'S MAKE THIS WORLD MORE LIVEABLE, LET'S HAVE FUN IN IT."

ANTAL DOBOSY

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1. General hydrogeographic and natural geographic characterisation of the Upper Tisza catchment area

1.1. Hydrogeographical characteristics of the river basin

The catchment area of the Upper Tisza, including the Bodrog river basin, covers a total of 49 082 km2. The length of the river to the Bodrog estuary is 416 km. The highest point of the basin is the Nagy-Pietrosul (Pietrosul Rodnei), 2305 m high, located in the Radna Hills, and the lowest point is 90 m high in the area of Bodrogköz. The areas above 1600 m above sea level represent 1 % of the total catchment area, the areas between 1600 and 600 m account for 25 %, the areas between 600 and 200 m for 42,6 % and the areas below 200 m for 31,5 %. 47 % of the catchment area belongs to Romania, 25 % to Ukraine, 14-14 % to Hungary and Slovakia (Figure 1.1). The catchment is geographically divided into four major regions. These are: North-Western Carpathians, North-Eastern Carpathians, Transylvanian Mountains and the North-Eastern part of the Great Plain. The catchment area is made up of tectonically and structurally well separated parts. The mountainous and hilly areas of the catchment area are the Prešov-Tokaji Mountains the Vihorlat / Vihorlatské vrchy / Вигорлат, Szinyák / Синяк, Borló / Великий Діл, Hát, the small volcanic cones of the lowland edge (Tarpai-Hill, Koszony- Hills / Косонь, *Berehove*-Hill (Берегове), Vinohragyiv-Hills (Виноградів), Munţii Oaşului / Avas, Kőhát / Igniş / Creasta Pietrii, Rozsály, Munții Călimani / Kelemen-Hills, Gutin / gutinska / Munţii Gutâi, Sălaj / Szilágysági-Hills, as well as the Eastern-Beszad / Bieszczady / Bukovské vrchy and the Muntii Maramureșului / Мараморошський масив / Máramarosi-Hills which are mainly composed of flisch. The lowlands include the Ugocsa plain, the Ungi plain, the Satu Mare plain, the Beregi plain, the Bodrogköz, the Rétköz and the Nyírség.

The highest ridges of the area absorb the humid air masses from the west and south-west, and therefore the average annual precipitation is 1400 mm here. 80% of the precipitation comes from the Atlantic and the Mediterranean, and 20% from local upwelling. The climate of the North-Eastern Carpathians is dominated by continental influences. January mean temperatures range between -2 and -4 degrees Celsius. Annual precipitation is between 1200 and 1600 mm at higher altitudes and between 800 and 1000 mm at lower altitudes. Only in the closed, low-lying basins and in the Nyírség area of the Plain, does it fall below 600 mm.

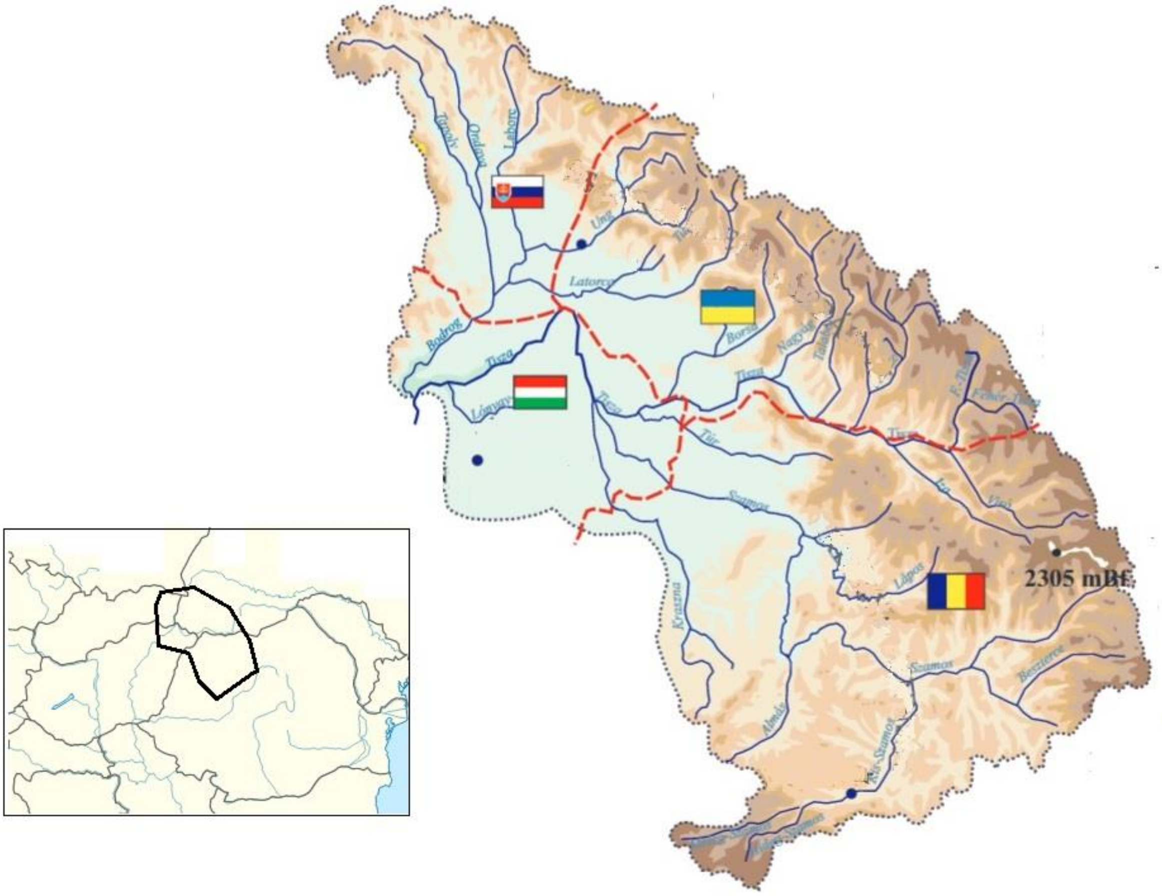

Figure 1.1: Situation of the Upper Tisza river basin

Source: after Konecsny (2004)

On the mountainous section of the river, the average fall over the 200 km from the source of the Fekete-Tisza to Tiszaújlak is 8 m/km (Andó 2002). From Tiszaújlak it has a further drop of 190 cm/km, then drops to 70 cm/km on the Ugocsai plain to Tiszabecs. From Tiszabecs, the river becomes completely lowland in character, falling 13 cm/km to the Szamos estuary, and from there to the inflow of the Bodrog 9.5 cm/km (Vágás 1979, Lászlóffy 1982).

The Upper Tisza catchment area is influenced by continental, oceanic and Mediterranean climate systems, which have a decisive influence on the distribution of precipitation over the year and thus on the timing of floods. The most frequent flood events in the Upper Tisza occur in March-April and during the winter season (Lászlóffy 1982). The little precipitation of the winter months usually arrives in the form of snow, which melts at the end of February in the Great Plain, although the number of snow-covered days has decreased significantly in the last three decades. At higher altitudes, melting occurs in March and April (Andó 1979, Konecsny 2002). Floods fed by snowmelt rarely reach record levels and usually consist of a prolonged series of smaller floods.Only if significant precipitation falls at the same time as the snow melts can exceptional water levels develop (Konecsny 2002). This was the case for the floods of 1999, 2000 and the dam burst floods of 2001. In late spring and early summer, cyclones from the Atlantic often cause floods, but they only reach higher elevations if they are accommodated by a full floodplain due to prolonged spring flooding (Lászlóffy 1982). The south-western exposure of the Upper Tisza's right-bank tributary catchment provides a barrier to autumn cyclones from the Mediterranean, which causes frequent flooding in November and December. Examples include the floods of 1915-16, 1947-48 and the record high water level (LNV: 953 cm, Figure 1.2) at Tivadar in November 1998 (Konecsny 2002). Based on the above, the Upper Tisza may therefore experience three major floods per year.

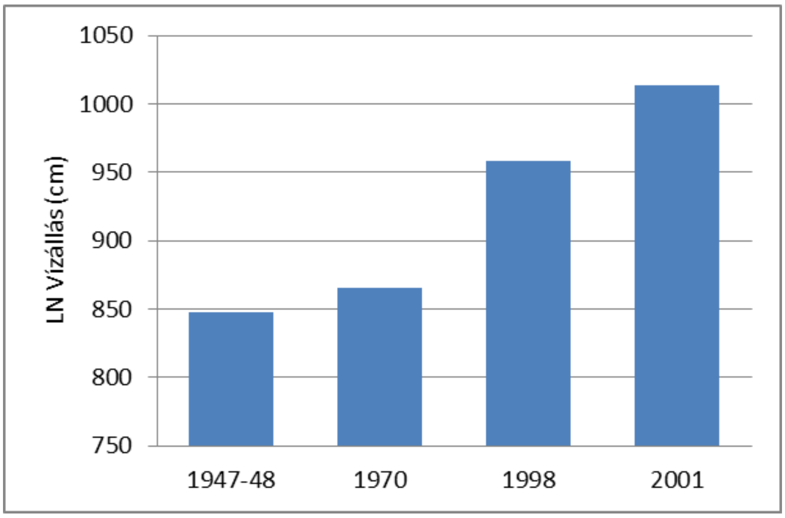

Figure 1.2: Evolution of maximum water levels of the Tisza in the Tivadar section of the Tisza *Source: (Konecsny 2003*)

1.2 Hydrogeographical characterisation of the Upper Tisza sub-basin above the Szamos estuary

The Upper Tisza above the Szamos / Someș estuary covers an area of 13500 km2, with a total river length of 2080 km and a density of flows of 6.36 km/km2. The sub-basin has a very high relief energy, with steep slopes with steep gradients and relatively short streams, which reach the receiving waters quickly, almost simultaneously. Floods are usually concentrated due to high rainfall and heavy precipitation. Due to geological and hydrological conditions, the Upper Tisza alone (without the flooding of the Szamos / Someș) is capable of triggering a flood wave of such magnitude that it is also strongly felt in the Lower and Central Tisza.

The table in Figure 1.3 illustrates the significant role of snow-stored precipitation in the distribution of water resources in the Upper Tisza

Sub-catchment	J	F	M	Ap	M	Jun	July	Aug	S	O	N	D	Year
Area averages of surface water input (mm)													
Upper-Tisza	22	42	122	124	101	122	118	116	91	94	73	45	1070
Szamos Someș	21	39	79	72	81	102	91	86	60	64	51	40	786
Bodrog	27	46	87	70	75	98	95	98	71	75	66	47	855
Average snow cover over the area (mm)													
Upper-Tisza	20	40	106	71	12	0	0	0	2	11	25	29	316
Szamos Someș	18	34	59	19	2	0	0	0	0	4	14	22	172
Bodrog	21	40	62	16	1	0	0	0	0	4	15	25	184
Share of surface water inputs from snow (%)													
Upper - Tisza	91	95	87	57	12	0	0	0	2	12	34	65	30
Szamos Someș	86	88	75	26	2	0	0	0	0	6	28	55	22
Bodrog	78	87	71	23	1	0	0	0	0	5	23	53	22

Figure 1.3: Water resource distribution of the Upper Tisza sub-basins based on a multi-year average *Source: Andó (2002)*

In areas above 2,000 metres above sea level, snow accumulation starts as early as October, while above 1,500 metres it starts in November. (Andó 2002). The Upper Tisza is characterised by extreme extremes in flow and runoff in a year. In the mountainous section at Raho, the ratio between minimum flow (1.14 m3/s) and maximum flow (734 m3/s) is 1:700 due to rapid runoff and lack of summer snowpack. At Tivadar the ratio is only 1:150, with an average flow of 244 m3/s, at Vásárosnamény below the Szamos estuary 1:106, with an average flow of 350 m3/s, and at Tokaj 1:74, with an average flow of 450 m3/s (Andó 2002, Konecsny 2002). From the above, it is clear that the low and medium flows of the Tisza are gradually increasing downstream, with a simultaneous decrease in the ratio between the extremes. This is due to the recharge of tributaries and groundwater (Andó 1979). There is a significant increase in maximum water levels (LNV) between 1947 and 2001 (Figure 1.3).

In addition, the increase in annual maximum water yields measured in the Tivadar section in the period 1955-2000 was approximately 20% (Konecsny 2002). In the Upper Tisza, the highest flow ever recorded (4 040 m3/s) was measured at Tivadar in 2001. During the same flood, the maximum was only 3620 m3/s at Záhony, confirming earlier observations that tidal surges are gradually flattening out below the Szamos estuary (Konecsny 2003). In the opinion of hydrologists, the rise in LNV (record high water level)in the Upper Tisza was not caused by wave-floor siltation, as described for the Middle Tisza (Nagy et al. 2001), but "by a strongly upward trend in water yield" (Konecsny 2003). Only 72 hours elapsed between the time of the 2001 Tarpa dam burst and the onset of the rainfall that caused it. During this time, a water level rise of 1200 cm was recorded at Tivadar (Konecsny 2003). The minimum annual runoff at Tivadar is about 3 km3/year and the maximum is 12 km3/year. As with the water yield, this value increased by an average of 20 % between 1955 and 2000, despite the fact that the area average precipitation decreased by 8-10 % during the period under consideration. This shift represents an increase in the average annual runoff from 0.5 to 0.65 (Konecsny 2002). According to Illés and Konecsny (2000), the increase in runoff is clearly due to anthropogenic activities in the catchment and their interaction:

- a 17-20% reduction in forest cover in the catchment (Illés and Konecsny 2000),
- changing agricultural practices (land improvement, water management)
- creation of floodplains, reservoirs
- urbanisation effects (increase in paved surfaces, sewerage)

Although deforestation has had a negative impact on runoff, it has not played a decisive role in the development of record floods (Illés and Konecsny 2000). The persistence of floods increases downstream, primarily due to the high flows of tributaries and the Tisza, which peak at different times (Figure 1.4).

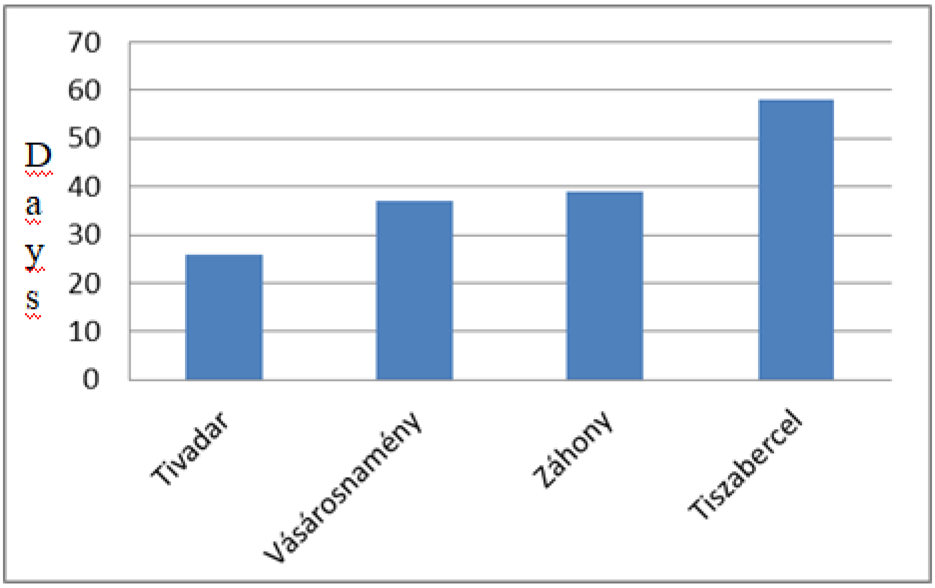

Figure 1.4: Flood wave persistence in the Upper Tisza based on a multi-year average

Source: (Konecsny 2003)

During the November 1998 flood, measurements of the water flow in the 1500 m wide bridge section of the Tisza in Vásárosnamény showed that only 16% of the total water flow of 3480 m2/s is transported over the floodplain, so most of the water flow is delivered to the main Tisza riverbed (Illés-Konecsny 2000). For a 50% reduction in total flow, the transport capacity of the floodplain is reduced to 2%. At low tide, a concave water surface, clearly visible to the naked eye, was formed on the section of the basin above the Vásárosnamény bridge, due to the suction effect of the main basin on the wave field (Konyecsny 2002). This phenomenon may have a major influence on the processes of wave-field accumulation and erosion.

Of particular note are the much less important watercourses that flow directly into the Tisza. The river Kraszna (length: 193 km, average flow: 3 m^3/s, catchment area: 3142 km^2) and Túr (length: 95 km, average flow: 8.8 m^3/s, catchment area: 1262 km^2), as well as the Lónyai main channel (length: 91 km, average flow: 1.8 m^3/s, catchment area: 1960 km^2), which collects water from the areas north of the Nyírség watershed.

1.3 Hydrogeographical characterisation of the Szamos sub-basin

The Szamos (Somes) is a left tributary of the Tisza. The Nagy- and Kis-Szamos (Big-and Small Szamos), which merge at Dés, flow into the Tisza at Vásárosnamény. The Szamos sub-basin is characterised by much lower altitudes than the Upper Tisza above the Szamos estuary. The extension of the sub-basin to the estuary of Szabos at Vásárosnamény is 15638 km2, the total river length is 1696 km, and the density of watercourses is 7.8 km/km2 (Lászlóffy 1982, Andó 2002). Most of the catchment area of the Szamos River (15262 km2 - 96.1%) belongs to Romania, the part in Hungary is 306 km2, the total area is 3.9%. Of the total river length of 411 km, the upper 376 km is in Romania, the lower 49.4 km is in Hungary (Konecsny 2010). The mean flow of the river over many years is 5.50 m3/s at Rodna Veche and 131 m3/s at Csenger (Konecsny-Bálint 2010).

The majority of the catchment area is composed of hilly and low-mountainous (below 1500 m) landscapes, most of whose surface is covered by young (Miocene) clay-loam layers, resulting in less steep valley sides, which also affect the flow conditions. Only 1.1 % of the area (160 km2) falls within the 1 600 m elevation range, compared with 2.4 % (318 km2) for the Upper Tisza to the mouth of the Szamos. The higher parts of the sub-basin, with a greater and more balanced water supply, are located in the east and south. The Radna Hills (Muntii Rodnei), the Clement Hills (Muntii Calimani), the Gyalui Hills (Muntii Gilaului). On its lower course it receives the waters of the Cibles, Gutin (Muntii Gutinului) and Bükk (in Szatmár county). Due to the altitude, the amount of precipitation falling on the area is also lower, averaging 600-700 mm. Consequently, although the catchment area of the Szamos is about 2000 km2 larger, its flow is only 126 m3/s, while the Upper Tisza to the mouth of the Szamos is 224 m3/s. Precipitation in mountain and hilly areas is much higher than on the plains. The highest multi-year mean precipitation is recorded in the Gutin and Cibles mountains, in the Radnai hills, Muntii Rodnei (1000-1200 mm), in the Kelemen hills, Muntii Calimani and in the Vládeasa (Vládeasa) area. The smallest is recorded in the lower Szamos sub-basin with a total of 550-650 mm (Konecsny-Bálint 2010).

The maximum estimated yields during the 1970 flood were as high as 3000-3800 m3/s, while some calculations put the value as high as 4200 m3/s (Vágás 1979), which exceeded the maximum yield of the Upper Tisza (4040 m3/s). The Szamos was regulated in 1855 on the basis of plans by Frigyes Boros (Vágás 1979). The original 226 km long section between Vásárosnamény and Sikárló (Cicarlau) was shortened by 53 % to 119 km by the cut-offs, which resulted in a significant increase in the river's fall. The spring and summer floods of the Szamos usually coincide with those of the Tisza, while in autumn, when the

Transylvanian basin rarely receives significant rainfall, the Tisza does not increase its high flows. The Szamos valley has a forest area of 502000 ha, which represents 31.8% of the total catchment area.

1.4 Hydrogeographical characterisation of the Bodrog sub-basin

The rivers that make up the Bodrog (Latorca, Ung, Laborc, Tapoly, Ondava) originate in the north-eastern Carpathians and have a catchment area of 13579 km2. The merged Latorca and Ondava now continue their course as Bodrog, which is 65 km long to its mouth at Tokaj.Its Hungarian section is 51.1 km long, while its catchment area in Hungary is 972 km2.

At Sárospatak the mean discharge is 122 m2/s, the maximum discharge is 1250 m2/s (Lászlóffy 1982).

The average fall of the Hungarian section of the river is 20 cm/km. Its sediment yield is minimal, except during periods of high water, when it mainly transports suspended sediment (Borsy et al. 1988). Despite the relatively large fall, the low sediment yield and flow velocity is due to the Tiszalök dam, which has an effect up to km 37 of the Bodrog. As a consequence, a significant part of the sediment is already deposited in the upper stretches (VKKI 2010).

The Bodrog floods have not had a decisive influence on the Tisza floods. An exceptional case was the flood of 1888, when the two rivers partially met and the LNV (record high water level) at Tokaj was 872 cm (Andó 1979). Thanks to the efficiency of the reservoir system built on Slovak territory since then, a new LNV was only formed in 1998, when the Tisza was re-injected. The 55-year water level data for the Bodrog in Sárospatak and the 110-year water level data for the Tisza in Tokaj show that the number and duration of flood surges and water levels reaching flood protection level III are continuously increasing (Szabó et al. 2011). This phenomenon is probably due to anthropogenic causes as described for the Upper Tisza. Since the Tisza has a significant and long-range backwash effect on the Bodrog, the course of the floods affecting the Bodrog can be well studied using the water balance data from Tokaj (Szabó et al. 2004).

According to the Tokaj data series from 1980-2002, the water level exceeded 600 cm on 54 occasions, which is associated with 100% flooding of the Bodrogzug river basin (Figure 1.4), but even 550 cm flooding covers more than 80% of the area (Figure 1.5). There are three peaks in the distribution of tidal surges over the year. The most frequent are the snowmelt-fuelled floods in March and April, followed in roughly equal numbers by the late spring, early summer green tides and the autumn and winter floods caused by the Mediterranean cyclones. The highest persistence of water levels above level 1 is in the spring months, followed by November and December, and the lowest persistence in summer floods (Szabó et al. 2004).

Figure 1.5: Surface of the Bodrogzug at a water level of 596 cm measured at the Tokaj water level gauge, corresponding to 100% flooding of the area. *(Photo by Dr. József Szabó, March 2005)*

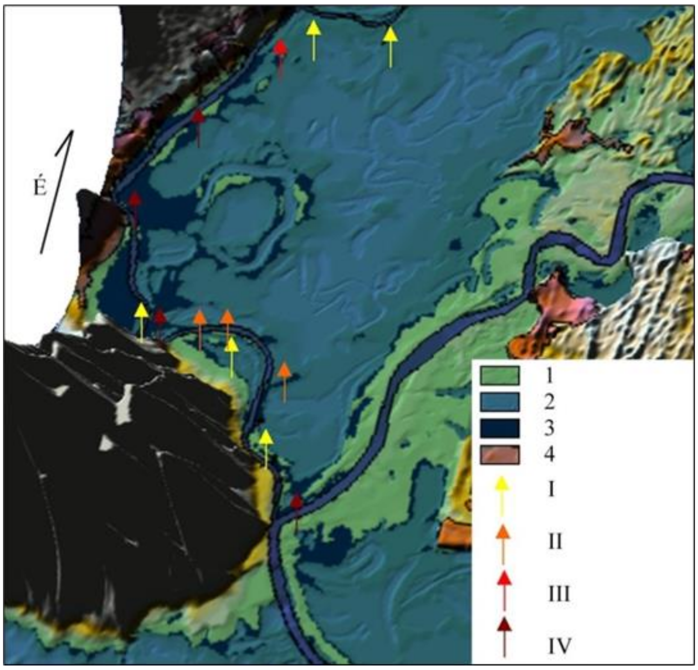

Figure 1.6: Flood map of the southern part of the Bodrog river basin for different water levels. 1: areas higher than 575 cm water level. 2: areas deeper than 550 cm, 3: areas deeper than 575 cm. I, II, III, IV: natural flood gates affecting water movement. (*Szabó et al. 2004*.)

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2. Climatic characteristics of the Upper Tisza catchment

For the climate characterization of the Upper Tisza catchment, we largely used the CarpatClim database, which is a homogenized grid point database of observations (Kovács et al., 2013; Spinoni et al., 2015). These are the most reliable data available for climatological analyses for the study area (Lakatos et al., 2013; Szentimrey et al., 2010). In addition, for the Hungarian catchment area, the homogenised grid point database available in the National Meteorological Service meteorological database was used, which covers the period 1971-2020 (https://odp.met.hu).

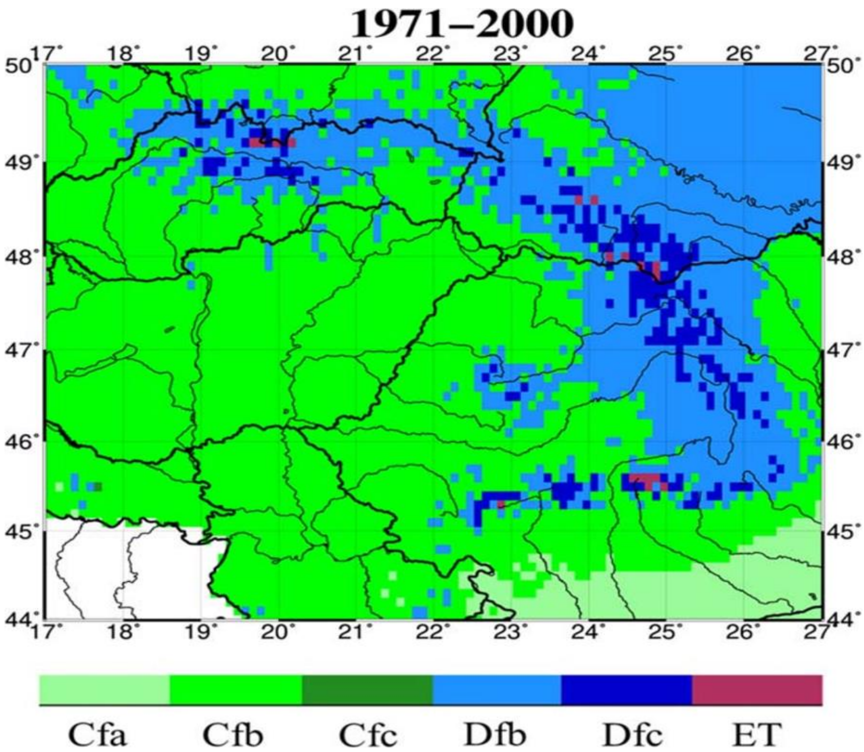

Figure 2.1: Climate of the Carpathian Basin based on Köppen's climate classification for the period 1971-2000 *(Ács et al., 2020; Szabó, 2017)*

Climatic characteristics of the catchment according to Köppen's global climate classification, the lowland areas fall into zone Cfb (C: warm temperate zone with mean temperatures of the coldest month between 18 °C and -3 °C, no regular snow cover; f: uniformly wet; b : long, cool summers), while the mountain areas are mostly in zone Dfb (D: continental boreal, a belt characterized by extreme interannual temperature variations; f : uniformly wet; b : long, cool summers), and in some places Dfc (f : uniformly wet; c : short, cool summers) and ET (ET: high mountain tundra climate with short summer growing season) (Ács et al. , 2020; Szabó, 2017).

2.1. Climatic characteristics of the Hungarian catchment

2.1.1. General climatic characteristics

The Hungarian catchment area is characterised by three main climatic influences, such as continental, oceanic and Mediterranean. Of these, the continental is the most dominant, giving the region a moderately cool and moderately dry climate. According to Köppen's global climate classification, a large part of the catchment falls within the Cfb zone, while a small part falls within the Dfb zone (Figure 2.1).

2.1.2. Solar radiation characteristics in the Hungarian catchment area

Annual daylight hours vary between 1950 and 2100 h in Szabolcs-Szatmár-Bereg county (Bihari et al., 2018). Most sunshine occurs in July and August, while the least in December, which is related to the amount of cloud cover, which is highest at this time. The average annual amount of global radiation in the county varies between 4300 and 4600 MJ/m2, increasing from north to south.

2.1.3. Temporal and spatial variation of temperature

The mean annual temperature in the parts of the Upper Tisza region belonging to the Great Plain and in the northern part of the Nyírség is around 9.7 °C in Sátoraljaújhely, 9.7 °C in Mándok, and around 10 °C in Napkor in the western part of the county. In the eastern part of the county, more specifically in Csaroda, the multi-year average temperature is 9.9 °C, while in the southern part of the area it is 10.1 °C in Pátyoda. The average annual temperature trend in the northern part of the county is lower by 0.2 to 0.4 °C, with no significant differences between the several stations (Figure 2.2).

The coldest month is January, with average temperatures ranging from -2.2 to -2.6 °C in the lowlands of the county. The hottest month is July, with averages over many years of between 20.2 and 22.5°C in the lowlands. The average number of summer days ranges from 60 to 70 days, while the average number of winter days ranges from 30 to 35 days, with more, up to 40 days, in the eastern parts of the county. The highest temperature was 40.2 °C, recorded on

16 August 1952 in Nyíregyháza, while the absolute minimum was -27.8 °C on 18 February 1940 in Nyíregyháza.

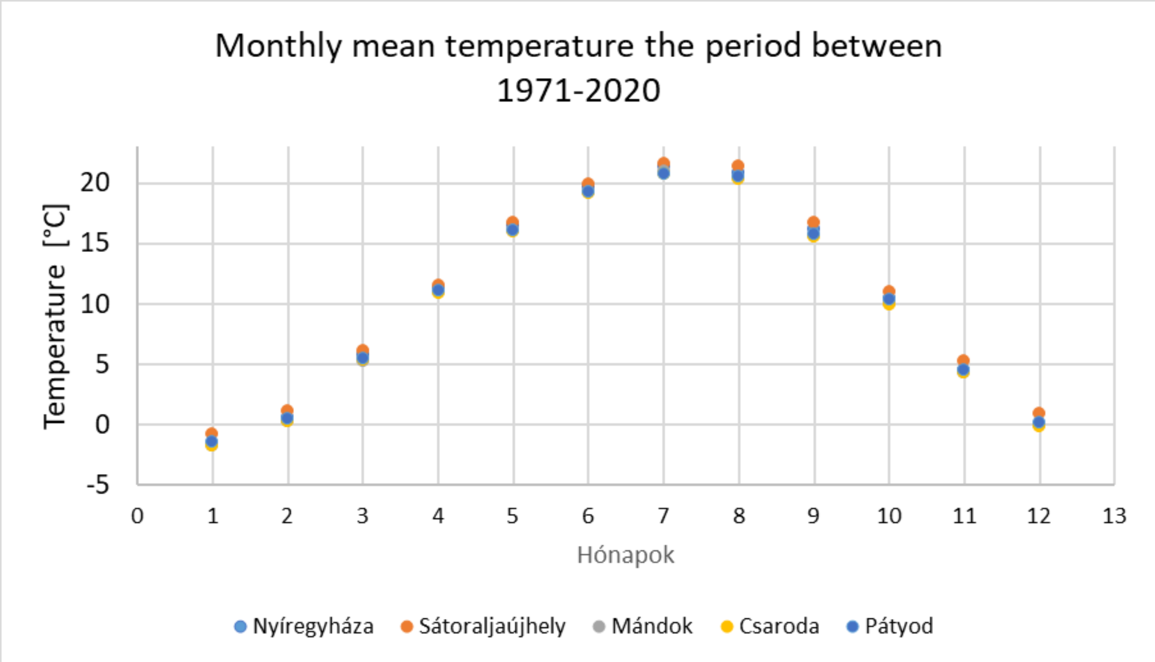

Figure 2.2: Annual trend of monthly mean temperature in the Hungarian catchment area (*based on OMSZ database 1971-2020*)

Over the period 1991-2020, Hungary has experienced a higher warming in this area (reference period 1961-1990), around 0.9°C. During this period, summer (1.3-1.4 °C), winter (0.5-0.6 °C) and spring (0.6 °C) were warmer than in other parts of the country. In the following years, the north-eastern part of the country was also consistently the warmest in relation to the 1971-2000 climatic reference. In 2013 it was 1.2-1.3°C, in 2014 2-2.3°C, in 2015 1.5-1.8°C and in 2016 1.25-1.75°C warmer than the 1971-2000 period, according to OMSZ studies (Figure 2.3). With the increase in temperature, the number of heat wave days (TN25) increased by 10 days in the county over the 1981-2016 period.

OMSZ – Hungarian Meteorological Service

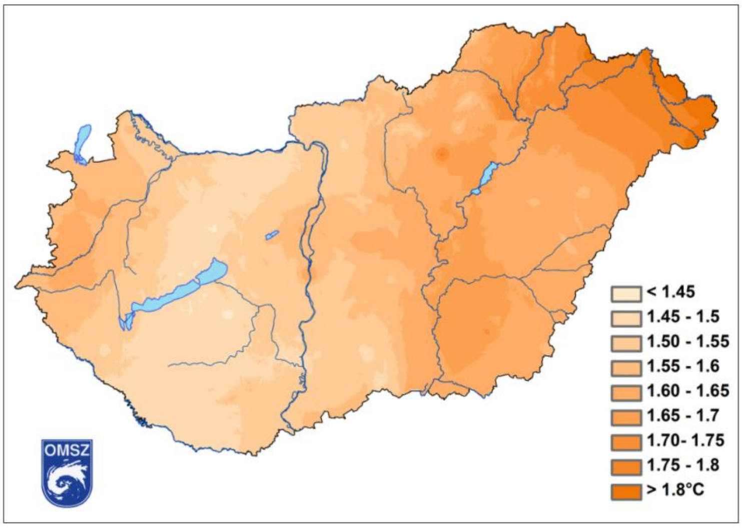

Figure 2.3: Spatial distribution of annual mean temperature change over the period 1981-2016

Source : OMSZ:https://www.met.hu/eghajlat/eghajlatvaltozas/megfigyelt_valtozasok

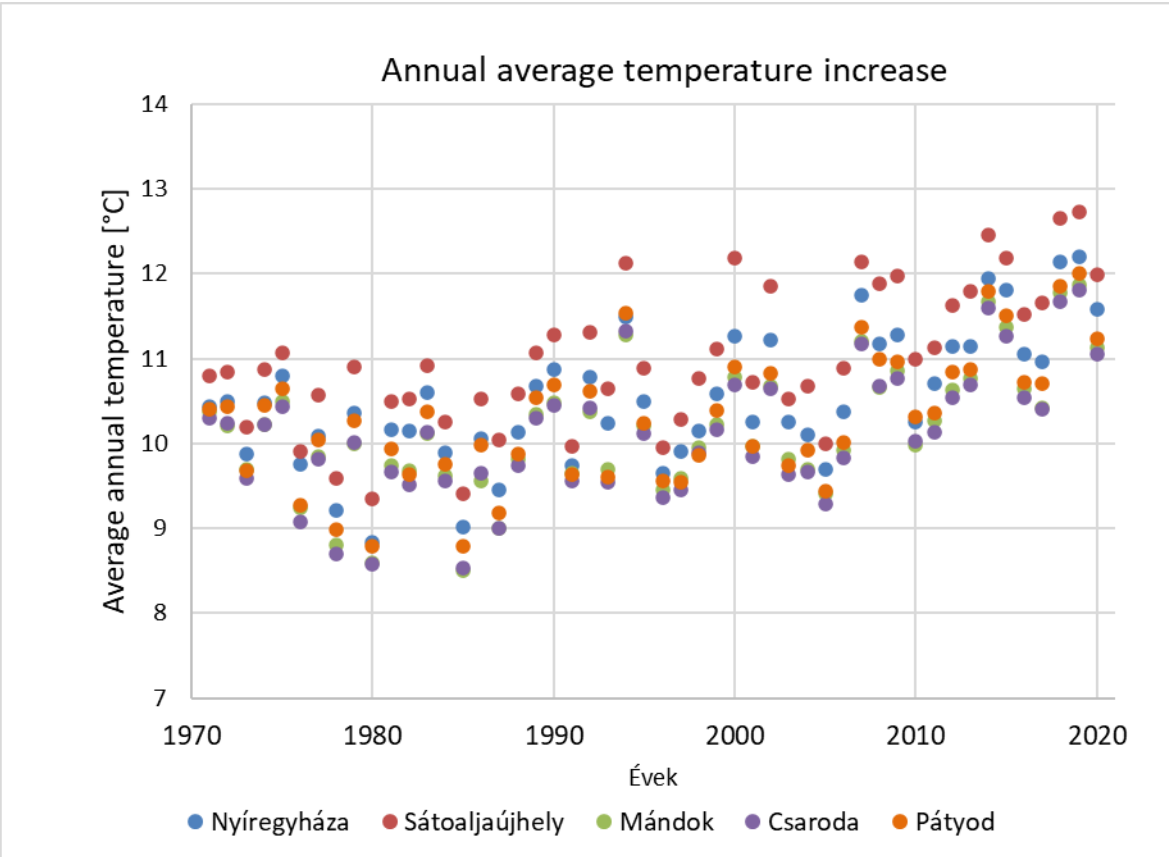

Figure 2.4: Time trends in mean annual temperatures over 1971-2010 *(based on OMSZ database)*

The effects of global warming can also be observed in the Hungarian catchment area. In the lowland area, an average increase of around 0.8-1.1°C is clearly visible in the respective municipalities over the last twenty years, compared to the 1971-2000 climate reference (Figure 2.4).

2.1.4. Temporal and spatial variation of precipitation

The region is characterised by rainfall between 500-700 mm in the period 1981-2010 (Bihari, 2018), but extreme rainfall events are becoming more frequent in the region.

The distribution of precipitation is characterised by an increasing annual amount as one moves eastwards. The central and western parts of the region are the driest - around Nyíregyháza - but local maxima are frequent at any point of the county.

The annual precipitation pattern in Nyírség bears the characteristics of the Great Plain, i.e. a humid continental climate, mild summer maxima and the influence of cyclones from the Mediterranean region. The wettest month in the plain is June, with a maximum in Pátyod and the least in the Sátoraljaújhely area. The months with the least rainfall are January and February (Figure 2.5).

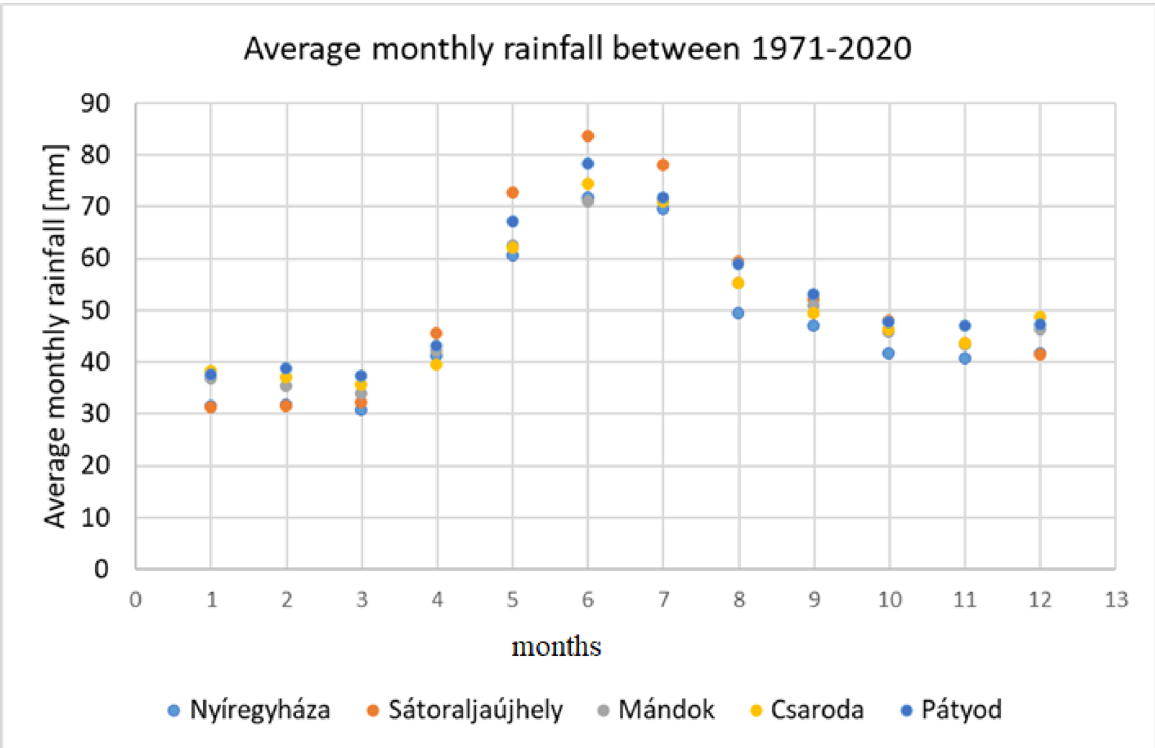

Figure 2.5: Annual trend of monthly average precipitation in Szabolcs-Szatmár-Bereg county

(based on OMSZ database 1971-2020)

The distribution of precipitation is characterised by increasing annual amounts as you move eastwards. The central and western parts of the region are the driest - around Nyíregyháza - but local maxima are often found anywhere in the county.

The annual precipitation pattern in Nyírség bears the characteristics of the Great Plain, i.e. a humid continental climate, mild summer maxima and the influence of cyclones from the Mediterranean region. The wettest month in the plain is June, with a maximum in Pátyod and the least in the Sátoraljaújhely area. The months with the least rainfall are January and February (Figure 2.5).

The trend in precipitation change over the period 1971-2020 shows that precipitation increased by 5-15% in the area, while no significant change was observed in the majority of the country. Of particular note is the year 2010, when the county received well above average rainfall of 900-1200 mm, while 2011-2012 had drier, drought-like characteristics (Figure 2.6). In the last decade, average rainfall amounts were observed with a drought year.

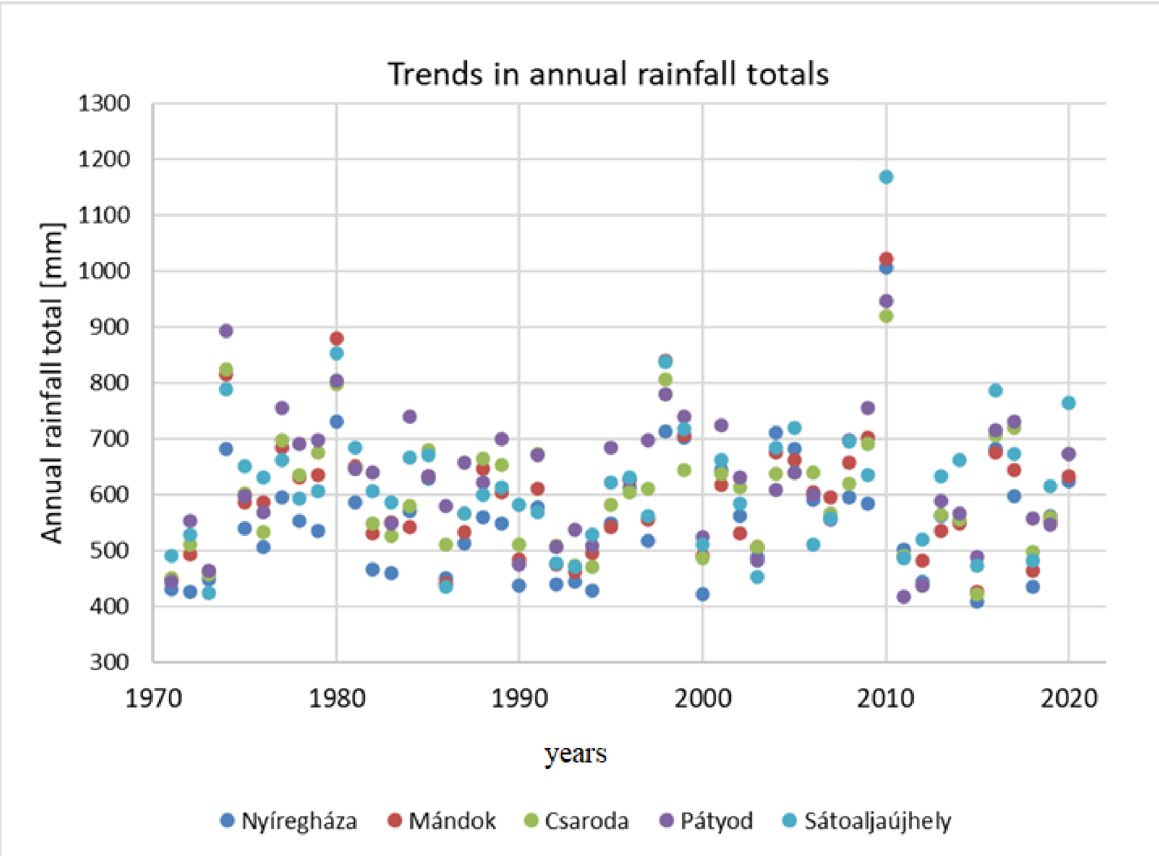

Figure 2.6: Temporal variation of annual precipitation in Szabolcs-Szatmár-Bereg county

(based on OMSZ database 1971-2010)

2.1.5. Temporal and spatial changes in wind conditions

The region is subject to average annual winds of around 3 m/s. The prevailing wind direction is N-NE and SW, but there is also a significant proportion of calm winds (Figure 2.7).

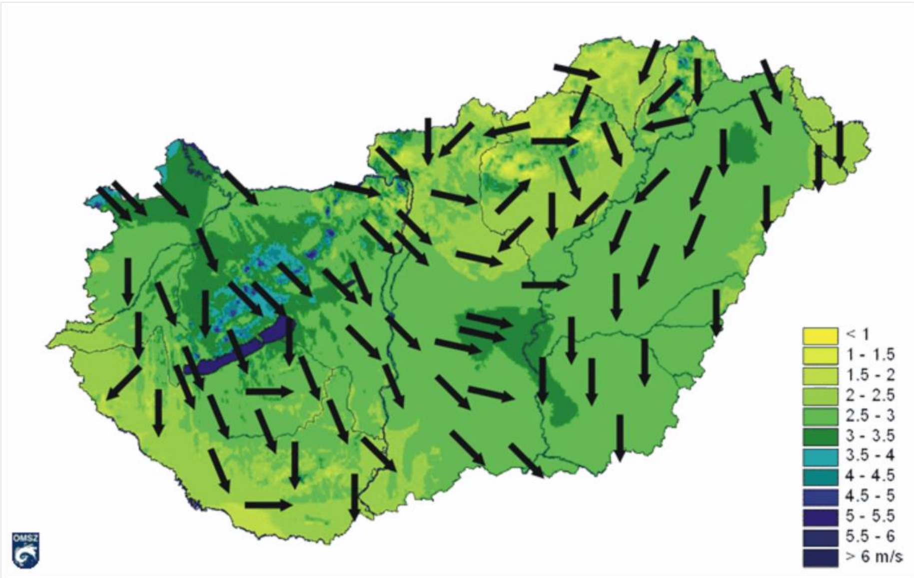

Figure 2.7: Average annual wind speeds [m/s] and prevailing wind directions in Hungary (2000-2009) *(Source: OMSZ https://www.met.hu/eghajlat/magyarorszag_eghajlata*)

In the eastern parts of the county, average wind speeds range between 2-2.5 m/s with a northerly wind direction, while in the western parts they vary between 2.5-3.5 m/s.

2.2. Climatic characteristics of the Romanian catchment

2.2.1. General climatic characteristics

Northwestern Transdanubia is a temperate belt with a humid continental climate, located in the transition zone between oceanic and continental. The climate of the region is strongly influenced by topography, with a smaller part by latitude. Climate and weather variations are a function of the relative altitude above sea level, and the Carpathians and the Transylvanian Central Mountains play a major role in modifying the climate. According to Köppen's global climate classification, lowland areas belong to the Cfb zone, while mountain-valley areas are mostly in the Dfb zone and the mega-mountain ET zones.

2.2.2. Solar radiation characteristics

The average number of hours of sunshine is below 1600 hours in the Carpathians, while in the Transylvanian basin it can exceed 1900 hours, and in Cluj Napoca 1949 hours. The Carpathians and the Transylvanian-Middle Mountains are the most overcast in the region. The global irradiance, i.e. the amount of solar radiation per unit horizontal surface area, varies between 4815 MJ/m2 and 4920 MJ/m2 in the largest areas of the region. In the higher mountain ranges, this amount remains below 4600 MJ/m2 due to the overcast, while in the lowlands and plains it can exceed 4950 MJ/m2.

2.2.3. Temporal and spatial variation of temperature

The multi-year average temperature ranges over a wide range in the Upper Tisza catchment (Romania). In the lowland areas, the mean temperature is around 10 °C (10.4 °C in Satu Mare), while in the basins and valleys values between 8 and 9 °C are observed, and -2 °C in the high peaks of the Eastern Carpathians. The variation in altitude is also clearly distinguishable: 10.5 °C in Satu Mare (123 m), 9.9 °C in Banya (216 m), 8.9 °C in Cluj Napoca (410 m), 4.4 °C in Vladeasa (1404 m) and 1.1 °C on the Vladeasa peak.

July is the hottest month, with averages over many years, with values ranging from 20-21 °C in the lowlands, Satu Mare-Nemét, 18-20 °C in the hills and 6-8 °C in the mountains.

The coldest month is January, with mean temperatures ranging from -1 to -2 °C in the lowlands, -3 to -4 °C in the higher hills and -4 to -10 °C in the mountains (Figure 2.8).

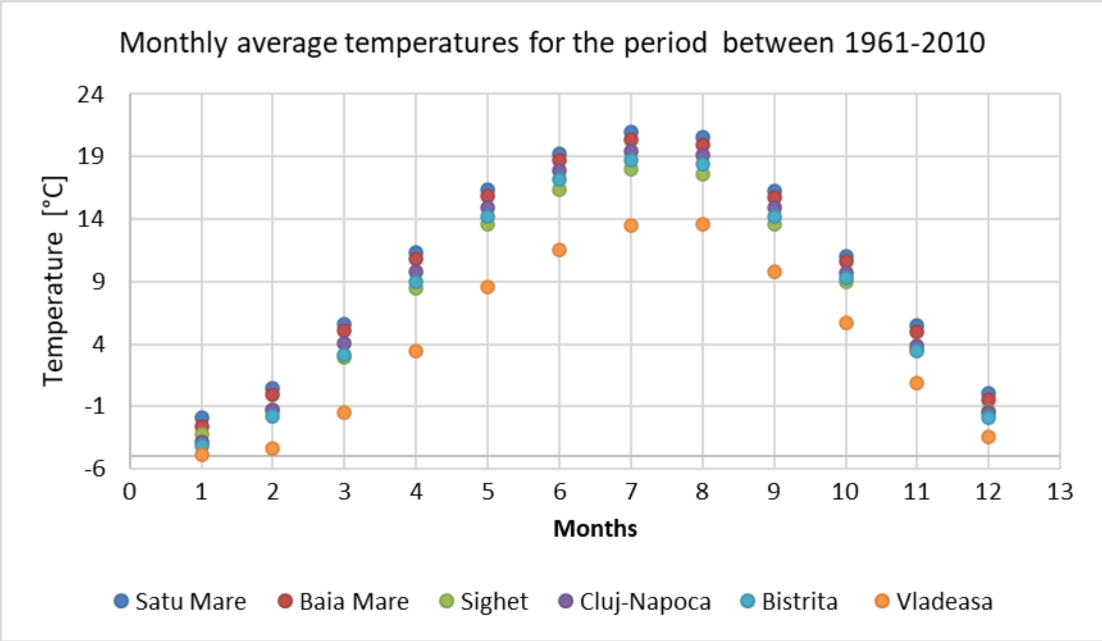

Figure 2.8: Annual cycle of monthly mean temperature in the Romanian catchment area

(based on CarpatClim database 1961-2010)

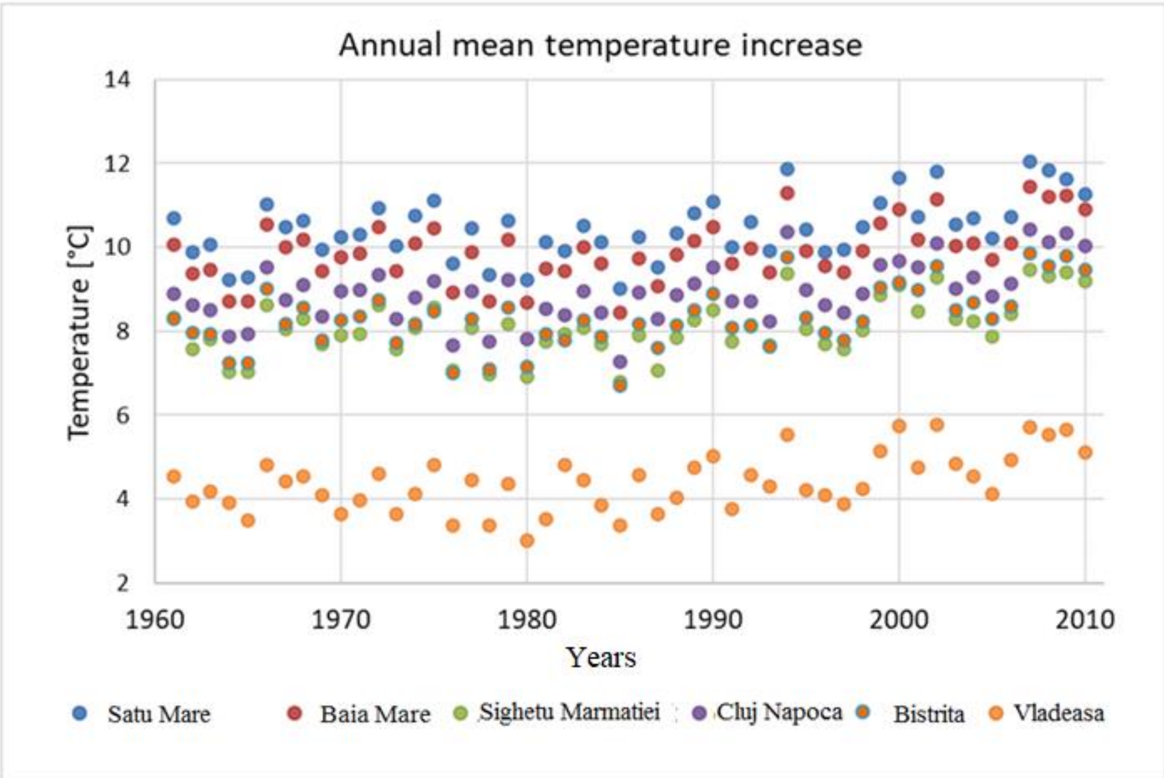

Figure 2.9: Time trends in mean annual temperatures over 1961-2010

(based on CarpatClim database)

The effects of global warming can also be observed in northwestern Transylvania, with significant temperature increases in both lowland and hilly settlements, even in the mountainous areas around the Vladeasa region. In Satu Mare, the increase observed in settlements was 0.7 °C. In the hilly settlements: 0.7 °C in Banská Bystrica, 0.7 °C in Sighetu Marmatiei, 0.72 °C in Cluj Napoca, 0.77 °C in Banská Bystrica, there was a mean temperature increase, and in the mountainous area: 0.78 °C in Vladeasa, while the global scale temperature increase was around 0.4 °C during this period (Figure 2.9).

2.2.4. Temporal and spatial variation of precipitation

The spatial distribution of precipitation in the Upper Tisza catchment shows a varied pattern. This is mainly determined by the prevailing wind directions and exposure, the orientation of mountain ranges and the influence of distance from west to east. The average precipitation over many years is around 660 mm in the lowland area, while in the hilly areas it varies between 650 and 800 mm (Satu Mare 664 mm, Baia Mare 771 mm, Sighetu Marmatiei 880 mm, Cluj Napoca 660 mm, Bistrita 693 mm). In the mountainous areas it exceeds 1000 mm (Vladeasa 1151 mm). 40% of the precipitation falls in summer (Figure 2.10).

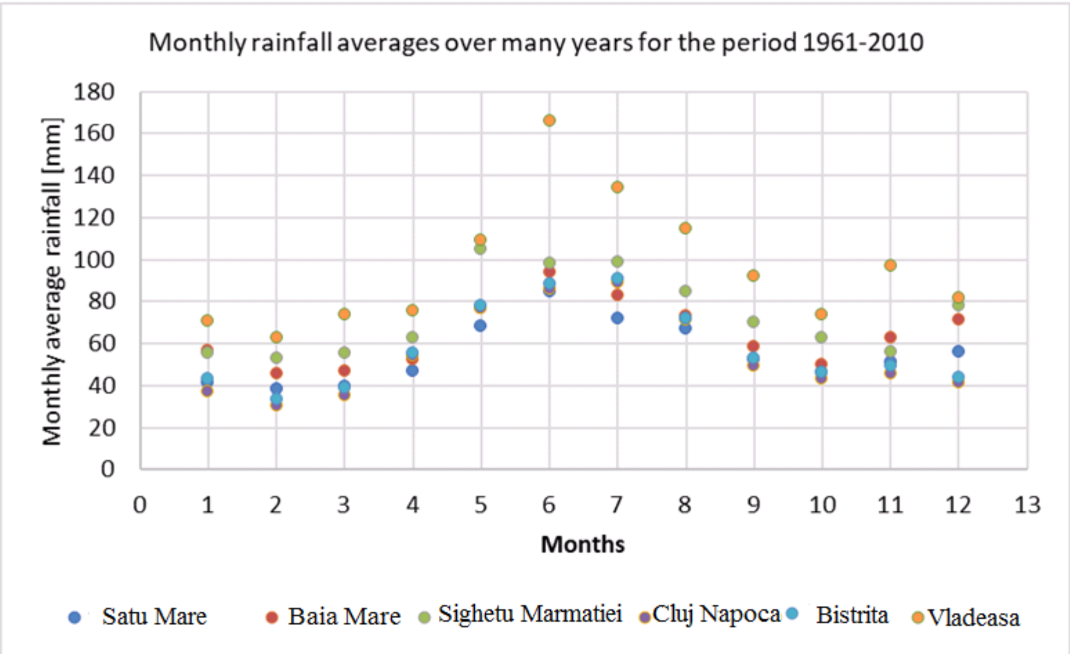

Figure 2.10: Annual trend of monthly average precipitation in the Romanian catchment area
(based on CarpatClim database 1961-2010)

The annual rainfall cycle is determined by both altitude and exposure. The basin is also affected by the mild summer maximum typical of a humid continental climate and by cyclones from the Mediterranean. The wettest month is June (Satu Mare, Banská Bystrica), while in the higher basin areas the maximum precipitation is observed in July (Cluj Napoca, Banská Bystrica), with a marked summer maximum of 165 mm in the high mountain areas (Figure 2.10). The month with the least rainfall is February for all municipalities.

The number of days with precipitation is correlated with the precipitation amounts presented. In the lowland areas 115-130 days, while in the high mountain areas up to 150-200 days are possible.

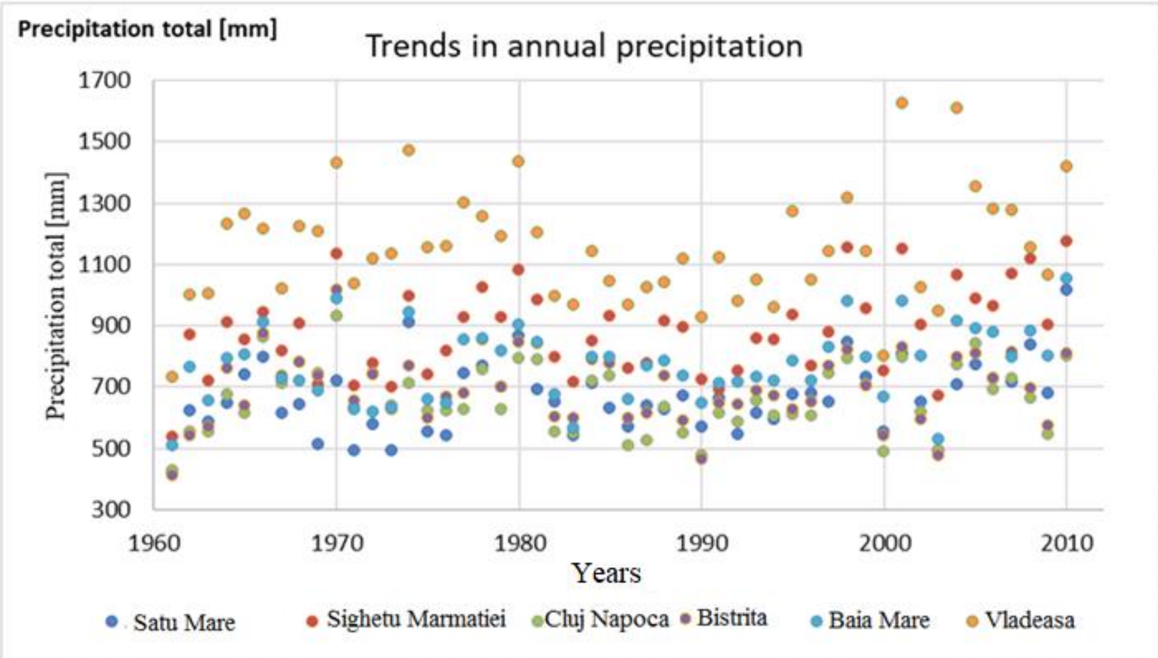

Figure 2.11: Temporal variation of annual precipitation in the Romanian catchment area

(based on CarpatClim database 1961-2010)

Long-term trends in the precipitation sum can be observed in Figure 2.11. Among the stations, a significant upward trend is observed for Satu Mare, Sighetu Marmației and Baia Mare. In seasonal breakdown, Satu Mare and Baia Mare showed a significant increase in precipitation over the period 1961-2010. Furthermore, for the monthly trend changes, an increase in precipitation is observed in the month of September (Figure 2.11). In recent years, extreme weather events (heavy and sudden rainfall causing floods) have become more frequent.

2.2.5. Temporal and spatial variation of wind conditions

Significant differences in the general atmospheric circulation can be observed near the higher and lower surface. At an altitude of 5500 m, wind directions from the southwest, west and northwest are predominant 65% of the time, with average wind speeds ranging from 12-13 m/s. The near-surface wind field is more varied in the region due to the complexity of the topography. The predominance of westerly wind direction is typical for the high mountains (Vladeasa, 36% of the time north-westerly winds with an average speed of 11 m/s), while the hills are dominated by the direction of the valleys, for example in Cluj Napoca the most frequent wind direction is north-westerly. In the case of Banská Bystrica, the prevailing wind direction is north-easterly, which is in line with the topography. In the lowland municipalities, the wind direction is determined by the mountain range bordering the plains, as in the case of Satu Mare, easterly winds blow in 12% of cases.

2.3. Climatic characteristics of the Slovak catchment area

2.3.1. General climatic characteristics

The climatic conditions in Slovakia are varied, with altitude differences giving rise to the characteristic vertical zone. Depending on the topography, the main features can be divided into four groups: high mountains, medium mountains, lowlands and intermountain basins.

2.3.2. Solar radiation characteristics

There are no fundamental differences in the climatic conditions of the eastern Slovakian lowlands: the number of hours of sunshine varies between 1800 and 1950. The average annual amount of global radiation is the highest in the ski area and high mountains, varying between 4320 and 4680 MJ/m2 (in the Tatras it can be as high as 4700 MJ/m2). In the basins, global radiation is influenced by inversions and low clouds, ranging from 3900 to 4320 MJ/m2, while in the central highlands it is lower at 3780 to 3960 MJ/m2, influenced by cloud cover (Source: http://www.shmu.sk/sk/?page=1064).

2.3.3. Temporal and spatial variation of temperature

In the Upper Tisza catchment area of Slovakia, the annual mean of the 50-year average temperature ranges from 8.5 to 9.5 °C in the lowland areas and from 7 to 9.5 °C in the mountain-valley areas. January is the coldest month, with mean temperatures ranging from -2.4 to -3.4 °C in the lowlands and -2.8 to -3.5 °C in the mountain-valley areas. The hottest month is July, with averages over many years of around 20°C in the lowlands and between 17°C and 19°C in the mountain valley (Bardejov and Medzilaborce).

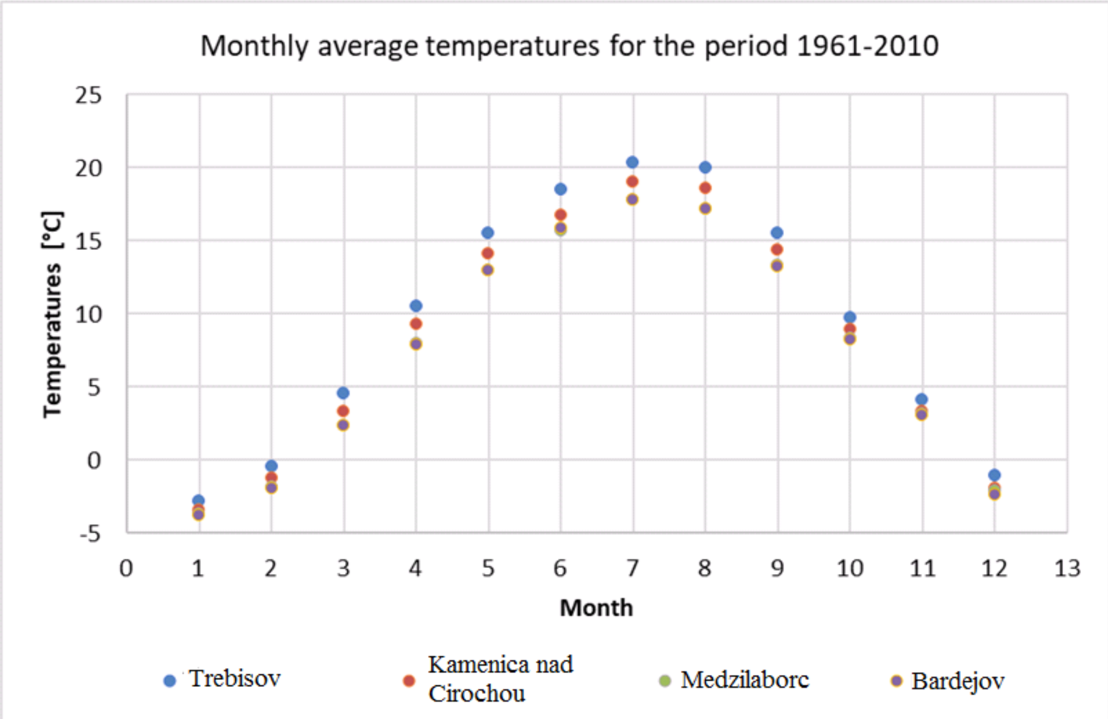

Figure 2.12: Annual trend of monthly mean temperature in Slovakian river basin (*based on CarpatClim database 1961-2010)*

There are temperature differences between lowland and mountain-valley settlements due to the variation with altitude. This difference is larger in summer (around 2.7°C in July) and smaller in winter (around 1°C in July). In eastern Slovakia, the continental climate is more dominant than in the western part of the country, as indicated by the lower mean temperatures in January. Monthly average air temperatures in the basins range between -3 and -4 °C in January. In winter, temperature inversions are frequent, bringing the monthly average air temperature in the basins down to the level of the central mountains. The number of summer days when the maximum daily air temperature reaches 25 °C occurs annually in our southern areas and in some basins in the southern half of Slovakia, averaging 50 days per year up to an altitude of about 350 m. Above sea level, at altitudes of around 1000 m, there are on average 5-10 summer days per year. The occurrence of frosts, characterised by frosty days when the minimum daily temperature falls below 0 °C, can also vary widely across Slovakia (Figure 2.12)

The trend of global warming is also observed in the Slovakian catchment, with the last two decades (1991-2010) compared to the reference period (1961-1990), representing a temperature increase of 0.7°C in the lowland and mountain-valley areas of eastern Slovakia in the Upper Tisza catchment (Figure 2.13).

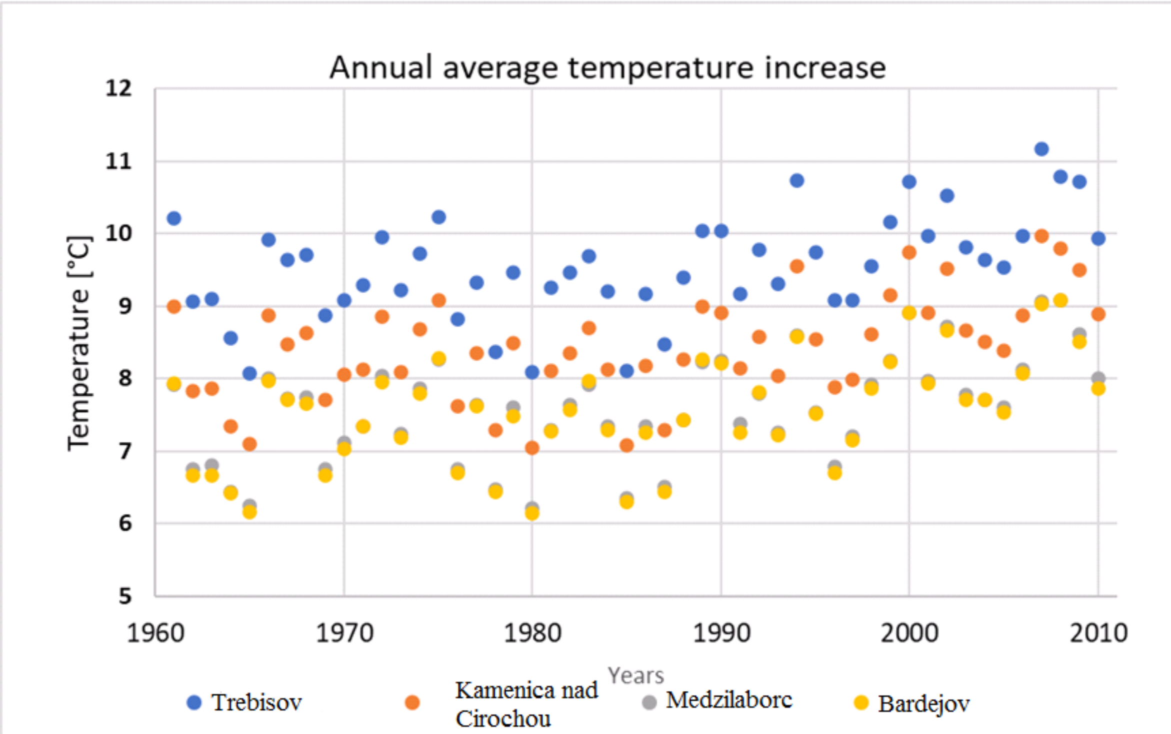

Figure 2.13: Temporal trends in mean annual temperatures over the period 1961-2010 in the Slovakian river basin *(based on CarpatClim database)*

The temperature increase in the study area has exceeded the global average, which means that the effects of climate change are strong in this region.

2.3.4. Temporal and spatial variation of precipitation

There are no fundamental differences in the climatic conditions of the eastern Slovakian plain, such as the annual amount of precipitation (500-600 mm), while in the mountain valleys and mountainous areas there are significant differences in precipitation (700-900 mm). In eastern Slovakia, rainfall generally increases by about 50-60 mm/100 m altitude.

The annual rainfall, is typical of the humid continental climate of the lowlands, with a mild summer maximum. The wettest month in the plain is June, with an average of 86 mm. The least rainy month is January, the multiannual average rainfall is 36 mm (Figure 2.14).

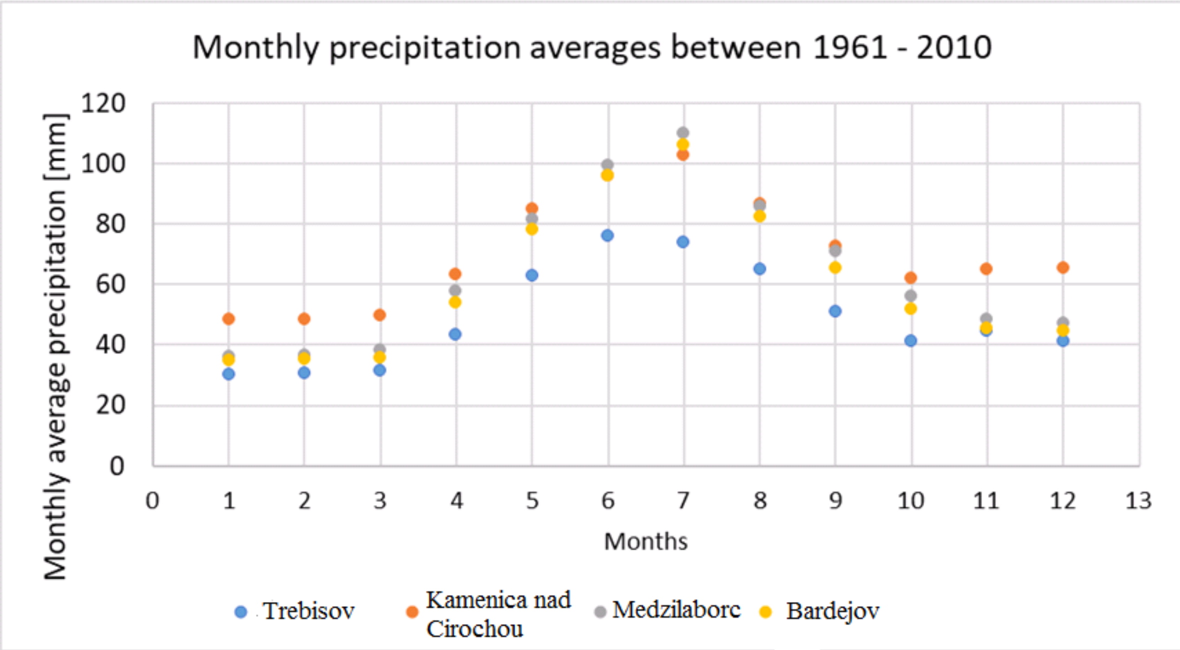

Figure 2.14: Annual course of monthly average precipitation in the Slovakian catchment area
(based on CarpatClim database 1961-2010)

In the northern parts of eastern Slovakia, in the mountain-valley areas, July is the maximum (Kamenica nad Cirochou, Medzilaborc, Bardejov), while the least rainy period is in the second half of winter and early spring (Figure 2.14)

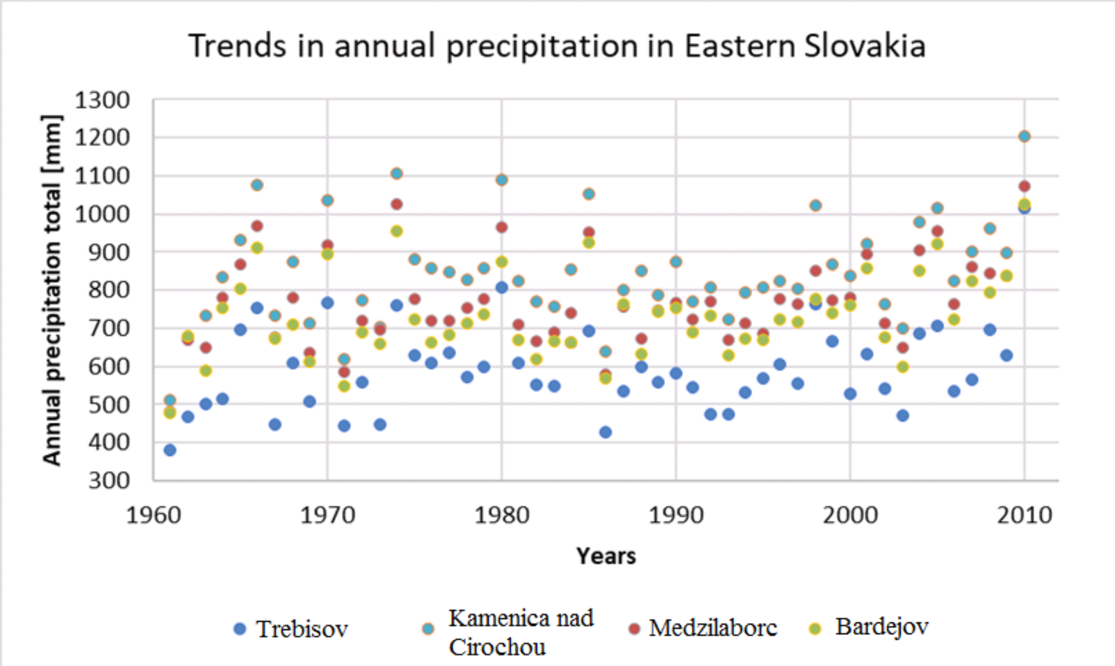

Figure 2.15: Temporal variation of annual precipitation in the Slovak catchment area *(based on CarpatClim database 1961-2010)*

The trend in precipitation change over the period 1960-2010 indicates that there is no significant change in the amount of precipitation in the area. The area is characterised by significant variations in annual rainfall totals, in Tőketerebese (590) and at higher altitudes (Kamenica nad Cirochou, Medzilaborc, Bardejov) the average rainfall exceeds 840 mm (Figure 2.15).

2.3.5. Temporal and spatial changes in wind conditions

The wind conditions in Slovakia are not only complicated because of the complex topography, but are also determined by the considerable variability of the weather throughout the year and the homogeneity of the active surface, which determines the roughness characteristics. The average annual wind speed in the plains of eastern Slovakia is 2-3 m/s at 10 m above the active surface. The prevailing wind direction in eastern Slovakia is northerly, which may be modified by topography.

2.4. Climatic characteristics of Ukraine, Transcarpathia

2.4.1. General climatic characteristics, Transcarpathia

Transcarpathia is characterised by varied topography and as a consequence diverse climatic features. The lowland part of the county has a humid-continental climate type, while the highland areas are characterised by a mountainous climate.

The climate of Transcarpathia is mainly determined by the alternation of temperate marine and temperate terrestrial air masses throughout the year. In winter, Arctic air masses can often invade, resulting in cold and dry weather. In summer, tropical land masses (Saharan) rarely reach the region, creating hot dry weather (Molnár, 2009).

2.4.2. Solar radiation characteristics

The length of daylight hours at the summer solstice is 16 hours in the south of the county and 16 hours 10 minutes at the northern border, and at the winter solstice it is 8 hours 20 minutes in the south and 8 hours 10 minutes in the north. The number of hours of sunshine in the lowlands is 2025 hours per year, which is only 43% of the maximum possible 4453 hours, while in the mountains it is 30% less. Relative insolation reaches a maximum in August and a minimum in December (Molnár, 2009). The value of global irradiance, i.e. the solar radiation reaching the horizontal surface, is 4370 MJ/m2 in the lowland area (Berehove) and lower in the mountain area (Mizshirja) at 3114 MJ/m2 because it is significantly influenced by horizon limitation and cloud cover.

2.4.3. Temporal and spatial variation of temperature

The 50-year average annual mean temperature ranges from 9.5 to 10.5 °C in the lowlands and from 6.5 to 9.5 °C in the mountain valleys. January is the coldest month, with mean temperatures ranging from -2 to -3 °C in the lowlands and -3 to -4 °C in the mountain valleys. The hottest month is July, with averages over many years of data showing values between 20 and 21 °C in the lowlands and between 16 and 19 °C in the mountain valley stations (Figure 2.16).

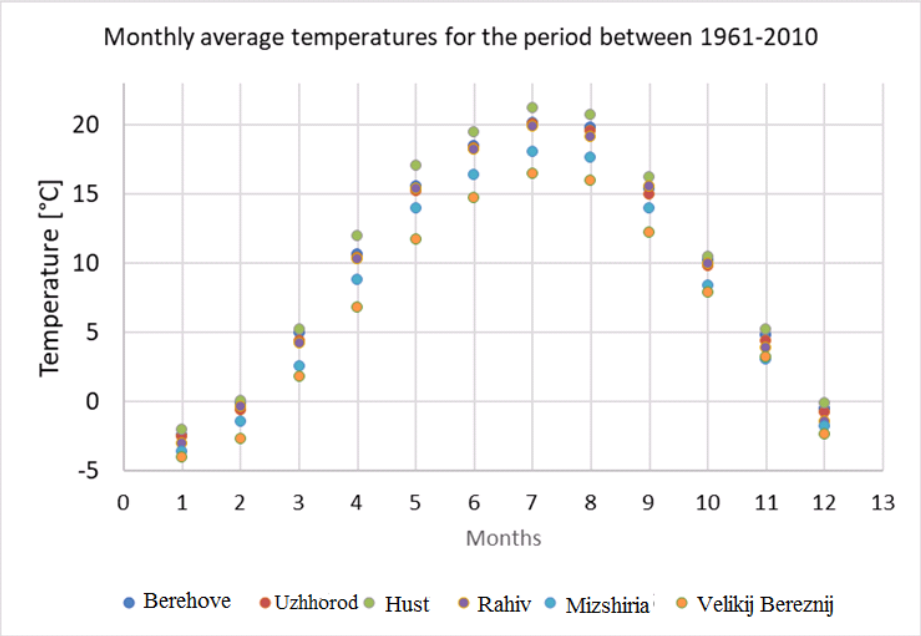

Figure 2.16: Annual course of monthly mean temperature in Transcarpathia *(based on CarpatClim database 1961-2010)*

According to the literature, the highest absolute maximum temperature in Transcarpathia has been recorded at the Berehove meteorological station, which was 38.5 °C in July 2007, while the lowest temperature was -32.5 °C in January 1954 (Molnár, 2009). Among the lowland settlements, one of the highest absolute maximum temperatures in Hust (38.16 °C) was also observed in July 2007, according to the grid point database.

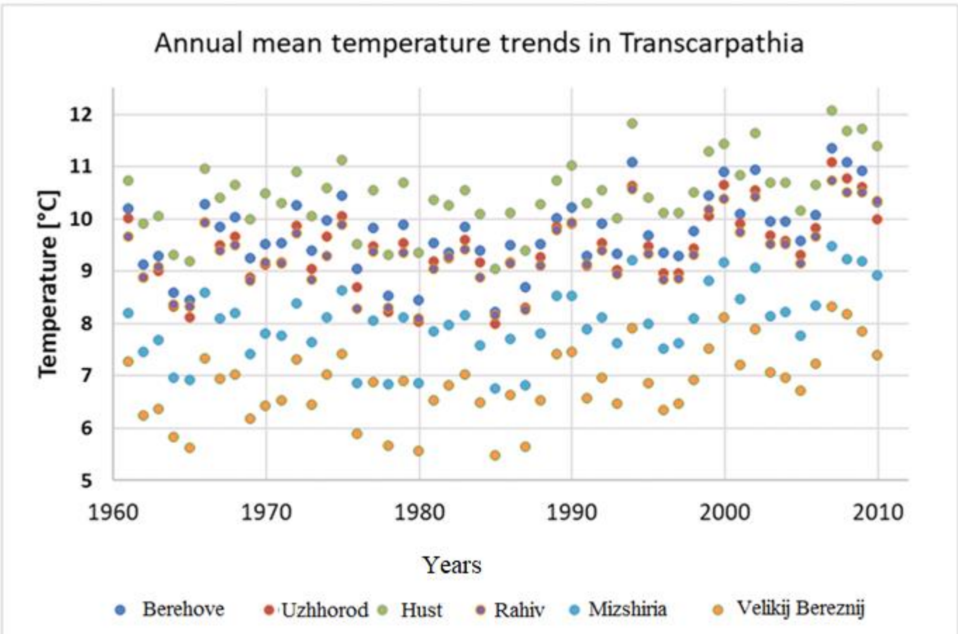

Figure 2.17: Time trends in mean annual temperatures over 1961-2010 *(based on CarpatClim database)*

There are significant temperature differences between lowland and mountain cities, as the mean annual temperature drops by 6°C per thousand metres. The temperature variation with altitude is more significant in summer (7-8 °C) than in winter (3-4 °C). In mountain valleys, mean temperatures vary between 5 and 8 °C depending on altitude, and between 0 and 3 °C on ridges above 1000 m.

The annual temperature range is between -4 and -6 °C in the mountain valleys and around -7 °C on the ridges. Temperatures on ridges are higher than in valleys when there are clear nights.

The effects of global warming can also be observed in Transcarpathia, with significant temperature increases in both lowland and mountain-valley settlements. The increase observed in lowland settlements was 0.7 °C. In the mountain-valley settlements, there was an average increase of 0.7 °C in mean temperature. The global scale temperature increase was around 0.4 °C during this period, while the Carpathian data show a more significant increase in the municipalities (Figure 2.17).

2.4.4. Temporal and spatial variation of precipitation

Average annual precipitation in the lowland areas ranges from 600 to 750 mm. In Berehove the precipitation amount is 690 mm, while in Uzhhorod it is 715 mm. As the foothills and mountainous areas are approached, the precipitation amount increases, reaching 800 mm at the foot of the mountains. In the mountainous areas, precipitation totals continue to increase, reaching 910 mm in Velikij Bereznij, and in some places exceeding 1500 mm, such as at the Plaj meteorological station. In the mountain valley settlements, precipitation totals are somewhat lower, ranging from 1000 to 1200 mm, such as 1200 mm in Mizshirja, 1254 mm in Rahiv and 1051 mm in Hust.

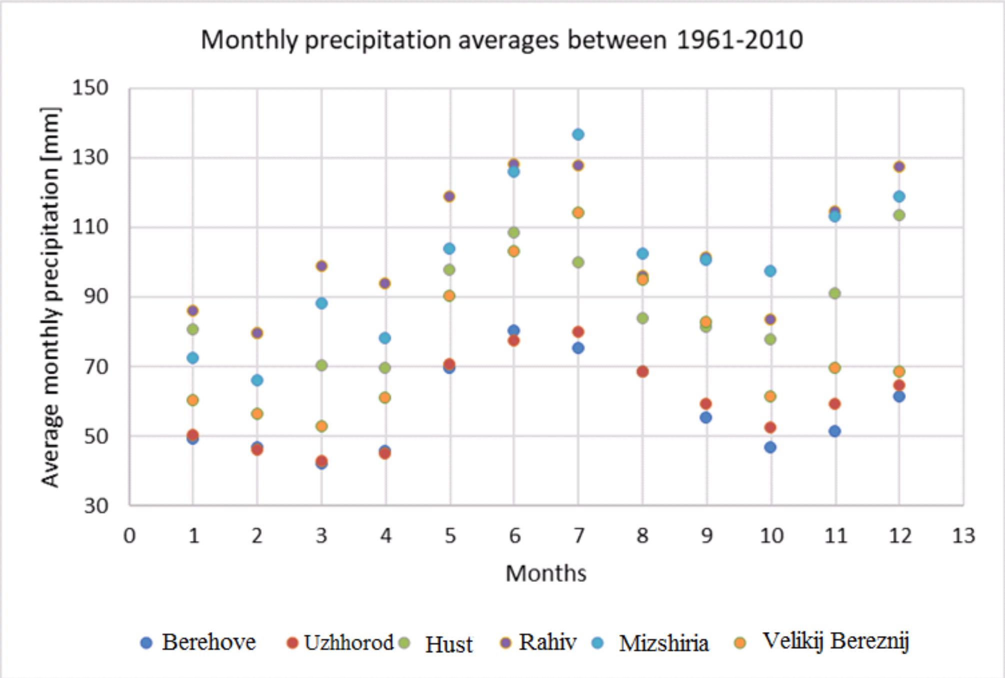

Figure 2.18: Annual trend of monthly average precipitation in Carpathian Basin *(based on CarpatClim database 1961-2010)*

The annual precipitation pattern carries the characteristics of the Carpathian Basin, with a mild summer maximum that is typical of a humid continental climate, and the influence of cyclones from the Mediterranean is also observed. June is the wettest month in the lowland and mountainous areas (Berehovo, Uzhhorod, Hust), while the mountain-valley and mountainous areas are characterised by a July maximum Velikij Bereznij, Mizshirja, Rahiv, Plaj station). The period of the year with the least precipitation is the end of winter and the beginning of spring (Figure 2.18).

Monthly precipitation amounts in Berehove vary between 40-80 mm, with a similar pattern observed in Uzhhorod (42-80 mm). In the mountainous areas, monthly precipitation values increase with the annual precipitation sum, i.e. between 79 mm (February) and 127 mm (July) in Rahiv, and between 65 mm (February) and 136 mm (July) in Mizshirja. The number of days with rainfall ranges from 135 to 160 in the lowlands and up to 190 in the mountains.

Long-term trends in precipitation amounts can be observed in Figure 2.18. An increasing trend is observed for the stations (Figure 2.19). In the lowland settlements, the increase is less pronounced, while in Rahiv it is more pronounced (r=0.37, 1% significance level). These findings are consistent with the results of previous studies (Molnár & Izsák, 2011).

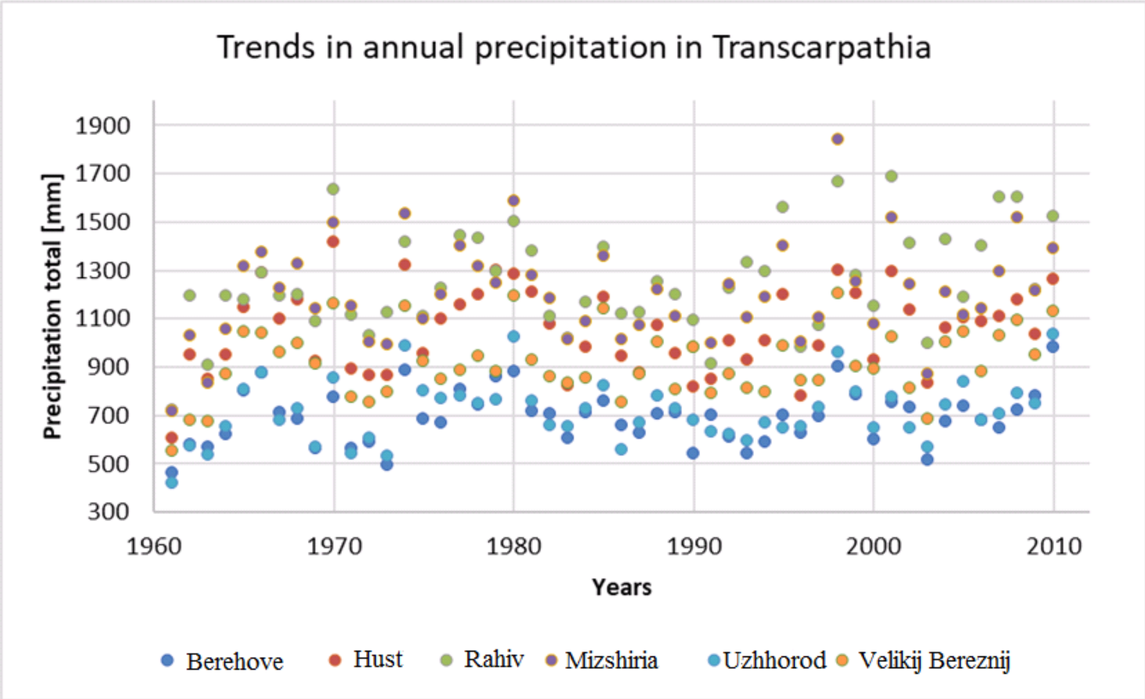

Figure 2.19: Temporal trends in annual precipitation totals over the period 1961-2010

2.4.5 Temporal and spatial variation of wind patterns in Transcarpathia

The characteristics of annual, seasonal and monthly wind speeds are basically determined by the large-scale meteorological processes, and the low or high pressure atmospheric formations, through their characteristic properties, essentially determine the wind field properties in Transcarpathia Cyclonic activity is common in winter and transition periods (spring, autumn). While cyclonic activity weakens in summer, local atmospheric circulation and convective processes determine the flow conditions. Therefore, wind patterns in the summer months are more even than in other seasons. According to the measured data, spring is the windiest (2.3 m/s) and summer is the calmest (1.7 m/s) in Transcarpathia, while winter and autumn have average wind speeds of 2.6 m/s and 1.8 m/s, respectively. In terms of seasonal breakdown, the data show that three groups can be distinguished: 1. where spring wind maxima and autumn minima occur (Uzhhorod and Velikij Bereznij); 2. where spring wind maxima and summer minima occur (Rahiv and Mizshirja); 3. where winter maxima and summer minima occur (Nizsnyi Vorota, Nizsnyij Sztudenij, Plaj and Pozsezsevszka) (Hadnagy, 2020).

Wind speeds in lowland areas and mountain valleys are generally low, averaging between 1.2 and 2.4 m/s per year, and there are high frequencies of calm periods in these areas. The average wind speed values increase in proportion to the increase in altitude. The Borza Mountains / Полонина Боржава (the Plaj measuring point) and Chornohora (the Pozsezsevszka measuring point) have higher average wind speeds than their surroundings. Furthermore, the Havasi- and Watershed lines have similar characteristics (Hadnagy, 2020; Molnár, 2009).

2.5. Climate characteristics between 2010-2021

The preparation of climate strategy started in 2020 and the general climate characteristics of the four country was defined by the data available at that time. The last decade has produced "extremes" of climate. Temperature maxima, minima and heatwave days have been repeatedly exceeded. In 2010, there was an exceptional amount of precipitation and since then we have been facing periods of extreme drought. Because of the extension of the project, we felt it was necessary to examine the extent to which the results of the last decade justify the conclusions drawn from the previous data, and the relevance of the measures and proposals planned. Based on data from the National Meteorological Service, we had the opportunity to check our own data. Using data from 25 meteorological stations on temperature, relative humidity, precipitation, average wind speed and average air pressure, we present the general climate characteristics in each country for the period 2010-2021.

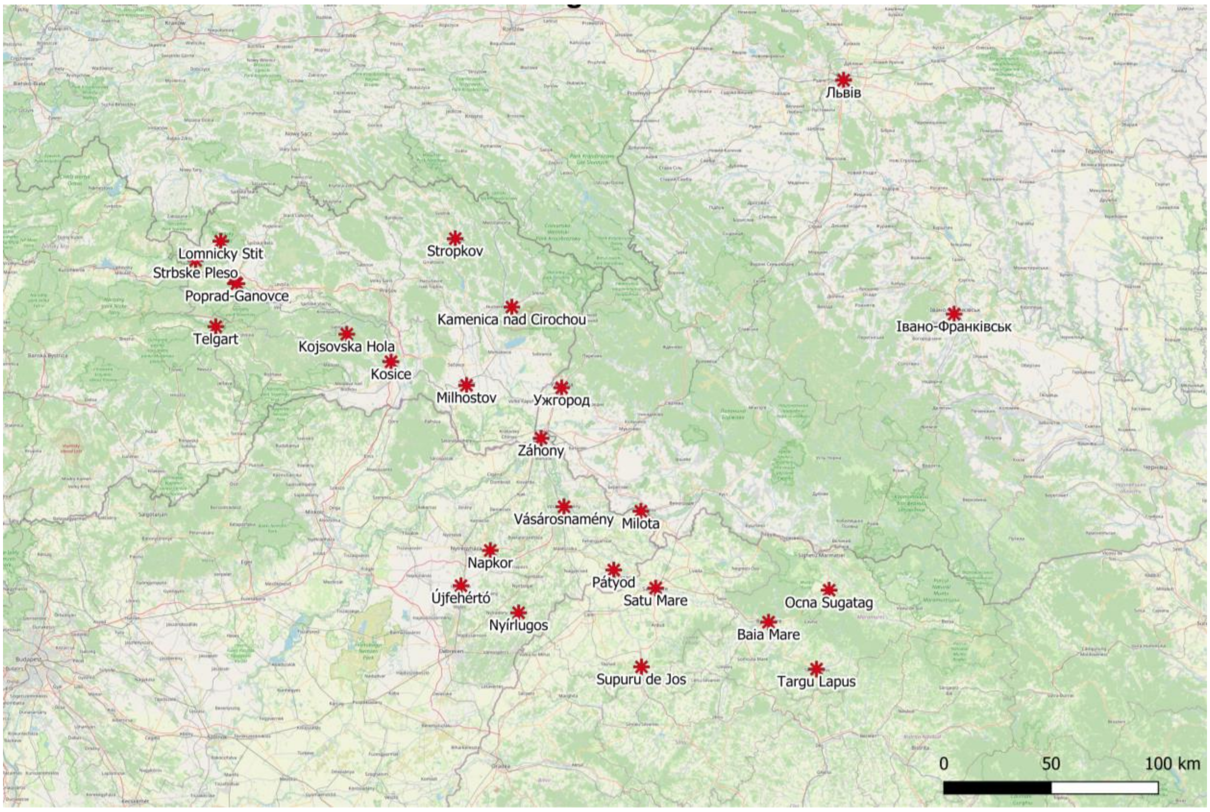

Figure 2.20: Location of meteorological stations (own source)

2.5.1. Hungarian river basin

For the meteorological data in Hungary, the following municipalities were used: Napkor; Újfehértó; Záhony; Vásárosnamény; Milota; Pátyod/Csenger; Nyírlugos.

2.5.1.1. Temporal and spatial variation of temperature

In the Hungarian river basin, data were previously available until 2020. Using data obtained from the National Meteorological Service, we compared the previously analysed meteorological data with data from other monitoring stations.

For meteorological data in Hungary, we used data from the following municipalities. Napkor; Újfehértó; Záhony; Vásárosnamény; Milota; Pátyod/Csenger; Nyírlugos.

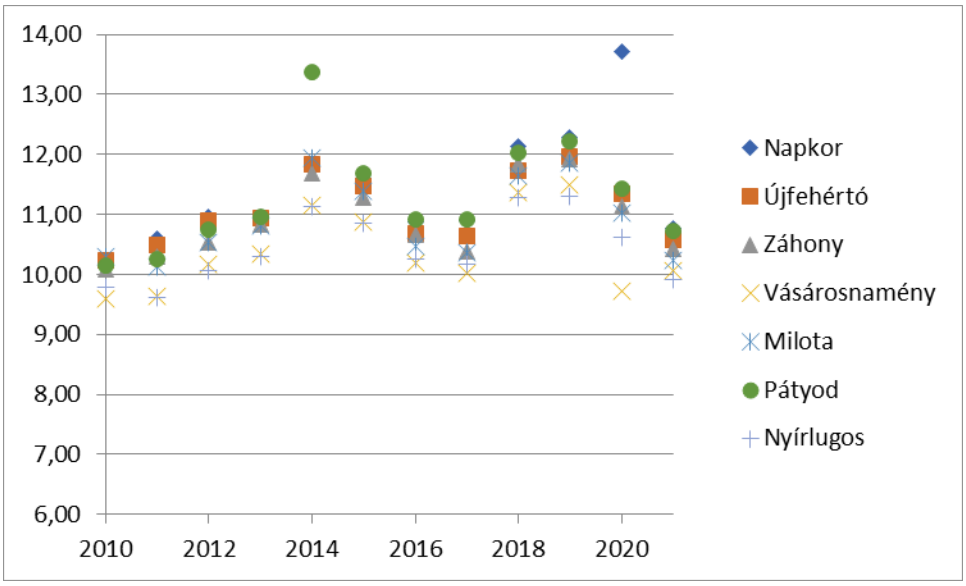

Figure 2.21: Annual mean monthly temperature trends in the Hungarian river basin *(based on OMSZ-National Meterological Service data)*

The annual mean temperature's average annual values are similar to those presented in section 2.1.3, showing an increase in mean annual temperature, but with more stations located further east, so that the annual values here are 0.5 °C lower.

July and August are the hottest months, with average values increasing, with values above 23°C in 2015 and 2021.

The coldest month is January, which had the lowest value in 2017.

2.5.1.2. Temporal and spatial variation of precipitation

The average multi-year rainfall has increased over the last 11 years, with a particularly high rainfall in 2010. At stations further east, rainfall totals are significantly higher than in the southern and western parts of the Nyirség.

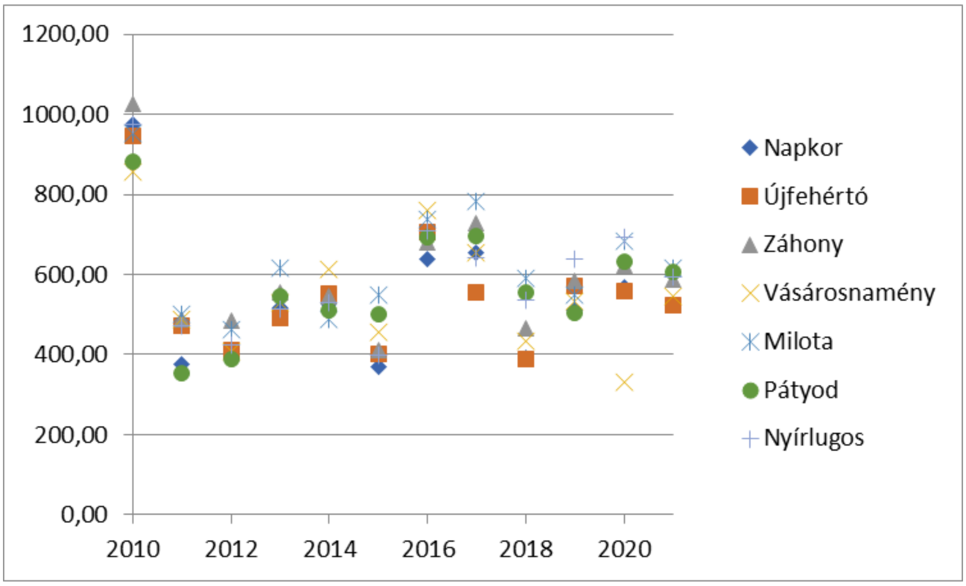

Figure 2.22: Temporal variation of annual precipitation totals between 2010 and 2021 in the Hungarian river basin *(based on OMSZ - National Meterological Service data)*

June and December are the months with the lowest precipitation. In 2011, 2013 and 2021, no measurable precipitation was recorded at any station.

June and July are the wettest months, but May values are barely below the summer months. In 2010 and 2020, monthly rainfall in June and July was around 200 mm.

2.5.1.3. Temporal and spatial variation of wind conditions

Annual average wind speeds between 2011 and 2021 were between 1-3 m/s. The months of October to November are the quietest, while the beginning of spring (March to April) produces the highest wind speeds.

2.5.2. Romanian river basin

2.5.2.1. Temporal and spatial variation of temperature

The annual average mean temperature over the past 11 years has ranged between 10-13°C in lowland areas and between 8-11°C in mountain-valley areas. The results show a warming of nearly 2°C compared to the average over the last 50 years, but the rate of increase has stagnated in recent years.

For meteorological data in Romania, we used data from the following municipalities. Satu Mare; Baia Mare; Ocna Sugatag; Supuru de Jos; Targu Lapus.

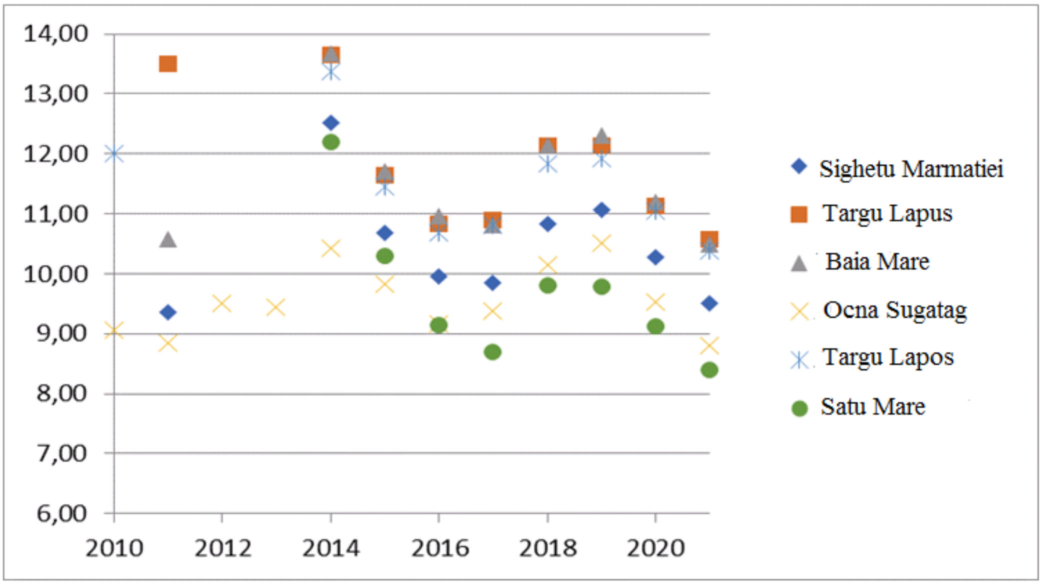

Figure 2.23: Annual mean monthly temperature trends in the Romanian river basin *(based on OMSZ-National Meteorological Service data)*

July continues to be the hottest month, with average values increasing and fluctuating in the higher ranges, with average temperatures in Satu Mare between 20-23°C, while at higher altitudes the average temperature varied between 18-21°C.

January was the coldest month, with mean temperatures ranging from -1 to +2 °C in the lowlands and -2 to -4 °C in the higher areas, showing an increase of 1-2 °C.

2.5.2.2. Temporal and spatial variation of precipitation

The average multi-year precipitation has increased over the past 11 years, both in the lowlands and at higher elevations, but drier, wetter periods are observed.

Figure 2.24: Temporal variation of annual precipitation totals between 2010 and 2021 in the Romanian river basin *(based on OMSZ-National Meteorological Service data)*

At lower altitudes June continous to be the wettest months, but May values are barely below the June value. There is also a large, almost sevenfold difference between the June values for each year (Satu Mare - Satu Mare 2021: 30 mm, 2018: 200 mm).

At higher altitudes, however, the wettest month was June instead of July, but the strong summer precipitation maximum persisted.

February is still the month with the least precipitation, both on the lowlands and at higher altitudes, but the precipitation totals are more evenly distributed, with only one and a half to twofold differences being observed between years.

2.5.2.3. Temporal and spatial variation of wind conditions

Wind speeds varied between 2-4 m/s in the lowland areas and in the foothills of the mountains, and between 2-4 m/s in the more sheltered areas (Marmaros Island - Sighetul Marmatiei; Aknasugatag - Ocna Sugatag), but there were also periods of almost no wind at some times of the year.

2.5.3. Slovakian river basin

For meteorological data in Slovakia, the following municipalities were used: Lomnicky Stit (Lomnicky Peak); Strbske Pleso (Strbske Lake); Poprad (Poprad); Telgart (Garamfő); Poprad-Ganovce (Gánóc); Kosjovska Hola (Kosjovska Hola); Kosice (Kosice), Milhostov (Milhostov); Nagykemence (Kamenica nad Cirochou); and in the earlier data, Medzilaborce and Bardejov were replaced by Stropko (Stopkov).

2.5.3.1. Temporal and spatial variation of temperature

The annual average mean temperature over the past 11 years has ranged between 9-11°C in lowland areas and between 8-10°C in mountain-valley areas. The results show a warming of nearly 2°C compared to the average over the last 50 years, with a downward trend after a four-year upward cycle, but a steady upward trend in mean annual temperature. For meteorological data in Slovakia, we used data from the following municipalities. Lomnicky Stit; Strbske Pleso; Poprád; Telgart; Poprad-Ganovce; Kosjovska Hola; Kosice, Milhostov; Kamenica nad Cirochou; and in the earlier data, Medzilaborce and Bardejov were replaced by Stopkov.

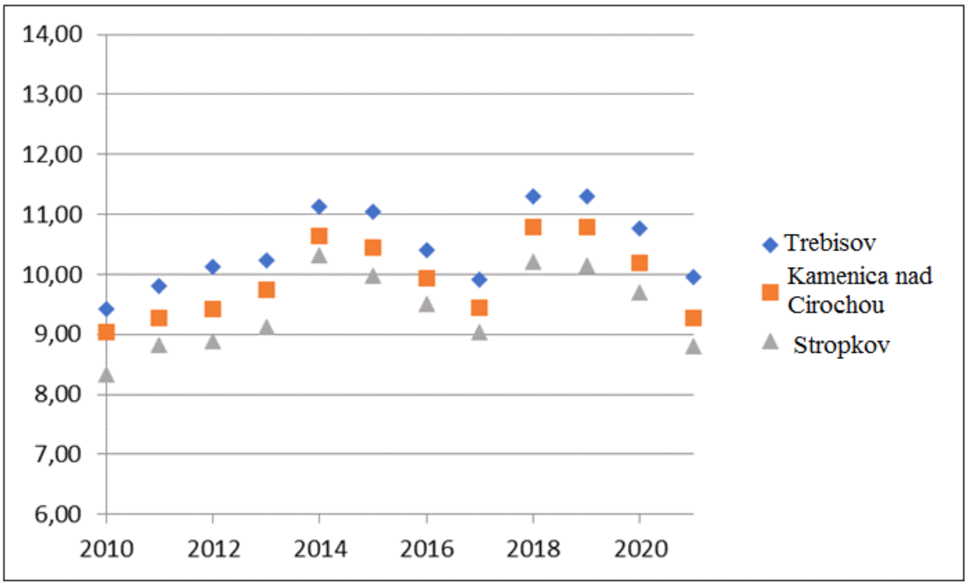

Figure 2.25: Temporal variation of annual precipitation totals between 2010 and 2021 in the Slovakian river basin *(based on OMSZ-National Meteorological Service data)*

In the lowland areas (Kamenica nad Cirochou; Milhostov), January continues to be the coldest month, with the average temperature becoming more extreme, four times in the last

11 years with a positive average temperature, 1.82°C in Kamenica nad Cirochou in 2014 and around -7°C in 2017. January is also the coldest month in the mountainous areas (Stropko - Stropkov), where the average temperature has also become more extreme, exceeding 1°C in 2014 and 2018, and -7.04°C in 2017.

July remains the hottest month, according to multi-year averages, with temperatures ranging from 19-22°C in the lowlands to 18-21°C in the mountain valley stations, showing an increase of 2°C compared to previous years, with a larger increase in the lowlands.

2.5.3.2. Temporal and spatial variation of precipitation

The annual distribution of precipitation has become more extreme, with a nearly twofold difference between the minimum and maximum annual precipitation over the last 11 years (2010-2015).

The difference in rainfall between lowland and mountain areas has decreased in recent years.

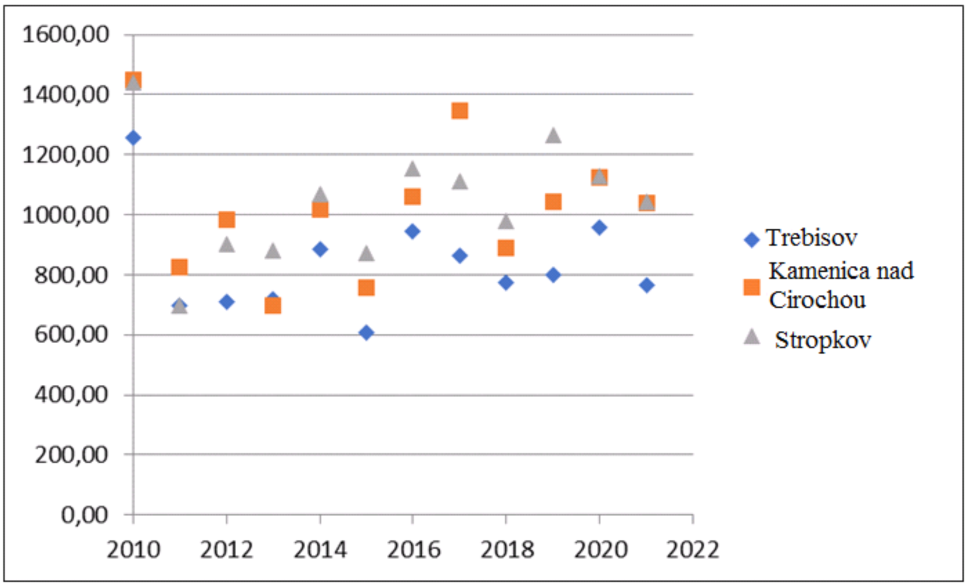

Figure 2.26: Temporal variation of annual precipitation totals between 2010 and 2021 in the Slovakian river basin *(based on OMSZ-National Meteorological Service data)*

The annual precipitation pattern remains at a summer maximum, but the distribution of monthly averages is hectic. The wettest month on the plain is June, which increased from 86 mm to 101 mm on average between 2010 and 2021, but in 2014 and 2021 the monthly average was less than 20 mm, while in 2018 and 2020 it was around 200 mm. January continues to be the month with the least rainfall, with the multi-year average rainfall increasing from 36 mm to 43 mm between 2010 and 2021 compared to previous years, but the average does not show the extreme distribution, with 2018 at less than half the average (19.8 mm) and 2015 and 2021 at more than twice the average (90.4 mm and 109.2 mm). In mountainous areas, the distribution of precipitation was more even, with smaller extremes.

2.5.3.3. Temporal and spatial variation of wind conditions

In terms of wind conditions, the average of previous decades has not changed, but in the period 2010-2021 the average wind speed exceeded 4 m/s in 7 months, while in September 2016 there was practically no wind (0.73 m/s) in Kamenica nad Cirochou.

2.5.4. Ukranian river basin

For the Ukrainian meteorological data, the following municipalities were used: Milota (Hungary - instead of Berehove (Berегове)); Uzshorod (Ужгород); Lviv (Львів); Ivano-Franszkivszk (Івано-Франківськ).

2.5.4.1. Temporal and spatial variation of temperature

The annual average mean temperature over the past 11 years has ranged between 10-12°C in lowland areas and between 8-10°C in mountain-valley areas. The results show a warming of 1- 2°C compared to the average over the last 50 years, with the annual mean temperature increase not as intense as in the surrounding countries.

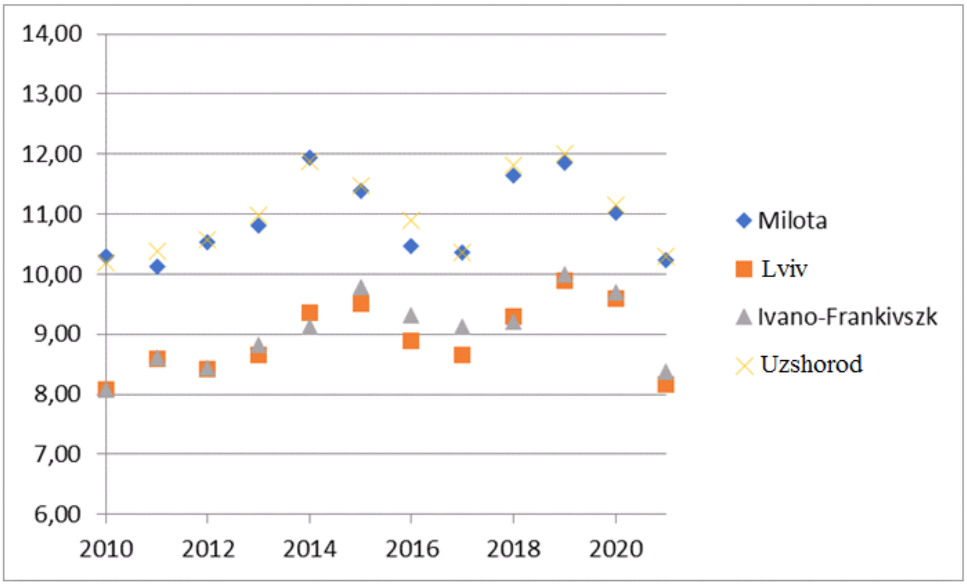

Figure 2.27: Annual mean monthly temperature trends in Transcarpathia *(based on OMSZ-National Meteorological Service data)*

January continues to be the coldest month with average temperatures becoming more extreme, with four of the last 11 years having a positive average temperature, with 2014 and 2018 above + 2°C, while in 2017 the average January temperature was above -7°C.

July remains the warmest month, with averages over many years that range from around 19-22°C in lowland areas to 18-21°C at higher altitudes, showing an increase of 2°C compared to previous years, with higher temperature increases in lowland areas.

2.5.4.2. Temporal and spatial variation of precipitation

The annual distribution of precipitation has become more extreme, with a nearly twofold difference between the minimum and maximum annual precipitation over the last 11 years, but in different periods in lowland and montainous areas. (2010-2011; and 2015-2011).

The difference in rainfall between lowland and mountain areas has decreased in recent years. especially at precipitation minima, where the previous difference has disappeared.

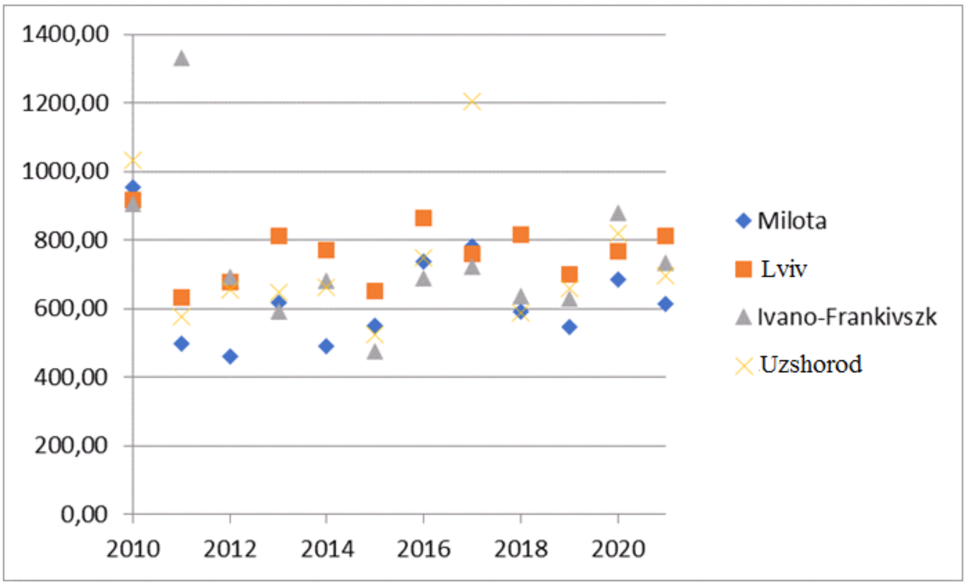

Figure 2.28: Annual trend of monthly average precipitation in Transcarpathia *(based on OMSZ data -National Meteorological Service data)*

2.5.4.3. Temporal and spatial variation of wind conditions

In the case of wind conditions, the average of the previous decades has not changed, the averages are stable compared to the neighbouring countries, and the monthly values are the same.

2.6 Future climate in the Upper Tisza catchment

2.6.1 Future temperature variability in the catchment area

The simulations for the Upper Tisza catchment do not indicate any change in the annual temperature trend, but a substantial change in the monthly and seasonal warming of the mean temperature is expected. In the near future, an increase of up to 1.2 to 1.5°C in annual mean temperature is expected, while an increase of around 2°C is estimated for the different seasons, with warming values could exceed 3°C in the summer season. For the more distant future, simulation results project that temperature increases could exceed 3.5°C in all months, and that the mean temperature of all months will be above freezing, with the coldest month of January likely to have a mean temperature increase to 0.3°C, while raw simulations suggest that January and February temperatures will remain below 0°C. The largest increase is likely to be 6.2°C, based on simulations, so the average could rise above 22°C in the month of August in the more distant future. It can be concluded that in the future, higher temperatures are expected in the Upper Tisza catchment in all months of the year (Figure 2.20). The greatest warming is likely to occur in the summer months. By the end of the 21st century, a temperature rise of 0.5°C is likely in the Upper Tisza catchment (Kis, 2018).

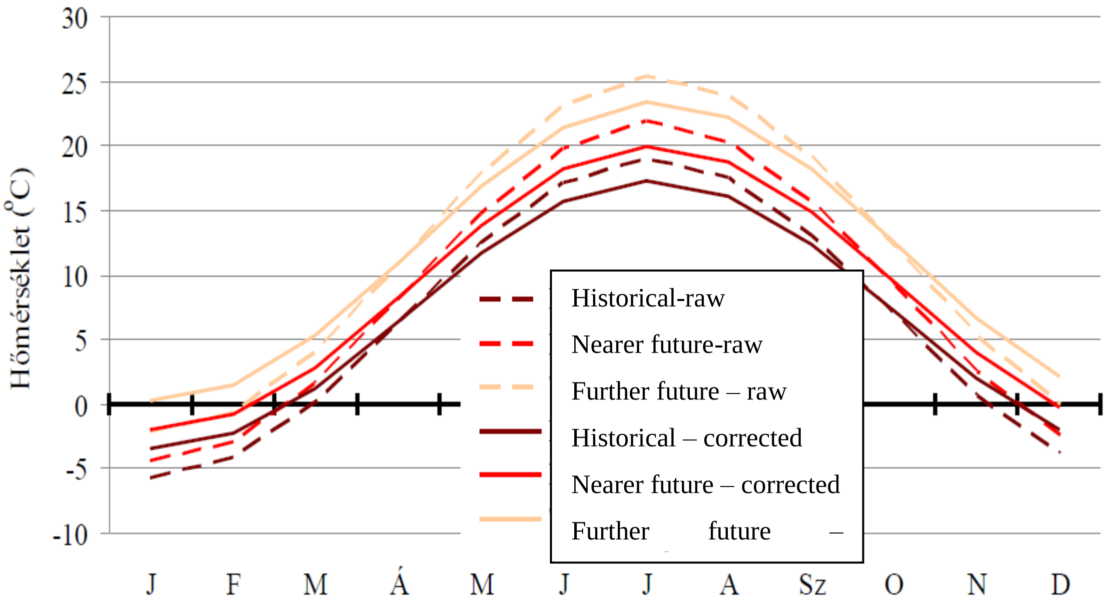

Figure 2.29: Monthly mean temperature in the Upper Tisza catchment for the three tested periods based on the average of the simulation of the weather generator embedded in the MC cycle, raw and driven by the error-corrected parameters *(Kis, 2018)*

The regional bounded-range climate models (ALADIN-Climate and REMO) used by the OMSZ (Hungarian Meteorological Service) Climate Modelling Unit, in which different scenarios are used and projected for different time periods, such as the period between 2021-2050 and the period between 2071-2100. For these periods, the projected changes in temperature and precipitation are calculated for the Carpathian Basin. In the analysis of the model outputs, a reference period is used, such as 1961-1990, so the changes are compared to this. The regional climate models project an upward trend in average temperature for the 21st century, although at different scales. For the period 2021-2050, 1.7°C is projected, while an average of 3.5°C is assumed for the period 2071-2100. For the seasons, the projection shows a different temperature increase, with the largest change projected for summer in 2050 at 1.4-2.6°C. For the transition seasons, a temperature increase of 3-3.5°C is projected for spring in 2050, 2-2.5°C for autumn and 2.1-2.6°C for winter. Also by the end of the century, by 2100, the largest change is expected in the summer season, with a temperature rise of 3.7-4.9°C. In the transition seasons, by 2100, temperatures are expected to rise by 2.7-3.8°C in spring and

3.1-3.4°C in autumn. A more significant change is likely in the winter season with a rise of between 2.8-6.3°C by the end of the century.

2.6.2. Future evolution of precipitation patterns

Based on the results of two models (ALADIN-Climate and RegCM), no significant change in average annual precipitation is expected by the mid-21st century to 2050. Seasonally, however, changes can already be observed based on the results of the two models, i.e. a decrease in average precipitation in summer and winter is expected for the period 2021-2050, so a decrease of 10-15% is expected for the catchment area. This decrease will be compensated by an increase in average rainfall in spring and autumn, according to the Aladin-Climate results, while the RegCM model results suggest a decrease. For these months, the uncertainty of the model results is high, with up to 10-20 mm difference between estimated and future values.

For the second half of the 21st century, both models predict a significant decrease in precipitation for the summer season, with Aladin-Climate predicting -25% and RegCM -10% for the catchment area, and for the autumn season a slight increase. No change is expected for spring, while no clear change can be identified for winter based on model results (Bihari et al., 2018).

The results of simulations (RegCM4) carried out at the Department of Meteorology at the University of ELTE are specific to the Upper Tisza catchment. An important aspect of the study was to improve the raw simulation results by error correction methods, including probabilities for the magnitude of changes. Based on the future estimates, the most significant change in precipitation is likely to occur in the summer season, as a marked decrease in catchment area appears during this period (Figure 2.21). The month of August will become particularly drier with corrected and raw estimates of 62 mm and 34 mm of average precipitation, compared to the historical period (99 mm; 75 mm).

There is a discrepancy between the simulation results for the driest and wettest months likely to occur by the end of the 21st century. Based on the raw data, January will be the wettest month in the region, with an average rainfall of 148 mm/month, while the corrected results show that the maximum rainfall will remain in June (112 mm/month). July-August could be the driest month based on raw simulations (34 mm/month), while corrected results suggest September (55 mm/month).

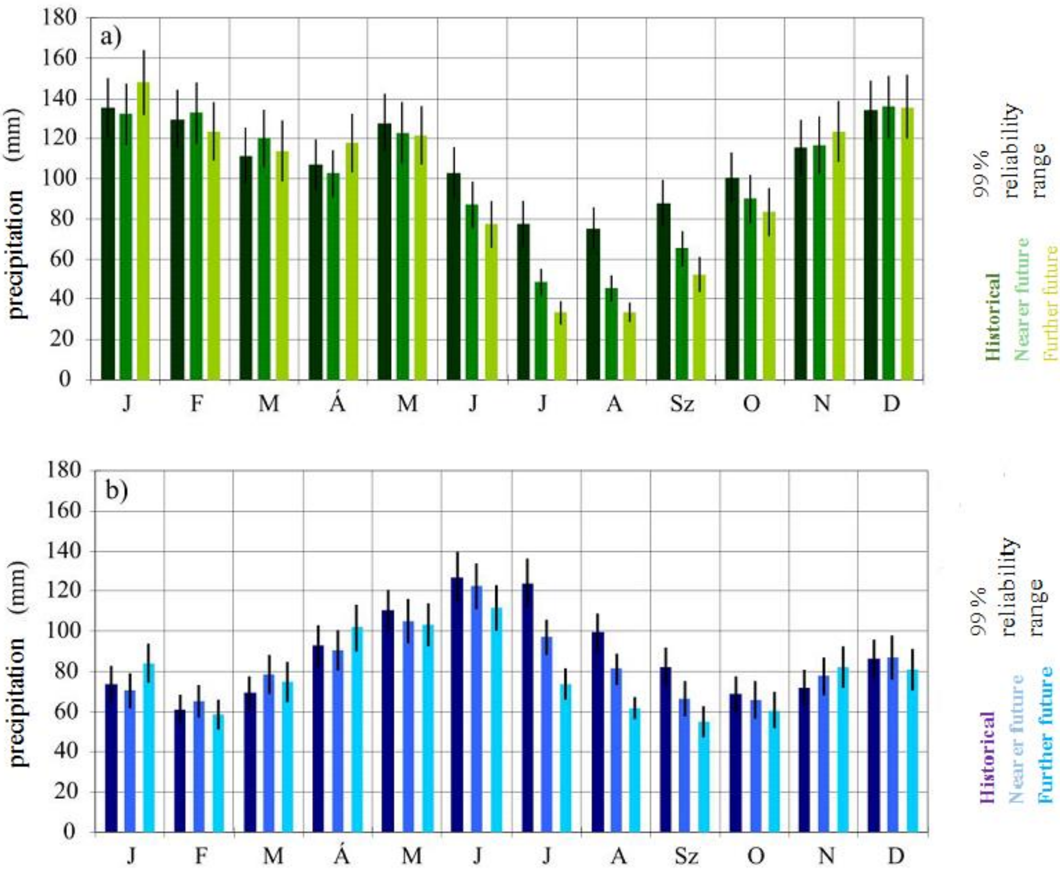

Figure 2.30: Monthly average precipitation totals in the Upper Tisza catchment for the three tested periods based on the average of (a) raw and (b) error-corrected parameter-driven weather generator simulations embedded in the MC cycle *(Kis, 2018)*

Most simulations for the future suggest that the most significant changes are likely to occur in the summer season, as average rainfall is likely to decrease in the area, especially in the months of July-August. Independent model experiments confirm that significant changes are expected in the summer season.

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3. Mitigation assessment

The mitigation situation assessment is carried out separately for each country region. The situation assessment will cover the determination of greenhouse gas (GHG) emissions for each country region. We also provide a country situation assessment for each country, based on documents published by the relevant ministries in each country. The GHG inventory of the Upper Tisza river basin as a single geographical area is not carried out as a whole, but country by country, due to the different social, economic and political specificities. These data are then summed up to obtain the total GHG emissions of the catchment area. The results of the calculation are presented in alphabetical order by country.

Applied methodology

Global Warming Potential (GWP) is used to quantify the greenhouse effect of gases in the atmosphere. Its values are used to convert greenhouse gas emissions into CO2 equivalents. The Global Warming Potentials used (for a 100-year time horizon) are CH4 = 25; N20 = 298; SF6 = 22 800; NF3 = 17 200; HFCs and PFCs are composed of different substances, so GWPs must be calculated individually, depending on the substance. Therefore, when converting to CO2 equivalent, each gas is taken into account with the multipliers above (e.g. 1 t CH4 = 25 t CO2 equivalent).

For each of the four countries concerned (Hungary, Romania, Slovakia, Ukraine), GHG emissions were analysed for the years 2016-2018. However, the methodology used for processing, analysing and evaluating the data for the different regions of the countries differed in some cases. This is because, while for Hungary, basic regional data were available (e.g. electricity and gas consumption, transport data, organic and fertiliser use, forest area, etc.) and could be used to determine the GHG emissions of the region, regional data were not always available for other countries (e.g. Romania, Ukraine, Slovakia). In these cases, national data were used to determine regional data on a population and/or area basis. These cases are given separately in the GHG emissions data.

It should be mentioned here that among the four areas under study (Hungary - Szabolcs-Szatmár-Bereg county; Romania - Maramures and Satu Mare counties; Slovakia - Košice district; Ukraine - Carpathian county), Szabolcs-Szatmár-Bereg county already has an accepted and approved climate strategy, so in this case the data for the previous years (2012-2015) are updated for the period 2016-2018.

The GHG values have been determined on the basis of the methodology developed by the Climate Friendly Municipalities Association (CMAA). On this basis, this methodology has been applied for the determination of GHG values in this document. The exact definition of the methodology is described in the following document: Methodological Guide for the Development of County Climate Strategies (CMMA, 2017).

3.1. Hungary - Szabolcs-Szatmár-Bereg County

National situation

The national picture is based on the "Climate Change Action Plan I" and the "Hungary National Energy and Climate Plan".

Hungary's (gross) GHG emissions excluding land use, land use change and forestry were 63.8 million tonnes of CO2 equivalent in 2017, 31.9% lower than the 1990 level of 93.7 million tonnes of CO2 equivalent. Gross emissions per capita are around 6.5 tonnes, which is below the EU average (Figure 3.1).

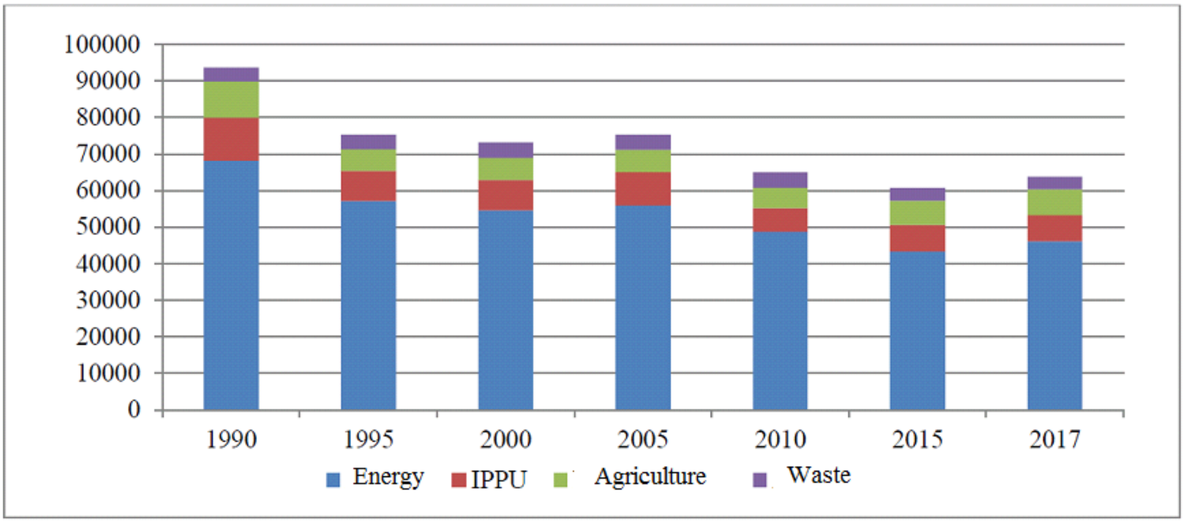


Figure 3.1. Greenhouse gas emissions by sector 1990-2017 (kt CO2eq) *Source: National Energy and Climate Plan of Hungary*

An analysis of the data in Figure 3.1 shows that GHG emissions have decreased in almost all economic sectors, including the energy sector, industry (IPPU) and agriculture, which are important for GHG emissions. Then, emissions decreased by 25% between 2005 and 2013. The global financial and economic crisis in 2008 had a significant impact on the performance of the Hungarian economy and hence on GHG emission levels. Emissions then fell for 4 years after a small increase in 2010. It is important to highlight that, in the meantime, the decline in economic performance stopped in the first quarter of 2010 and by 2015 had already exceeded pre-crisis levels. After 2013, emissions grew again by 12% until 2017, with all economic sectors contributing.

According to the findings of Hungary's National Energy and Climate Plan, the most significant anthropogenic greenhouse gas is carbon dioxide (CO2), which accounts for 77% of total emissions. Carbon dioxide is mainly produced in the energy sector through the combustion of fossil fuels. Overall, Hungary's CO2 emissions have fallen by 44% since the mid-1980s.

Energy sector

The energy sector accounts for the largest share of total emissions, around 72%. This can be explained by the fact that carbon dioxide from the combustion of fossil fuels is the largest GHG emission from the energy sector, with its share of 96%. In Hungary, natural gas is known to be the most important fossil fuel, accounting for 44% of fuel-related emissions. In fact, in the middle of the last decade, the share of natural gas consumption has increased further to 55%. In addition, the share of liquid fuels is 30%, while coal accounts for only 10%.

A fundamental characteristic of the Hungarian energy industry is that half of electricity generation comes from nuclear sources (Paks Nuclear Power Plant) and 40% from fossil sources. Production does not cover national demand, and electricity imports remain significant, at around 30%.

Within the energy sector, the most GHG-emitting sector is the energy industry, which accounts for 30% of the total. This is followed by transport and other sectors (e.g. trade, residential) with 28-28%. Leakage emissions associated with the extraction, processing, transformation and distribution of oil and natural gas contribute only 2% to the sector's emissions (Figure 3.2).

The residential sector's emissions have increased in the last three years of the period analysed. They show that in 2017, household fuel consumption increased by 2%, while biomass use decreased by 6% and natural gas consumption increased by 6%. Coal use also increased. Although residential natural gas use has increased by 27% since 2014, it is still 16% below the average of the last decade.

Manufacturing output has also increased in recent years.

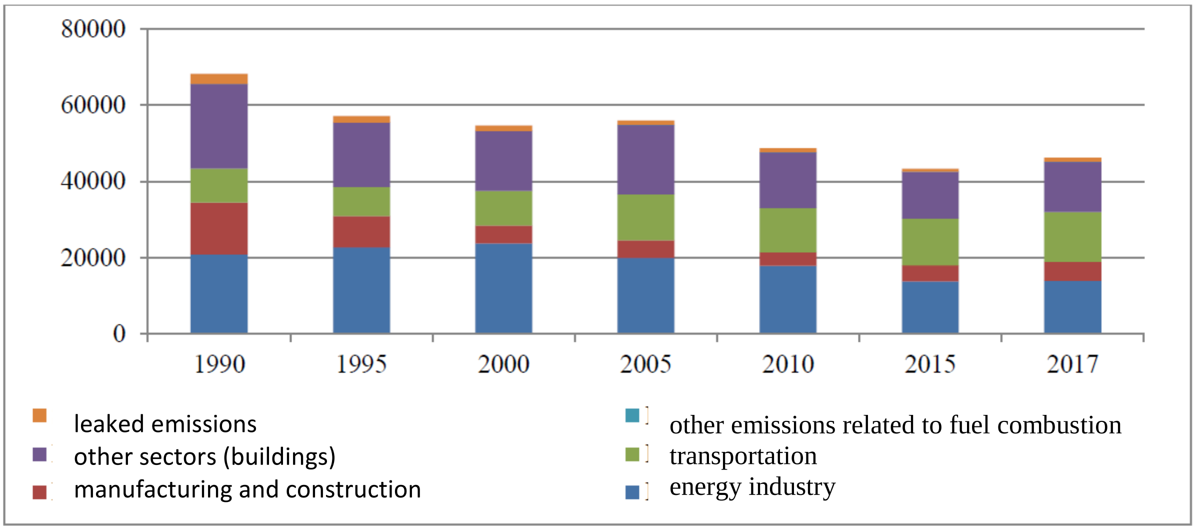


Figure 3.2. Energy sector emissions by source between 1990 and 2017, kt CO2eq
Source: National Energy and Climate Plan of Hungary

Emissions under ESD (Effort Sharing Decisions) totalled 43.14 million tonnes in 2017. This represents a decrease of 6.7% compared to 48.3 million in the 2005 base year, 17% and 2% below the 2020 and 2030 targets respectively.

The transport, buildings, agriculture and waste management sectors are responsible for the largest share of emissions below the ESD, but industrial energy use and F-gas emissions also contribute.

Transport emissions have increased by 9.3% since 2005.

In 2017, agriculture contributed 11% to total emissions. Agricultural production is known to produce methane (CH_4) and nitrous oxide (N_2O) emissions. Since 2011, GHG emissions from agriculture have been steadily increasing, mainly due to fertiliser use and an increase in cattle numbers and milk production per cow.

The waste sector contributes 5% of total emissions. Landfilling of solid waste accounts for the majority of emissions (84%), while wastewater treatment accounts for 11%, composting for 4% and non-energy waste burning for 1%. The increase in emissions stopped in the previous decade, with a decrease of 19% between 2005 and 2017.

F-gas emissions accounted for 3% of total emissions in 2017. F-gas emissions peaked in 2015 and started to rise again in 2017 after a significant decrease.

Hungary's GHG emissions under the non-aviation ETS (Emission Trading Scheme) in 2017 were equivalent to 20.1 million tonnes of CO_2 equivalent, 26% less than in 2005 (Figure 3.3).

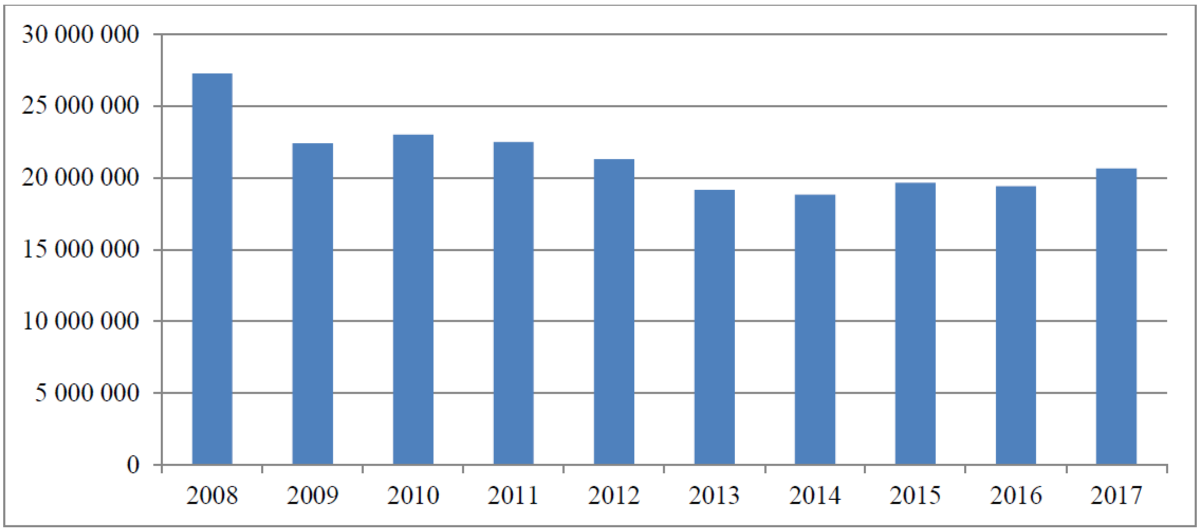


Figure 3.3. Evolution of emissions under EU ETS 2008-2017 (kt CO_2eq)
Source: National Energy and Climate Plan of Hungary

The country's GHG emissions under the EU ETS fell continuously between 2009 and 2014, except for a small jump in 2010. After 2014, the trend reversed again, with emissions increasing by almost 10% in total until 2017.

The land use, land-use change and forestry (LULUCF) sector in Hungary can be considered as a sink overall due to the significant CO_2 sequestration of forests. The average sequestration rate is 3.5 million tonnes of CO_2eq per year, but there are significant fluctuations (between 0.4 million tonnes and 5.8 million tonnes of CO_2eq). In year 2017, forests sequestered 4.9 million tonnes of CO_2.

Szabolcs-Szatmár-Bereg County

Szabolcs-Szatmár-Bereg County had already developed its own climate strategy within the framework of the KEHOP-1.2.0-15-2016-00012 project, which was adopted by the Szabolcs-Szatmár-Bereg County Council in 2018. Chapter 2.1.1 of the document contains the GHG inventory of the county for the years 2012-2015. The emission data of the Sustainable Energy and Climate Action Plan for Szabolcs-Szatmár-Bereg County, prepared within the framework of the project TOP-3.2.1-15-SB1-2016-00062, which includes the practical implementation of the development framework identified by the Climate Strategy, are based on the electricity consumption data of the County Climate Strategy, and for the other energy carriers on the fuel emission factors published by the Climate and Energy Association of Mayors.

In the present document, we use the methodology provided to determine the GHG emissions of Szabolcs-Szatmár-Bereg County as the Upper Tisza catchment area in Hungary for the years 2016-2018, continuing the previous data series.

3.1.1. GHG emissions from electricity consumption

The county of Szabolcs-Szatmár-Bereg mainly relies on imported energy sources. In terms of fossil fuels, the county has no operating coal mines, and there is no extraction of natural gas or oil in the county. The source of natural gas consumption comes primarily from Russia.

The range of renewable energy sources is very diverse in terms of their use. In the field of hydropower, the Tiszalök hydropower plant (12.9 MW), in operation since 1959, is a notable example. The power plant also has a solar panel system. The largest power plant in the county is the Nyíregyháza Combined Cycle Power Plant (48 MW), which uses natural gas. There are several biogas production plants in the county. - Dombrád (0,63 MW); "Erdőhát" Mezőgazdasági Termelő- Szolgáltató- és Kereskedelmi Zrt. - Vámosoroszi (0,6 MW); Csengersima (0,53 MW); Nyírségvíz Zrt. - Nyíregyháza (0,537 MW). Of these, the agriculture-based ones are Nyírbátor, Nyírtelek, Dombrád, Vámosoroszi and Csengersima. Wastewater based in Nyíregyháza is located in the area of the wastewater treatment plant II. The latter's energy production is mainly captive use (both heat and electricity). Biomass power plant operates in Szakoly, with a nominal capacity of 19.8 MW, Hungary's first greenfield biomass-fired power plant, which produces electricity by burning pure biomass - wood chips and sawmill by-products. District heating systems are fuelled by natural gas fuelled gas engines, which produce electricity and heat (including cooling in summer) (University of Nyíregyháza: 2 MW, Nyíregyháza Örökösföld). LEGO has a gas turbine unit of 7.5 MW. Bio-briquette and bio-pellet production plants are operating in several locations in the county. There are currently no biofuel production plants in the county.

The use of geothermal energy is mainly for therapeutic (balneological) purposes. There are 38 thermal wells in the county, of which 12 have a temperature of at least 50 ^{0}C. The highest temperature is 67 ^{0}C, which is located in Tiszavasvári. The wells in operation supply thermal water to indoor swimming pools, open air swimming pools, and spas.

Geothermal energy is already used in the form of district heating. In Mátészalka, a project to build a 1200-metre deep thermal well on land owned by the municipality was completed in 2020. Based on the planned water yield, a thermal capacity of 2.5 MW can be achieved. A single-pipe cascade system has been installed for recovery. The heat is supplied to the existing 7 heat centres in succession via an NA 150 pipeline. The heat exchangers are connected to the existing return lines of the district heating system, so that the thermal energy is harnessed by preheating the return water.

In Nyíregyháza, geothermal energy is also used to heat 1.07 ha of foil and a greenhouse where ornamental plants are produced by a Ltd.

There are no wind power plants in the county. However, there are small wind turbines and wind turbines for water pumping in the residential and agricultural sectors. The number of solar power plants in the county has increased considerably in recent years (e.g. University of Nyíregyháza - 0.367 MW; Tiszabezdéd - 0.617 MW; Baktalórántháza - 2x0.499 MW; Balkány - 2x0.499 MW; Fehérgyarmat - 9 MW, etc.).

The two major parts of the energy transmission network are the electricity and gas transmission pipeline systems. The electricity transmission network consists of 750, 400 and 220 kV lines running through the county from Ukraine towards Debrecen and Sajószöged.
In 2018, the county consumed 1,584,632 MWh of electricity for municipal, residential, street lighting, industrial, agricultural and other purposes (Figure 3.4).
Residential and industrial consumption accounted for the largest share of electricity consumption, 533,528 MWh and 635,009 MWh, respectively. Overall, electricity consumption shows an increasing trend. Compared to the 2012 consumption figures examined in the climate strategy, the county's electricity consumption is expected to increase by around 15% by 2018.

Carbon dioxide emissions from electricity generation are shown in Figure 3.5. These values show an increasing trend in line with consumption. A decrease is expected if the share of renewables and nuclear power in the national electricity generation resource side continues to increase. The aggregated carbon dioxide emission data are presented in Figure 3.6.

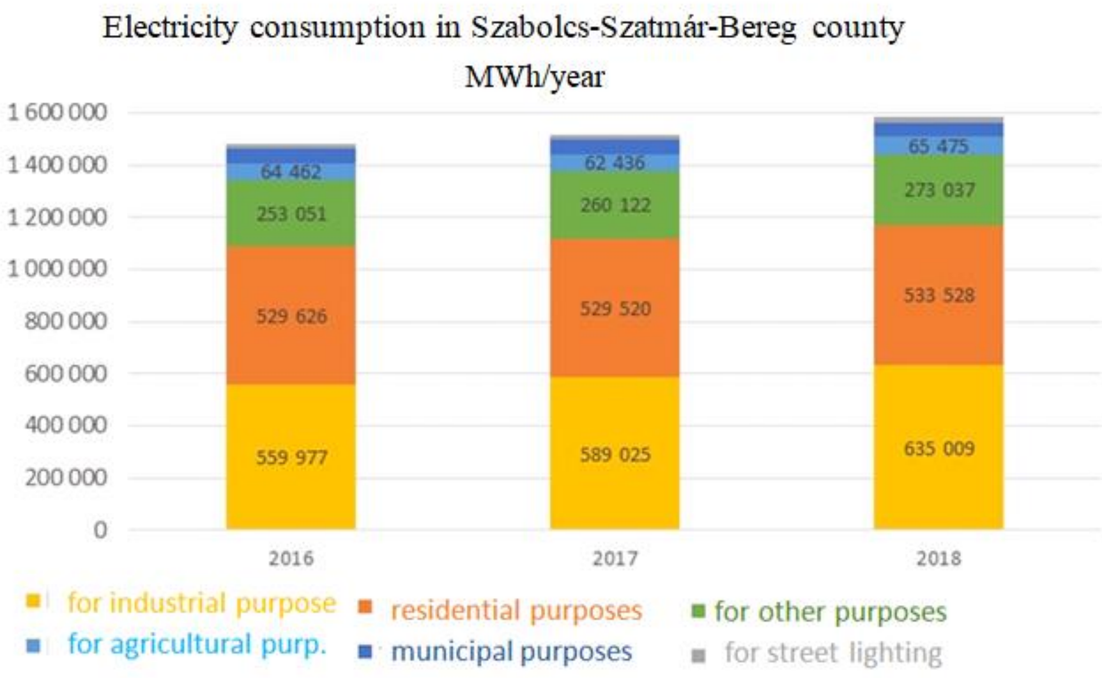


Figure 3.4. Electricity consumption in Szabolcs-Szatmár-Bereg county

Source: edited from KSH data

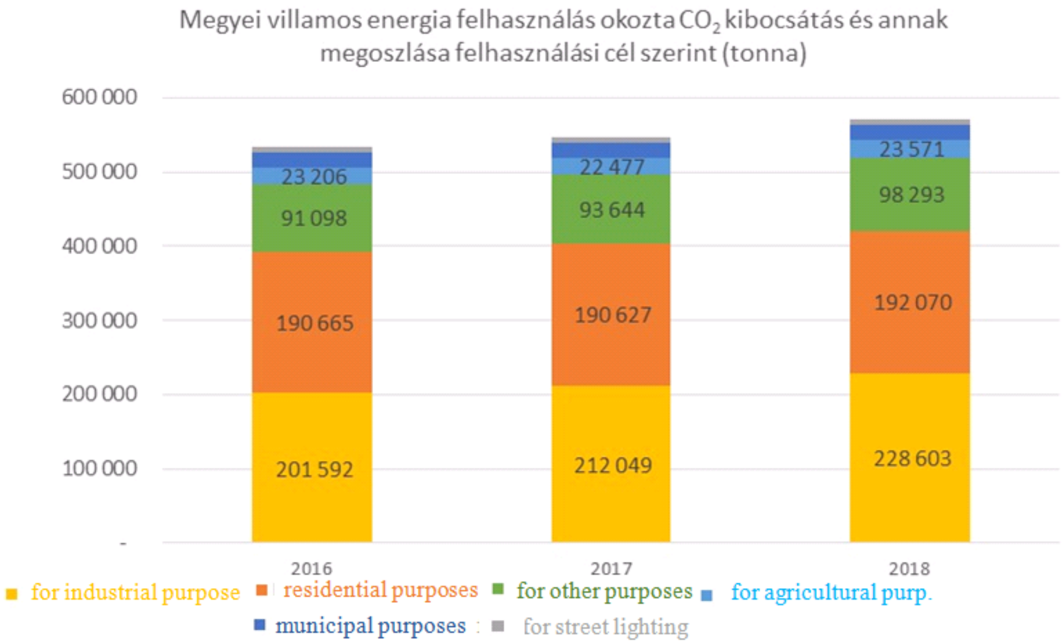


Figure 3.5. Carbon dioxide emissions from electricity use in the county

Source: edited from KSH data

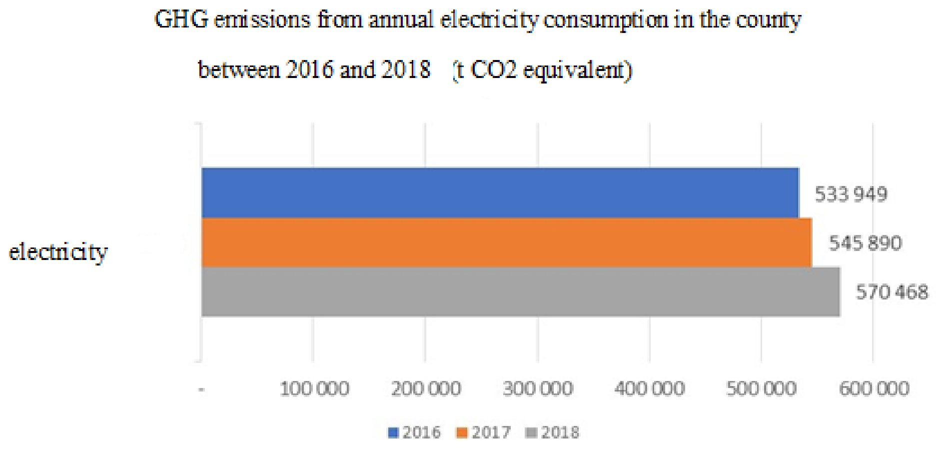


Figure 3.6. Total carbon dioxide emissions from electricity use in the county

Source: edited from KSH data

3.1.2. GHG emissions from natural gas consumption

Figure 3.7 illustrates the evolution of the county-wise distribution of natural gas consumption by consumers

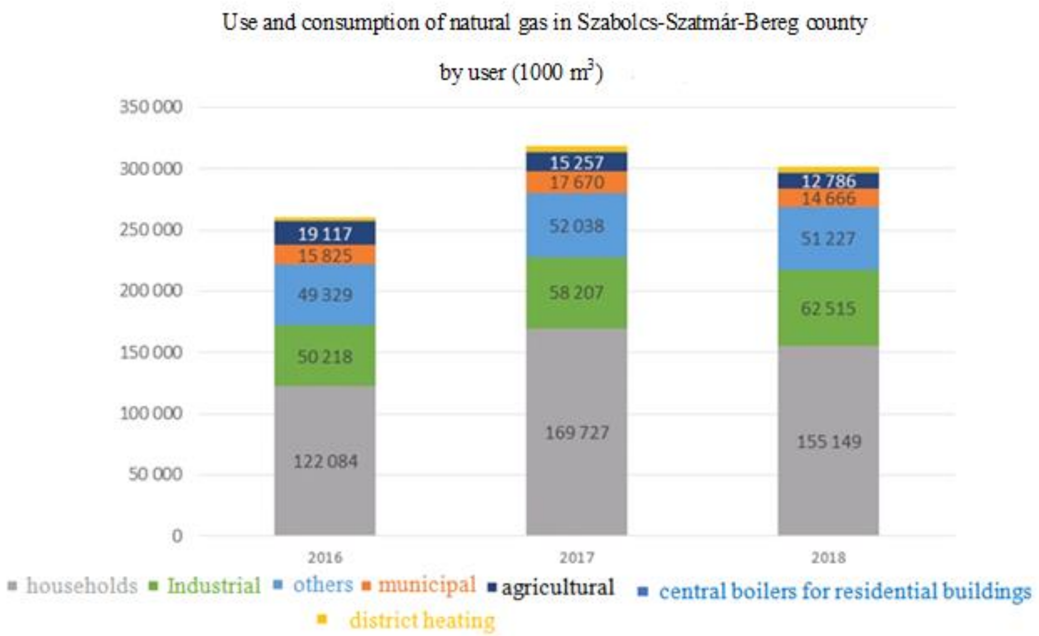


Figure 3.7. Total natural gas consumption in Szabolcs-Szatmár-Bereg county

Source: edited from KSH data

Residential consumption (central boilers in households and residential buildings) accounts for the largest share of the total. Although there is a changing trend in this segment, the reason for this is related to the change in outdoor temperatures. The amount of natural gas consumed is used to determine the amount of carbon dioxide produced, the annual evolution of which is shown in Figure 3.8.

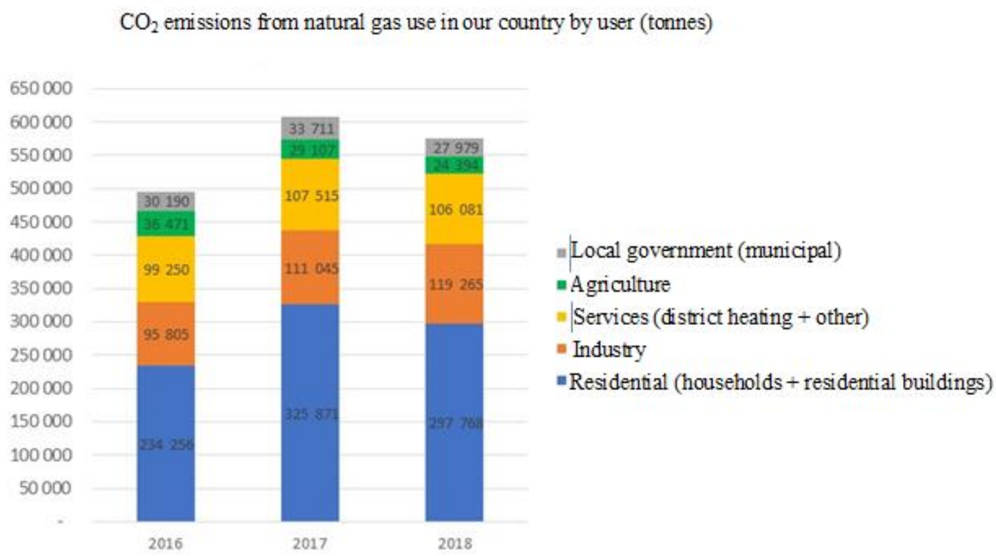


Figure 3.8. Carbon dioxide emissions from natural gas use in our county

Source: edited from KSH data

Carbon dioxide emissions from natural gas consumption increased slightly between 2016 and 2018, in line with consumption. Natural gas is considered the cleanest of the fossil fuels, with perfect combustion releasing carbon dioxide and water vapour into the atmosphere.

3.1.3 GHG emissions from residential firewood and coal consumption

The two most popular energy sources for domestic heating are firewood and coal, which are mainly used in villages and small towns. The former is considered a renewable energy source as it is carbon neutral, while the latter is a fossil fuel. In the case of firewood, it is important to ensure timely storage, which can provide the wood with the right dryness, which affects its perfect combustion and the transfer of the right heat value. In 2018, the estimated residential firewood consumption in Szabolcs-Szatmár-Bereg County was 477,740 tonnes, while coal consumption was 10,385 tonnes. In energy terms, this corresponds to 2,654,133 MWh and 56,080 MWh of heat value per year. On average, the annual consumption of firewood per dwelling was 5,356 tonnes and of coal 3,194 tonnes. Based on this, the County's GHG emissions from residential firewood and coal consumption were 40,478 tons.

3.1.4. Large industrial emissions

Large industrial emitters include establishments using energy sources other than electricity and natural gas (e.g. fuel oil, biomass, coal). The greenhouse gases that can be considered for large industrial emissions are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Carbon dioxide emissions occur in direct and indirect forms, i.e. as a result of the use of natural gas and electricity and during technology. Emissions of methane and nitrous oxide from large industrial emissions in the county were not reported in the period under review according to EU ETS data. Aggregate carbon dioxide emissions are shown in Figure 3.9 and are derived from energy sources other than pipeline natural gas use. For the period under review, it can be clearly seen that the 2018 value shows an increase of more than 100% compared to 2015.

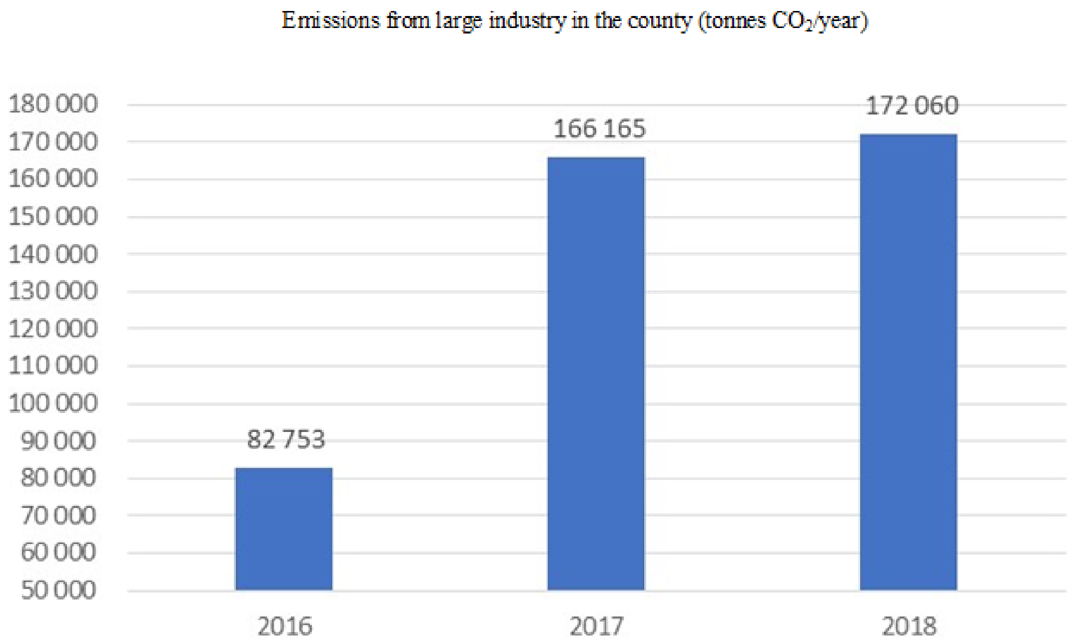


Figure 3.9. Trends in GHG emissions from large industrial emissions

Source: edited from KSH data

3.1.5. GHG emissions from transport in Szabolcs-Szatmár-Bereg county

Transport is a fundamental condition for the functioning of society and the economy, and its quality is a measure of economic development. The dominance of road transport is expected to continue in the near future, despite the fact that the European Union's transport policy strategy aims to change the modal split and shift to more environmentally friendly modes of transport over longer distances in the interests of sustainable development. At present, limits for nitrogen oxides (NOx), hydrocarbons (HC), carbon monoxide (CO) and particulate matter (PM_{10} and $PM_{2.5}$) are regulated for most vehicles, including cars, lorries, tractors, trains and river boats, but not for seagoing vessels and aircraft. As Szabolcs-Szatmár-Bereg county borders Romania, Slovakia and Ukraine, the road and rail networks play an important role in international relations and in the national context. The evolution of GHG emissions from transport for the period under review is shown in Figure 3.10 (data exclude emissions from water and aviation).

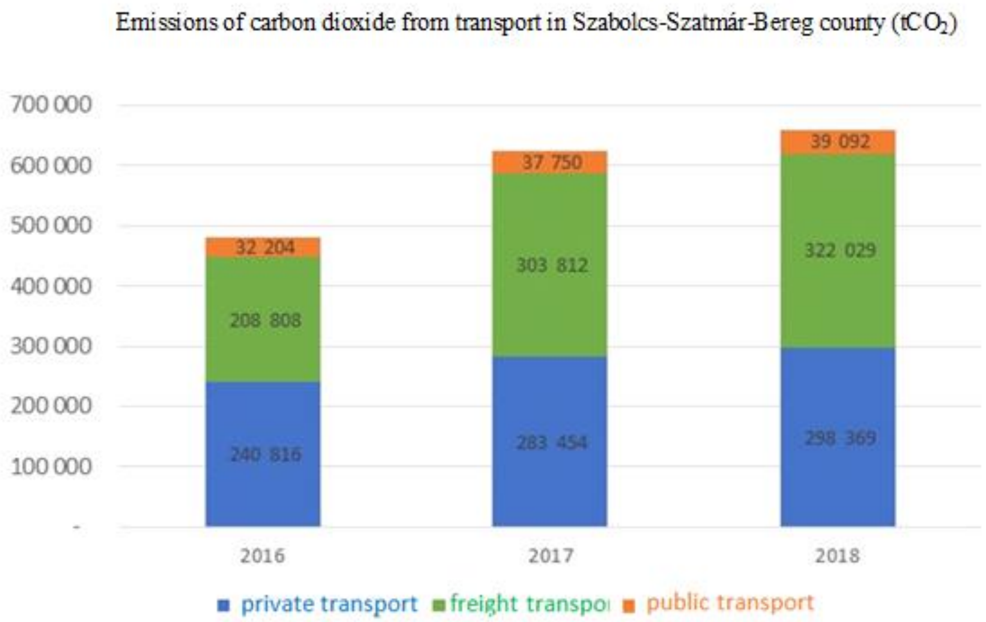


Figure 3.10. GHG emissions from transport (tCO_2 equivalent) in Szabolcs-Szatmár-Bereg county. *Source: data provided by Magyar Közút Zrt. and calculated according to the methodology of the KBTSZ*

If we look at the share of each sector in the total volume, we can make the following observations (Figure 3.10):

- GHG emissions from private transport are steadily increasing year by year
- public transport has the lowest GHG emissions of the three sectors and is also growing;
- GHG emissions from freight transport also show a significant increase.

Based on these data, the annual breakdown of GHG emissions from transport in Szabolcs-Szatmár-Bereg county is as follows:

- 2016: 481.828 tonnes
- 2017: 625.016 tonnes
- 2018: 659.490 tonnes
- 2016-2018 average: 588.778 tonnes..

Despite technological progress, road transport-related carbon dioxide emissions have increased over the period. The decline at county level may be partly resolved in the future by technological advances, which mean that cars and trucks with increasingly stringent Euro standards will become more energy efficient in the future, thus consuming less fuel per kilometre and emitting less carbon dioxide and other pollutants. The reduction could be further enhanced by the uptake of electric vehicles, improved public transport conditions and the growth of cycling, provided that the infrastructure is in place. Cycling can be linked to both access to jobs and leisure (tourism) activities. For this reason, improving the possibilities of cycling has become a social policy objective, and its environmental and climate protection aspects are also significant, which has led to a number of developments in this area throughout the country, including Szabolcs-Szatmár-Bereg County.

In transport, a change of attitude is needed regarding the way people travel, as a significant part of the county's GHG emissions are generated in this area. This is mainly due to the spatial separation of jobs and housing, the deterioration of public transport infrastructure and spatial location, and changes in consumption patterns. What is needed is not only technological innovation, but also a change in the structure of transport, both passenger and freight, and rationalisation. This means encouraging a shift from private transport (private car) to public transport and, for private transport itself, modes of transport that influence car use patterns (e.g. cycling, public transport, possibly carpooling) and are considered more favourable in terms of specific emissions and GHG emissions. For motorised modes of transport, encouraging the use of alternative powertrains (electric or hybrid, CNG, etc.) can contribute to reducing GHG emissions from transport. In addition, the expansion of cycle routes, the development of incentives for cycling (e.g. support for commuting by bicycle, following international examples) and the provision of appropriate infrastructure could also enhance the future value of this mode of transport in the county of Szabolcs Szatmár Bereg.

3.1.6 Evolution of GHG emissions from agricultural activity

The analysis of GHG emissions from the agricultural sector should also be based on the assumption that the primary function of agricultural production is to meet the food needs of the world's growing population. The amount of biomass that needs to be re-grown each year is produced by agriculture primarily based on the energy and renewable resources that are constantly coming from the sun. Meeting the growing demand for food is naturally associated with increasing GHG emissions due to the biological processes of production technologies.

GHG emissions from agriculture can be traced back to the use of organic fertilisers and fertilisers, animal farming and the use of agricultural technologies. The total GHG emissions from the agricultural sector in CO_2 equivalent decreased from 103,161 tonnes in 2016 to 101,197 tonnes in 20101 (Figure 3.11). The emissions in CO_2 equivalent are mainly due to methane emissions from cattle, but emissions from slurry manure production are also significant. In comparison, the use of organic and manure fertilisers is a minor source of GHG emissions.

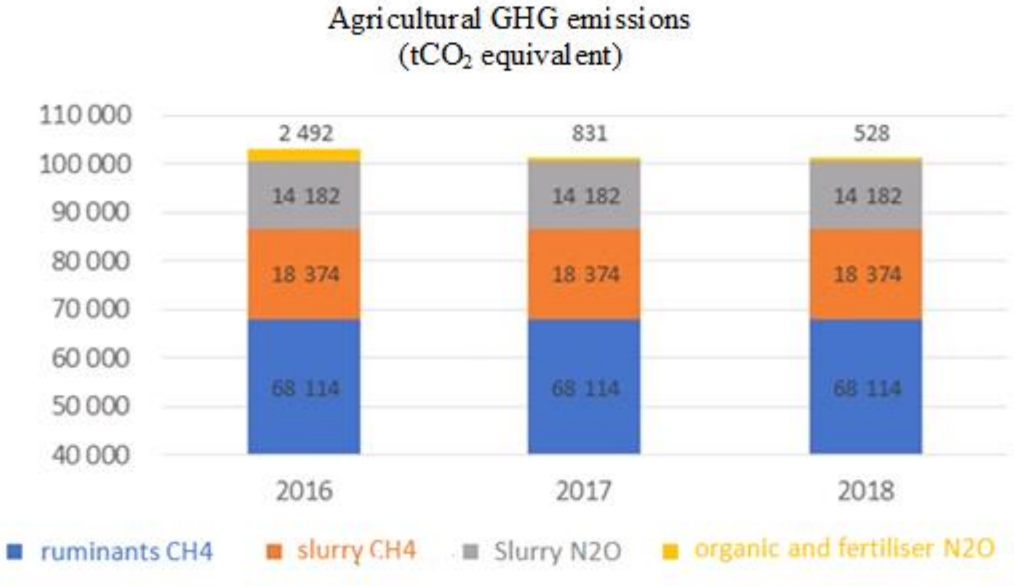


Figure 3.11. GHG emissions from agriculture in Szabolcs-Szatmár-Bereg county
Source: Calculated on the basis of the KBTSZ methodological guide

GHG emissions of the agricultural sector in Szabolcs-Szatmár-Bereg county in 2018 according to the GHG inventory:

- 68,114 t of methane emissions from ruminants, calculated on a CO_2 equivalent basis;
- 18,374 t CO_2 equivalent of methane and 14,182 t CO_2 equivalent of nitrous oxide emissions from manure storage from the cattle and pig herds in the county responsible for slurry emissions,
- and the county's organic and fertiliser emissions consist of 528 t of nitrous oxide emissions calculated as CO_2 equivalent.

Overall, it can be concluded that the GHG emissions of the agricultural sector of the county are mainly determined by the development of the cattle population, based on the calculation model prepared by the KBTSZ. An increase in the livestock population is desirable from a national economic and agricultural sector perspective, even if it results in increasing GHG emissions. Based on the GHG inventory, emissions from the agricultural sector can be reduced through the use of sustainable manure management and application technologies.

3.1.7. GHG emissions from waste management

Municipal waste management in Szabolcs-Szatmár-Bereg County is provided by a regional waste management association. Selective waste collection is possible in practically all settlements of the county, but further improvements are needed to reach the desired quantity (new waste collection centres, establishing waste yards, raising the level of service) and it would be important to create the conditions for better utilisation of the waste collected separately.

In Szabolcs-Szatmár-Bereg County, in the period 2016-2018, the annual breakdown of the amount of carbon dioxide equivalent greenhouse gases generated in the context of municipal solid waste and wastewater treatment is shown in Figure 3.12.

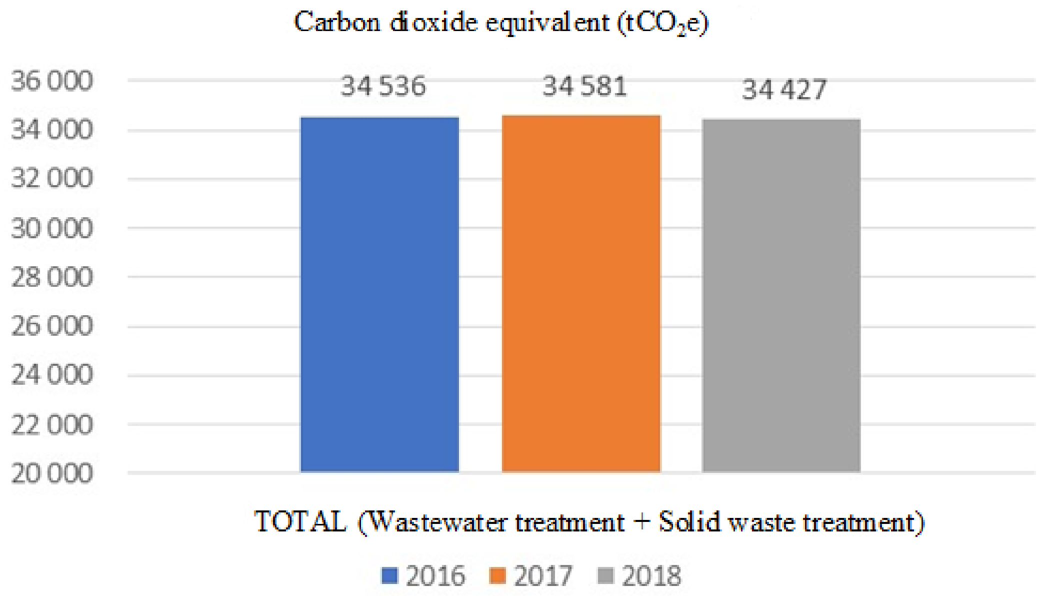


Figure 3.12. GHG emissions from wastewater and solid waste treatment
Source: calculated on the basis of the KBTSZ methodological guidance

A The GHG inventory methodology developed by the Climate Friendly Communities Association takes into account the formation of greenhouse gases from solid waste management and wastewater treatment. In waste management, solid waste landfilling is responsible for methane formation, while wastewater treatment is responsible for nitrous oxide emissions in addition to methane. ‚For the period 2016-2018, GHG emissions from waste treatment are basically stagnating, with a slight downward trend, one of the likely reasons being the development of waste treatment technology and the introduction of more strict regulatory regimes in line with EU and national standards (e.g. biogas collection and recovery in landfills).

In summary, GHG emissions from solid waste management and wastewater treatment have shown a slight downward trend over the period under review.

3.1.8 GHG sequestration trends - forest areas (sinks)

The extent of Hungary's forested areas has increased steadily over the last decade. In 2017, the forest area of Szabolcs-Szatmár-Bereg county was about 118,240 ha, which is 21.3 % of the county's area. This proportion is almost the same as the national average (20.9 %).

According to the methodology used to compile the GHG inventory, the forest areas of the county sequestered a total of 198,397 tonnes of carbon dioxide in 2018. The extent of the

County's forested areas for the period 2016-2018 and the resulting GHG sequestration rate (ingestion) is shown in Figure 3.13.

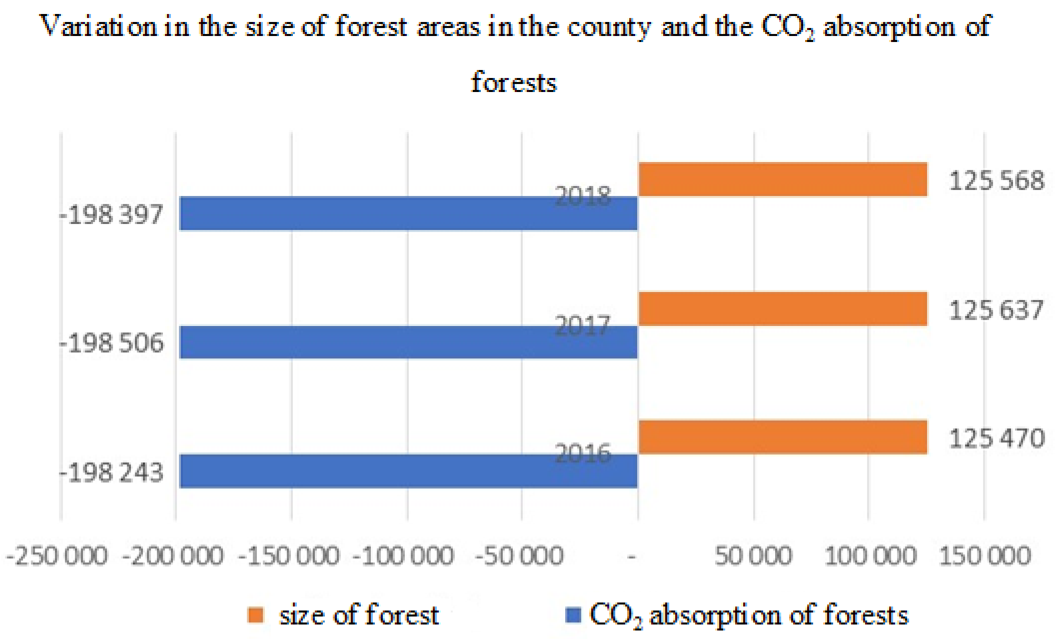


Figure 3.13. Evolution of carbon sequestration in the county's forest area 2016-2018

Source: KBTSZ methodological guide and calculated on the basis of data from KSH

3.1.9. *Summary findings on the GHG inventory*

Based on the GHG inventory of Szabolcs-Szatmár-Bereg county, the development of the share of each emitter can be determined, the data of which are presented in Table 3.1.

Pollutant source (sector) name	**Estimated emissions in the year under review ($t\ CO_2$ equivalent)**					
	2016		**2017**		**2018**	
	$t\ CO_2$ equivalent	**%**	**$t\ CO_2$ equivalent**	**%**	**$t\ CO_2$ equivalent**	**%**
Energy consumption	1.070.399	60,4	1.193.618	56,3	1.186.434	55,1
Large industrial emissions	82.753	4,7	166.165	7,8	172.060	8,0
Transport	481.829	27,2	625.017	29,5	659.489	30,6
Agricultural activities	103.161	5,8	101.500	4,8	101.197	4,7
Waste managment	34.536	1,9	34.581	1,6	34.427	1,6
Total emissions (gross):	**1.772.678**	**100,0**	**2.120.881**	**100,0**	**2.153.607**	**100,0**
Sinks (forests)	-198.243	-11,2	-198.506	-9,4	-198.397	-9,2
Balance (net emissions)	**1.574.435**	**88,8**	**1.922.375**	**90,6**	**1.955.210**	**90,8**
Balance (net emissions) excluding large industry	**1.491.683**	**84,1**	**1.756.210**	**82,8**	**1.783.150**	**82,8**

Table 3.1: Summary of GHG emissions in Szabolcs-Szatmár-Bereg county
Source: own calculation according to KBTSZ methodology.

Analysing the data in Table 3.1, the following general observations and conclusions can be drawn:

1) Energy-related emissions account for a significant share of the county's GHG emissions (around 30-55%) and have been increasing over the period under review. It is primarily gas, electricity, and residential firewood and coal. Therefore, an important objective for the future is to reduce the share of fossil fuels and to propose and enable alternative solutions. Another important long-term objective is to increase energy efficiency and modernise the energy efficiency of homes, private houses, public institutions, community buildings and business premises.
2) Emissions from large industry account for around 5-8% of total GHG emissions, which also show an upward trend over the period under review.
3) Transport is considered a significant emitting sector. The transport sector is responsible for almost one third (27-30%) of the total GHG emissions, which also showed an upward trend during the period under review. In 2016-2018, the average GHG emissions from the transport sector at the county level amounted to 588,778 tonnes. Within the transport sector, the largest GHG emitting segment is private transport, which, moreover, shows an increasing trend. The second largest GHG emitter is freight transport, which also shows an increasing trend over the period under review. The third segment is public transport, which accounts for a fraction of total GHG emissions from transport.
4) The reduction of emissions caused by private transport could be achieved basically by changing attitudes: encouraging carpooling, promoting the use of more environmentally friendly vehicles, developing a network of cycle paths and promoting cycling, etc.
5) The amount of GHG emissions attributable to agriculture is not significant (just 5-6% of the total), and is decreasing both in nominal terms and as a share of total emissions. The structural composition of GHG emissions from agriculture in the county, expressed in CO_2 equivalents, has remained essentially unchanged over the period under review.
6) In general, the contribution of GHG emissions from waste management and wastewater treatment in the county is slightly below 2% of total GHG emissions. This segment shows a slight downward trend in terms of its share over the period under review. For the future, the use of sustainable waste management technologies, the promotion of selective waste collection from the public, the promotion of energy recovery from

waste, the reduction of waste per capita, the increase of re-use and recycling are all important objectives.

7) Forest areas play a crucial role in carbon sequestration. In the county, a small increase in forest cover was observed in the period under study (2016-2018). This trend is certainly desirable, as the "management" of local GHG emissions is a very important future task in which the role of forests will be enhanced. In terms of their share, forests absorb, i.e. neutralise, about 10 % of the total GHG emissions in the county.

In summary, GHG emissions from energy use, large industrial emissions and transport are showing significant increases. At the same time, GHG emissions from agricultural production and waste management are decreasing, if only slightly. Carbon dioxide sinks show a minimal increase.

3.2. Romania - Maramures and Satu Mare counties

National overview of the situation

The document "Romania's Fourth Biennial Report under the UNFCCC. Ministry of Environment, Waters and Forests, December 2019" was used to outline the country situation.

3.2.1. Trend in total GHG emissions

Total greenhouse gas emissions in Romania in 2017, excluding the LULUCF sector, were estimated at 113,795 Mt CO_2 equivalent. Between 1989 and 2017, total GHG emissions (excluding the LULUCF sector) decreased by 62.90% and net GHG emissions (including the LULUCF sector) decreased by 68.19%.

The overall GHG emission trend in Romania shows a sharp decrease compared to the base year (1989) (Figure 3.14).

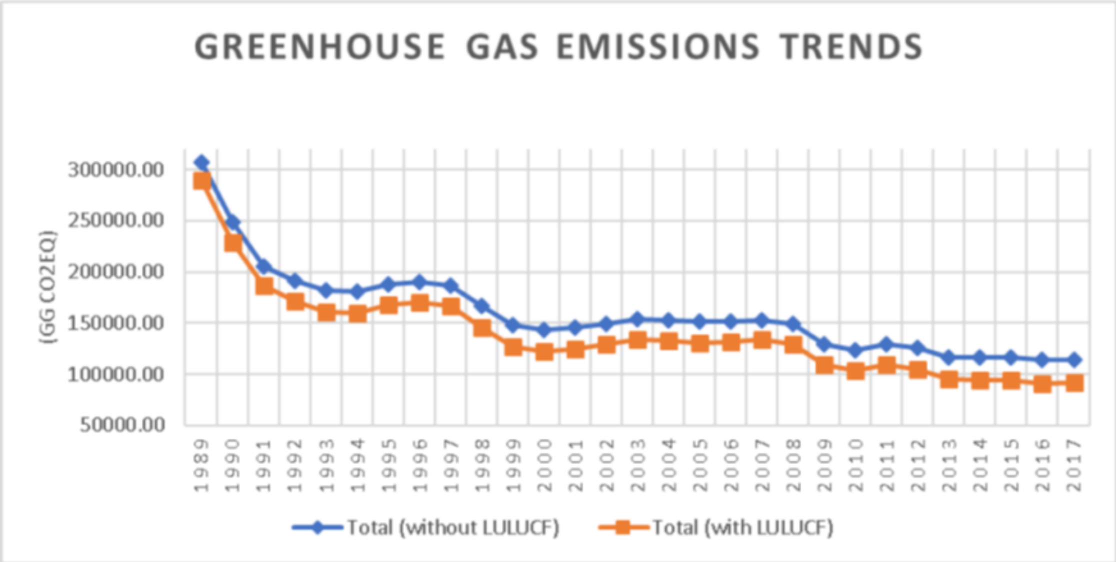


Figure 3.14. Trends in Romania's total GHG emissions from 1989 to 2017 (unit: Gg CO2 equivalent = 10-3 Mt) *Source: Romania's Fourth Biennial Report under the UNFCCC, Ministry Of Environment, Waters And Forests, December 2019*

However, the evolution of GHG emissions can be divided into three periods: 1989-1999, 2000-2007 and 2008-2017. The period 1989-1992 was characterised by a steady decline in GHG emissions, as a direct consequence of the decline in economic activity and the resulting reduction in energy demand. The transition period of economic activity also included a decline in the activities of certain energy-intensive industries, which led to a decrease in GHG emissions. In the period that followed, GHG emissions showed an upward trend until 1996, which can be linked to a recovery in economic activity. Then, from 1997 onwards, GHG emissions started to decrease again, due to a significant change in the energy mix with the commissioning of Unit 1 of the Cernavoda nuclear power plant (1996), which replaced a number of other fossil power plants. The decline then continued until 1999. After 1999, the evolution of greenhouse gas emissions faithfully reflects the economic boom and development between 2000 and 2007. The slight decrease in GHG emissions in 2005 compared to the levels recorded in 2004 and 2006 was due to a further change in the energy mix, as hydropower contributed significantly to energy production in that year.

The economic and financial crisis that unfolded in 2018 has already had a significant impact on greenhouse gas emissions by 2010. The decrease compared to 2008 is significant. In the following period 2010-2017, GHG emissions remained relatively stable.

3.2.2. Trends in greenhouse gas emissions

Analysis of the data shows that greenhouse gas emissions (except HFCs and SF6) have decreased compared to the base year (1989). CO_2 is the largest contributor to total GHG emissions, followed by CH_4 and N_2O. In the base year, total GHG emissions (excluding the LULUCF sector) were as follows: 68.13% for CO_2, 24.15% for CH_4, 6.27% for N_2O and 1.45% for total F-gases. The total GHG emission trends by gas type (with and without LULUCF sector values) are shown in Figure 3.15.

Carbon dioxide (CO_2) is the most important greenhouse gas of anthropogenic origin. The rate of reduction of CO_2 emissions in 2017 compared to the 1989 baseline is 64.11% (1989: 208.946 Mt CO_2 equivalent; 2017: 74.998 Mt CO_2 equivalent), mainly due to the reduction of fossil fuels used in the energy sector (mainly in the public electricity and heat generation, manufacturing and construction sectors).

Methane (CH_4) comes mainly from the extraction and distribution of fossil fuels. Methane emissions from fugitive emissions have decreased by 61.22% in 2017 compared to 1989 levels (from 74,073 Mt CO_2 eq. in 1989 to 28,725 Mt CO_2 equivalent in 2017). The decrease in CH_4 emissions in the agricultural sector is due to a reduction in livestock.

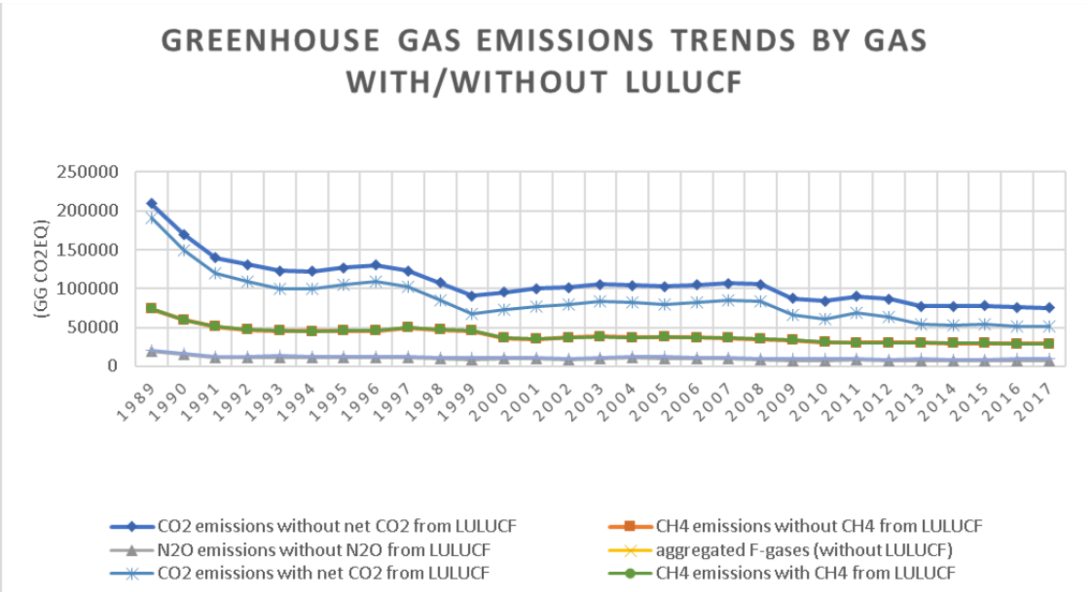


Figure 3.15. Evolution of GHG emissions in Romania 1989-2017 with and without LULUCF sector (unit: Gg CO_2 equivalent = 10-3 Mt) *Source: Romania's Fourth Biennial Report under the UNFCCC, Ministry Of Environment, Waters And Forests, December 2019*

Nitrous oxide (N_2O) emissions are mainly generated by the agricultural sector (agricultural land cultivation) and industrial processes and product use (chemical activities). The evolution of N_2O emissions reflects the downward trend of these activities: a decrease in livestock numbers, the amount of synthetic nitrogen fertiliser applied to the soil and the level of crop production. In 2017, N_2O emissions decreased by 59.24% compared to base year emissions.

Fluorinated gases (F-gases) have been used since 1995 to replace ODS in refrigeration and air conditioning systems. PFC emissions from the primary aluminium production process have decreased significantly (99.87%) by 2017 compared to 1989.

3.2.3 Evolution of greenhouse gas emissions by sector and by sink category

The emission trends for the period 1989-2017 are shown in Figure 3.16. In 2017, the Energy sector (Energy) accounted for the largest share of total GHG emissions (66.39%), followed by Agriculture (Agriculture) with 16.92%, and then the IPPU sector (IPPU = Industrial Process and Product Use) with 11.52%. The Industrial Process and Product Use (IPPU) sector includes greenhouse gas emissions from various industrial activities that are not directly caused by the energy consumed in the process and the use of man-made greenhouse gases in products.

The energy sector is the most important sector in Romania. This sector had approximately a 66.39% share of total GHG emissions (excluding the LULUCF sector) in 2017, corresponding to 75,543 Mt CO_2 equivalent. Compared with the base year, GHG emissions decreased by 65.41% in 2017. The main reason for this trend is the process of transition to a market economy, which has led to a significant and rapid reduction in demand for heat and energy produced by power plants.

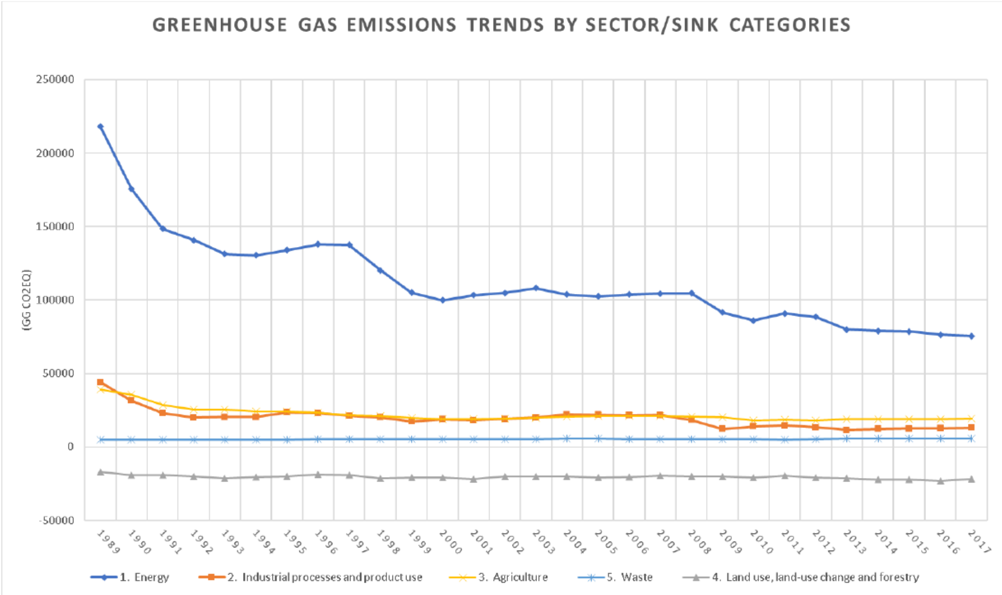


Figure 3.16. Evolution of GHG emissions and removals by sector in Romania 1989-2017 (unit: Gg CO_2 equivalent = 10-3 Mt) *Source: Romania's Fourth Biennial Report under the UNFCCC. Ministry Of Environment, Waters And Forests, December 2019*

Over the period 1989-2017, the overall GHG emission trend was basically characterised by a downward trend as follows: manufacturing and construction (82.46%), other emitters (72.33%) and energy (70.29%) showed a significant decrease in emissions, while the transport sector showed a significant increase (61.47%) as shown in Figure 3.17.

In 2017, total GHG emissions related to energy use were the highest (31.66%), followed by transport (23.8%) and manufacturing and construction (15.46%). In addition, CO_2 emissions from energy use accounted for 85.04% of total national GHG emissions (excluding the LULUCF sector), CH4 emissions (in CO_2 equivalent) accounted for 14.13% and N_2O (in CO_2 equivalent) for 0.80%. Compare to 2016, GHG emissions from the energy sector decreased by 1.32% in 2017.

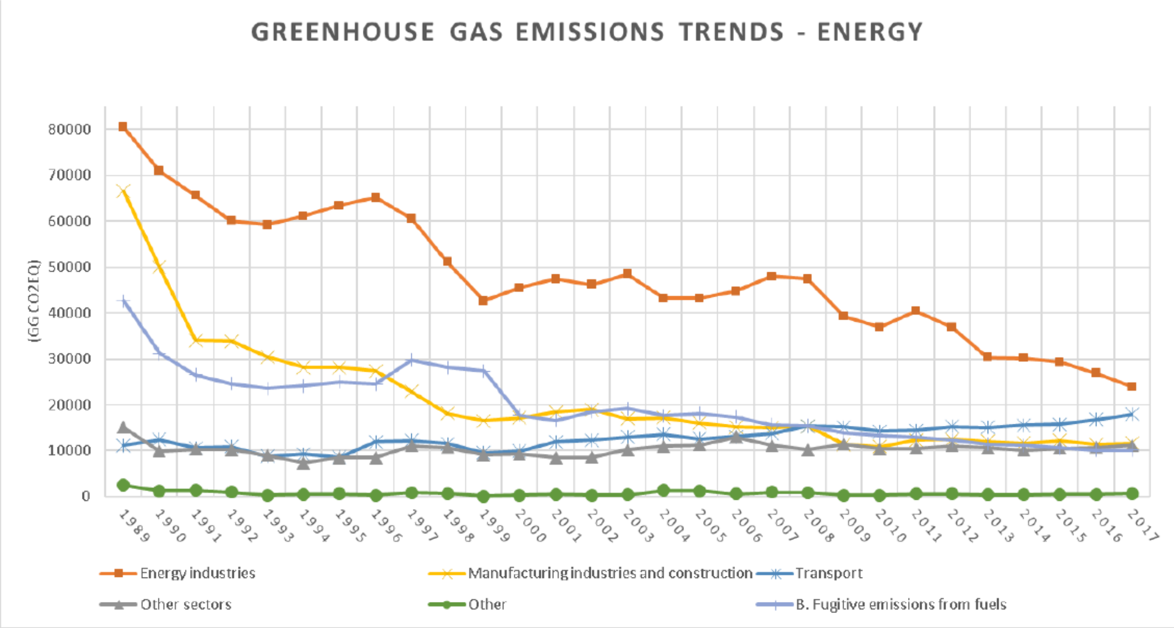


Figure 3.17. Evolution of energy-related GHG emissions in Romania 1989-2017 (unit: Gg CO_2 equivalent = 10-3 Mt)

Source: Romania's Fourth Biennial Report under the UNFCCC. Ministry Of Environment, Waters And Forests, December 2019

In 2017, the IPPU sector accounted for 11.52% of total greenhouse gas emissions (excluding the LULUCF sector), which means 13,105 Mt CO_2 equivalent. Compared to the base year, greenhouse gas emissions decreased by 70.23% in 2017 (Figure 3.18).

Since 1989, overall GHG emissions from the IPPU sector have been on a downward trend due to restructuring and privatisation processes, the consequences of the economic and financial crisis and the implementation of specific policies and measures (e.g. EU ETS) that have led to a reduction in production levels and emission factors.

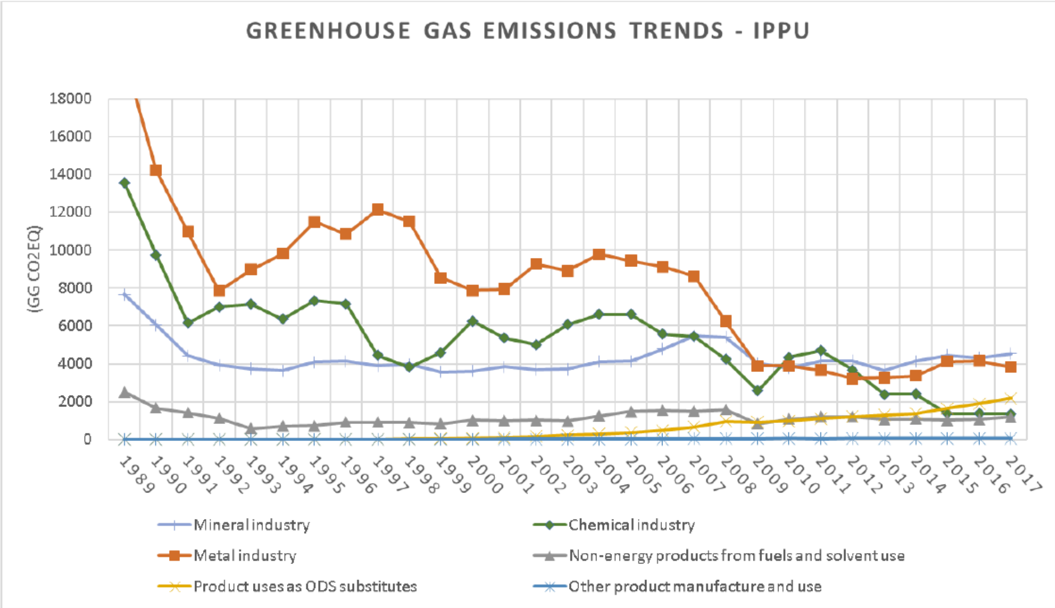


Figure 3.18. GHG emissions from Romania's IPPU sector between 1989 and 2017 (unit: Gg CO_2 equivalent = 10-3 Mt)

Source: Romania's Fourth Biennial Report under the UNFCCC. Ministry Of Environment, Waters And Forests, December 2019

The trend in total GHG emissions between 1989 and 2017 was characterised by a significant decrease in emissions from the following sectors: chemicals (90.12%), metals (81.13%), non-energy products from fuels and solvents (53.18%).

In 2017, emissions from the mineral industry accounted for the largest share of total GHG emissions (34.54%), followed by the metal industry (29.18%) and emissions from products used as ODS substitutes (16.62%). CO_2 emissions also accounted for 80.93% of total GHG emissions (excluding the LULUCF sector), HFC emissions (CO_2 equivalent) for 16.62% and N2O (CO_2 equivalent) for 1.93%. Compared to 2016, GHG emissions in this sector increased by 0.72% in 2017.

In 2017, total GHG emissions from the agricultural sector accounted for 16.92 % of total GHG emissions (excluding the LULUCF sector), equivalent to 19,255 Mt CO_2 equivalent. Compared to the base year, GHG emissions decreased by 50.79% in 2017 (Figure 3.19).

Since 1989, the total GHG emissions of the agricultural sector have been on a downward trend due to the level of livestock production, rice production, crop production and the reduction in the amount of synthetic nitrogen fertilizers applied.

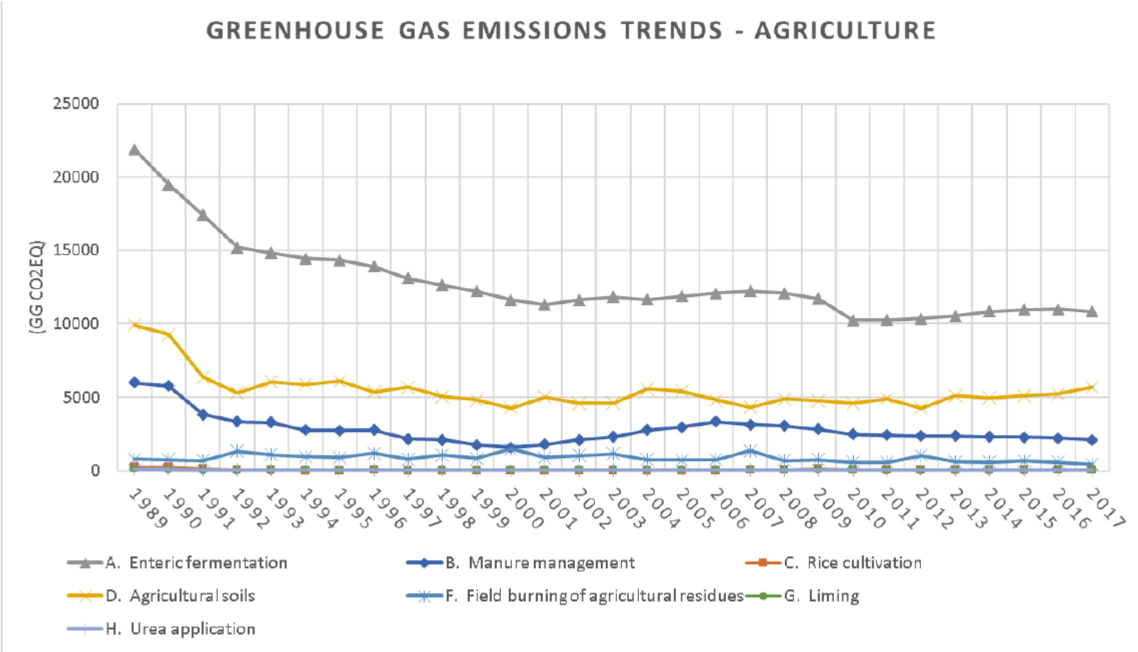


Figure 3.19. GHG emissions from agricultural production in Romania between 1989-2017 (unit: Gg CO_2 equivalent = 10-3 Mt)

Source: Romania's Fourth Biennial Report under the UNFCCC. Ministry Of Environment, Waters And Forests, December 2019

The trend in GHG emissions between 1989 and 2017 was characterised by significant reductions in emissions from the following sectors: liming (61.50%), rice cultivation (72.98%), manure management (64.82%), enteric fermentation (50.49%), agricultural land use (42.76%), urea use (42.66%) and field burning of agricultural residues (43.30%).

In 2017, enteric fermentation accounted for the largest share of total GHG emissions (85.25%), followed by agricultural soil use (26.32%) and manure management (12.16%). In addition, CO_2 emissions from agriculture accounted for 0.08% of total GHG emissions (excluding the LULUCF sector), CH_4 emissions (CO_2 equivalent) for 10.98% and N_2O emissions (CO_2 equivalent) for 4.93%. Compared to 2014, GHG emissions from this sector increased by 2.32% in 2015.

Agricultural land, including ploughland, orchards, vineyards, pastures and meadows, accounts for 62.22% of Romania's total land area. Forests occupy 27.92%, while built-up areas and road/railways account for about 4.88%, wetlands, water and lakes for about 3.53% and other areas for 2.1%.

Emissions from the LULUCF sector include CO_2, CH_4 and N_2O emissions from biomass combustion (Figure 3.20). Net greenhouse gas sinks/emissions were 26.99% higher in 2017 compared to base year levels, due to a downward trend in emissions from all other sectors.

The Romanian land use sector is a net sink with an average of 21.680 Mt CO_2/year. This value has been relatively stable over the last 28 years.

In 2017, the waste management sector's aggregate GHG emissions accounted for 5.95% of total GHG emissions (excluding the LULUCF sector), which is equivalent to 5,843 Mt CO_2 equivalent. Compared to the base year, GHG emissions increased by 13.78 % in 2015. Between 1989 and 2015, total GHG emissions from the waste management sector increased due to an increase in residential consumption, an increase in the number of landfills and an increase in the volume of waste water due to new connections.

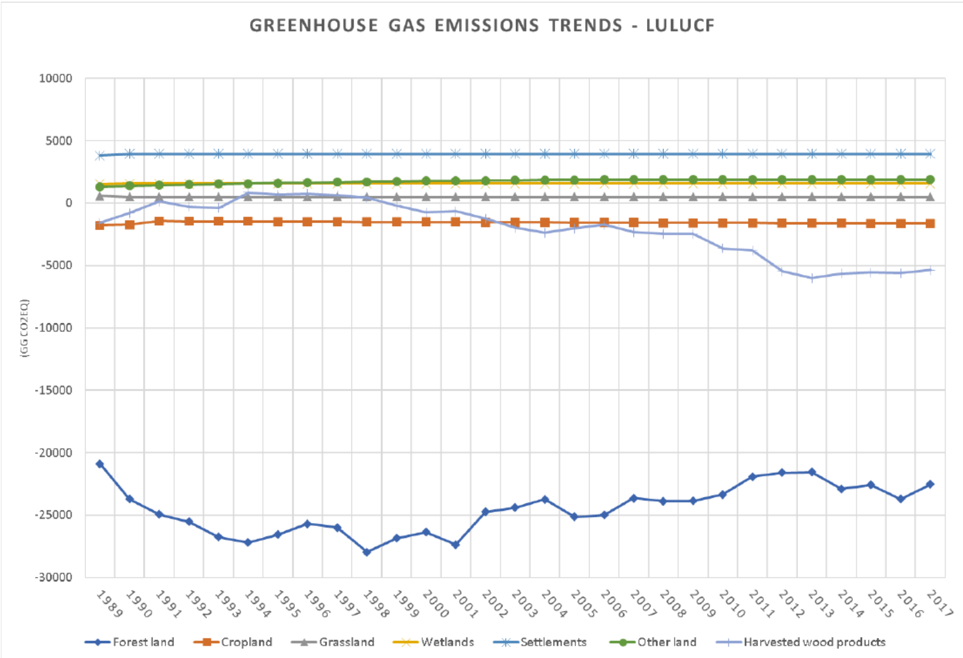


Figure 3.20. GHG emissions from Romania's LULUCF sector 1989-2017 (unit: Gg CO_2 equivalent = 10-3 Mt) *Source: Romania's Fourth Biennial Report under the UNFCCC. Ministry Of Environment, Waters And Forests, December 2019*

3.2.4. Maramures and Satu Mare counties

The counties of Maramures and Satu Mare have a medium-high potential (compared to the rest of the country) for renewable energy production from solar, wind, agricultural and forest biomass, but these are currently under-utilised. The electricity transmission and distribution network is managed by state-owned companies. The network is in some places outdated and undersized, and despite declining consumption (especially industrial), supply disruptions occur.

In the Maramures department, there are a number of small villages, especially in mountainous areas, where there is no developed electricity supply network. 98.8% of dwellings are connected to the electricity supply system. The electricity transmission infrastructure in the Maramures county is operated by the company CNTEE TRANSELECTRICA S.A. and includes the following main facilities:

- 400 kV transmission line to Gădălin - Roșiori - Mukacevo;
- 220 kV transmission line towards Roșiori - Baia Mare III;
- 220 kV transmission line towards Biaia Mare III - Tihău;
- Conversion station 220/110 kV Baia Mare III.

The electricity distribution infrastructure is managed by the public company ELECTRICA - FDFEE Transilvania Nord, the main elements of which are:

- 425 km of 110 kV lines;
- 2.252 km of medium voltage lines;
- 4.517 km of low voltage lines;
- 19 110 kV substations;
- 1,627 low and medium voltage transformer stations.

The county of Maramures has a relatively high potential for renewable energy production, which is currently considered to be under-exploited. In terms of photovoltaic energy, the measured potential of solar radiation intensity in the county varies between 1,100 and 1,300 kWh/m2/year, which is low by national standards (the maximum value is around 1,700 kWh/m2/year in the Dobrudzsa area), but sufficient to ensure the profitability of photovoltaic parks. The highest solar radiation intensity is in the south-western part of the county, on the border of Satu Mare and Silajd county, and the lowest in the mountainous area (Maramures Mountains). The average duration of sunshine varies from 1,600 hours/year in the high mountain areas to more than 2,000 hours/year in the western part of the county. The solar parks already installed at county level are located in the following municipalities: Baia Mare (0,72 MW), Coltău (0,98 MW), Remetea-Chioarului (0,224 MW), Mireșu Mare (3,917 MW), Tămășești (3, 522 MW) and Recea (4,55 MW), as well as Vadu Izei (2,90 MW), Băiuț (0,874 MW), Berchez (4, 374 MW), Ariniș (0,799 MW), Satulung (0,565 MW), Coltău (2,5 MW), Șișești (0,15 MW)), Răzoare (0,99 MW), the upper reaches of the Suciu-Minghet (0,98 MW), Cicârlău (0,95 MW) and Seini (0,315 MW).

The wind energy potential of the Maramures region is high, with average wind speeds of more than 10 m/s in the high mountain areas (e.g. the Radna mountains) and 2-3 m/s in the lowlands, at 50 m above the ground during the period 1961-2005.

The county has a potential for biomass energy production of about 206.2 TJ, of which agricultural biomass accounts for 71.3% and forest biomass for 28.7%.
The micro-hydropower potential of the Maramures department is considered to be very high. Some 19 micro-hydroelectric power plants are in operation, 15 of which are located in protected areas.
In terms of geothermal energy, the Radna Mountains, where geothermal groundwater is found (with temperatures of 40-120 0C), are considered a perspective area.

According to data from TRANSELECTRICA, the total installed renewable energy capacity in the Maramures department is 66,044 MW.

95.5% of the energy consumed in the county comes from the national energy system and only 5.5% from the hydroelectric power plants in Maramures. Based on previous data, the average annual electricity consumption per capita reached 496 kWh/capita in 2010, almost double the 1995 figure.

The city of Baia Mare has already developed its Sustainable Energy Action Plan, in which it committed to reduce local CO_2 emissions by more than 20% by 2020. In addition, an Energy Management Agency has been set up at county level and several stakeholders at local level have joined it.

Satu Mare County is located in the north-western part of Romania. Its seat is Satu Mare. Neighbouring counties are: in the east Maramures County, in the south Bihor County and Silajd County, in the west Szabolcs-Szatmár-Bereg County (Hungary), in the north Ukraine (Carpathian Mountains). Main industries: automotive, food, wood and textiles. Satu Mare County covers an area of 4418 km² (1.9% of the country's territory). Land use distribution: 72% agricultural land, 18% forest, 3% rivers and 7% other classified areas.

3.2.5. GHG inventory

In Romania, some regional or county data are available to determine GHG emissions, but they are not as complete as in Hungary. Accordingly, comparisons between countries are not applicable in this case either, as GHG emissions are partly determined on the basis of different methodologies and baseline data. For this reason, the main focus is on the trend in GHG emissions in the country concerned over the period under review.

The GHG inventories for the counties of Maramures and Satu Mare were not prepared separately, but for the two counties together, as the two counties can be considered as a single area within the Tisza river basin within the country.

In determining the emission data where county data were not available for the calculation, the national data were used on a per area or per population basis. In all cases this is indicated in the data.

The source for the county data is the database maintained by the Romanian Statistical Office, available at http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table .

Based on the calculations carried out, the aggregated GHG emissions of the counties of Maramures and Satu Mare for the years 2016-2018 are presented in Table 3.2.

Name of pollutant source (sector)	Estimated emissions in the year under review ($t\ CO_2$ equivalent)					
	2016		**2017**		**2018**	
	$t\ CO_2$ equivalent	**%**	**$t\ CO_2$ equivalent**	**%**	**$t\ CO_2$ equivalent**	**%**
Energy consumption[1]	1.615.687	56,3	1.476.181	53,1	1.600.697	54,7
Large industrial emissions[2]	5.985	0,2	5.958	0,2	5.958	0,2
Transport[3]	822.405	28,7	878.465	31,6	909.726	31,1
Agricultural activity	399.689	13,9	394.253	14,1	382.961	13,1
Waste management	24.788	0,9	24.794	0,9	24.808	0,9
Total emissions (gross):	**2.868.554**	**100,0**	**2.779.651**	**100,0**	**2.924.149**	**100,0**
Sinks (forests)	-511.604	-17,8	-512.236	-18,4	-512.236	-17,5
Balance (net emissions)	**2.356.950**	**82,2**	**2.267.415**	**81,6**	**2.411.913**	**82,5**

1 - excluding residential firewood and coal use
2 - based on EU ETS scheme
3 - estimated as a share of population based on national data

Table 3.2: Summary of GHG emissions from the counties of Maramures and Satu Mare

The aggregated GHG emissions of the counties of Maramures and Satu Mare are as follows:

- the average annual GHG emissions of the county correspond to about 2.8-3 million tonnes of CO_2 equivalent;

- energy consumption accounts for the largest share of gross emissions (between 53% and 56%);

- the second largest share is GHG emissions is from the transport sector (around 30% on average);

- the value of the large industrial emissions sector as a share of total GHG emissions is considered to be small based on the data recorded in the EU ETS;

- GHG emissions from the agricultural sector account for around 13-14% of total emissions;

- GHG emissions from waste and waste water treatment account for less than 1% of the total emissions in the county;

- gross GHG emissions have been essentially stagnant with little fluctuation over the period under review;

- a relatively large forest area means that the county is characterised by a moderate level of emissions (around 17-18% of total emissions);

- gross GHG emissions per capita for the period under review, based on the combined data of the counties of Maramures and Satu Mare, are estimated at 3.47-3.66 t/person, while net GHG emissions are estimated at 2.83-3.02 t/person.

3.3. Slovakia - Kosice kraj region

National overview of the situation

For the outline of the national situation, the document "Fourth Biennial Report Of Slovak Republic. Slovak Hydrometorological Institute and Ministry of Environment of Slovak Republic. Bratislava, December, 2019" was used.

3.3.1. Trend in total GHG emissions

Total GHG emissions in Slovakia amounted to 43,316.45 Gg CO_2 equivalent in 2017 (excluding the LULUCF sector), a 41% decrease compared to the 1990 base year. However, compared to 2016 levels, emissions in 2017 increased by 2.8%. The increase in total emissions in 2017 compared to 2016 levels was due to growth in the Energy (Energy), Industrial process (Industrial process) and Waste (Waste) sectors, a trend that coincides with Slovakia's economic growth. In general, total GHG emissions (excluding the LULUCF sector) in the Slovak Republic did not exceed 1990 levels in the period 1991-2017 (Figure 3.21).As shown in Figure 3.21, Slovakia reduced its GHG emissions by about 13% between 2008 and 2017. According to an in-depth analysis carried out by the International Energy Agency in 2018 (http://www.oecd.org/slovakia/), the Slovak Republic has made significant progress in a number of energy policy areas. In addition, the energy intensity of the Slovak economy has decreased and the share of renewable energy in the energy supply has increased. The reduction in emissions in recent years in Slovakia has been the result of a combination of industrial and technological changes from coal and oil to natural gas, the restructuring of the economy towards less energy-intensive production (especially in recent years), and temporary changes in production intensity driven by global and EU markets.

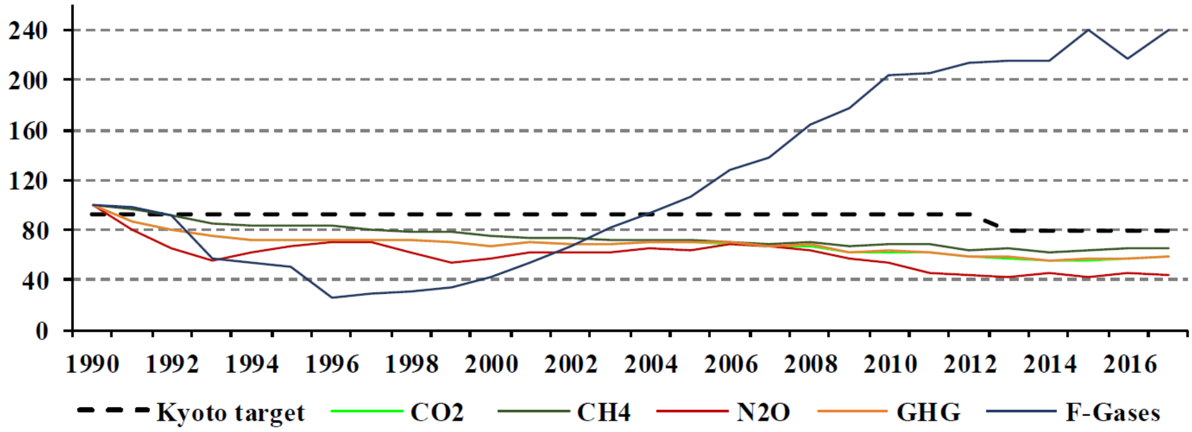


Figure 3.21. GHG emission trends (excluding LULUCF sector) in the Slovak Republic compared to those of the Kyoto targets (%)
Source: Fourth Biennial Report of Slovak Republic. Slovak Hydrometorological Institute and Ministry of Environment of Slovak Republic. Bratislava, December, 2019

At the same time, transport (especially road transport) is characterised by steadily increasing emissions. At the same time, however, there is constant pressure to develop an effective strategy and policy which would help to reduce emissions in this sector too: e.g. A combination of regulatory and economic instruments (tolling of heavy goods vehicles based on their environmental characteristics combined with fuel consumption and emission standards for new cars). The vehicle taxation system and fuel tax rates, which are close to the EU average, can also contribute to limiting the growth of GHG emissions in the transport sector.

The positive downward trend developed in previous years has slowed down and/or reached its lowest level in the last 3 years for several indicators (e.g. GHG emissions per capita or GHG/GDP). GHG emissions reached a minimum level in 2014 and since then the trend has stabilised or a slight increase can be observed (Figure 3.22).

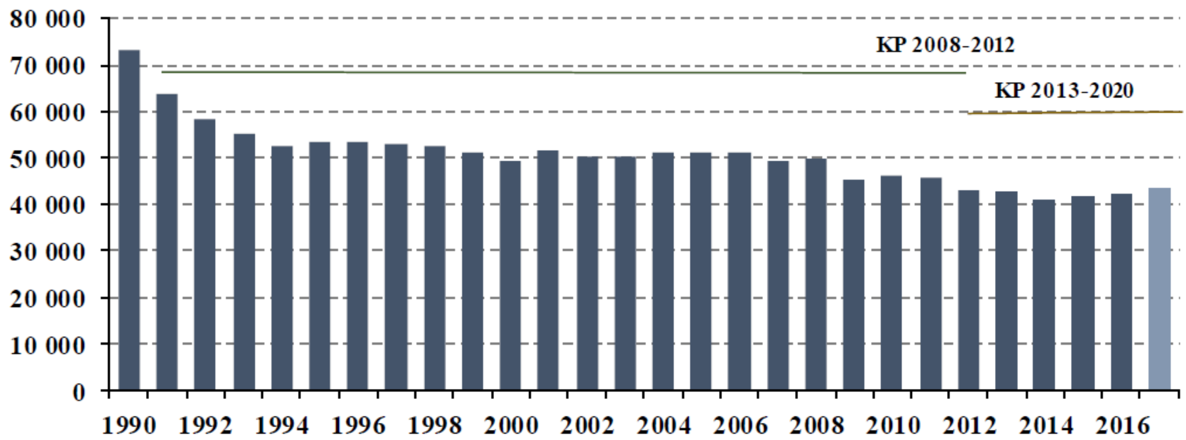


Figure 3.22. Cumulative GHG emissions in Slovakia between 1990-2017
Source: Fourth Biennial Report of Slovak Republic. Slovak Hydrometorological Institute and Ministry of Environment of Slovak Republic. Bratislava, December, 2019

The report concludes that structural changes in the energy sector and the implementation of economic instruments have played an important role in reaching the current level, while the trend in GHG emissions has not followed the rapid growth of GDP. In this context, the most important measure is the adoption of a national law on air quality in 1991, which was a milestone that started the reduction of key air pollutants and thus indirectly the reduction of GHG emissions. At the same time, the use of primary energy sources and total energy consumption was also reduced.

According to data from the Statistical Office of the Slovak Republic, the energy industry, including industrial processes (production and distribution of electricity, natural gas and water), accounted for 28% of the country's total GDP in 2017. Energy intensity in the Slovak Republic has been decreasing over the last decade. In the period between 2007 and 2017, Slovakia reduced its energy intensity by 11%. This is the second largest decrease among EU Member States. At the same time, the largest decrease in energy intensity values over the 15-year period between 2000 and 2014 was recorded in the Slovak Republic, with a value of 82.5% (http://iet.jrc.ec.europa.eu/energyefficiency/node/9145).

3.3.2. Evolution of GHG emissions by gas

Total anthropogenic emissions of carbon dioxide (CO_2) excluding the LULUCF sector decreased by 41.5% in 2017 compared to the base year (1990) (a decrease similar to that of total GHG emissions), amounting to 36,033.64 Gg of CO_2 emissions (excluding LULUCF) in 2017. This represents an increase of more than 3% compared to 2016 (similar to aggregated GHG emissions). The increase in carbon emissions in 2017 is due to the increase in CO_2 emissions mainly in the energy, transport and industrial process sectors, which can be explained by the growth of the Slovak economy and productivity. Including the LULUCF sector, CO_2 emissions in 2017 are almost at the same level as the previous year, a decrease of 43.2% compared to the base year (Figure 3.23).

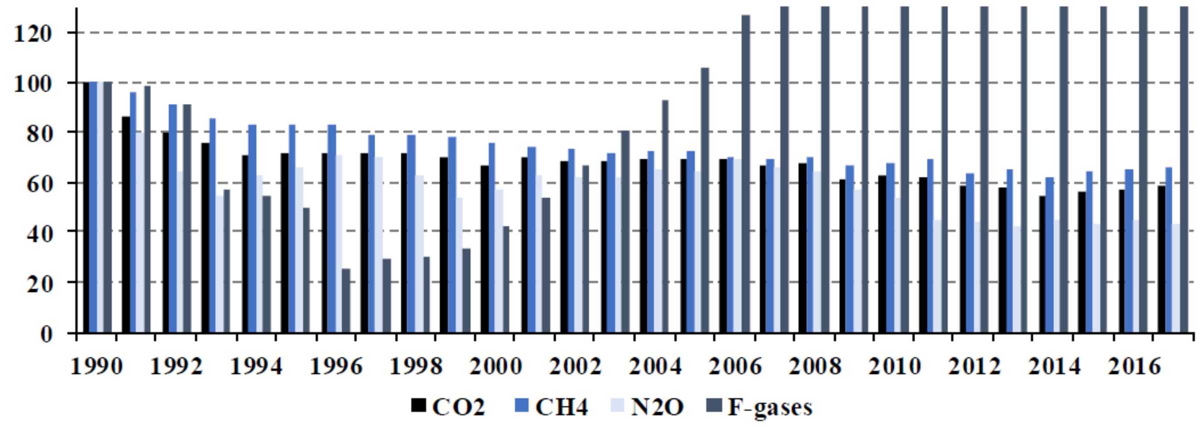
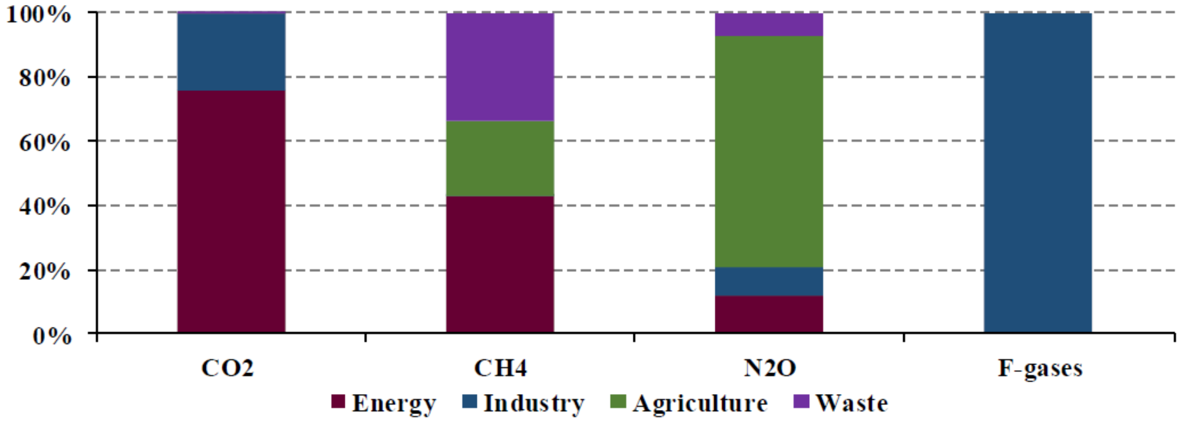


Figure 3.23. Trends in gas emissions between 2000 and 2017 compared to 1990 levels (in %)
Source: Fourth Biennial Report of Slovak Republic. Slovak Hydrometorological Institute and Ministry of Environment of Slovak Republic. Bratislava, December, 2019

Cumulative anthropogenic methane emissions excluding the LULUCF sector decreased by 34.2% compared to the base year (1990) and amounted to 4,601.17 Gg CO_2 equivalent in 2017. In absolute terms, CH_4 emissions excluding the LULUCF sector amounted to 184.05 Gg, while methane emissions from the LULUCF sector reached 0.85 Gg, mainly due to forest fires. The trend can be considered relatively stable over the recent period.

Total emissions of nitrous oxide (N_2O) of anthropogenic origin, excluding the LULUCF sector, decreased by 57.0% compared to the base year (1990), and in 2017 emissions amounted to 1,926.87 Gg CO_2 equivalent. In absolute terms, N_2O emissions in this year were 6.47 Gg (excluding LULUCF), while the LULUCF sector accounted for 0.12 Gg of nitrous oxide emissions. Contrary to the increasing trend of CO_2 and CH_4 emissions, N_2O emissions decreased by 4% compared to the previous year 2016 due to a decrease in chemical production. In Slovakia, this trend is mainly due to nitric acid production. The overall downward trend was mainly due to a decrease in agricultural production, caused by a reduction in the number of animals and a reduced use of fertiliser inputs. The total anthropogenic emissions of F-gases in 2017 were 754.76 Gg, of which 739.06 Gg were HFCs, 8.62 Gg were PFCs and 7.08 Gg were SF6 gases expressed in CO_2 equivalents. Overall, emissions of HFCs have increased since 1995 due to increased consumption and the replacement of PFCs and HFCs. From this date, the first decrease was observed in 2016. The decrease was for all F-gases, a consequence of the EU's introduction of legislation in compliance with the regulation on F-gases. The emission trend for PFCs is decreasing and SF6 emissions are slightly increasing due to increasing industrial consumption.

The energy sector (combustion and transport of fuels) accounts for the largest share of carbon dioxide emissions, accounting for 76% of total carbon dioxide emissions in 2017. 24% of

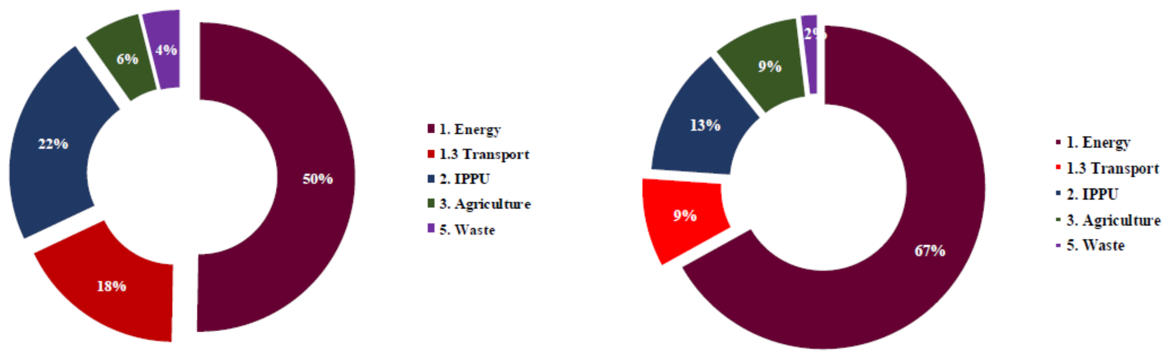


emissions are from industrial processes and product use sectors, while agriculture (0.2%) and waste processing (0.01%) contribute a negligible amount. CO_2 emissions from waste incineration are part of the energy sector. The waste sector accounts for nearly 34 % of CH_4 emissions, the energy sector for 43 % and agriculture for 24 %. More than 72% of N_2O emissions are from agriculture, 9% from industrial processes, 7% from waste and 12% from the energy sector. F-gases are produced exclusively by sectoral industrial processes (Figure 3.24).

Figure 3.24. GHG emission trend proportions by sector in 2017
Source: Fourth Biennial Report of Slovak Republic. Slovak Hydrometeorological Institute and Ministry of Environment of Slovak Republic. Bratislava, December, 2019

3.3.3 GHG emission trends by main sources and sinks

Total GHG emissions from the energy sector based on sectoral data are estimated at 27,706 Gg CO_2 equivalent in 2017 (including transport emissions, which represent about 7,660 Gg CO_2 equivalent). This represents a 49% decrease from the base year (1990) and a 3.4% increase from 2016. Emissions from the transport sub-sector increased by 2% compared to



2016 and by almost 13% compared to the base year (Figure 3.25).

Figure 3.25. Share of each sector in total GHG emissions in 2017 (left side) and 1990 (right side) *Source: Fourth Biennial Report of Slovak Republic. Slovak Hydrometorological Institute and Ministry of Environment of Slovak Republic. Bratislava, December, 2019*

Total emissions from the industrial processes and product use (IPPU) sector) amounted to 9,646.59 Gg CO_2 equivalent in 2017, a decrease of 1% compared to the base year and an increase of 3% compared to the value in year 2016. This sector includes emissions from the use of solvents.

Emissions from the agricultural sector (Agriculture) were estimated at 2,546.79 Gg CO_2 equivalent. Compared to the base year, there is a decrease of 57% in year 2017 and 0.5% compared to the previous year. In terms of proportions, the agriculture sector has the largest decrease compared to the 1990 base year, which can be explained by a decrease in the number of cattle and the amount of fertiliser used.

GHG emissions from the Waste sector (Waste) are estimated to have been equivalent to about 1,680.72 Gg CO_2 equivalent. The increase is nearly 2% compared to the value in year 2016, while the increase compared to the base year (1990) was more than 17%. This is due to increased methane emissions from solid waste landfills.

3.3.4. GHG inventory

For Slovakia, some regional and district (kraj) data are available for the determination of territorial GHG emissions, but they are not as complete as in Hungary either. Accordingly, comparisons between countries are not applicable in this case either, as GHG emissions are partly determined on the basis of different methodologies and different baseline data. For this reason, in Kosice District (Košický kraj), we also examine what trends in GHG emissions can be observed over the period under review.

The GHG inventory was carried out using national data on a per area or per population basis to determine emissions data where the territorial data for the calculation were not available. In all cases this is indicated in the data. The source of the data used for the calculation is the database maintained by the Statistical Office of the Slovak Republic (Štatistický úrad SR), available at:
http://datacube.statistics.sk/#!/lang/sk/?utm_source=susr_portalHP&utm_medium=page_database&utm_campaign=DATAcube_portalHP

Based on the calculations performed according to the applied methodology, the total GHG emissions for the Kosice District (Košický kraj) for the years 2016-2018 are presented in Table 3.3.

Name of pollutant source (sector)	Estimated emissions in the year under review (t CO2 equivalent)					
	2016		2017		2018	
	t CO_2 equivalent	%	t CO_2 equivalent	%	t CO_2 equivalent	%
Energy consumption[1]	1.276.649	14,4	1.355.752	15,3	1.334.519	15,3
Large industrial emissions[2]	7.336.852	82,7	7.252.653	81,7	7.080.524	81,3
Transport[3]	143.518	1,6	148.319	1,7	175.628	2,0
Agricultural activity	26.192	0,3	27.699	0,3	28.065	0,3
Waste management	88.461	1,0	88.488	1,0	88.510	1,0
Total emissions (gross):	**8.871.672**	**100,0**	**8.872.911**	**100,0**	**8.707.246**	**100,0**
Sinks (forests)	-440.096	-5,0	-440.499	-5,0	-440.858	-5,1
Balance (net emissions)	**8.431.576**	**95,0**	**8.432.412**	**95,0**	**8.266.388**	**94,9**
Balance (net emissions) without large-scale industry	**1.094.724**	**12,3**	**1.179.759**	**13,3**	**1.185.864**	**13,6**

1 - excluding residential firewood and coal use
2 - under the EU ETS scheme
3 - estimated as a share of population based on national data

Table 3.3: Summary of GHG emissions for the Kosice district

An analysis of the data in Table 3.3 clearly demonstrates that GHG emissions in Kosice district (Košický kraj) are dominated by large industrial emissions (more than 80%). As large industrial emissions represent a prominent value and therefore distort the ratios significantly, the ratios have been recalculated without taking into account the large industrial emissions. These data are presented in Table 3.4.

Name of pollutant source (sector)	Estimated emissions in the year under review (t CO2 equivalent)					
	2016		2017		2018	
	t CO_2 equivalent	%	t CO_2 equivalent	%	t CO_2 equivalent	%
Energy consumption[1]	1.276.649	83,2	1.355.752	83,7	1.334.519	82,0
Transport[3]	143.518	9,4	148.319	9,2	175.628	10,8
Agricultural activity	26.192	1,7	27.699	1,7	28.065	1,8
Waste management	88.461	5,7	88.488	5,4	88.510	5,4
Total emissions (gross):	**1.534.820**	**100,0**	**1.620.258**	**100,0**	**1.626.722**	**100,0**
Sinks (forests)	-440.096	-28,7	-440.499	-27,2	-440.858	-27,1
Balance (net emissions)	**1.094.724**	**71,3**	**1.179.759**	**72,8**	**1.185.864**	**72,9**

1 - excluding residential firewood and coal use
3 - estimated as a share of population based on national data

Table 3.4: Summary of GHG emissions in the Kosice district (excluding large industrial emissions)

Based on the data in Table 3.4, the following can be said about the aggregated GHG emissions of the district of Kosice:

- the district's average annual GHG emissions are equivalent to around 8.3-8.4 million tonnes of CO_2 equivalent per year, due to significant emissions from large industry;
- emissions from large industry account for the largest share of gross emissions (82% on average);
- GHG emissions from energy use account for the second largest share (15% on average);
- GHG emissions from transport account for just under 2 % of total GHG emissions in the district;
- GHG emissions from the agricultural sector account for only 0.3% of total emissions;

- GHG emissions from waste and waste water treatment account for only 1% of the district's total emissions;
- gross GHG emissions excluding emissions from large industry have been on an upward trend over the period under review;
- thanks to the forest areas, the absorption can neutralise around 5 % of total emissions;
- gross GHG emissions per capita in the Kosice district (Košický kraj) over the period under review, based on aggregated data, are estimated at 10.88-11.12 t/person due to significant emissions from large industry, while net GHG emissions are estimated at 10.33-10.55 t/person.

If we exclude large industrial emissions from the data (Table 3.4), our findings can be summarised as follows:

- the district's average annual GHG emissions, excluding emissions from large industry, are equivalent to around 1.5-1.6 million tonnes of CO_2 per year;
- GHG emissions from energy use account for the largest share of gross emissions (83-84% on average, but including electricity and natural gas consumption by industrial operators);
- GHG emissions from transport account for 9-10% of total GHG emissions in the district;
- GHG emissions from the agricultural sector account for less than 2% of total GHG emissions;
- while GHG emissions from waste and waste water treatment account for nearly 6% of the district's total emissions;
- gross GHG emissions show a slight decrease with small fluctuations during the period under review;
- thanks to forest areas, the absorption can neutralise around 27-28% of total emissions excluding large industrial emissions;
- the gross GHG emissions per capita (excluding emissions from large industry) in the Kosice district (Košický kraj) based on aggregated data for the period under review are 1.92-2.03 t/person, while net GHG emissions are 1.37-1.48 t/person.

3.4. Ukraine - Transcarpathia (Zakarpatska Oblast)

National overview of the situation

For the outline of the national situation the "Climate change risk profile in Ukraine. Country Fact Sheet - USAID" and the "Ukraine's Greenhouse Gas Inventory 1990-2018 (draft). Ministry of Energy and Environmental Protection of Ukraine, 2020" documents were used.
Ukraine is a large, diverse country with high agricultural production potential, rich natural resources and an established industrial base (Figure 3.26).

Figure 3.26. Agroecological zones of Ukraine
Source: Climate change risk profile in Ukraine. Country Fact Sheet - USAID

The world's fifth most energy-intensive country is Ukraine, one of Europe's biggest energy users because of its low energy-efficient infrastructure. Historically characterised by low energy prices and high industrial and agricultural energy use. In the spirit of climate awareness, efforts so far have focused mainly on reducing emissions and improving energy efficiency and increasing the use of renewable energy sources.

The situation that emerged in 2014 and has continued since then in the Eastern region, and the economic shock and humanitarian situation that has unfolded, has diverted resources from climate change adaptation strategy and planning.

3.4.1. Trend in total national GHG emissions

The dynamics of national GHG emissions show a trend that can be broken down into five phases over the period 1990-2018 (Figure 3.27). In the first phase (between 1990 and 1999), the country's GDP declined at a catastrophic rate, with a corresponding decline in energy consumption, leading to a significant reduction in GHG emissions.

In the second phase (2000-2007), the trend stabilised and there was a gradual increase in emissions due to economic growth (including GDP growth), but there is no direct correlation between emissions growth and GDP growth. This is mainly due to structural changes in the economy and the increasing role of trade, services and the increase role of the financial sector relative to industrial production.

In the third phase (2008-2013), the greenhouse gas emissions can be linked to the global financial crisis (2008-2009), which had a major influence on the production volumes of the country's main export-oriented sectors: metallurgy, chemicals, machinery, which in turn affected other sectors such as electricity production and mining.

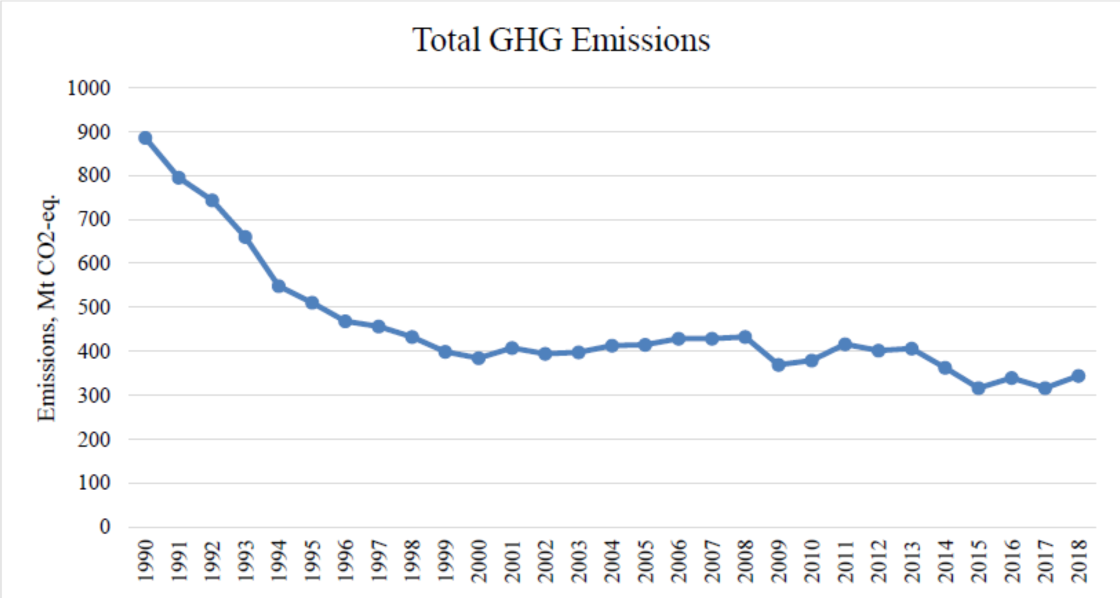


Figure 3.27. Evolution of Ukraine's aggregate GHG emissions between 1990 and 2018 (unit: Mt CO_2 equivalent)

Forrás: Ukraine's Greenhouse Gas Inventory 1990-2018 (draft). Ministry of Energy and Environmental Protection of Ukraine, 2020

Examining this period further, it can be stated that greenhouse gas emissions fell sharply in 2014 (by around 12% compared to 2013), and this trend continued in 2015 (a further 13% reduction compared to 2014). Key factors behind the sharp fall must be mentioned, the secession of Crimea and the armed conflict in the eastern provinces, which led to a significant drop in industrial production there. This in turn has contributed to the fall in energy consumption in direct proportion.

Table 3.5 shows the numerical evolution of GHG emission dynamics in Ukraine by emitters for the period between 2016 and 2018.

Name of polluting substance	2016	2017	2018
CO_2- emissions without LULUCF sector	234,2	223,2	231,7
CO_2- emissions including LULUCF sector	232,3	212,8	234,1
CH_4- emissions without LULUCF sector	69,4	67,1	71,1
CH_4- emissions including LULUCF sector	69,4	67,1	71,1
N_2O- emissions without LULUCF sector	36,3	34,9	38,6
N_2O- emissions including LULUCF sector	36,4	35,0	38,8
HFCs*	889,1	1009,5	n.i.
PFCs	n.i.	n.i.	n.i.
SF_6*	24,3	28,4	n.i.
NF_3	n.i.	n.i.	n.i.
Total (without LULUCF sector)	340,8	326,2	341,5
Total (including LULUCF sector)	**339,1**	**316,0**	**344,1**

* - the emission value is expressed in kilotonnes of CO_2 equivalent
n.i. - no information

Table 3.5: Values of GHG emissions in Ukraine by emitters between 2016 and 2018 (Mt CO_2 equivalent)

Source: Ukraine's Greenhouse Gas Inventory 1990-2018 (draft). Ministry of Energy and Environmental Protection of Ukraine, 2020

It can be stated from the analysis of the data in Table 3.5 that the largest share of greenhouse gas emissions in 2018 was carbon dioxide (CO_2) (68.0%), including the LULUCF sector. The share of methane (CH_4) emissions in 2018 was 20.7%, while nitrous oxide accounted for 11.3%. The share of the same gases in 1990 emissions was distributed as follows: carbon dioxide (CO_2) 72.9%, methane (CH_4) 21.0%, nitrous oxide (NO_2) 6.0%.

Evolution of carbon dioxide (CO_2) emissions

Figure 3.28 illustrates the evolution of carbon dioxide emissions in Ukraine over the period 1990-2018. On the basis of further analysis, it can be stated that CO_2 emissions including the LULUCF sector amounted to 234.14 Mt in 2018, which is more than 2.5 times lower than the value recorded in 1990 (646.41 Mt). The energy sector also registered a significant decrease in CO_2 emissions in 2018 (180.71 Mt), which is 69.5% lower than the base year (1990). In 1990, the value of CO_2 emissions from the combustion of fossil fuels was 592.25 Mt, which is 68.0% of the total emissions in the country. This structure of such a CO_2 emission can be explained by the high energy intensity of the economy.

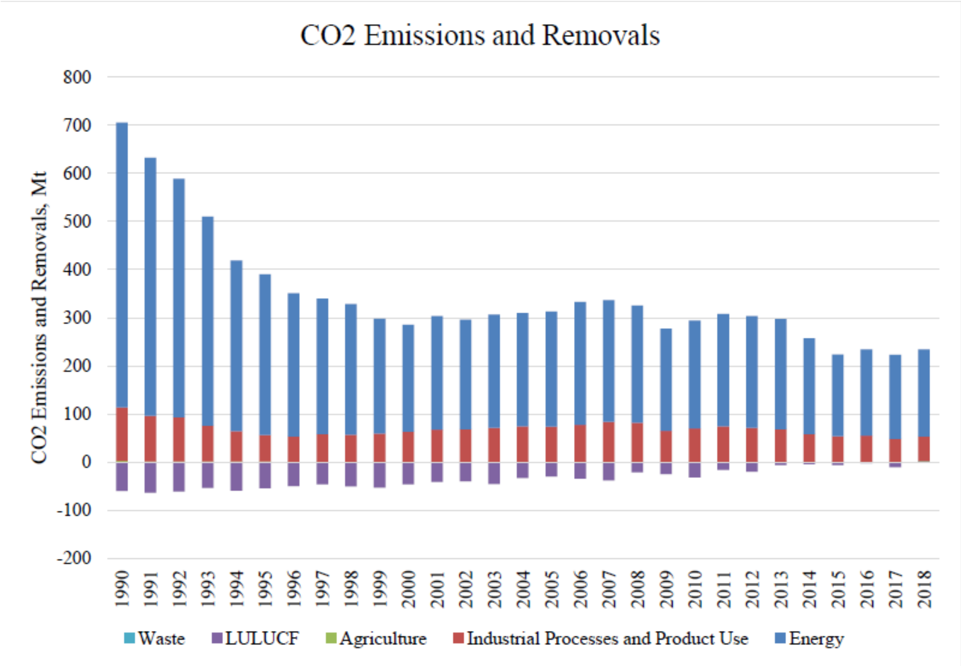


Figure 3.28. Evolution of carbon dioxide emissions and removals (Mt) in Ukraine between 1990 and 2018*Forrás: Ukraine's Greenhouse Gas Inventory 1990-2018 (draft). Ministry of Energy and Environmental Protection of Ukraine, 2020*

The economic downturn following the collapse of the Soviet Union led to a significant reduction in energy consumption and carbon emissions in the energy sector between 1990 and 2018. Carbon dioxide emissions in the IPPU sector in 2018 were 50.55 Mt, 54.3% lower than the base year (1990) value, but 6.1% higher than the 2017 value. The largest source of CO_2 emissions from the IPPU sector is iron and steel production, which accounts for 77% of total CO_2 emissions from the sector. Between 1990 and 2018, carbon emissions from this sector decreased significantly due to the reduction in production output caused by the collapse of the Soviet Union.

Evolution of methane (CH_4) emissions

In terms of share, CH_4 emissions represent the second largest share after CO_2. In 2018, CH_4 emissions in Ukraine were equivalent to 71.12 Mt CO_2 equivalent (Figure 3.29).

Compared to the 1990 value (186.31 Mt CO_2 eq.), emissions decreased by 61.8%. Based on the reported data for 2018, the largest source of methane emissions was the Energy sector (Energy) with 61.8%, but significant emissions were also observed in the Agriculture sector (Agriculture) with 13.2% and the Waste sector (Waste) with 20.6%. In the base year (1990), the Energy and Agriculture sectors contributed more to emissions (68.7% and 23.1% respectively), while the Waste sector had lower emissions (7.5%). In the energy sector, the largest CH_4 emissions come from coal mining and the production, transport, storage, distribution and consumption of oil and natural gas.

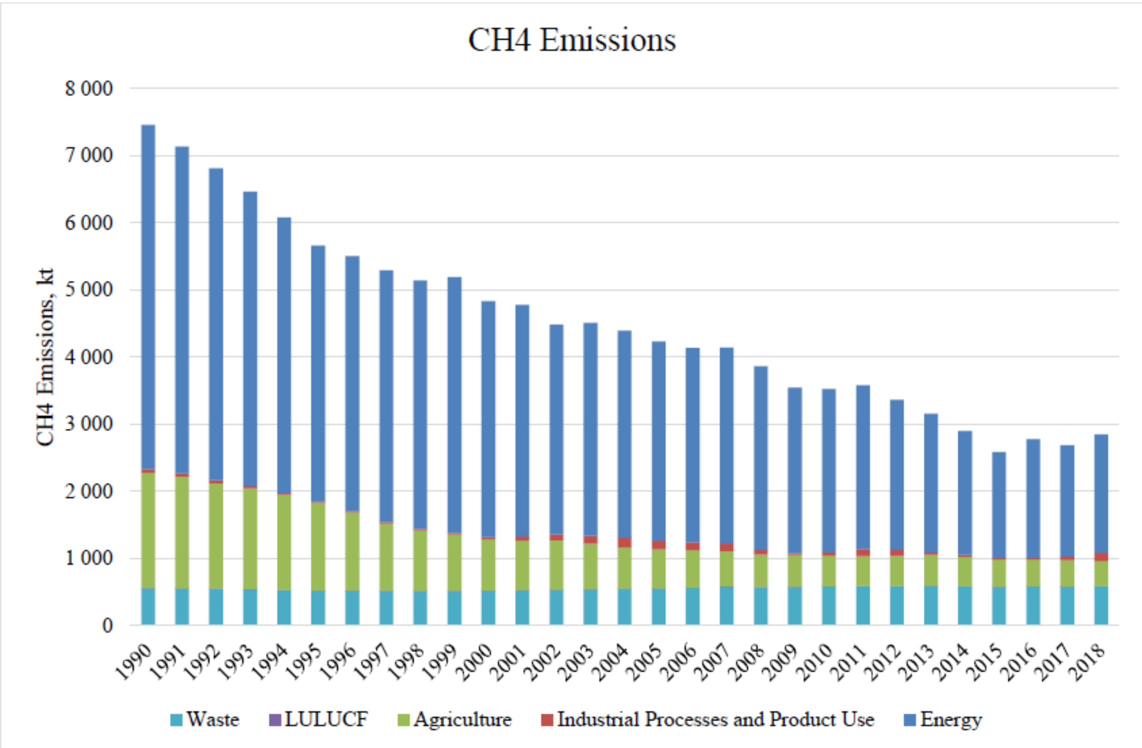


Figure 3.29. Evolution of methane emissions (kt) in Ukraine between 1990 and 2018
Source: Ukraine's Greenhouse Gas Inventory 1990-2018 (draft). Ministry of Energy and Environmental Protection of Ukraine, 2020

In agriculture, the main source of CH_4 emissions is related to cattle rearing. The economic downturn has led to a decline in agricultural production, and as a result, methane emissions from agriculture decreased to 375.68 kt in 2018, a decrease that is more than four times compared to the 1990 base year.

In the waste management sector, the largest CH_4 emissions were from the processes involved in the anaerobic digestion of municipal solid waste and wastewater. Compared to 1990, emissions from solid waste disposal installations decreased by 30.5% and emissions from waste water decreased by 19.9%.

Methane emissions in the IPPU sector occur in the production of crude iron, silicon carbide, methanol, carbon black, ethylene, coke and some other products. Between 1990 and 2018, the amount of CH_4 emissions in the sector increased from 55.73 kt to 123.79 kt (122.1%), which is related to the increase in production volume. Over the same period, CH_4 emissions from the LULUCF sector accounted on average for less than 0.1% of total methane emissions.

Evolution of nitrous oxide (N_2O) emissions

In Ukraine, nitrous oxide emissions in 2018 were equivalent to 38.8 Mt CO_2 equivalent which was 27.6% (53.6 Mt CO_2 equivalent) lower than in 1990 (Figure 3.30).

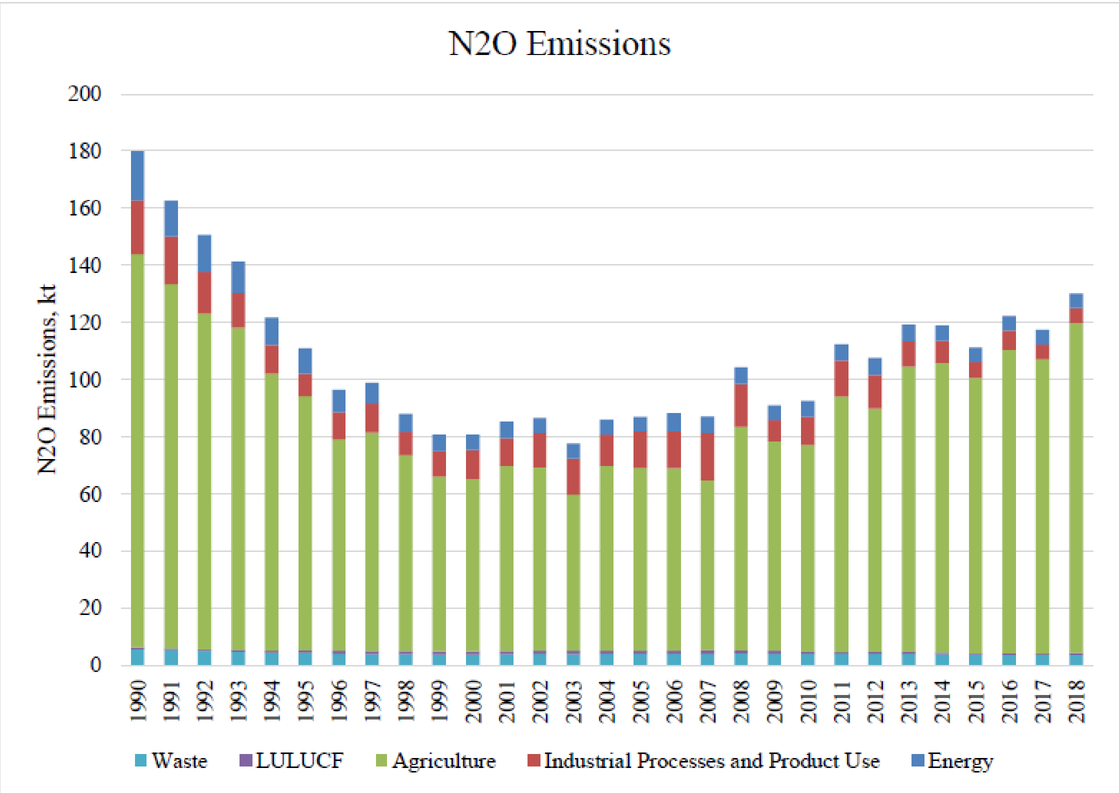


Figure 3.30. Evolution of nitrous oxide emissions values (kt) in Ukraine between 1990 and 2018

Source: Ukraine's Greenhouse Gas Inventory 1990-2018 (draft). Ministry of Energy and Environmental Protection of Ukraine, 2020

In 2018, nitrous oxide emissions increased by 10.9% compared to 2017. In Ukraine, the largest source of nitrous oxide emissions is the agricultural sector, which is responsible for 88.8% of total nitrous oxide emissions in 2018. These emissions come from agricultural land use and manure management activities.

The energy sector is responsible for the second largest share of nitrous oxide emissions, accounting for only 4.0% of the total in 2018. The IPPU sector is responsible for 3.9% of N_2O emissions. The most important sources of emissions from this sector are the production of nitric acid and adipic acid and the use of nitrous oxide for medical purposes.

In addition, N_2O emissions also occur in the waste management sector (2.9%) and a small amount in the LULUCF sector (0.4%).

3.4.2. Transcarpathia (Zakarpatska Oblast)

At the end of 2018, there were 10 hydropower plants, 6 solar plants and one biogas plant operating in Transcarpathia. The total capacity of these renewable energy installations is 90.4 MW. The largest share of electricity generation capacity is represented by solar power plants (55.7%, corresponding to 50.35 MW). The county has one mini (1 MW), eight small (up to 10 MW) and one large (10 MW) solar farm. Electricity from biogas is produced by one site, which accounts for only 1.1% (1 MW) of the total capacity. In 2018, these installations produced 168.8 million kWh of electricity, which was 18.5% more than in the same period of the previous year. Most electricity (112 million kWh) was produced by hydroelectric power plants (77.7%). Solar power plants produced 56 million kWh, which represents 21.7% of total production. Biogas produced 0.78 million kWh, less than 1%.

Electricity consumption in Transcarpathian region is about 1,800 million kWh, with electricity production from own hydroelectric power plants amounting to about 112 million kWh, which represents 6.2% of total consumption. This confirms that the region is almost entirely dependent on electricity supply from the grid.

The water resources of Transcarpathia are the largest in Ukraine in relation to the catchment area. Out of Ukraine's 42 billion kWh of potential hydropower, Transcarpathia accounts for 10.2 billion kWh, i.e. a quarter of the total potential, despite the fact that the oblast covers only 2.1% of the country's territory. It is calculated that 4.5 billion kWh of this is technically feasible hydropower potential for electricity generation.

Today, there are 10 hydroelectric power plants in operation in the county with a total capacity of 39.05 MW:

- Tereble-Rikszkij (Теребле-Ріксьқій) - 27,0 MW;
- Onokivszkij (Оноківській) - 2,65 MW;
- Uzhhorod (Ужгородській) - 1,9 MW;
- Nyizsnyij Bisztrij (Hust district) (с. Нижній Бистрий Хустського р-ну) - 1,7 MW;
- Krasznyanszkij (Краснянській) - 1,16 MW;
- Turja-Paszitszkij - Shipit-1 (Тур’я-Пасіцькій – Шипіт-1) - 1,02 MW;
- Turja-Poljanszkaja - Shipit-2 (Тур’я-Полянській – Шипіт-2) - 1,0 MW;
- Lopuhovoi (Técsői district) (с. Лопухово Тячівського р-ну) - 0,996 MW;
- Ruszka Mokra (Técsői district) (с. Руська Мокра Тячівського р-ну) - 0,996 MW;
- Bilinszkij (Білинській) - 0,63 MW.

The actual electricity production of these hydropower plants in 2018 was 112.0 million kWh. The first hydroelectric power plants in Transcarpathia were built by the Hungarians in 1941 (Onokotci and Uzhhorod) on the basis of Czech designs and are still in operation today without major reconstruction.

The use of solar energy is promising in the lowland parts of the county, as the hours of sunlight in these areas are 2000 hours per year. In Transcarpathia in 2018, 6 solar power plants generated electricity with a total capacity of 50,351 MW, which are the following:

- „SZE-3” Téglási (district of Uzhhorod) (с. Тийглаш, Ужгородського р.) – 21,478 MW;
- "Irlyava" Irljavai (district of Uzhhorod) (с. Ірлява Ужгородського р-ну) – 9,6 MW;
- "SZESZ Dobrony" Nagydobrony (district of Uzhhorod) (с. Велика Добронь, Ужгородського р-ну) – 7,393 MW;
- "Chaslivtsi" SOLAR Császlóc (district of Uzhhorod) (с. Часлівці Ужгородського р-ну) – 5,4 MW;
- SZESZ "GUTA-2" (district of Uzhhorod) (Ужгородського р-ну) – 3,48 MW;
- "Kamjanyitszka SES" (Guta, district of Uzhhorod) (с. Гута Ужгородського р-ну) – 3,0 MW.

The electricity production of these solar power plants in 2018 was 56.014 million kWh, which corresponds to 33.2% of the total electricity production of renewable energy installations in Transcarpathian region.
The Ukrainian Carpathians are a promising area for economically competitive local use of wind energy, but the wind potential of each area needs to be determined very carefully due to the large number of possible shading possibilities, especially in valleys and on mountain slopes. There is still no significant experience of wind energy use in Transcarpathia. Exploitation of this area is still to be developed. The Gimba Mountain (1180 m), located 6 km from the village of Pilipec, appears to be a promising area for wind power. According to measurements, the average annual wind speed here is above 7.5 m/sec. Good meteorological conditions are also found in the Javornyik and Mencsul mountain ranges. Plans include the construction of a 120 MW wind farm in the Volovec and Solovyva districts.

Greenhouse gas inventory

In Ukraine, some regional or county-level data are available concerning GHG emissions, but they are not as complete as in Hungary.
Accordingly, comparisons between countries are not applicable, as some of the data required for the calculation is determined on the basis of a different methodology. For this reason, we do not attempt to compare the data of individual countries, but instead we rather investigate the trend in GHG emissions in the country concerned over the period under consideration. The basic data for the determination of GHG emissions were taken from the databases of the State Statistics Service of Ukraine (Державна служба статистики України), available at http://www.ukrstat.gov.ua/. Some regional data were provided by the county branch of the State Statistics Service. In cases where data from the Statistical Office were not available, we used data which were published by service providers (e.g. forestry, etc.), and in some cases, where neither regional nor sectoral data were available, we used population proportion estimates based on national data. The emissions of the transport sector were based on the amount of fuel sold (petrol, diesel).

According to the annual reports of the Department of Ecology and Natural Resources of the Transcarpathian County State Administration (Zakarpatskaya Oblastna Derzhavna Адміністрація Департамент Екології Та Природних Ресурсів), the emissions of pollutants into the atmosphere have been as follows (Table 3.6.).

Name of polluting substance	Value of emissions in the year under review (thousand t)			
	2015	2016	2017	2018
total emissions of pollutants	4,4	4,9	3,2	3,9
of which greenhouse gases	2,61	2,78	1,95	2,23

Table 3.6: Pollutant emissions from stationary sources in Transcarpathia

Source: Transcarpathian Regional State Administration

In the data in Table 3.6, only the values of GHG emissions from stationary polluters (presumably calculated on the basis of self-reporting) are included. However, the actual GHG emissions should also take into account the following emission sources:

1) GHG emissions resulting from energy use (including: electricity, natural gas, residential firewood and coal usage);
2) GHG emissions from large industrial installations (e.g. chemicals, metallurgy, steel, power plants, etc.)
3) GHG emissions generated by transport;
4) GHG emissions generated by agricultural activities (ruminant emissions, slurry emissions, organic and fertiliser emissions);
5) GHG emissions resulting from waste management (solid waste, waste water);
6) carbon dioxide absorbed by sinks (power plant).

Based on this we introduce in Table 3.7 a summary of the estimated balance of greenhouse gases absorbed by the above listed emitters and sinks (forests) for Transcarpathia.

Name of pollutant source (sector)	Estimated emissions in the year under review (t CO2 equivalent)					
	2016		2017		2018	
	t CO2 equivalent	%	t CO2 equivalent	%	t CO2 equivalent	%
Energy consumption	1.090.724	46,7	1.138.628	46,9	1.027.816	45,2
Large industrial emissions[1]	144.600	6,2	218.700	9,0	177.500	7,8
Transport	674.337	28,9	660.853	27,2	649.191	28,6
Agricultural activity	408.318	17,5	393.474	16,2	400.999	17,6
Waste management	17.920	0,8	18.010	0,7	18.030	0,8
Total emissions (gross):	**2.335.899**	**100,0**	**2.429.665**	**100,0**	**2.273.536**	**100,0**
Sinkers (forests)	-1.099.206	-47,1	-1.099.206	-45,2	-1.099.206	-48,3
Balance (net emissions)	**1.236.693**	**52,9**	**1.330.459**	**54,8**	**1.174.330**	**51,7**
Balance (net emissions) excluding large industry	**1.092.093**	**46,8**	**1.111.759**	**45,8**	**996.830**	**43,8**

1 - stationary emitters

Table 3.7: Summary of GHG emissions from Transcarpathia *Source: own calculation*

The following can be said about the GHG emissions of Transcarpathia:

- the average annual gross GHG emissions of the county are equivalent to about 2.3-2.4 million tonnes of CO_2 equivalent;
- energy consumption accounts for the largest share of gross emissions (almost half);
- the second largest share comes from GHG emissions from transport (average between 27-29 %);

- the large industrial emissions sector is considered to be relatively small (between 6-9%), but this may not necessarily reflect reality as these plants are not included in the EU ETS and therefore their actual emissions cannot be verified;
- GHG emissions from the agricultural sector account for around 16-18% of total emissions;
- GHG emissions from waste and waste water treatment account for less than 1% of the total emissions in the county;
- gross GHG emissions have been essentially stagnant with little fluctuation over the period under review;
- because of the significant forest area, the county is characterised by a substantial absorption (almost 50 % of total emissions);
- gross GHG emissions per capita in Transcarpathia during the period under review are estimated at 1.81-1.94 t/person, while net GHG emissions are estimated at 1 t/person.

3.5. Summary findings of the GHG inventory related to the Upper Tisza river basin

For the Upper Tisza catchment area, the GHG inventory was carried out for the following country areas based on the methodology described above:

- Ukrajna – Transcarpathia county (Закарпатська область),
- Romania – Maramures and Satu Mare and Satu Mare counties (Județul Maramureș, Județul Satu Mare),
- Slovakia – Kosice district (Košický kraj),
- Hungary – Szabolcs-Szatmár-Bereg county.

Based on the calculations carried out, the aggregated GHG inventories for the four countries' respective areas can be determined and are presented in Table 3.8.

Name of pollutant source (sector)	**Estimated emissions in the year under review (t CO_2 equivalent)**					
	2016		**2017**		**2018**	
	t CO_2 equivalent	**%**	**t CO_2 equivalent**	**%**	**t CO_2 equivalent**	**%**
Energy consumption	5.053.506	31,9	5.164.179	31,9	5.149.464	32,1
Large industrial emissions	7.570.196	47,8	7.642.564	47,2	7.434.803	46,3
Transport	2.122.118	13,4	2.312.654	14,3	2.394.034	14,9
Agricultural activity	937.378	5,9	916.926	5,7	913.222	5,7
Waste management	165.706	1,0	165.873	1,0	165.775	1,0
Total emissions (gross):	**15.848.904**	**100,0**	**16.202.196**	**100,0**	**16.057.298**	**100,0**
Sinkers (forests)	-2.249.196	-14,2	-2.250.447	-13,9	-2.250.697	-14,0
Balance (net emissions)	**13.599.707**	**85,8**	**13.951.749**	**86,1**	**13.806.601**	**86,0**
Balance (net emissions) excluding large industry	**6.029.511**	**38,0**	**6.309.185**	**38,9**	**6.948.291**	**39,7**
Population, persons	**3.423.792**	**-**	**3.418.874**	**-**	**3.414.825**	**-**
Gross emissions, t/person	**4,63**	**-**	**4,74**	**-**	**4,70**	**-**
Gross emissions excluding large industry, t/person	2,42	-	2,50	-	2,53	-
Net emissions, t/person	**3,97**	**-**	**4,08**	**-**	**4,04**	**-**
Net emissions excluding large industry, t/person	1,76	-	1,85	-	1,87	-

Table 3.8: Summary of GHG emissions in the Upper Tisza catchment area

Source: own calculation

Based on the data in Table 3.8, in relation to the aggregated GHG emissions of the Upper Tisza river basin as a single geographical unit, the following can be said:

- the average annual gross GHG emissions of the area are equivalent to about 16 million tonnes of CO_2 equivalent per year;
- large industry accounts for the largest share of gross emissions (almost half of the total);
- the second largest share of GHG emissions is from energy use (on average almost 1/3 of the total);
- GHG emissions from transport account for 14-15% of total territorial GHG emissions;
- the agricultural sector is responsible for about 6 % of GHG emissions;
- GHG emissions from waste and waste water treatment account for only 1% of total emissions in the area;
- gross GHG emissions show a slight upward trend over the period under review;
- gross GHG emissions excluding emissions from large industry have shown a more significant upward trend over the period under review (close to 1 Mt CO_2 equivalent);
- thanks to forested areas, the absorption can on average neutralise around 14% of total emissions;
- gross GHG emissions per capita in the Upper Tisza catchment area show a slight upward trend over the period under review, based on aggregated data;
- the same is true for net specific emissions, even though the population of the area is showing a decreasing tendency.

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Szabolcs-Szatmár-Bereg County Sustainable Energy and Climate Action Plan (SECAP) - Szabolcs-Szatmár-Bereg County Municipality, 2019 (TOP-3.2.1-15-SB1-2016-00062)

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4. Adaptation situation assessment, identification of relevant climate change issues and impact bearers

In this chapter we discuss the typical climate change issues and the main impact bearers in the Upper Tisza river basin, which will worsen because of the negative effects of climate change, or their conditions will deterior significantly.

The social (demographic), economic situation, the range of natural assets to be protected, the vulnerability caused by drought, the state of some infrastructure elements are presented for each country region.

In contrast other environmentally problems and impact bearers are going to be presented for the entire river basin via using the examples of its public administration unit where the problem is most typical, e.g. pine forest destruction, storm surges (Kosice district), anthropogenic or natural source of mass movements (Kosice district, Carpathian region).

In Hungary, the Association of Climate Friendly Settlements (KBTSZ) has identified ten prior impact bearers in Szabolcs-Szatmár-Bereg County based on their vulnerability to climate change issues. The degree, extent and number of the affected bearers provide guidance for the determination of significance; i.e., if the proportion of the affected by a problem area is high, then that problem area can be considered highly significant. The problem classification does not classify the severity of the processes, nor the extent of the risks and threats, but determines their relevance on the basis of the number and extent of the affected bearers.

On the basis of this methodology, the scope of the impact bearers identified in Szabolcs-Szatmár-Bereg county was extended to the entire Upper Tisza river basin, and the significance of each impact bearer was determined on the basis of its impact on the entire basin.

The Upper Tisza river basin is classified as a class of high importance:

- vulnerability to flooding, flash floods,
- vulnerability to anthropogenic and mass movements of natural sources
- vulnerability to drought in lowland areas
- risk of activation of toxic pollutant sources from industrial activities

Average level of involvement:

- the vulnerability of natural assets,
- threat to forests from fire and insect pests,
- vulnerability to inland flooding in lowland areas,
- vulnerability of drinking water sources
- vulnerability of tourism.

Particular attention should be paid to the vulnerability to floods, flash floods, activation of toxic pollutants from industrial activities, anthropogenic mass movements due to mining, deforestation, fire and pest risks in forest areas.

It is necessary to take into account the social and economic conditions of each administrative unit because this is the only way to assess the expected reactions of the society and its adaptive capacity to the impacts of climate change. An ageing society in poor medical condition is at increasing risk from an increase in the number of heatwave days. Based on modelled data, the number of excess deaths due to heat waves in Szabolcs-Szatmár-Bereg County could be as high as 175% compared to the experienced number of cases today. Infants, young children, people over 65, people with disabilities and people suffering from chronic cardiovascular diseases are considered particularly vulnerable. A society's capacity for adjustment is much better if the proportion of elderly people in need of care is not too high in the population.

The population also has better adaptive capacities and can lead a more climate-conscious life if they have better financial conditions. With better financial conditions, they can consume healthier food and, in the absence of daily living problems, they can treat their environment more carefully. People living on low incomes burn harmful combustion products during the

heating season and are unable to afford the costs of municipal waste disposal, water and sanitation facilities.
The structure of agriculture has a strong influence on adaptation opportunities. There has been a growing shift towards monoculture in the sector, which is indirectly leading to a decrease in biodiversity. The importance and role of forests in the fight against climate change cannot be overemphasised. On the one hand, forests possess a significant carbon sequestration capacity, with the consequent ability to reduce the concentration of the greenhouse gas CO_2 in the atmosphere, in the soil and in the hydrosphere. The amount of CO_2 absorbed per 1000 ha of forest is equivalent to 1581 tonnes per year.

In addition, forests play an important role in delaying run-off in mountainous areas and can therefore prevent or delay the development of catastrophic floods. They also provide a variety of protective functions, such as noise and dust protection in forest strips adjacent to industrial sites, or a network of field protection strips to moderate wind erosion. In addition to their protective functions, urban green spaces also improve the conditions for human recreation, especially if they have an appropriate orientation and structure.

The adaptability of society or local authorities is largely determined by the condition and quality of municipal services. Although the GHG emissions of municipal waste are generally only a few percent of total emissions, but its professional collection, transport and then the disposal in technically secure landfills is equally important for the protection of soil and surface and groundwater. Today, there is a growing emphasis on selective waste collection and recycling. This not only reduces the introduction of newer materials (mainly plastics) into the system, but also increases the environmental awareness of society. If an area has a high rate of selective waste collection, it is more likely to have a climate-conscious population.

A stable and continuous water supply is also important of the area concerned, as global warming will clearly increase the demand for water for both the population and agriculture. The main obstacle to ensuring this is the drought, which is also a direct consequence of climate change. In addition to a general reduction in water yield and groundwater levels due to the lack of rainfall in the summer, the increase in the number of heat-wave days will increase water demand. This can only be managed with the help of well developed water supply systems, taking into account the vulnerability to increasing storm intensity. The main problems could be under-lining of water pipes and saturation of drainage systems. The latter may also pose an increased epidemiological risk.

Although the vulnerability of tourism to climate change in the lowland areas of the catchment is low, it is medium or high in mountainous areas. The main problem is the reduction in the number of days with frost and snow cover in winter. This threatens the existence of ski resorts in particular, due to the season's shortening. The aptitude of the topography does not allow for expansion to higher altitudes, so a change of profile for operators may be the appropriate solution.

4.1. Climate profile of the administrative units of the Upper Tisza river basin

In this chapter, in addition to the main socio-economic characteristics of the administrative units in the Upper Tisza river basin, their natural values, the most typical environmental problems and the most relevant natural or anthropogenic hazards are presented. The administrative units studied are the following: Hungary, Szabolcs-Szatmár-Bereg county; Romania, Maramures county (Judetul Maramures), Satu Mare county (Judetul Satu Mare); Slovakia, Kosice district (Kosice Kraj); Ukraine, Carpathian region (Zakarpatszka oblaszty);.

4.1.1. Hungary, Szabolcs-Szatmár-Bereg county

Socio-economic characteristics

The county of Szabolcs-Szatmár-Bereg is located in the north-eastern part of Hungary, bordering Slovakia, Ukraine and Romania in the north and east, and Borsod-Abaúj-Zemplén and Hajdú-Bihar counties in the west and south (Figure 4.1). The county lies in the area of the Great Plain, with a significant portion covered by the Upper Tisza region and the Nyírség Central Land, and the Central Tisza region, with the Hortobágy and Taktaköz small areas in the western part of the county and Hajdúház in the Hajdúság Central land. The geographic diversity of the county is reflected in the fact that there are 12 small areas covering an area of 5936 km².

The county has a mix of tiny- and small villages, as well as more distant settlements away from one another with a larger population. The structure of tiny- and small villages is typical of the Szatmári plain, the Beregi plain and parts of the Rétköz, where the upper limit of village size is strongly determined by the narrow river floodplains that accommodate them. Small village areas are generally considered to be disadvantaged, with low population retention potential, and therefore have suffered from a significant decline in population and ageing in recent decades. A significant proportion of these areas are urban deprived, economically peripheral, and in many cases have transport and accessibility problems.

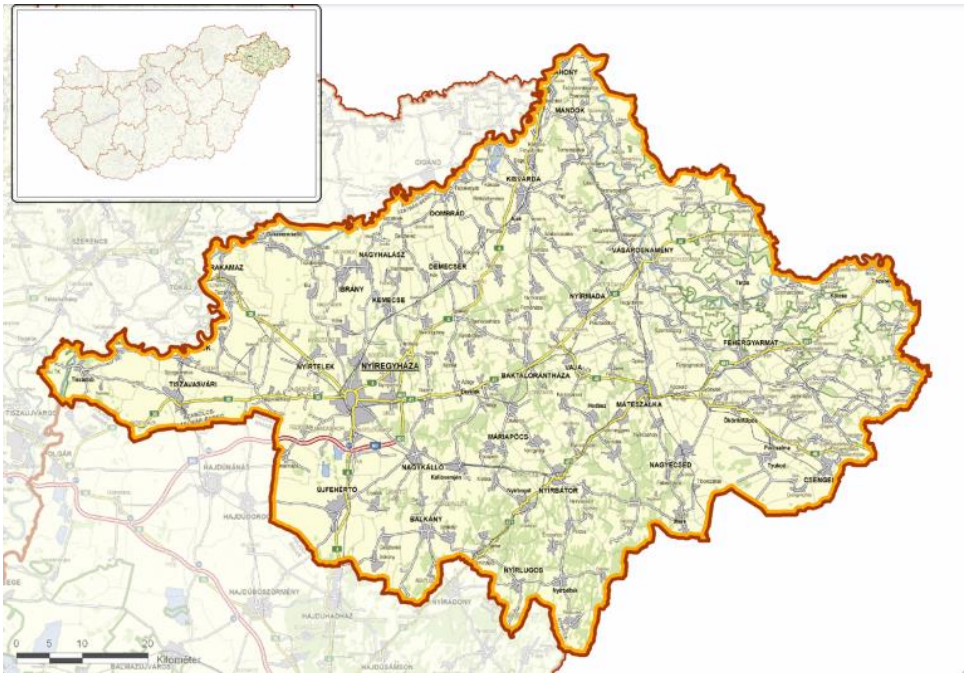

Figure 4.1.: Situation of Szabolcs-Szatmár-Bereg county. *Source: TeIR.*

The permanent population of Szabolcs-Szatmár-Bereg county at the time of the last population census in 2011 was 572,734, compared to 586,158 in 2001, a significant decrease of 13,424 in 10 years. The 2019 data shows a total population of 552,964, a decrease of more than 20,000 since 2011 (Table 4.1). There are 29 cities in the county, with 55% of the population being urban residents. The largest town, acting as a major centre, is Nyíregyháza the county seat with 117,000 inhabitants, while the smallest town is Máriapócs with 2,153 inhabitants.

Év	Total population (peson)	
	Szabolcs-Szatmár-Bereg county	Nyíregyháza
2017	562.058	117.689
2018	558.361	117.121
2019	552.964	116.799

Table 4.1.: Population of Szabolcs-Szatmár-Bereg county and Nyíregyháza between 2017 and 2019

Source: Eurostat

The natural increase/decrease balance of the county's population has been negative for the last two decades. The age composition of the population also shows negative trends (Table 4.2). The proportion of the population under 15 years old in 2011 was 17,4 % and in 2019 it is 15,7 %. The proportion of the population over 60 years old has increased by 3,7 %, so that by 2019 the proportion of this age group is 24 %. The proportion of the population over 60 years old is the highest here in the catchment municipalities, 4 % more than in the district of Kassa. These indicators point to an ageing society, and the trend shows no signs of improvement in the future.

	Total population	Age 0-14	%	Age 15-59	%	Age 60 +	%
2011	559.272	97.284	17,4	348.743	62,3	113.279	20,3
2017	562.058	90.051	16,0	346.219	61,7	125.788	22,3
2018	558.361	88.932	15,9	341.616	61,1	127.813	23
2019	552.964	86.835	15,7	333.713	60,3	131.980	24

Table 4.2.: Population change by age group between 2001 and 2016.
Source: KSH, Information database*

The economic activity of the population of Szabolcs-Szatmár-Bereg county has picked up significantly in recent years. The number of employed persons was 176,000 in 2009, considered to be the low point of the crisis, and 230,000 in the first quarter of 2016 (Figure 4.2). This expansion is clearly visible in the economic activity of the 15-74 age group. While in 2009, 50 % of the total age group (215 000 people) were economically active, in 2016 this figure had risen to 260 000 people, or 60.3 % of the age group. In terms of unemployment rates, Szabolcs-Szatmár-Bereg county has the highest rates, although the unemployment rate fell from 18.5% in 2009 to 11.6% in the first quarter of 2016. The regional rate for North Great Plain was 9.3% and the national rate at this time was 5.1%.

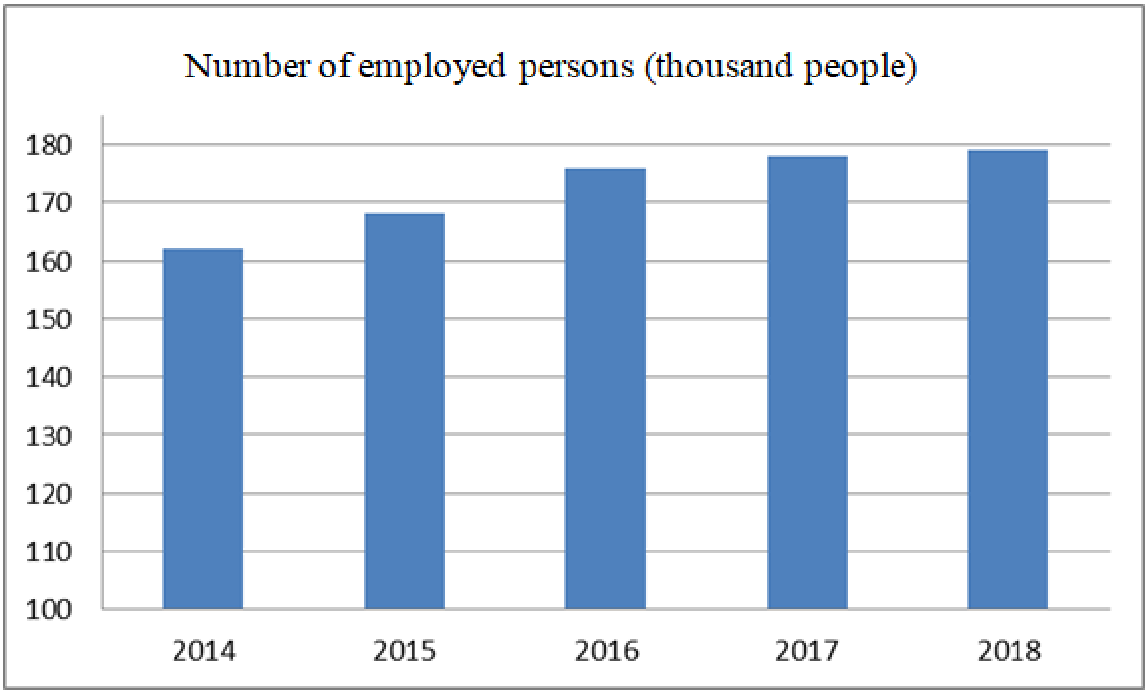

Figure 4.2: Number of employed persons in Szabolcs-Szatmár-Bereg county between 2014-2018

Source: Eurostat.

KSH- Hungarian Central Statistical Office

The total net income per capita was HUF 819 thousand in 2017. This value has practically doubled since 2008. The health status of the county's residents compares unfavourably with the national average. The quality of primary health care has improved recently, but still has shortcomings, especially in the small rural areas of the county. There is a correlation between high unemployment, low income and education levels and poor health conditions. The county's population shows an ageing structure in line with national trends. Thus, there will be an increasing proportion of older people who will react with increased sensitivity to the adverse effects of climate change. The problem is mainly due to the increase in the number of heat days and heat waves. This can be significantly reduced by creating a wide range of air conditioning conditions. In addition, there may be an increase in certain types of cardiovascular disease, which can be aggravated by rapidly and frequently changing air pressure.

Agriculture

The total usable area for agriculture in the county is 390 thousand ha, of which 280 thousand ha are arable land (Figure 4.3). Cereals account for 65 % of the arable land and 15 % of oilseeds production on arable land. The department accounts for 35 % of the country's fruit-growing area and more than 60 % of the apple-growing area. The most important fruits are apples and sour cherries. As can be seen from the distribution of cultivated areas in the county, arable land dominates (42 %) and forest cover is above the national average (21 %)

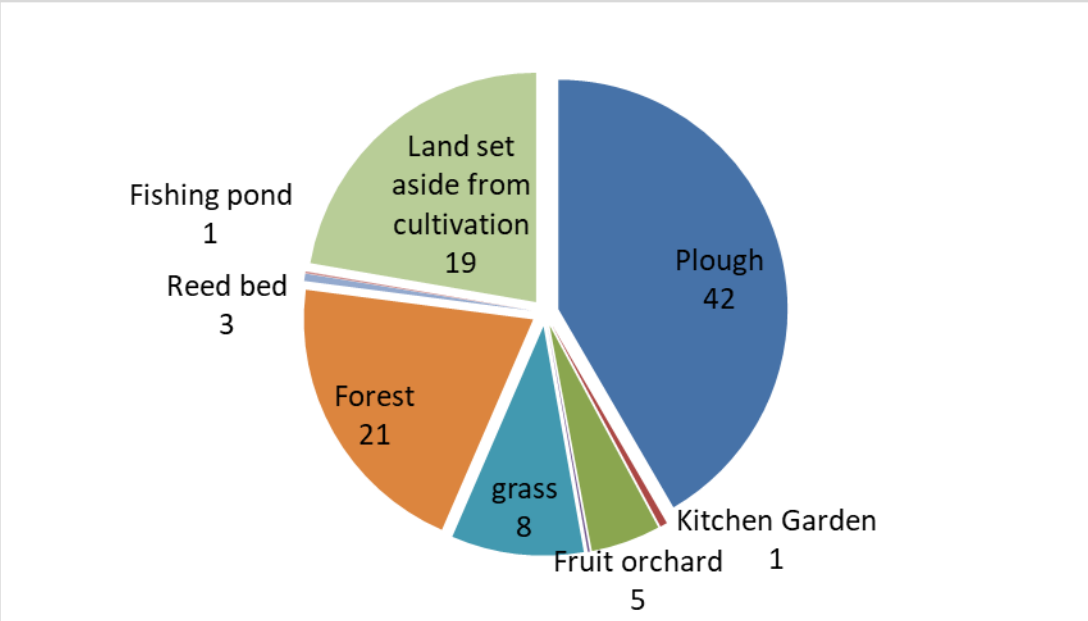

Figure 4.3: Distribution of types of farming *Source: KSH*

Nature conservation and the values to be protected

The natural values to be protected in Szabolcs-Szatmár-Bereg county are managed by the Hortobágy National Park Directorate. In administrative terms, its extent covers approximately the territory of Szabolcs-Szatmár-Bereg county, and in terms of its landscape classification it includes several medium and small landscapes and landscape types. The landscape type of the flood plain includes the Szatmári plain, the Beregi plain and the Rétköz. The most beautiful parts of the former river floodplain are the Szatmár-Beregi Landscape Protection Area (including the Lónyai Forest and the Bockerek Forest), the Tiszadob Floodplain and parts of the Tiszatelek-Tiszaberceli Floodplain Nature Reserve.

Two small Miocene volcanic cones on the Beregi plain, Tarpai-hegy (Mount Tarpai) and Kaszonyi-hegy (Mount Karosznyi), are also protected. The latter is a nature reserve in its own right. On the Szatmári plain, the Kende Mansion and its wild English-style landscape garden have been protected as the Cégénydányád Park Nature Reserve.

The varied landscape of the birch landscape, characterised by shear flats, deflation flats and hollows, as well as sand humps, represents an outstanding natural landscape. Other protected areas include the Baktalórántház Forest Nature Reserve, the Bátorligeti Pasture Nature Reserve, the Bátorligeti Primeval Marsh Nature Reserve, the Fényi Forest Nature Reserve, the Kállósemjén Mohos Lake Nature Reserve, the Tiszavasvár White-szik Nature Reserve and the Vajai Lake Nature Reserve.

Within the landscape unit, the nationally important nature conservation areas include several small-scale "ex lege" protected marshes and salt lakes, while the Ramsar Convention floodplain of the Tisza River is of international importance as a wild water of outstanding importance for the protection of waterfowl habitats. The Natura 2000 network delineated under the European Union's Birds and Habitats Directives overlaps to a large extent with the designation of other protected categories.

In addition to its natural assets, the county has a number of built cultural heritage sites. Noteworthy are the churches, ecclesiastical buildings, castles, fortresses, ruins and manor houses of exceptional appearance built in the Árpád period or later. The Cultural Heritage Protection Office lists a total of 357 monuments in the county (Table 4.3).

Protected values	quantity (db)
Ecclesiastical buildings	206
Cemetery	3
Folk religious and architectural monument	63
Municipal building, public institutions	34
Castle, castle ruins	3
Castle, mansion, garden, other related buildings	47
Economy, infrastructure, storage, transport	8
Outdoor artwork	3
Total	357

Table 4.3: Monumental values in Szabolcs-Szatmár-Bereg county
Source: Cultural Heritage Protection Office.

Waste management, utilities

On 5 March 2006, the Szabolcs-Szatmár-Bereg County Municipal Solid Waste Management Association was established. There are 241 founding municipalities in the association, which fall under three separate collection districts: the Nyíregyháza and its Region Waste Management Association (with Nyíregyháza as its centre), the Upper Szabolcs - Bereg Region Waste Management Association (with Kisvárda as its centre) and the Szatmár Regional Waste Management Association (with Nagyecsed as its centre). Coordinated developments are underway in the administrative areas of the associated municipalities to establish a modern, EU-compliant regional waste management system in the county, including waste collection, sorting, recycling and landfilling of sorting residues in accordance with modern EU legislation. This will involve the development of technical and technological methods, the purchase of equipment, the implementation of the necessary investments and the rehabilitation of illegal or abandoned landfills (www.zoldmegye.hu).

The total amount of municipal solid waste disposed in Szabolcs-Szatmár-Bereg county increased from 120.7 thousand tonnes in 2012 to 144.4 thousand tonnes in 2019 (Table 4.4). The amount of separately collected waste increased almost sevenfold in the same period, and exceeded 25 thousand tonnes in 2019.

	2012	2013	2014	2015	2016	2017	2018	2019
Municipal solid waste (tonnes)	120689	115407	129060	126765	133529	138062	133528	144419
Household selective waste (tonnes))	3759	7792	16719	15365	17944	28090	19995	25384

Table 4.4: Evolution of solid and selective waste in Szabolcs-Szatmár-Bereg county
Source: KSH

According to the Action Plan on Climate and Nature Protection adopted in Hungary, the authorities will take vigorous action to eradicate illegal landfills and to punish the perpetrators. In addition, the distribution of single-use plastics, in particular plastic cups, cutlery, plates, straws and shopping bags, has been prohibited from 1 July 2021. Another target is to recycle 90% of plastic bottles by the end of the decade.

One of the fundamental requirements for adapting to the adverse effects of climate change is access to piped water for all, as global warming increases the number of heatwaves and thus the demand for water from the population increases significantly. In Szabolcs-Szatmár-Bereg

County, a significant part of the drinking water network was completed by the 1990s and early 2000s. Its current length is 3966 km (Figure 4.5). Accordingly, total and residential water consumption did not increase much between 2011 and 2019, with the former stabilising at around 21 million cubic metres and the latter at around 16 million cubic metres. The number of newly connected dwellings shows an upward trend.

	2011	2012	2013	2014	2015	2016	2017	2018	2019
Length of drinking water network (km)	3 859	3 849	3 887	3 882	3 925	3 930	3 938	3 956	3 966
Drinking water consumption in thousands (m3)	20655	20743	20078	19661	20549	20898	20631	20805	21356
Of which residential thousands (m3)	16082	16225	15740	15412	16244	16460	15764	16178	16631
Number of dwellings connected to the network (units/year)	903	532	516	611	1553	1039	1219	1195	2330

Table 4.5: Water utility data for Szabolcs-Szatmár-Bereg county
Source: KSH

The length of the sewer network increased by more than 1,100 km between 2012 and 2019, with the number of newly connected dwellings reaching a peak in 2015 and 2016 (Table 4.6). Extreme weather events due to climate change can produce rainfall events of extreme magnitude, which require a properly constructed and sized drainage system to ensure safe drainage. The total volume of wastewater discharged increased by around 4 million cubic metres between 2012 and 2019, while the volume of wastewater discharged by the public increased by just over 1 million cubic metres.

	2012	2013	2014	2015	2016	2017	2018	2019
Length of public sewer network (km)	2057	2123	2350	2878	3145	31121	3149	3195
Number of dwellings newly connected to the sewerage network (number)	5060	3258	5158	10983	9986	3258	2145	4029
Total wastewater discharged in thousands (m3)	17231	18276	15560	16136	18069	22369	22260	21020
of which residential thousands (m3)	11798	12076	10072	10844	11970	12119	12515	12910

Table 4.6: Data of the public sewer system of Szabolcs-Szatmár-Bereg county
Source: KSH

4.1.2. Romania, Maramures County (Județul Maramureș) and Satu Mare County (Județul Satu Mare)

4.1.2.1. Maramures County

Socio-economic characteristics

Maramures County is located in the northern part of Romania (Figure 4.4). The population of the county in 2019 was 520,605 inhabitants. Its county seat, Baia Mare, had a population of 145,220 in 2019 (Table 4.7). Both the county and the county seat experienced a slight decrease in population between 2017 and 2019, but the rate of population loss is proportionally much lower than the national average. The county covers an area of 6,304 km². The highest point, and the highest peak in the whole basin, is the 2303 m high Great Pietros in the Radna Hills. The neighbouring counties are: Suceava County (Județul Suceava) in the east, Szilagy County (Județul Sălaj) in the south, Cluj County (Județul Cluj) and Bistrița-Năsăud County (Județul Bistrița-Năsăud) in the west, Satu Mare County in the west and Ukraine in the north (Figure 4.4). There are eleven cities in the county, two of which are cities with county status, namely Baia Mare, which is also the county seat, and Sighetu Marmației. There are also 63 communes and 214 settlements with village status in the county.

Figure 4.4: The situation of the county of Maramures in Romania

43% of the county is occupied by the Maramures Mountains, the Radna Mountains, the Gutin - and the Cibles Mountains, which are part of the Eastern Carpathians. The foothill and hilly areas occupy about 30 % of the county, while the lower-lying flat and terraced areas account for 27 %.

Its most important river is the River Tisza, whose main local tributaries are the Iza and the Visó, and in the south the Szamos (*Someș*). An important tributary of the Szamos is the Lăpuș (Lăpuș), which flows into its host river west of Baia Mare. The original eponymous river of the county, whose modern name is Mára, flows into the Iza.

year	Total population (persons)	
	Maramarus county	Baia Mare
2017	523.858	146.724
2018	522.154	145.899
2019	520.605	145.220

Figure 4.7: Change in the population of Maramures county and the capital city of Baia Mare between 2017 and 2019

Source: Eurostat

The age composition of the county of Maramures shows that the proportion of the population aged 0-14 years is low, it was below 15% in 2018, the lowest among the administrative units in the catchment area. The proportion of people aged 65 and over was slightly above this value (Figure 4.8). The ageing of society is indicated by the fact that the proportion of the generation aged 65 and over increased by 1.15% compared to 2015.

Due to the unfavourable age structure, a strong focus on elderly care will be needed in the future, as a significant part of society will suffer from health problems caused by heat waves.

	Total population (persons)	age between 0-14 (persons)	%	age between15-64 (persons)	%	age 65+ (persons)	%
2015	525.846	80.102	15,23	371.781	70,70	73.963	14,07
2016	524.871	79.337	15,12	369.491	69,15	76.043	14,48
2017	523.858	79.152	15,11	367.120	69,78	77.586	14,81
2018	522.154	78.187	14,97	364.520	69,81	79.447	15,22

Figure 4.8: Age structure of Maramures County

Souce: http://www.dspmm.ro/

The gender distribution of the county's population is typical of the regional average, 49% male and 51% female. The county's GDP in 2017 was 3.17 billion Euros, or 6037 Euros per capita. This value represents about 64% of the GDP per capita in Romania in 2017. The number of employed persons in 2017 shows a slight decrease compared to 2014 (Figure 4.5).

Figure 4.5: Number of employed persons in Maramures County between 2014 and 2017
Source: Eurostat

Agriculture

Taking into account the land use of the county, it can be noted that 48.5% of the land is occupied by agricultural land. Since 2007, the share of agricultural land has decreased, if only slightly. Arable land has decreased by 2874 ha, pasture by 3225 ha, while the proportion of forest land has decreased by 1342 ha (Figure 4.6). Due to the topography of the county, the share of arable land is only 13 %. The combined share of meadows and pastures is remarkable at 35 %.

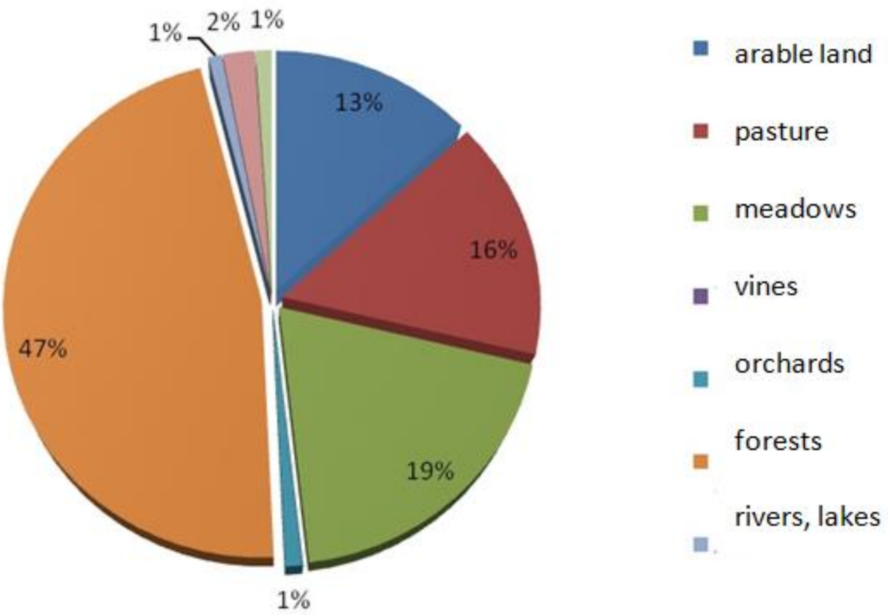

Figure 4.6: Land use in the county of Maramures in 2019 *Source:https://insse.ro/*

The forest cover of the Maramures county in 2019 was 261952 ha (2619.52 km2) (Table 4.9). Therefore, forests occupy 41.5% of the county's area, a value exceeded only by the forest cover of Transcarpathia. In the period between 2012 and 2019, the area of harvested forests increased annually, but nevertheless the forest area increased, if only slightly, thanks to plantations.

	2012	2013	2014	2015	2016	2017	2018	2019
forest resources (ha)	261.012	259.062	259.270	259.573	259.573	259.755	259.900	261.952
logged forest (ha)	3.801	3.775	3.658	3.636	3.759	4.433	3.848	4.479

Figure 4.9: Forest cover and annual harvested area in Maramures County, 2013-2019 Source: https://insse.ro/

The state of nature conservation

The Igniş Natura 2000 site on the Avas-Gutâi Plateau in the Maramures department is one of the few relict sites in Europe that provides habitat for a number of rare and endangered animal and plant species (Figure 4.7). The Natura 2000 site contains more than 90 % of Romania's quasi-endemic and threatened plant species and 66 % of the country's Red List plant and animal species. The plateau is one of the richest peatland regions in Romania, with 56 peat bogs covering a total of 260 ha. These ecosystems, although relatively small in size, contribute to climate change mitigation by providing important carbon sequestration potential.

Figure 4.7: Panorama of the Avas-Gutin plateau

In addition to its natural values, the area is also notable for its rich cultural heritage, including wooden churches and monasteries built using exceptional techniques. The area is a UNESCO World Heritage site, with ornate carved wooden houses and monumental wooden gates.

The Avas-Gutin plateau is primarily a living cultural landscape, where traditional farming practices have been preserved alongside the original character and function of much of the landscape.

Main architectural assets in the Maramures county: The Apafi Castle (Castelul Apaffi din Costiui Rónaszék), the historical centre of Baia Mare (St Stephen's Tower), the historical centre of Máramarossziget (Sighetu Marmației), the wooden churches of Máramarosszék, the wooden churches of Lápos, the wooden churches of Kővárremete (Chioar), Church of St. Peter and Paul the Apostles and Roman Catholic Church, Reformed Church of Hosszúmező (Câmpulung la Tisa), Bârsana Monastery, Moses Monastery, Piarist Monastery of Maramuresiget, Rohi Monastery, Săpânța-Peri Monastery, Săpânța Fun Cemetery.

Waste management, utilities

In Romania, under the Law on Waste Management, the local authorities of the administrative-territorial units and, where applicable, the administrative-territorial subdivisions of municipalities and their inter-communal development associations are obliged to ensure the separate collection of paper, metal, plastic and glass waste from municipal waste.

By 31 December 2020, the target was to recycle at least 50% of paper, metal, plastic and glass waste from household waste or, where appropriate, the total amount of waste generated (these targets also apply to Satu Mare County, discussed in the next sub-chapter).

In 2018, a total of 290.27 waste bins with a capacity of between 80 and 20,000 litres were placed on the territory of the county. For selective waste collection, 8.619 waste bins between 15-4.000 l were in use. A total of 75 vehicles were used for waste transport.

The amount of municipal waste collected in the county decreased from 104-117 thousand tonnes collected in 2013-2016 to less than 80 thousand tonnes per year in 2017-2019 (Table 4.10). The amount of waste collected separately shows a much larger difference. It has increased from under 3 thousand tonnes in 2013 to over 10 thousand tonnes.

Waste type	2013	2014	2015	2016	2017	2018	2019
Municipal waste (tonnes)	103.924	107.073	115.398	117.182	79.442	79.442	78.523
Separately collected household waste (tonnes)	2.964	18.755	13.453	11.759	9.866	9.862	13.238

Table 4.10: Municipal and separately collected waste in the county of Maramures, between 2013 and 2019 *Source:https://insse.ro/*

The county's drinking water network has shown a steady growth from 2010 to the present, increasing by almost 600 km reaching 2,393 km in 2018 (Table 4.11). In any case, the fact that the growth of the backbone water network will allow more people to access piped water and consequently meet the expected increase in water demand is a positive development from a climate change perspective. The expansion of the drinking water network is accompanied by a slight decrease in the volume of water consumed, which may be related to the decreasing population and the upgrading of the piped system. The county's sewer network has grown to two and a half thousand in 2018 compared to 2010 (Table 4.12).

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Length of drinking water network (km)	1802	1903	1977	1991	2042	2112	2123	2305	2393
drinking water consumption in thousands (m3)	17754	17256	17333	16396	16819	16127	16435	16192	16126

Table 4.11. Length of the drinking water network and volume of drinking water consumed in the Maramures county between 2010-2018 *Source: https://insse.ro/*

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Length of sewer network (km)	373,8	425,9	470,6	516,2	545,3	574,1	616,3	916,7	945,6

Figure 4.12: Length of the sewerage network in the Maramures department 2010-2018
Source: https://insse.ro/

The damaging impact of mining on nature

On 30 January 2000, at 10 pm, a dam burst on the Upper Tisza near Baia Mare, Romania, caused by heavy rainfall from the Aurul mining company's tailings pond, resulted in hundreds of thousands of cubic metres of industrial water containing high concentrations of cyanide compounds and heavy metals flowing into the Lápos (Lăpuș) River and from there into the Tisza via the Szamos (Someș) River. The pollution left the Hungarian section of the

Tisza on 12 February, causing serious ecological damage to both invertebrate and vertebrate fauna. The scale of the pollution has caused unprecedented environmental damage in the Tisza river basin.

The highly toxic sodium cyanide (NaCN) released into the water system is the sodium salt of hydrogen cyanide. Cyanide entering the organisms paralyses the cytochrome oxidase enzyme, which plays a key role in oxygen uptake, when it enters the mitochondria. As a result, the oxygen uptake capacity of cells is reduced to negligible levels (Nagy 2013). Cyanide levels measured in the Szamos River at Csengern on 1 February were 32.6 mg/l. In the Tisza water system, it was reduced by less than half to 13.5 mg/l at Lónya. On leaving the country, cyanide concentrations of 1.49 mg/l were still measured at Tiszasziget. According to the mass balance, the total amount of cyanide entering the area was estimated at 130-175 tonnes.

According to the findings of the Upper Tisza Environmental Protection Inspectorate, the microscopic biota in the cyanide-contaminated stretch of the river has been significantly damaged. On 2 and 3 February, the rate of destruction in the Szamos reached 100%; no living plankton organisms could be detected. A high mortality rate of about 50% was also observed for larvae of the damselfly. The mortality rate of microscopic organisms in the Vásárosnamény section of the Tisza was 10 % on 2 February, ranged from 0 to 80 % between 2 and 4 February at Lónya, from 20 to 90 % during the same period at Zahony, from 15 to 80 % between 4 and 9 February at Tuzsér, from 30 to 60 % between 4 and 6 February at Dombrád and from 10 to 40 % between 4 and 8 February at Tiszabercel.

The mortality in the Csenger section of the Szamos was 100% between 10.00 and 18.35 on 2 February. At Tunyogmatolcs between 10.00 and 14.30 and at Olcsvaapatti between 14.00 on 2 February and 9.15 on 3 February, total mortality was observed, following the departure of the polluting wave (Nagy 2013). The most spectacular consequence of cyanide pollution was the mortality of fish, the aquatic organism group most sensitive to poisoning (Figure 4.8).

Figure 4.8: Collection of dead fish carcasses from cyanide pollution in the lower Upper Tisza

Comparing the results of the surveys carried out in previous years and the fish stock assessment carried out after the pollution, the calculations show that the total mortality was 1241 tonnes. Of these, 33.8% were predatory fish, 13.5% carp (Cyprinus carpio), 8.1% goatfish (Acipenser ruthenus) and 44.6% herbivores, mainly busa and other fish. The estimated and calculated value of dead commercial fish is 874 million HUF (Nagy 2013). Based on the results of biological surveys conducted before and during the cyanide pollution, the planktonic fauna was characterised by low numbers of species and individuals, in line with the winter conditions.

After the cyanide pollution had subsided, the recovery of the fauna was promising, with the detection of all the groups that had previously been present. The results show that a significant part of the macroscopic invertebrate fauna of the two rivers survived the pollution (https://www.terra.hu/cian/elovalt.html).

In addition to the cyanide content, heavy metals dissolved in the water (in complexed form) were also transported via the river system of the Szamos. The results of the measurements showed that copper was present in the highest concentration. In addition, concentrations of zinc in particular, and to a lesser extent lead and silver, were measured in excess of naturally occurring concentrations. The concentration of dissolved copper in water in the Szamos at

Csenger on 1 February was 18 mg/l during 18 hours of measurement, which is 180 times the health limit value (0.1 mg/l). The highest concentration at Olcsvaapati was 16 mg/l. The highest value in the Tisza was measured at Lónya, where the concentration was 7.4 mg/l. Thanks to dilution, as with cyanide, copper concentrations showed a steady decrease. However, these values do not show as steady a variation as cyanide. Accordingly, 6.8 mg/l at Zahony, 4.2 mg/l at Tuzsér, 6.1 mg/l at Dombrád, 3.1 mg/l at Tiszabercel, 5.9 mg/l at Balsa, 4.4 mg/l at Tiszalök, 4.1 mg/l at Polgár, 3.7 mg/l at Tiszakeszi, 2.4 mg/l at Csongrád, 1.6 mg/l at Mindszent and Szeged and 1.1 mg/l at Tiszasziget. The ratio compared to each other of the cyanide and dissolved copper concentrations measured in the lower part of the river shows that the concentration of heavy metal ions in the lower part of the river decreased more than that of cyanide. The highest value for dissolved zinc in the Samos at Csenger was 0.95 mg/l, which is about 3 times the limit value for heavily polluted (Class V) surface water (0.3 mg/l). Dissolved heavy metal concentrations after the pollution wave had subsided were in line with pre-pollution water quality. Dissolved copper concentrations were below 0.01 mg/l in the April measurements. In addition to the results presented, it should be emphasised again that these relate to the dissolved metal content of the water, but there is no specific information on the total (dissolved and suspended) copper and zinc content of the water, nor on the increase in the heavy metal content of the sediment (https://www.terra.hu/cian/elovalt.html). The metal complexes of cyanides, which are a major part of the contamination, are highly soluble in water and stable under the chemistry generally found in surface waters, i.e. they remain unchanged in water over long periods of time. As a result, both cyanide and the associated heavy metals have left Hungary in practically their entirety and have not accumulated in the sediments. Due to the water level, the contamination did not affect the wetlands of the floodplain and tests of nearby wells proved that the contamination did not occur in groundwater. The free cyanide content evaporated out of the system by the mid-Tisza section. A mass balance, which is difficult to calculate due to variable water flows, showed that the typical amount of total cyanide in the Hungarian section of the Tisza was around 100-200 tonnes in the measured sections (https://www.terra.hu/cian/elovalt.html).

A few weeks after the heavy metal pollution that went down with the cyanide poisoning, the river was hit by another, but much more serious, heavy metal pollution in several waves. The first wave reached the Hungarian section of the Tisza at Tiszabecs in the evening of 11 March

2000, the second at dawn on 15 March and the third in the morning of the same day. The dam of the Remin mining company's tailings dam near Băile Borșa (Borsabánya) burst due to a sudden rise in water levels caused by a sudden snow melt, and an estimated 20,000 m3 of heavy metal-contaminated sludge was released into the valley below the reservoir (https://www.terra.hu/cian/elovalt.html).

The ore leaching technology, also used by Aurul company, has been known since 1890. The process involves first treating the powdered ore-bearing tailings with a sodium cyanide (NaCN) solution, which causes the gold content to be dissolved in the form of a gold cyano-complex Na [Au(CN)2]. The solid gold is separated from this solution by the addition of zinc powder (Zn).

The contamination appeared in smaller and smaller peaks in the month of March and the last wave left the country in early April. Post-poisoning investigations showed that lead, copper and zinc were present in the contaminated sediment in the highest concentrations, mostly in a suspended form (Nagy 2013).

The results of the water chemistry tests carried out by the Upper Tisza Rural Environmental Protection Inspectorate showed that the water quality was in line with the values typical of the flooding periods. Measurements of heavy metal concentrations in the section entering the country at Tiszabecs showed that lead, copper and zinc were the main pollutants, mostly bound to very fine-grained floating particles of the accompanying sedimentary rocks. In this section the maximum suspended solids were 1150 mg/l, with an average of 700-900 mg/l. The maximum concentration of lead (total lead) was 2.9 mg/l, with an average of 1.0 mg/l. Zinc (total zinc) was similar (max. 2.9 mg/l; average 1.0 mg/l), while the maximum concentration of total copper was 0.86 mg/l, average 0.30 mg/l. These concentrations are significantly above the values for the water quality class "heavily polluted" (Class V) (MSZ 12749:1993), and by an order of magnitude for lead. The different specific gravities of the metals in the pond indicate that each metal occupied a particular position in the pond. The heavy metal content tended to decrease downstream, with a peak concentration of 0.34 mg/l for lead and 0.18 mg/l for copper at Tokaj (https://www.terra.hu/cian/elovalt.html).

In the downstream direction, the lower specific gravity zinc and copper fraction was predominant in the float at the beginning of the float, while lead content was predominant in the float in the second half of the float. This relationship is characterised by the temporal variation of the maximum of the total lead, copper and zinc test results, so that usually the maximum of the zinc and copper pollution was followed by the maximum of the lead pollution with a 4-6 hour delay within the 50-70 km long float.

The mass balance at Tiszabecs indicates that the amount of lead passing with the first pollution wave was about 50 tonnes, copper 20 tonnes and zinc 70 tonne (https://www.terra.hu/cian/elovalt.html).

The results of biological tests carried out by the Environmental Inspectorate show the following picture. The algal flora of the water was typical of the flood period, with small numbers of individuals. No fish mortality was observed in the stretch. Ecotoxicological tests did not show any toxic effects in any of the cases. These results were typical for the whole Hungarian Tisza section.

Heavy metals bound to suspended matter are typically insoluble under the chemical conditions of surface waters, but will precipitate with different specific gravities as the flow rate decreases. Their further fate is determined by the chemistry of the sediment (pH, oxygen) and its biological characteristics.

The effects of heavy metals on living organisms are serious because they are not excreted once they enter the body, but instead have the potential to accumulate. The so-called essential heavy metals (e.g. Zn, Cu) are needed in small amounts by living organisms, so if there are not enough of them in the body, deficiencies can lead to diseases. There is an optimum level, but if, for example, zinc exceeds 100 mg/kg or copper 60 mg/kg, essential heavy metals can also cause poisoning. Non-essential heavy metals (e.g. Hg, Pb) are not needed by living organisms, so even if they are present in the body of living organisms in any small amounts, this can be considered as a maximum tolerable level. If lead exceeds 0.5 mg/kg, mercury 0.3 mg/kg and cadmium 0.1 mg/kg, these heavy metals are considered to be in a state of toxicity.

Sediment analyses carried out after the contamination had run its course showed that the high heavy metal content of the suspended sediment deposited from the contaminating wave increased the lead content of the sediment at Tiszabecs to around 900 mg/kg. At the same sampling site, the copper content reached about 500 mg/kg and the zinc concentration 1400-1500 mg/kg. These data represent a tenfold increase in heavy metal concentrations compared to baseline values (typical concentrations of lead and copper in the Tisza sediment not affected by the heavy metal pollution wave are 20-70 mg/kg and zinc concentrations are 100-400 mg/kg).

The heavy metal pollution came with tidal surges, which had two consequences. On the one hand, the increase in water velocity reduced the rate of sedimentation and, on the other hand, the contaminated water escaped into the floodplain, including part of the dead pools in the floodplain. After the wave had receded, grey sediment of a few centimetres thickness was clearly visible in these areas. The heavy metals (mainly lead) that accumulate in the floodplain can have a longer lasting effect on plants and animals. Given the poor solubility properties of lead, the heavy metal is not expected to dissolve in the soil. Information on the fate of the heavy metal deposited in the sediments is also not available, as it may have been significantly rearranged by the high tidal surge following the pollution, and therefore only new research results can provide concrete data. It is interesting to note that the analysis of the heavy metal content of the sediments of the Tisza dead pools confirms that Havaria-type heavy metal pollution has been occurring since the last century.

Although the two types of pollution have in common that they are related to mining and, even more so, to irresponsible management and disregard for basic environmental and safety requirements, there are major differences in the nature, extent and impact of the pollution. Overall, pollution has affected not only wildlife but also the society living along the Tisza water system. The number of people affected and directly or indirectly threatened exceeded one million inhabitants.

Increasingly frequent heavy rainfall due to climate change may further increase the likelihood of dam failure in reservoirs. Preventing this will present companies with an extraordinary technical challenge, and the most forward-looking step would be to abandon the mining of precious ore using these technologies. Although the Remin mining plant in Borsabánya (*Băile Borșa)*, which caused heavy metal pollution, was closed down, mining in the area led to further heavy metal pollution reaching the Tisza from the Csiszla stream (*Raul Cisla)* via the Visó (*Vișeu*) river in 2009. A year before that, also as a result of the weakening of the dams of the dredger due to rainfall, the Visó (*Vișeu*) River was also affected by significant heavy metal pollution.

4.1.2.2. Satu Mare County

Socio-economic characteristics

Satu Mare County is located in the North-Western Region of Romania. It shares borders with Ukraine, Hungary, the counties of Bihor (Judeţul Bihor), Silajd and Maramures (Figure 4.9). The county covers an area of 4,418 km2 and had a population of 332,572 in 2019, making it the lowest in terms of population and area among the surveyed administrative units (Table 4.13). The population has decreased by more than 9,000 since 2012, and its age structure can be considered unfavourable. In 2018, the proportion of the population under 15 years of age was 16.9%, while the proportion of the population over 60 years of age was over 22% (Table 4.14). Since 2012, the share of the latter age group has increased by 2.5%, while the share of the under-15s has decreased by 0.5%. There are six towns in the county, two of which are county towns, Satu Mare and Carei. There are 58 municipalities and 220 villages in the county. The county seat is Satu Mare, with an area of 150.3 km2 and a population of 119,788 in 2018. The share of agricultural land in Satu Mare County is 72%, 17% of forests, 3% of water surfaces and 8% of other land.

Figure 4.9: Situation of Satu Mare County in Romania

	total population (persons)	year 0-14 (pesons)	%	year 15-59 (persons)	%	year 60+ (persons)	%
2012	342.880	59.205	17,26	216.425	63,11	67.250	19,61
2013	341.660	58.221	17,04	214.860	62,88	68.579	20,04
2014	340.592	57.757	16,37	212.984	62,53	69.851	20,42
2015	339.176	57.447	16,82	210.517	62,06	71.212	20,99
2016	337.456	57.073	16,91	207.830	61,58	72.553	21,49
2017	335.727	56.762	16,90	205.171	61,11	73.794	21,98
2018	333.731	56.238	16,85	202.834	60,07	74.659	22,23

Table 4.13: Population and age structure of Satu Mare County between 2012 and 2019
Source: https://insse.ro/

The population of the counties is 49% male and 51% female, with 45.6% of the population living in urban areas. In terms of the spatial structure of the county, the southern part of the county is considered to be deprived of urban areas. Satu Mare is the most ethnically diverse of the county capitals in the catchment area. 58% of its population is of Romanian ethnicity, 40% of Hungarian ethnicity and 1% of Roma ethnicity (Figure 4.14). The GDP generated in the county in 2017 was 2.37 billion Euros, which is 7043 Euros per capita, 74% of the Romanian average in 2017. The number of employed persons in the county is 47%, a clear decrease compared to 50% in 2014 (Figure 4.10).

ethnicity	persons	%
Romanian	66638	58
Hungarian	45298	40

Table 4.14. Ethnic composition of Satu Mare *Source:https://insse.ro/*

Figure 4.10. Number of persons employed in Satu Mare County between 2014 and 2017
Source: Eurostat

Agriculture

A significant part of the county's territory is used for agriculture. In terms of land use categories, arable land accounts for 54%, while the other two most important land use types are forest and grassland (Figure 4.11). Besides the county of Szabolcs-Szatmár-Bereg, the area of forest is the smallest in this county, the main reason being the significant deforestation for agricultural purposes in recent centuries.

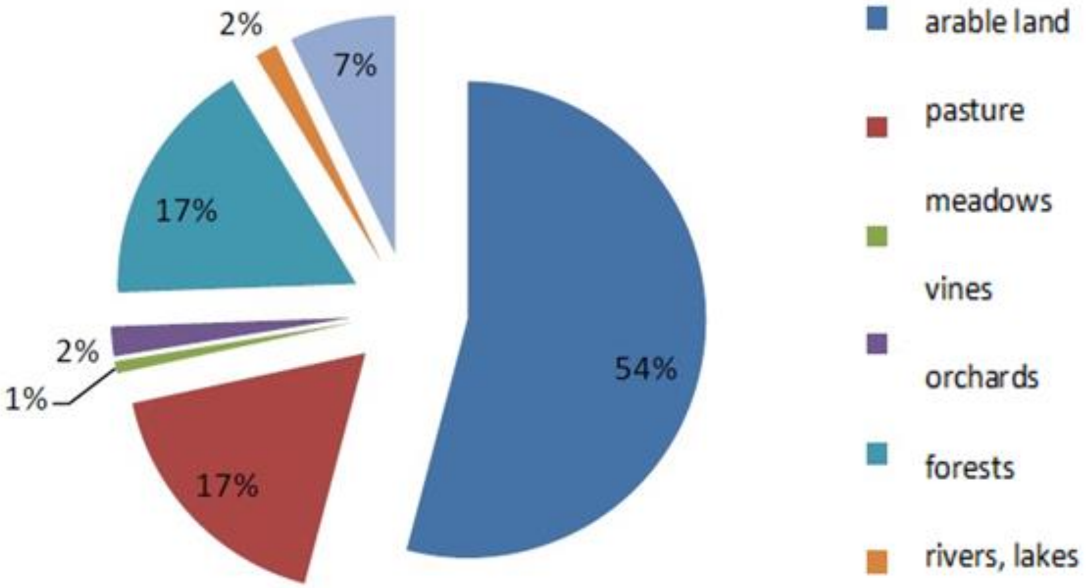

Figure 4.11: Land use in Satu Mare County in 2019 *Source: https://insse.ro/*

The forest area increased by several thousand hectares between 2015 and 2019, despite the fact that the volume of harvesting was around 2000 ha per year (Figure 4.15).

	2015	2016	2017	2018	2019
harvested forest (ha)	1.944	2.052,7	2.225,1	2.198	2.007
forest cover ha	44.878	46.040	46.521	46.783	46.316

Table 4.15: Forest cover and annual harvested area in Satu Mare County between 2013 and 2019 *Source: https://insse.ro/*

The state of nature conservation

Since 2007, the protected areas have included the Nagykároly (Carei) Plain (Nagykároly / Carei Sandy Plain), which is part of the Natura 2000 network. The area is a continuation of the Nyírség, which has a unique geomorphological form sequence in Central Europe. The sandy landscape, consisting of semi-consolidated quicksand forms formed during the glacial period, is home to numerous protected endemic plant species. The gallery forests along the rivers, e.g. along the Szamos (Someș), the Túr (Tur) and the Kraszna (Crasna*)*, play an important ecological corridor role. Other priority nature conservation areas are: Special Protection Area for Birds: the Moftinu Mic fish ponds, the sand dunes of Moftinu, the 10 ha Sanislău Vermes swamp, the 38.5 ha Urziceni-Pădure forest and the 0, 5 ha of the Comja pine forest on the border between Satu Mare and Maramures county, between the municipalities of Seini and Racșa, and 68,5 ha of the Runc forest in the neighbourhood of Maramures county, as well as the marshes of the Avas Mountains (Munții Oaşului).

Waste management, utilities

In Satu Mare County, the collection of municipal waste is the responsibility of the municipalities, directly or indirectly, in accordance with Romanian law (see Maramures County). The amount of waste collected in the county showed significant differences between 2014 and 2015 (Figure 4.16). In 2017 and 2018, the annual quantities were around 65 and 67 thousand tonnes respectively. The amount of waste collected separately increased fourfold by 2018 compared to 2014.

	2014	2015	2016	2017	2018
Municipal waste (tons)	48.610	90.533	81.200	65.136	67.326
Separately collected household waste (tonnes)	919	1.178	3.522	2.015	3.214

Figure 4.16: Municipal and separately collected waste in Satu Mare County, between 2014 and 2018 *Source: https://insse.ro/*

The number of municipalities in the county with a drinking water network was 60 in 2018, compared to 50 in 2010 (Table 4.17). In line with this, the length of the network has increased by 750 km over this period. Residential water consumption was around 10 000 m3 between 2010 and 2018, an increase of 300 000 m3 . The rate of increase is not considered significant, given the expanding network and the increase in the number of connected agglomerations.

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Number of agglomerations with urban drinking water supply	50	54	54	55	57	59	60	60	60
Length of drinking water network (km)	1161	1338	1387	1489	1537	1573	1647	1726	1811
Drinking water consumption in thousands (m3)	9707	9359	9202	8960	9405	9563	9146	9904	10144

Table 4.17: Data on the drinking water network in Satu Mare County *Source:* https://insse.ro/

Between 2010 and 2018, the number of cities with a sewerage network increased three and a half times, while the length of the sewerage network almost tripled (Table 4.18). The significant increase in the network is beneficial in draining the periodic increase in runoff due to climate change.

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Number of cities with sewerage networks	11	13	14	15	25	27	28	32	38
Length of sewer network (km)	363,2	424,3	450,6	492,3	630,1	684,4	753,4	877,4	964,6

Table 4.18: Data on the sewerage network in Satu Mare County *Source:* https://insse.ro/

4.1.3. Slovakia, Kosice Region (Košický kraj) Slovakia

Socio-economic characteristics

The Košický kraj (Košice Region) covers an area of 6,754.3 km2 in the south-eastern part of the Slovak Republic, occupying 13.8% of the country's territory (Figure 4.12). It is the second largest in Slovakia in terms of population and the fourth largest in terms of area. It is bordered by Hungary to the south, Ukraine to the east, the Prešovský kraj to the north and the Banskobystrický kraj to the west.

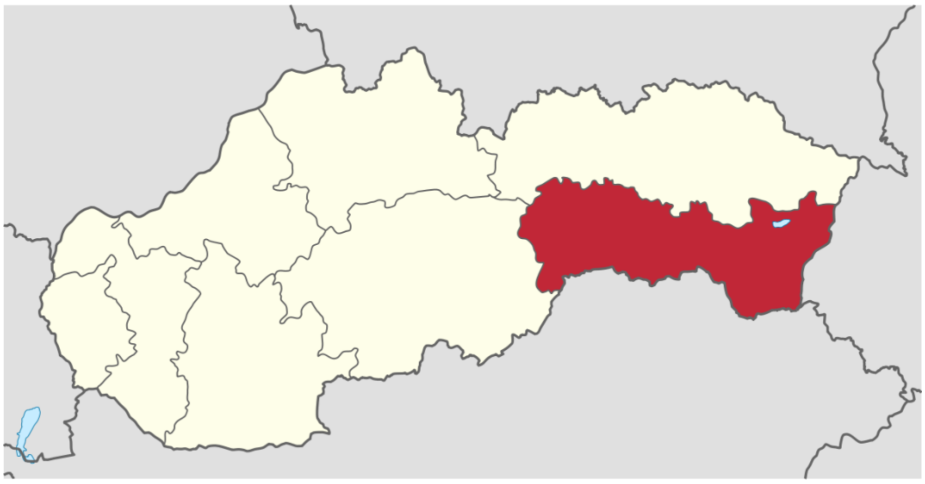

Table 4.12: Situation of the area of Kosice

The highest point of the region is the 1476 m high Stolica Hill located in the Slovak Ore Mountains, the lowest is along the Bodrog River at the Slovak-Hungarian border, at 94 m above sea level. The Bodrog is the largest river, which together with its headwaters drains the easternmost part of the region. River Herend and its branches collect the waters of the Basin of Kosice. The western part of the area belongs directly to the Sajó river basin, while the smallest parts in the south-east, belonging to the Bodrogköz, are part of the Bodrog and the Tisza river basin.

The area has significant areas of standing water, which, due to the topography, were mainly created by the construction of valley-closing dams. These are the Zemplínská šírava, Bukovec, Ružín, Dobšina and Palcmanská Maša reservoirs, which are of economic and recreational importance. (https://slovak.statistics.sk/).

Both ores and non-metallic minerals occur in the area. The most notable ores are iron and silver ores in the Rožňava and Spišská Sobota areas. Magnesite is significant in the district of Michalovce. In the district of Rozňava, there is rock salt, soapstone and gypsum. In the region there are various types of building stones, limestone, kaolin, gravel, river sand and clay for brick making. Among the energy sources, oil and natural gas are found in the districts of Michalovce and Trebišov. The Kosice Basin is one of the most promising areas for the use of geothermal energy. At a depth of 3000 m, water temperatures of 150 degrees Celsius are assumed. There is significant potential for geothermal energy in the area of Györke (Ďurkov) village and the Vihorlat (Vihorlatské vrchy) Mountains (https://slovak.statistics.sk/).

It is divided into eleven districts according to the territorial-administrative division: the districts of Gelnica (Gölnicbánya), Košice I, Košice II, Košice III, Košice IV, Košice and surroundings, Michalovce, Rožňava, Sobranac, Igló (Iglov*)* and Trebišov.

There are 440 municipalities in the region, 17 of which are urban, with 54.5% of the population living in urban areas. The administrative, economic, political, educational and cultural centre of the region is Košice, the second largest city in Slovakia, with 22 municipalities, each with its own local government. At the end of 2019, the city had 238,757 inhabitants, which accounts for almost 30% of the population of the Kosice region (Table 4.19). With 14.7% of Slovak population, the Kosice region was the second largest in Slovakia after the Eperjes (Prešov) region. The district is among the most densely populated regions, with an average of 119 inhabitants per km^2 (https://slovak.statistics.sk/).

Year	Total population (persons)	
	Area of Kosice	Kosice
2017	798103	239141
2018	799815	239095
2019	800937	238757

Table 4.19. Variation in the population of the district of Košice and Košice between 2017 and 2019 *Source: Eurostat*

The region's population is slightly younger than the Slovak average. The average age of the population in 2019 was 39.8 years, with an ageing index of 89.2. The under-15 age group accounted for 17.2% of the total population in 2019 (Table 4.20). The proportion of this age group remained practically constant between 2013 and 2019. The proportion of the population of working age, aged 15-59, decreased from 64.5% in 2013 to 61.4% in 2019. In contrast, the proportion of the population aged 60+ reached 20% in 2019. The changes observed in the age composition of the population show a similar trend to those observed in other administrative units of the catchment area.

	total population (persons)	year 0-14 (persons)	%	year 15-59 (persons)	%	year 60+ (persons)	%
2013	794.390	138.109	17,38	512.217	64,47	144.070	18,13
2014	795.160	137.200	17,23	509.323	64,05	148.634	18,69
2015	796.107	136.593	17,15	506.304	63,59	153.209	19,24
2016	797.376	136.601	17,13	502.812	63,51	157.963	19,81
2017	798.660	137.099	17,16	498.756	62,44	162.812	20,38
2018	799.815	137.576	17,20	494.941	61,88	167.306	20,09
2019	800.937	137.729	17,19	491.902	61,41	161.345	20,01

Table 4.20Variation in the population and age composition of the Kosice district
Source: https://slovak.statistics.sk/

In the region of Košice, job opportunities are mainly concentrated in the cities, in particular in Košice and its surroundings.In 2019, the employment rate was 62.9% and the unemployment rate was 7.9%. In the long term, the employment rate is increasing while the unemployment rate is decreasing (Figure 4.13). The average gross nominal monthly salary was €1,168 in 2019, 7.4% below the national average.

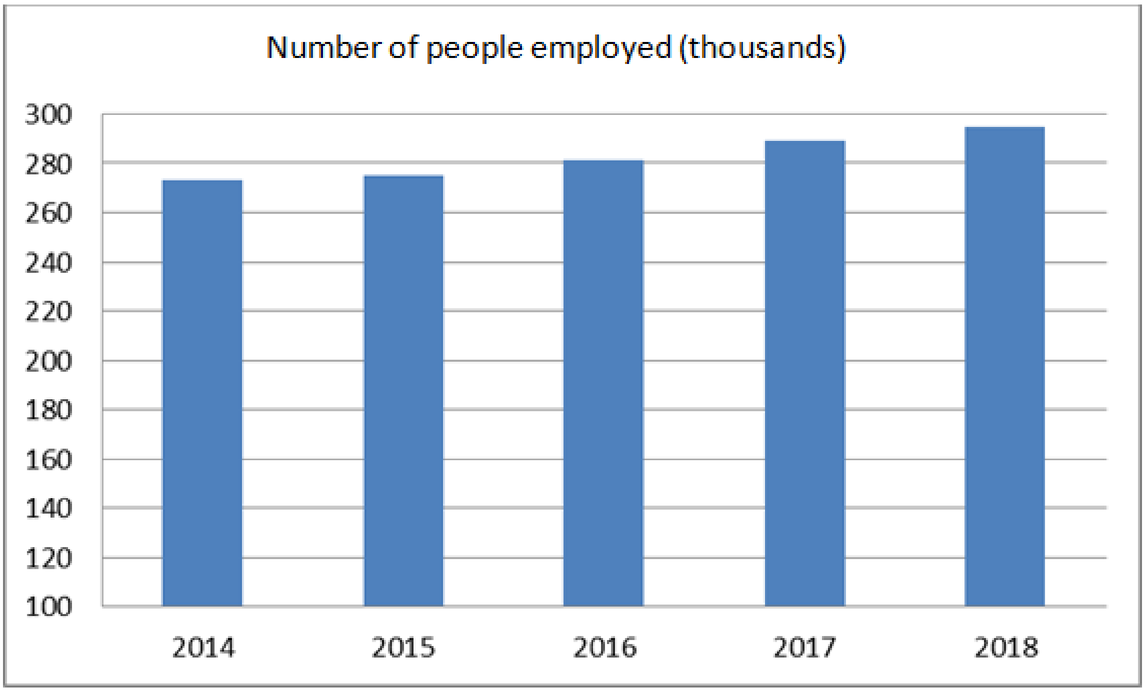

Figure 4.13.: Number of people employed in Kossice district between 2014 and 2018 között

Source: Eurostat

The district accounted for 11.9% of Slovakia's gross domestic product in 2018 and is therefore considered one of the most important regions in the Slovak Republic in terms of the structure of its economic base. The gross domestic product of the Kosice region amounted to €10.68 billion, equivalent to €13,353 per capita, or 81.1% of Slovakia's GDP per capita in 2018.

The raw materials of the Slovak Ore Mines were the basis for the region's mining, metallurgy and machinery production. These sectors have become the main pillars of industry with the dominance of modern metallurgical plants and chemical companies. The largest heavy industry plant is the Kosice Ironworks, which is also the largest GHG emitter in the study area (Figure 4.14).

Figure 4.14. Photo of the Kosice Ironworks
Source: https://felvidek.ma/

In 2019, the total length of the road network in the territory was 2,396 km, of which 22 km were motorways, 367 km were first class roads and 584 km were second class roads. There were 391,130 motor vehicles registered in the Kosice region, three quarters of which were passenger cars. The international railways and those of national importance are the Žilina - Kosice-Mezzolaborc and the Plaveč - Prešov-Kosice. There is an international airport in Košice (https://slovak.statistics.sk/).

Agricultural land covers 333 000 ha, almost half the area of the region, of which more than three-fifths is arable and one-third is grassland. More than three quarters of the arable land is located in the districts of Košice and its surroundings, Michalovce and Trebišov, where at the same time agricultural production is most intensive.

About 2/5 of the district of Košice is covered by forest. In 2015, this amounted to 267,000 ha, and in that year the volume of timber extraction was 1,944 ha, i.e. 0.72% of the total forest stock. In recent years, 2017 was the year with the highest volume of logging, but the 2,225 ha still did not reach 1% of the total forest stock.

The state of nature conservation

There are two national parks in the Kosice district, the Slovak Paradise National Park and the Slovak Karst National Park. Two protected landscape areas are the Latorica and Vihorlát

(Vihorlatsko) forests, 31 national nature reserves, 43 nature protection areas, 23 national natural monuments, 25 natural monuments, 11 protected areas and 10 bird conservation areas (Figure 4.1.5). The Dobsina Ice Cave is a Site of European Importance. The Ochtiná aragonite cave, the Domica ice cave and the Jasovská jaskyňa cave are also of unique natural value.

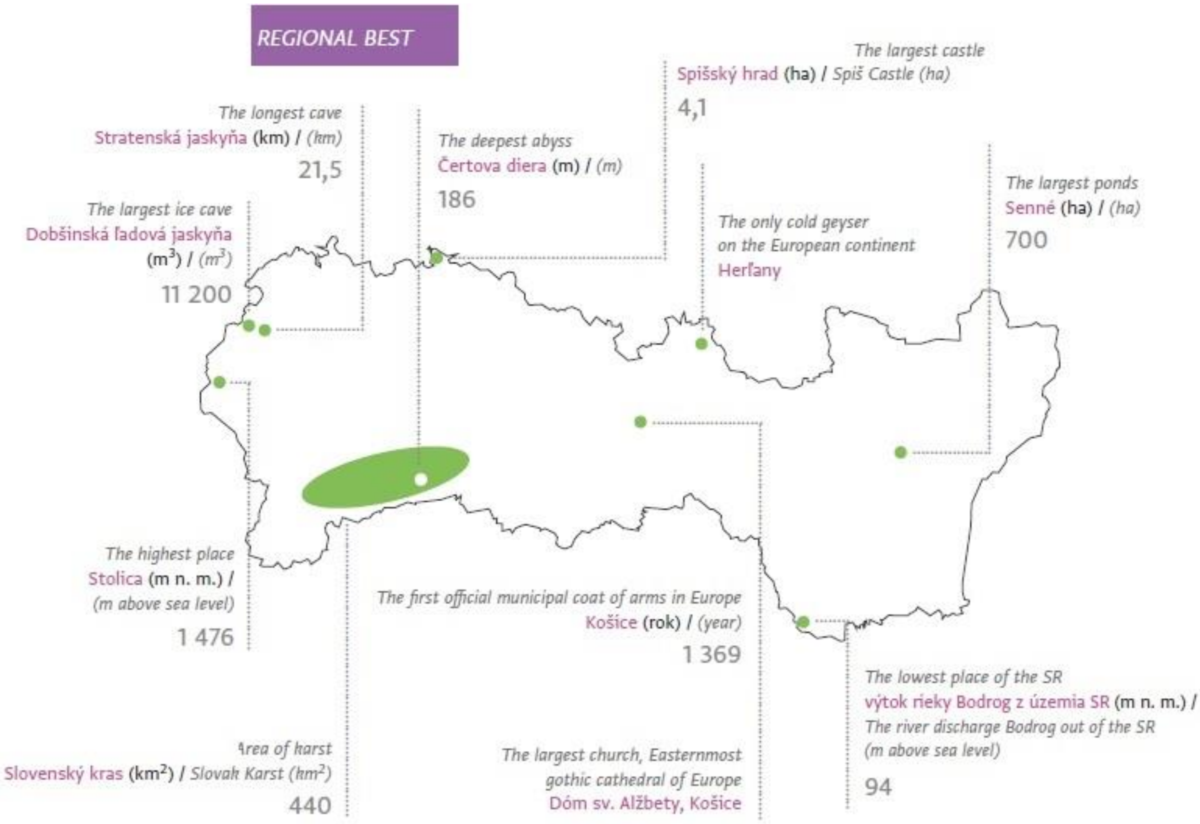

Figure 4.15.: Natural values of the Kosice district
Source: slovak.statistics.sk

The Slovak Paradise covers an area of about 210 km² in the area of the districts of Spišské Podhradie and Rožňava. The Hernád (Hornád) and Gölnic (Hnilec) rivers carry the waters of the area. The forest cover of the national park reaches 90 %. The forests are characterised mainly by beech and pine and deciduous communities. 930 plant species occur in the park, 35 of which are protected. In addition, there are 6 endemic plant species, which are found only in the Slovak Paradise. In addition to these, there are 19 other endemic plants that occur only in the North-Western Carpathians.

The Slovak Karst National Park is located in the south of Slovakia, on the border with Hungary. The Gemersko-Turniansky Karst (Gemersko-Turniansky kras), which extends into Hungary, is the largest karst area in Central Europe. It is a World Heritage site with around

1100 caves and gorges (Figure 4.16). The Slovak Karst National Park covers 346 km2 (plus 117 km2 of protected area) and the national park was established in 2002.
Its main tourist attractions are the Zádielska tiesňava (Zádiel Valley) and the Domica Cave, the longest cave in the Slovak Karst.

Figure 4.16.: Area of the Slovak Karst
Source: https://slovakia.travel/hu/szlovak-karszt-nemzeti-park

Waste management, utilities

The amount of municipal waste in the Slovak Republic decreased by 28.1% between 2005 and 2019 compared to the previous period (www.enviroportal.sk/). Greener Slovakia - The Slovak Republic's environmental policy for 2030 calls for a 60% recycling rate of municipal waste by 2030 and a reduction in the amount of waste going to landfills must reduced to the 25 % of the current level.

Since 2012, the amount of municipal waste collected in the Kosice district has been steadily increasing (Table 4.21). In 2019, the figure reached 272 thousand tonnes, equivalent to about 340 kg per capita. The rate of separately collected waste has also increased steeply between 2012 and 2019. While in 2012, the amount of waste collected separately was only 8% of municipal waste, in 2019 it was 25%. The proportion of hazardous waste collected increased from 583 tonnes in 2012 to 1339 tonnes in 2019.

	2012	2013	2014	2015	2016	2017	2018	2019
Total municipal waste (tonnes)	214.141	216.320	219.898	234.406	227.199	255.824	263.211	272.051
Separately collected waste (tonnes)	18.709	15.637	16.992	17.039	48.250	64.169	75.460	69.114
Separately collected hazardous waste (tonnes)	583	553	444	542	541	641	960	1.339

Figure 4.21.: Amount of municipal, separately collected and hazardous waste in the district of Kossice

Source: slovak.statistics.sk

The length of the water supply system in the area is 4,446 km, with more than 400 km extended since 2012 (Table 4.22). The volume of drinking water consumed between 2012 and 2019 is roughly constant, with only a slight decrease in 2019. The length of the wastewater network has increased by almost 400 km since 2012, reaching 1,827 km in 2019. The volume of waste water decreased from 48,174 thousand cubic metres in 2012 to 44,246 cubic metres in 2019. It is encouraging to note that the share of treated waste water has almost reached the total volume. The number of wastewater treatment plants was 96 in 2019, compared to 81 in 2012.

	2012	2013	2014	2015	2016	2017	2018	2019
Length of the water supply system (km)	4.015	4.101	4.165	4.250	4.334	4.357	4.406	4.446
Drinking water consumption (m^3)	36.825	36.220	35.226	34.693	34.104	33.570	34.040	34.181
Length of the wastewater system (km)	1.422	1.488	1.497	1.567	1.679	1.783	1.802	1.827
Volume of waste water (ezer m^3)	48.147	55.383	50.595	45.654	51.959	50.571	46.430	44.246
Volume of treated waste water (thousand m^3)	46.225	53.492	49.509	44.248	51.454	50.090	45.784	43.493
Number of wastewater treatment plants (pc)	81	86	84	87	92	93	95	96

Table 4.22.: Data on the water supply system in the district of Košice*Source: slovak.statistics.sk*

4.1.4. Ukraine, Transcarpathian (Закарпатська область)

Socio-economic characteristics

Transcarpathia (Ukrainian: Закарпатська область, Hungarian: Kárpátontúli oblast) is located in the south-western part of Ukraine, covering 12,752 km2, 2.1% of Ukraine's total area. its seat is Uzhhorod (Figure 16). The population of the region as of 1 January 2020 was 1,256,802, which is 3% of the total population of Ukraine. The urban population of the region is 465,904, the rural population 787,887 persons. 48% of the resident population is male (601,520), 52% female (649,438). 68.1 % of the population is aged between 15 and 65, the same as the national average, while the proportion of the population under 15 is 19.8 %, 3.5 % higher than the national average. The population in both Transcarpathia and the county capital Uzhhorod has stagnated between 2017 and 2019 (Table 4.23).

Figure 4.16: Situation of the Transcarpathia in Ukraine

year	population (persons)	
	Transcarpathia	Ungvár (uzhhorod)
2017	1 258 777	114 007
2018	1 258 155	113 996
2019	1 256 802	114 897

Table 4.23.: Changes in the population of Transcarpathia and the county seat of Uzhhorod between 2017-2019

Source: ДЕРЖАВНА СЛУЖБА СТАТИСТИКИ УКРАЇНИ ЧИСЕЛЬНІСТЬ НАЯВНОГО НАСЕЛЕННЯ УКРАЇНИ на 1 січня 2019 року.

The age distribution of the population in Transcarpathia is more favourable than observed in the other administrative units of the basin, based on regional statistical data. The available data set on the longer-term age composition, unlike in other areas, records the number of people in the age group 0-15 years (Figure 4.24). Only for the year 2018 do we have the number of people in the age group 0-14 years, which accounted for 19.8% of the total population. The proportion of the total population in the age group 0-15 years was 23% in 2002, while in 2017 it had decreased to 21%. Despite the 2% decrease, it is clear that the age composition here is the most favourable compared to the other administrative units in the catchment area. The same can be said for the age group over 60. The proportion of this group was 16% in 2002, rising to 17% in 2017, so there has been no significant increase. It should be stressed, however, that Carpathia has the lowest life expectancy at birth of the four regions concerned. The proportion of people in the age group 0-14 years is 17.1% in the district of Košice, 16.8% in Satu Mare County and 15.7% in Szabolcs-Szatmár-Bereg County. The proportion of people aged 60 and over is 20% in the district of Košice, 22.2% in Satu Mare County and 24% in Sabolcs-Szatmár-Bereg County.

	total population	0-15 years		16-59 years		above 60 years old	
2002	1.258.264	289.537	23	770.157	61	194.920	16
2010	1.244.828	249.476	20	797.468	64	195.051	16
2013	1.254.393	254.347	20	794.342	64	202.871	16
2014	1.256.850	257.243	20	792.603	64	204.171	16
2015	1.259.570	260.258	21	788.825	63	207.654	16
2016	1.259.158	262.686	21	788.825	63	209.075	17
2017	1.258.777	264.053	21	780.400	63	211.491	17

Figure 4.24.: Age composition of the population of Transcarpathia
Source: Statistical publication, regions of Ukraine 2017.

The number of hospital beds in Transcarpathia decreased between 2010 and 2016 from 10,047 to 8,669. This means 81 hospital beds per 10,000 inhabitants in 2010, while in 2016 there were only 69 beds per 10,000 inhabitants.

The age composition of the region's population can be considered favourable, with the proportion of the population under 15 years of age 4% higher than the proportion over 60 years of age in 2017. This is certainly an advantage in the context of climate change, as the expected increase in hot days and heatwaves puts residents over 60 at increased risk. People suffering from cardiovascular diseases are the most threatened.

In the last hundred years, the territory of Transcarpathia has been part of five constituent entities. Within the Austro-Hungarian Monarchy, it belonged to the Kingdom of Hungary until 1920, when it was annexed to the then newly formed Czechoslovakia as a result of the Treaty of Trianon. It then became part of the Kingdom of Hungary again from 1938 to 1945, before becoming part of the Ukrainian Republic of the Soviet Union under the Treaty of Paris. After the break-up of the Soviet Union in 1992, it became part of the independent Ukraine.

Generally speaking, the region was always part of the periphery of the state and therefore underdeveloped compared to the rest of the state. The same is true today, due to the distance from the capital Kiev, the main industrial areas, the coast and the geographical situation, as well as the difficulties of transport. The fact that it shares borders with four EU Member States is also a locational asset for the region.

It has a peripheral economic position within Ukraine, despite the fact that between 2000 and 2010 the GDP of the territory increased sevenfold. The GDP value in 2010 exceeded UAH 15299, which is only 1.4% of the total Ukrainian GDP. The GDP per capita is 52% of the total Ukrainian average (Imre 2012).

Thanks to the geological conditions, the area has a wide variety of mineral deposits, but with a few exceptions they are scarce. Noteworthy are the unworkable 5-6 g/tonne gold ore-bearing rock masses in the Berehovo Hills, and the minor occurrences of lead, zinc and copper. In the same area, almost 50 million tonnes of perlite and 4.3 million tonnes of kaolin are currently being mined. Near Velika Bijhany is the only barite deposit in Ukraine, estimated at 5.7 million tonnes, which has been discovered so far (Molnár 2014). For centuries, the rock salt mined in Aknaslatina was considered a mineral treasure, with an estimated 250 million tonnes still being mined today. Extraction is currently suspended (Molnár 2014). In terms of energy carriers, the reserves are much more modest, with about 39 million tonnes of lignite and 3 md m3 of natural gas. Riverbeds are mined for river sand and gravel, which are important for the construction industry, and mountains for volcanic rocks of varying composition. In 2018, industrial production accounted for 1% of total Ukrainian output (Kovály 2018). However, the value produced shows an increasing trend (Figure 4.25). The priority industries in the Transcarpathian region remain: machinery, food, chemicals, light industry, and wood.

year	millian UAH	share of Ukrainian industrial production (%)
2010	7.079,1	0,7
2012	9.956,8	0,7
2013	10.035,9	0,7
2014	11.153,3	0,8
2015	13.872,5	0,8
2016	18.471,9	0,9

Figure 4.25: The value and share of industrial production in Transcarpathia in total Ukrainian industrial production *Source: http://www.ukrstat.gov.ua/*

The amount of total capital invested in the region has been steadily increasing since 2000, doubling between 2010 and 2016 (Figure 4.43).

year	2010	2011	2012	2013	2014	2015	2016
Capital investment (UAH million)	2205	3052	2736	2646	2639	3778	4663

Figure 4.26: The amount of capital invested in Transcarpathia between 2010 and 2016
Source: http://www.ukrstat.gov.ua/

Agriculture

In Transcarpathia, due to the natural geography characteristics, significant agricultural activity can be expected only in the flat countryside, which can be considered as a continuation of the Hungarian Great Plain. The main sources of income in the mountainous areas of the volcanic belt bordering the Great Plain, which is interspersed with river valleys, and in the Maramures Hills are mainly grazing livestock and forestry. Of the total area, 36,8 % (451 000 ha) is under agricultural cultivation, while 56,8 % is forested. Of the total agricultural land, 200.2 thousand ha are arable.

Agriculture accounts for 15% of the gross domestic product of Transcarpathia. In the lowland areas, the most typical activities are grain production, potato production, fruit and vegetable production, grape growing, fodder production, dairy cattle breeding and pig breeding. In the foothills and mountain areas, potato growing, beef and dairy cattle farming and sheep farming are practised, because of the unfavourable conditions for crop production.

Until the year 2000, 8,600 hectares of irrigated arable land were registered. By 2018, the proportion of irrigated land had fallen to 900 hectares. The reason for this significant decline can be found in the deterioration of water and other engineering facilities. Recently, however, an increasing number of agricultural enterprises have been using drip irrigation technology, which is very efficient in terms of water use. In the region, the former high water table areas, now drained, provide the highest yields. They account for 30 % of the total arable land. It accounts for 73 % of the region's grain production and 70 % of its vegetable production. Only a small part of the water supply for agricultural land comes from watercourses, mainly groundwater. The geological nature of groundwater makes it extremely vulnerable and requires special protection. *(ПРО СТАН НАВКОЛИШНЬОГО ПРИРОДНОГО СЕРЕДОВИЩА ЗАКАРПАТСЬКОЇ ОБЛАСТІ 2018)*.

In the lowland parts of the area, groundwater resources significantly exceed the extraction rate. In the mountainous areas, especially in areas of impermeable fluvial rocks, groundwater resources, including drinking water, are insignificant. In the municipalities in the higher altitude areas, water shortages are expected due to the more extreme rainfall and the decreasing rainfall in the summer season.

The state of nature conservation, main environmental problems

The Carpathian Biosphere Reserve, the most important nature reserve in Transcarpathia. It was established in 1968 by merging the then protected areas on an area of 12,600 ha. In 1997 and 2010, additional areas were added, and in 2019, the reserve now covers 58,035.8 hectares, making it the largest protected area in Ukraine. It has been part of the UNESCO International Network of Biosphere Reserves since 1992. One of its most spectacular areas is the 257 ha Daffodil Valley. In addition, there are three national parks covering a total area of 87,964.3 ha, two regional landscape parks and a botanical garden covering 87 ha. There are also several lower-level protected areas and natural values to be found here.

The main natural value and economic strength of Transcarpathia lies in its forests. In 2018, they covered an area of 541714 hectares. In this respect, it is comparable only with Slovakia, where this indicator is slightly above 40 percent.

The land cover of Transcarpathia is very diverse. Its mountainous areas are generally characterised by mixed brown-podzolic soils. In the volcanic mountain areas, erubase soils are typical. In the plains, brown forest soils are widespread, with saline-podzolic soils. In the alluvial parts, young cast soils and meadow soils are found.   The foothills are characterised by brown podzolic forest soils, while in the upland areas, podzolic forest soils and montane grassland soils predominate.

Transcarpathian forests differ in the composition of tree species, depending on their vertical distribution. In the lowland areas, the forest-steppe zone is more widespread. Only 15 % of the lowland areas are covered by forests. Alder and birch, as well as oak and hornbeam, are found in lowland forests. The higher foothill areas and the mountains of the volcanic crown are mostly covered with oak and beech. Beech predominates at altitudes between 700 and 800 m, with oak and oak-mixed beech forests below. Above this, at altitudes of 1000-1200 m, spruce mixes with beech, while in the higher regions the mixed forests give way to coniferous forests. Above 1500-1600 metres, subalpine and alpine meadows are found.

Environmental impacts of mining, natural hazards

One of the most dangerous and spectacular examples of the harmful consequences of anthropogenic impacts is the problem of salt karsts in the salt mine area of Aknaszlatina (Солотвино) in the district of Técsiai. The main centre of the technogenic-geological phenomenon are the mine shafts No 8 and No 9.

The salt mining industry in Aknaszlatina (Солотвино [Szolotvino]), which dates back several centuries, was already significant in volume during the Austro-Hungarian Empire. Nine extraction areas were established in the area around the municipality, of which only two, No 8 and No 9, have been in operation in recent years, as the other seven extraction areas had to be abandoned due to water ingress and mine collapses. Due to the salt excavated and the poor technical condition of the groundwater drainage systems, which have been neglected, large salt karsts have formed with the surface being depleted (Figure 4.17). The last two mines still in operation were flooded in 2006, flooding the shafts, and production was finally suspended in 2007. In October 2011, the volume of cave-ins was 2.6 million m^3 , in October 2014 it was 5.2 million m^3 and 5.4 million m^3 in 2016. In 2018 another 1313,000 m^3 collapsed. According to the January 2019 measurements, the total volume of the collapses was 5.455 million m^3 (PRO СТАН НАВКОЛИШноГО ПРИРОДНОГО СЕРЕДОVICHSCHA ЗАКАРПАТСЬКОЇ ОБЛАСТІ 2018).

The growth of collapsed and subsided areas directly threatens many industrial and public buildings.

Several buildings have already been demolished due to cracks caused by ground movements. A particular problem is that salt-laden groundwater can enter the Tisza through various ditches and canals, but for the time being it does not pose a threat to wildlife as concentrations remain within limits.

Figure 4.17: Anthropogenic salt karsts formed by salt mining and subsequent water intrusion
Source: https://ua-reporter.com/

In 2013, a decision was taken at government level on the closure, remediation and ecological rehabilitation of the Aknaslatina salt mine.

In 2019, five active landslides were recorded in the territory of Transcarpathia, covering a total area of 0.01625 km2. Thus, as of 1 January 2019, a total of 3286 landslides were recorded in the region, covering a total area of 385.21 km2, of which only five were partially or fully activated in 2019. No activation of lateral erosion of watercourses, karst and mudflows was observed in 2018, i.e. their number and parameters remained unchanged compared to 2017. Of the karst funnels directly connected to groundwater bodies, 24 were described, with a total area of 0.224 km2. 518 watercourse sections were affected by alluvial erosion, with a total length of 159.69 km. A total of 270 municipalities are exposed to direct flood risk, covering a total area of 1803 km2. More than 900 dwellings have become endangered and a further 1750 dwellings are at risk of destruction due to flooding.

Water usage and utilities

During the period 2000-2018, water abstraction and water use decreased significantly. Total water abstraction in 2018 was 47.20 million m^3, 59.2% of the 79.67 million m3 in 2000. Water abstraction has been steadily increasing since the minimum in 2014 (38.24 million m3). Waste water generated was 36.5 million m3 , 1.16% more than in 2017. Water used for domestic and drinking needs decreased by 58.4% between 2000 and 2013 (from 33.38 million m^3 to 13.88 million m3), but consumption remained practically stable between 2013 and 2018. Agricultural water abstraction has fallen by 96.83% since 2000, from 20.66 million m^3 to 0.65 million m^3, due to a large reduction in irrigated arable land. Industrial water use, on the other hand, is increasing. From 5.46 million m^3 in 2000 to 8.33 million m^3. On 31 December 2018, 32.2% of the region's population had access to piped water. For Uzhhorod and Mukachevo, this rate was 98.4% and 86.4% respectively. Excluding urban municipalities, 14.5% of the rural population have access to piped water. The municipalities without piped water supply obtain drinking water from groundwater wells, the quality of which does not always meet sanitary standards. In total, there are 85 major centralised waterworks and 4971 smaller facilities serving local needs. 24.7% of the total piped system does not meet sanitary standards for one reason or another, 15.2% due to the lack of sanitary protection zones, 1.9% due to the lack of the necessary technical facilities, or 7.6% due to the lack of adequate disinfection equipment. There were no infectious diseases in the region in the 5 years prior to 2018 for this reason. *(ПРО СТАН НАВКОЛИШНЬОГО ПРИРОДНОГО СЕРЕДОВИЩА ЗАКАРПАТСЬКОЇ ОБЛАСТІ 2018)*.

Due to the poor technical condition of water pipes, the rate of transport losses is increasing. In 2000 it was 7.834 million m^3, in 2018 it was 9.38 million m^3. The alarmingly high rate of water losses reaches 20% of the annual water consumption. The highest water loss rates are observed in the water supply systems of Mukachevo, Berehove and Oleh.

In 2018, the amount of wastewater discharged into surface water bodies decreased. 4.236 million m^3 of insufficiently treated or untreated wastewater was discharged into receiving waters in 2017, compared to only 3.567 million m^3 in 2018, a decrease of 16% *(ПРО СТАН НАВКОЛИШНЬОГО ПРИРОДНОГО СЕРЕДОВИЩА ЗАКАРПАТСЬКОЇ ОБЛАСТІ 2018).*

93% of existing wastewater treatment plants need reconstruction or significant capacity expansion as well as the introduction of new wastewater treatment technologies is required.

A comparison of some of the utility data for the administrative units in the catchment area reveals the spatial disparities (Table 4.27). The amount of waste collected per inhabitant is lowest in Transcarpathia and highest in the Kosice district. One of the two main reasons for the disparity is the inefficiency of waste collection in the territory of Carpathians and the lack of collection in some areas, while the other is the development and income situation in the Kosice district, which results in efficient collection and also high consumption. Similar differences in the amount of drinking water used are observed between regions. The highest volume per inhabitant (43 m3) is in the district of Košice, while the lowest is in Transcarpathia. The low value in Transcarpathia can be explained by the significant lack of drinking water networks in rural areas.

Administrative unit	Amount of waste collected in 2018 kg/person	Drinking water in 2018 m3/person
Transcarpathia	148	11
Maramures and Satu Mare county	170	31
Kosice region	329	43
Szabolcs-Szatmár-Bereg county	239	37

Figure 4.27: Some of the utility data for the river basin districts in 2018

Source: own editing based on statistical data

Waste management

In Transcarpathia, centralised collection of solid waste is carried out in 413 municipalities, which is 67.8% of the total (609) municipalities in the region. 29 specialised enterprises (the largest are LLC ABE in Uzhhorod, LLC ABE in Mykolaiv, LLC AVE in Mukachevo and JLC Bereg-Vertical) carry out centralised collection and disposal of solid waste. In addition, 14 centralised solid waste landfills operate on a voluntary basis.

According to data from the Department of Statistics of the Transcarpathian Region, in 2018 a total of 186.3 thousand tonnes of waste was generated in the region. Most of the total waste generated in 2018 was household waste, accounting for 82.6% (154.0 thousand tonnes). In 2017, the amount was only 145.4 thousand tons. Wood waste accounted for 15.4 thousand tonnes, making up 8.3% of the total, an increase of 2,600 tonnes compared to 2017. Glass waste accounted for 9,700 tonnes in 2018 (5.2%). Paper and cardboard waste accounted for

2,700 tonnes (1.45%). Plastic waste is 1,000 tonnes (0.54%), with an increase of 200 tonnes compared to 2017. Textile waste- 0.8 thousand tonnes, that is 0.43% of the total, just one tenth of the 2017 figure. Four Ukrainian-Hungarian companies collect and also export solid waste from a total of 197 municipalities. 25 companies manage municipal waste collection and transport from 216 municipalities in Transcarpathia. 40 companies specialise in the collection of hazardous waste (e.g. mercury waste, ferrous and non-ferrous metal waste, lead-acid batteries, plastic waste, polyethylene, slag, paper waste). According to the data provided by the companies involved in waste management, 409 tonnes of polyethylene waste, 3,160 tonnes of paper waste, 668 tonnes of slag, 681 tonnes of metal waste, 52 tonnes of used tyres, 2 tonnes of lead-acid batteries and 10,981 fluorescent tubes were collected in 2018. Most of the waste collected is sent to specialised processing companies outside the region.

There are two hazardous waste management and disposal companies in the region that are licensed by the Ukrainian Ministry of Environment (PRO STAN NAVKOLISHNOGO PRINCIPAL WASTE MANAGEMENT PLANT ZAKARPATSKY OBJIADOVYSTI 2018).

At the meeting of the Council of Ministers of Ukraine on 8 September 2016, the "Interactive Landfill Map" action plan was developed. It aims to introduce modern technologies in the field of waste management in the Transcarpathian region between 2016 and 2020.

Separate collection of solid waste (glass, plastic and paper waste) was introduced in 117 municipalities, for which 972 containers were placed. In the Raho district 271 containers were installed, while in the Huszti district 150 containers were installed. The collection of PET and glass bottles was carried out in the district of Nagyberezna with 122 pieces, in the district of Nagyszőlősz 18 pieces, in the district of Volotie with 178 pieces, in the district of Uzhhorod with 4 pieces, in the district of Perechynia with 11 pieces, in Uzhhorod with 96 pieces, in Chapor with 25 pieces, 77 containers were placed in Mukachevo, and 12 in Hust (PRO STAN NAVKOLISHNogo PRIVODINSKogo SEREDOVICHA ZAKARPATSKOY OBLASTI 2018).

A plant for sorting and mechanical processing of solid waste with a capacity of 20-30 thousand tonnes/year is under construction in the village of Makkosyanski (Yanovoshi) in

Berehove district, which will allow processing 100% of all solid waste generated in the region. Currently, a sorting line and transformer substation have been completed.
In order to ensure the implementation of the EOTS project, TISA prepared and submitted a joint application with a Hungarian partner under the European Neighbourhood Instrument's cross-border cooperation programme "Hungary-Slovakia-Romania-Ukraine 2014-2020". The construction of a waste treatment complex is planned in 2019 in the settlement of Pistryalovo, Mukachevo district.

The waste treatment plant will have the capacity to sort waste, dispose of organic waste and incinerate it to produce green electricity. The thermal energy generated would be used to heat the swimming pools, while the inorganic waste would be recycled as a secondary raw material after sorting. Negotiations are currently underway with foreign investors to finance the project.

An important by-product of the wood industry is sawdust, which amounts to about 71,940 m3/year. Briquettes and pellets made from sawdust are used to heat a number of social and municipal institutions. The planned thermal power plant in Raho (Rahiv), heated with wood by-products, will have a planned capacity of 6 MW of electricity and 4 MW of thermal energy.

According to the "Interactive Landfill Map", there are 374 landfills
in the Transcarpathian region, of which 134 are licensed (Table 4.28) and 240 are spontaneous landfills. With the exception of the landfills in Uzhhorod, Mukachevo and Nagyborzsova Боржава (Borzsava / Borzhava) in the Berehove district, most of the landfills have reached 75-85% of their reception capacity.

Name of administrative unit	number of landfills (pieces)	area of landfills (ha)
Districts	132	129,46
Cities with county status (Munkachevo, Uzhhorod)	2	21
Total:	134	150,5

Table 4.28: Data on legal landfills in Transcarpathia
Source: ПРО СТАН НАВКОЛИШНЬОГО ПРИРОДНОГО СЕРЕДОВИЩА ЗАКАРПАТСЬКОЇ ОБЛАСТІ 2018.

In some parts of the river basin, inadequate waste management, or a complete lack of it, is a major environmental problem. The most striking form of pollution is the mass of PET bottles and other plastics entering watercourses at a density lower than water.

This situation is due to the lack of organised, centralised collection of municipal waste in the higher regions of the catchment. The main obstacle to landfilling in the upper part of the catchment is the topography (narrow, steep valleys and floodplains) and the lack of appropriate legislation. The technical specifications require landfills to be located at an appropriate distance from residential areas, forests, roads, railways and nature reserves. In these areas, it is almost impossible to build a modern landfill site without complying with the regulations, and it is only possible with very expensive technologies. In addition to the legal difficulties in setting up landfills, there is the problem of inadequate road networks linking the centres with smaller settlements. A further constraint is the low population density in large areas, which generates high unit costs for waste transport, and therefore no incentives for the companies concerned to expand their services in these areas.

Due to the lack of waste collection and disposal, some of the waste is burned or buried, while others are dumped in the immediate floodplains of streams and rivers. Watercourses carry away the easily mobilised, mostly plastic (PET bottles) components as they leave their beds. The watercourses can deposit the plastic further away from the riverbed during their long journey during repeated flooding, thus polluting areas where there are no settlements nearby.

The first landfill site is located along the Upper Tisza in Raho. According to local, unconfirmed sources, part of the contents of the landfill, located on the floodplain of the Tisza, were washed away by the river as it left its bed (Figure 4.18). A further problem is that the landfill is not compacted and there is no impermeable layer at the bottom to prevent leachate from leaching into the soil. The landfill, which is protected by a barrier from the Tisza, can, according to its current parameters, receive waste for another 3-4 years.

Figure 4.18. The Raho municipal landfill on the Tisza floodplain (2021)
Source: KH/zak-kor.net

In Körösmező (Jaszinya), a waste sorting plant is operating as part of an entrepreneurial initiative, and due to the lack of municipal waste collection, PET bottle bins have been placed in public areas. According to local online surveys, waste is the main problem for the population of the area, along with the lack of schools, kindergartens and roads.

Pollution in Ukraine affects both Romanian and Hungarian areas, but due to the hydro-geographical situation, most of the problem is felt in Hungary.

In addition to local initiatives to organise waste collection, several projects to clean up rivers have been implemented or started in recent years. One of these is the Waste-free Tisza project, which has been a civil initiative since 2013, the PET Cup started in close cooperation with the relevant water management authorities. At first the Upper Tisza-Vidék Water Management Directorate helped the volunteers, and then this was supplemented by experts from the Central Tisza-Vidék Water Management Directorate and the North Hungarian Water Management Directorate.

Thanks in part to the efforts of the NGOs, the Hungarian state has also become involved in the problem. The HUF 1.3 billion Upper Tisza Waste Removal Project, funded by the Hungarian budget, completed by September 2019 a waste removal machine chain installed on barges at Vásárosnamény, which can remove at least 80% of the waste arriving on the Tisza (Figure 4.19). The efficiency of the technology could be further improved with operational experience. The project has developed four so-called 'water-damage' removal sites on the Tisza and the Szamos (Someș) to remove waste, refurbished several floating structures, two barges and a tugboat, and purchased a new waste collection vessel.

Figure 4.19. Chain of machines involved in the Upper Tisza waste clean-up project on the Vásárosnamény section of the Tisza *Source: origo.hu, MTI/Czeglédi Zsolt*

Coca-Cola Hungary, the Hungarian subsidiary of The Coca-Cola Foundation, a large user of PET bottles, has decided to support the efforts to clean up the Tisza River in 2019. In the competition organised by the company's foundation, the Board of Trustees considered the project of the Naturfilm.hu Association, a non-profit social organisation that runs the Tisza PET Cup, worthy of support. Thus, Coca-Cola Hungary will implement its two-year programme with them until the summer of 2021 with a total of USD 250,000 (HUF 73 million) in funding from the foundation. As part of the project, at least 80 tonnes of plastic will be removed from the Tisza (petkupa.hu).

4.2. Climate-related presentation of natural hazards throughout the Upper Tisza river basin

4.2.1 Presentation of and responses to flood and inland water hazards

Of all the natural disasters that have affected the Upper Tisza region over the centuries, floods have clearly had the greatest impact. Local efforts to prevent this had already been made in the early modern period, but concrete interventions had to wait until the end of the 18th century. Comprehensive water regulation and flood relief interventions, under national or county control, covering the entire water system, had to wait until the mid-19th century.

The aim of river regulation was to shorten the course of the mid-water courses of the lowland stretches, as the rivers entering the lowlands had a very high flow gradient due to their meandering nature. The total length of the river, which was overdeveloped and mature, often with river intermittent meanders, reached 1 419 km, whereas today, as a result of regulation, it is only 962 km long. The regulation has involved cutting through the overdeveloped meanders in the hope of speeding up the drainage of floods, which sometimes last several months and endanger production and human health. Cutting gullies to speed up flood drainage was only a partial solution to the problems. It was also necessary to build a system of embankments to protect the river banks. The state was responsible for the regulation of the entire river section, which required a coordinated, systemic approach, while the flood-relief work was carried out by the provincial authorities, which set up flood-relief associations to organise and carry out the work.

The regulation work started from the Tiszabecs section of the Upper Tisza, because the river had sufficient fall above this section due to its mountainous nature, so the floodwaters quickly left this section and the floods did not accumulate. Work started in 1853 on the section between Tiszabecs and Tokaj, and a total of 67 culverts were built, many of which became the mother river. The last such intervention was carried out at Tiszaszalka in 1974 (Vázsonyi 1973, Lászlóffy 1982).

The river, shortened and with increased gradient, was losing its equilibrium and began to develop a new, violent meander, which was stopped by the end of the 19th century when the most critical meander sections were stabilised by paving (Szappanos 1979, Mike 1991).

Flood relief interventions in the mid-1840s were limited to connecting the initial communal dam sections on the right bank of the Borsa and the Tisza. Then, by 1849, embankments were built from Vari to Tarpa, then to Lónya by 1856, and to the Bene (Бене)-Csap (Чоп [Csop]) line by 1876, with a total length of 95 km. From there, they were connected to the Tisza right bank embankment system of the Bodrog Inter-Bodrog Cooperative. Out of the total 95 km of embankments, 8 km were made up by the right bank dam of the Borsa (Vázsonyi 1973). By the 1870s, only the northern half of the floodplain remained open, where an area of about 100 km2 of the Bereg floodplain was threatened by the Latorca floods. In addition, the 'opening' also allowed the waters of the Bereg levees to escape towards Bodrogköz. The entire dam was completed by the mid-1880s, with a 3 m embankment crest over a 25.7 km stretch. Thus, by 1900, with the construction of the Latorca embankment on the left bank, the entire Bereg plain had become a flood-free plain. The section of the flood protection system that is now in Hungary stretches for 63 km between Tarpa and Lónya. Despite the considerable interventions, six of the floods that occurred between 1869 and 2001 resulted in the breach of the levees, with areas of varying extent being submerged (Vázsonyi 1973, Figure 4.29, table).

year of flooding	place of dam breach	area flooded (km^2)
1869	Gulács, Jánd	150
1870	Csap	74
1871	Eszeny	74
1888	ismeretlen	45
1947-48	Tivadar	212
2001	Tarpa	260

Figure 4.29: Floods in the Beregi Plain with levee breaches

The width of the swell varies between 300-2200 m. The current embankment crest level is 1 m above the MWL (maximum water level) measured in 2001. In addition to the raising of the dam, the upstream part of the Boroszló-kert floodplain (707.3 km) on the border of Gulács (Károlyi 1960, Mike 1991), which has an unfavourable alignment from the flood protection point of view, has been moved by about 1 000 m, thus increasing the spillway cross-section from 800 m to 1 800 m. In order to manage the exceptional floods of the last decade and a half, the system of tidal reservoirs along the Tisza was reintroduced and then implemented.

The flood safety of the areas of the Satu Mare Plain between the Tisza and the Szamos (Somes) River was severely compromised by the unregulated watercourse system of the Túr River. This shallow, heavily meandering watercourse, which splits into branches and then rejoins, was not only a source of sometimes considerable quantities of water from its catchment area, but also a drain for the floods of the Tisza and Szamos (Somes) (Ihrig 1973). Due to the low rainfall and the high water flows, the floods were extremely slow to recede. One branch of the river, which split into two main branches, flowed into the Tisza at the village of Nagyar, while the other was lost in the marshland between the mouths of the Tisza and the Szamos. The new Túr riverbed from Nagyhodos was "straightened" (Túr channel) by 12 cut-throughs during the regulation and flood relief works of 1927-1930, and runs for 18.2 km. From here, a new channel runs for 11.6 km, branching off from the Old Túr, which bypasses the municipality of Sonkád in a semicircle and flows into the Tisza in the areas of Coroi (Kóród) and Szatmárcseke. At the junction of the new channel, a distributor discharges a maximum of 5 m3/sec into the Old Tur, which feeds the Szatmárcseke Water Mill, a listed heritage site. In addition, today, as the main channel of the Túr River, it drains the inland waters of the region, and is therefore of great importance for the inland water safety of the area. The bottom level of the Túr canal is 290 cm higher than the low water level of the Tisza, so a reinforced concrete structure, known as a bund, had to be built at the mouth to prevent the riverbed from eroding backwards (Figure 4.20). This estuary has since become a popular tourist attraction, which has been severely threatened by low water levels in recent years.

Figure 4.20: Estuary of the Túr channel *Source: szatmartour.hu*

The spacing of the dams surrounding the Túr channel is 100 metres, between which up to 300 m3/s of water is discharged during the highest floods (Ihrig 1973).

The regulation of the Szamos, the most important tributary of the Upper Tisza, was completed in 1890 and a total of 39 culverts were constructed. Of these, 19 were above Satu Mare and 20 between Satu Mare and the estuary. A significant intervention was the relocation of the river's original mouth, opposite the village of Jánd, some 2 km downstream, so that today it flows into the Tisza at the Gergelyiugornya district of Vásárosnamény. As a result of the adjustments, the river's fall has increased significantly in the lowland section to between 20 and 60 cm/km.

A major problem for the Szamos River has been the extent of the inland flooded areas, which began with the large-scale inland flood management works started in 1926. The floodplain is divided into two parts by the Túr River, and a 67 km2 inland water area in the north-east is drained into the Tisza at Tiszakóród by the 22 km long Palád-Csécsei main channel. From a further 43 km2 area, the Öreg-Túr, which serves as the main inland waterway channel, transports inland waters to the Túr canal. The total length of inland water channels in the area is 83 km.

The waters of the larger western inland floodplain are collected and transported to the Tisza by the 64 km long Túr inland water main channel, which runs along the site of the Öreg-Túr riverbed. Its maximum discharge capacity is 37 m3/s. The length of the canals in the western basin is 456 km, giving a specific canal density of 1 km/km2, which is a very high ratio in the Upper Tisza catchment. The construction of the canals has been accompanied by negative deforestation activities. This is reflected in the increase in the share of land under arable and horticultural crops, which are important for supply, from 20 % to 66 %. The length of the canals in the entire Tisza-Szamos basin is 551 km, which certainly increases the inland water security of the area, but flooding from heavy rainfall and flash floods from the catchment can be expected. The high density of watercourses and canals can also have a positive impact on the agricultural sector, provided that they can maintain a constant water level ideal for irrigation (Ihrig 1973).

In addition, the share of existing recreational tourism in the area can be further increased, mainly through water tours. These could also serve as adaptation options to mitigate the adverse effects of heat waves. In addition to heavy rainfall and flooding, periods of drought, which can last for many years, must of course be expected, when water levels in both watercourses and canals can drop significantly, with a consequent significant drop in groundwater levels. A common feature of regulated accelerated flows is that the bed of a river with increased energy is cut deeper, thereby reducing the surrounding groundwater table during low flows.

The regulation of the Crasna River and with the draining of the Ecsedi marsh (Lacus Etsediensis) has been permanently resolved. Attempts to drain the marsh were made in the 18th century, but with little success. The canals built in the 18th and 19th centuries were silted up by the flooding of the Crasna, and the marsh was flooded again and again. The Lápi main canal, built at the turn of the 19th and 20th centuries, led the water to the Dead Somes, from where it was discharged into the Somes at Tunyogmatolcs (Ihrig 1973). In addition, the Crasna was given a completely new bed, passing through the villages of Ágerdőmajor, Nagyecsed, Kocsord, Ópályi, Nagydobos and Olcsva and flowing into the Tisza at Vásárosnamény instead of the Somes.

Rising tides following the regulation of the Tisza

Following river control and flood relief works, which were largely completed by the end of the 19th century, peak flood levels increased rapidly in the second half of the 19th century. Although the rate of increase declined in the 20th century (Szabó et al. 2011), dams had to be continuously raised and reinforced. A logical explanation for the rising flood levels was the damming of rivers, a clear consequence of the narrowed floodplain. The record-breaking flood levels of the 20th century, especially at the end of the 20th century, could no longer be explained by the situation in the floodplain. In any case, the explanation for this phenomenon must take into account that large floods, which occur rhapsodically, can reach peak levels over a long period of time (a century) even if external conditions remain unchanged. But this is not the only issue here. It is not simply the individual peaks that are being exceeded from time to time, but also the frequency and duration of exceedance of the dangerous level (Szabó et al. 2011). Based on studies by Szabó and his colleagues (2011), a 110-year time series analysis of water levels in four Hungarian water gauges of the Tisza (Vásárosnamény, Tokaj, Szolnok, Szeged) and four major tributaries (Szamos at Csenger, Bodrog at Sárospatak, Hernád at Hidasnémet, Maros at Mako) has shown that the increasing trend in the number and duration of floods exceeding the water levels of the flood protection alert level III. clearly indicates that, despite their irregularity, an increasing number of floods are to be expected, which will increasingly challenge the protection system.

The background to the increase in tidal surges is a combination of several unfavourable factors. The 6 record surges in the turn of the 2000s were linked to the exceptional weather of those years. A striking increase in weather extremes - e.g. unusually snowy winters, high intensity rainfall events, which is a concomitant of global climate change. The extent of flooding has increased gradually despite a clearly detectable decrease in annual rainfall. Climate change, as the general background to major floods, is therefore certainly a determining factor in the increase in risk. The development and intensification of extreme flooding is also contributed to by the recent increase in the municipal infrastructure in the Upper Tisza, especially paved surfaces, which clearly increases the volume and speed of run-off. This means that water, which is already collecting faster, reaches its receptor more quickly, which can also lead to the congestion of flows. This phenomenon is likely to become more pronounced in the future, both because the proportion of paved surfaces and built-up areas is likely to increase in the decades ahead and because precipitation intensity is expected to increase in the periods to 2050 and 2100 based on climate models.

Increased runoff from increased deforestation also plays an important role in the increase in flood flows, but recent studies have shown that deforestation as a whole increases the runoff factors and hence the severity and height of the resulting flood flows, but that the retention effect of forests is limited in the case of exceptionally high rainfall events that cause catastrophic increases in water levels (Konecsny 2002). This was particularly true in the case of the Upper Tisza floods of March 2001, when precipitation events of over 100 mm were expected.

Lóki (2004) and his colleagues have carried out detailed studies to investigate the extent of deforestation in the upper part of the Tisza catchment. Comparisons of 1990 and 2000 LANDSAT space images and detailed field monitoring showed that the loss of forest area in the last decade of the 20th century in the two major sub-basins of the upper Tisza in Ukraine (Săcărâmb) and Romania (in the upper part of the Great-Somes in the D foreland of the Radna Hills) was very modest, only around 2% (Table 4.30).

The catchment area of Nagyág				Radnai hills sample area			
Category	**1990 (km²)**	**2000 (km²)**	**area change (%)**	**Category**	**1990 (km²)**	**2000 (km²)**	**area change (%)**
Pine	118,30	96,77	***-18,4***	Pine	34,38	26,55	-22,8
Mixed forest	203,94	215,03	**+5,5**	Mixed forest	146,74	168,73	+14.9
Deciduous forest	306,13	301,34	***-1,4***	Deciduous forest	279,06	239,73	-14,1
Pasture	276,06	431,42	**+56,1**	Pasture	370,31	369,46	-0,01
Plough	193,79	35,36	***-71,7***	Plough	58,49	7,29	-87,5
Constructed / garden	36,63	76,67	**+110,1**	Constructed / garden	36,08	97,70	+170,7
Waters	17,56	6,02	***-65,9***	Waters	26,78	13,53	-49,5
Copse				Copse	36,42	65,35	+79,4
Forest cover (%)	54.53	52.74	***-1.79***	Forest cover (%)	46.56	44.01	**-2,55**

Table 4.30: Changes in farming types in two sample areas of the Upper Tisza catchment (Nagyág, Radnai-havasok) between 1990 and 2000 *Source: Szabó et al. 2011.*

The third reason for the increase in tidal surges is the gradual filling up and silting up of wave fields, which results in a significant reduction in the cross-section of the flow. This phenomenon is not directly related to climate change, although the amount of sediment entering watercourses increases with increasing rainfall intensity.

Further development of the Vásárhely Plan

Within the framework of the New Vásárhely Plan, 6 tidal reservoirs were constructed along the Tisza River and 1 on the Somes-Crasna (Figure 4.21). The 7 tidal reservoirs have been constructed on a total area of 296.5 km2 , with a total storage capacity of 860.5 million m3 of water. In total, the investments contributed to the flood safety of 61 municipalities. Of these, 4 are located in the Upper Tisza catchment area. These are the Szamos-Krasznaközi, Beregi-, Cigánd-Tiszakarád and the Tisza-Túr tidal reservoirs.

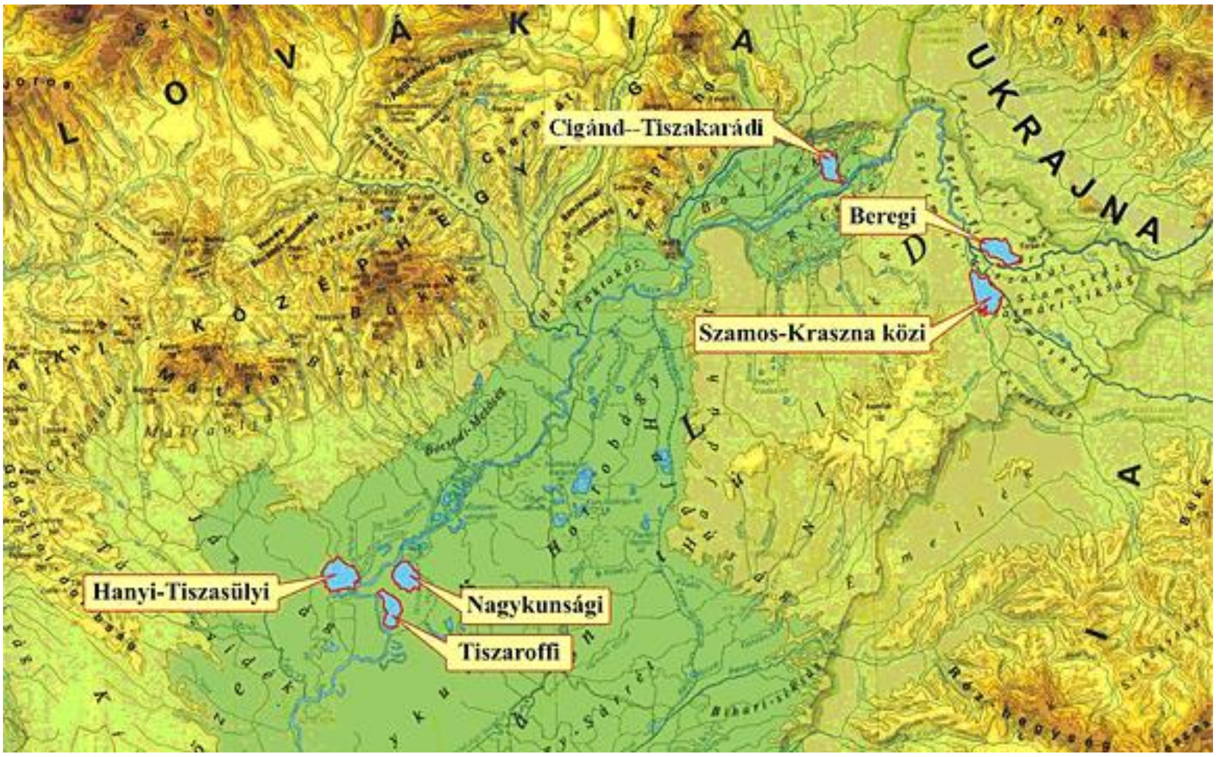

Figure 4.21: Location of the 7 tidal reservoirs *Source:vizugy.hu*

The Cigánd-Tiszakarád tidal reservoir is the first element of the Further Development of the Vásárhely Plan programme. The reservoir is located between four settlements in the Bodrogköz, Cigánd, Nagyrozvágy, Pácin and Ricse. The reservoir has a surface area of about 25 km2, with embankments averaging 4.5 m high, a 5 m wide crest and a total length of 23.8 km. When filled, the reservoir can hold and store nearly 94 million m3 of water. According to technical experts, the average water level at full flooding should not rise above 4 metres, so that in the event of a flood the water level will remain 1 metre below the crest of the dam (https://www.vizugy.hu). Based on modelling calculations, it is estimated that flooding will take place every 30 to 40 years.

It takes 3-10 days to fill the reservoir completely, depending on the situation, and the water is expected to be retained for about a month. The height of the water level in the reservoir can be controlled by means of an inlet and outlet structure. The reservoir's intake structure is a two-storey reinforced concrete structure built alongside the Tisza, with openings at the lower level to allow the water needed for landscape management to be released - this will allow the water needs of landscape management to be met even at lower water levels in the Tisza. Above these are significantly larger sluices for the release of excess flood water, capable of releasing 430 m3 of water per second if necessary (https://www.vizugy.hu). The almost 100 million cubic metres of water that the reservoir will hold will rise by 25 centimetres in the Tisza water level at the inlet section.

With an average water depth of 2.47 m, the Szamos-Kraszna intertidal reservoir has a total reservoir area of 51.1 km2 and is capable of retaining 126 million m3 of water from the exceptional tidal surges on the Samos River (Figure 4.22). The purpose of the reservoir is: to lower the water level of the Szamos in the event of a flood on the Szamos exceeding the MFL (mean flood level), to lower the water level of the Tisza by retaining the Szamos flood wave in the event of a flood exceeding the MFL below the mouth of the Szamos, and to ensure conditions and opportunities for landscape management in the inner area of the reservoir during the non-flood period. The technical handover took place on 07 November 2014.

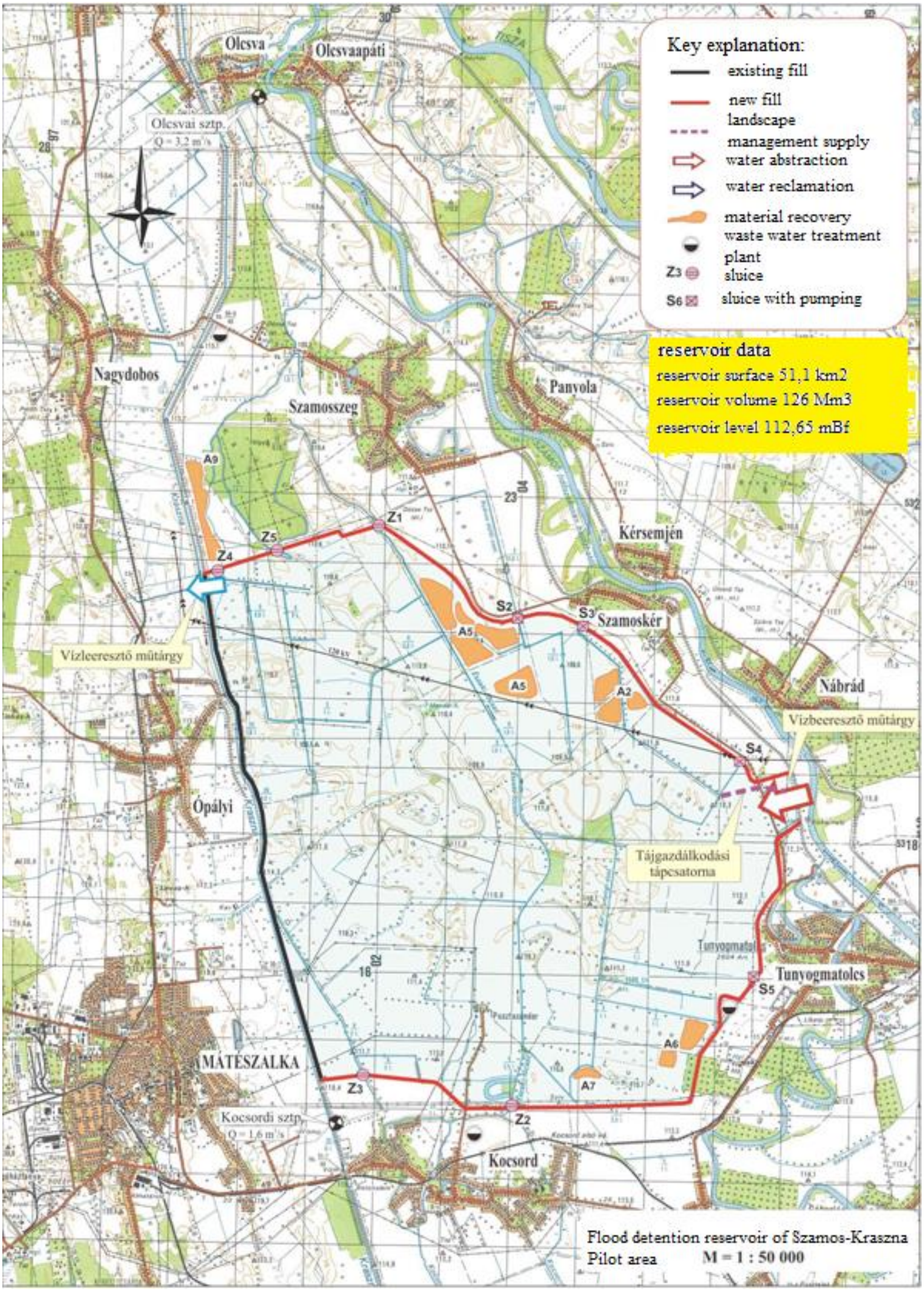

Figure 4.22: Overlook map of the Szamos-Kraszna tidal reservoir *Source: fetivizig.hu*

The construction of the Beregi Tidal Reservoir between the villages of Gergelyiugornya-Tákos-Hetefejércse-Gulács-Jánd, a 60 km2 tidal reservoir with a capacity of 58 million m3, was started in 2012 and handed over in 2015. The reservoir's inlet is located between Tarpa and Tivadar, at the site of the 2001 dam breach (Figure 4.23). With the full filling of the tidal barrier, a water level reduction of up to 100 cm can be achieved on the Tisza. It is of course very important that the reservoir is flooded neither too late nor too early. If a reservoir is filled too early and unnecessarily, it will not be able to absorb the rising water, while if it is kept closed while waiting for the reservoir to reach its maximum level, the dams may burst under the enormous mass of water. The tidal effect of the reservoir will gradually decrease from Tivadar to Záhony (80 cm to 20 cm). The establishment of the complex will also significantly improve the possibility of agricultural and nature conservation water management (in addition to flood protection), renewing the inland water drainage channels and ensuring the possibility of water recharge (fetivizig.hu).

Figure 4.23: The Beregi tidal reservoir's inlet structure, consisting of 6 segmental panels, between Tarpa and Tivadar *Source: MTI/Balázs Attila*

The latest reservoir, Tisza-Túr, which was opened on 26 October 2022, has a reservoir area of 17 km2 and, with an average water depth of 2.60 m, can hold a total of 42 million m3 of water from the exceptional tidal surges on the Tisza River. The design of the reservoir was justified by the fact that the embankments of the Túr River, which was constructed with Tisza regulation, can have a backwater effect that can result in 3-4 m flooding in the settlements of Tiszacsécs, Tiszakóród and Milota in a few hours.

The reservoir could have a dam-overflow effect on one of the most critical sections of the Upper Tisza (the constriction between Tiszabecs and Tiszaújlak). It has a dam-overflow effect of almost 50 cm, which would be the first to be opened in the event of flooding above the flood level.

Construction work, which started in February 2020, has included the resurfacing of nearly 18 kilometres of embankment, upgrading of seven kilometres of embankments on the Túr, construction of three mobile flood protection walls, upgrading of seventeen sluices and culverts, and reconstruction of 47 kilometres of surrounding canals. In addition, five hydrographic stations, a new dam warehouse and a defence depot were built.

A solar-powered electric pumping station at Tiszabecs will allow the Tisza to be fed into the existing inland canal system, providing the area with a permanent water cover; dead pools and material pits connected to the system will allow water to continuously seep into the ground, increasing groundwater levels.

The reservoir, as a complex water management system, will play an important role in reducing flood levels, recharging water and balancing the water balance in the area.

Figure 4.24: The Tisza-Túr reservoir dam at Milota *Source: sokszinuvidek.24.hu*

The further development of the Vásárhely Plan is linked to the implementation of the "Water Supply of Nyirség" concept. The investment is not for flood protection purposes, but it is of high importance for the improvement of the water balance of the Nyírség.By supplying water from the Tisza, a continuous water supply with a capacity of 1.0-3.0 m3/s can be ensured to meet irrigation and other water needs.

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Vulnerability to inland water

In Szabolcs-Szatmár-Bereg County, among the problems related to climate change, vulnerability to inland water is one of the priority problems and the second most important risk factor for the environmental security of the county after flooding.

The diversity of the area in terms of inland water resources is due to the diversity of topography, rainfall, soil conditions and hydro-meteorological characteristics of inland water basins. The Bereg, the Tisza-Szamosköz and the Szamos-Krasznaköz are at high risk of inland flooding, the Upper Szabolcs is at high risk and the Nyírség and the Eastern Nyírség are at moderate risk.

Of the 229 municipalities in the county, 89 are affected by inland water, accounting for almost two thirds of the county's population (373,823 inhabitants) (Figure 4.24).

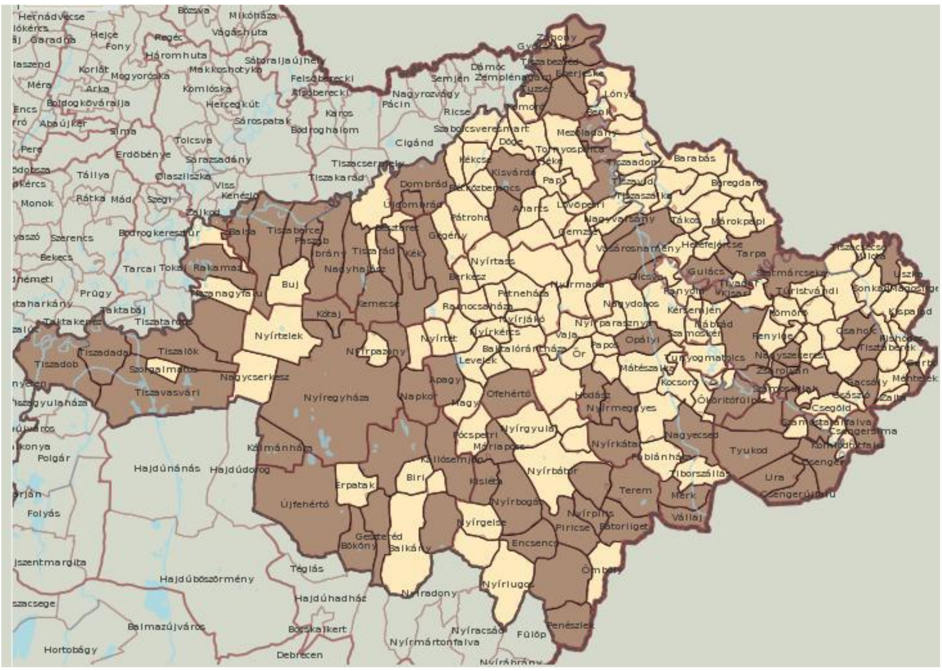


Figure 4.25: Municipalities affected by runoff, 2010 *Source: TeIR, Interactive analyser*

The total area of inland water systems in Szabolcs-Szatmár-Bereg county is 5,759 km2, of which 40% is low floodplain, i.e. formerly flooded area. Of the seven inland water systems, two are individual and five are shared catchments. Inland water drainage is provided by a 7,048 km long network of canals, the majority of which are managed by the Water Management Directorate. The average flooding is 16,200 ha per year, with the average flooding over a longer period of time, in wetter years, being 30-40% of the area of the inland water systems. In order to prevent and reduce the damage caused by inland flooding, various low lying, lowland reservoirs have been constructed in the county to hold inland flood waters. Their task is to prevent flooding caused by inland water, to collect and store rainwater, to reduce agricultural damage caused by drought and to provide extinguishing water where necessary (vizugy.hu). Such a water body is the Rétközi lake (Szabolcsveresmarti reservoir), which has been completely recultivated between 2014 and 2016.

Flood and inland water protection improvements in Ukrainian-Hungarian cooperation

The Joint Hungarian-Ukrainian Telemetry System currently consists of 192 stations, 142 Hungarian and 50 Ukrainian. The joint operation of the system is based on the Operational Rules approved by the Hungarian and Ukrainian Government Authorities for Border Waterways.

The joint system measures water level, water flow, precipitation, air temperature data every 5 minutes, but thanks to improvements the system also includes telemetry data from groundwater and stratified water wells, pumping stations and sluices.

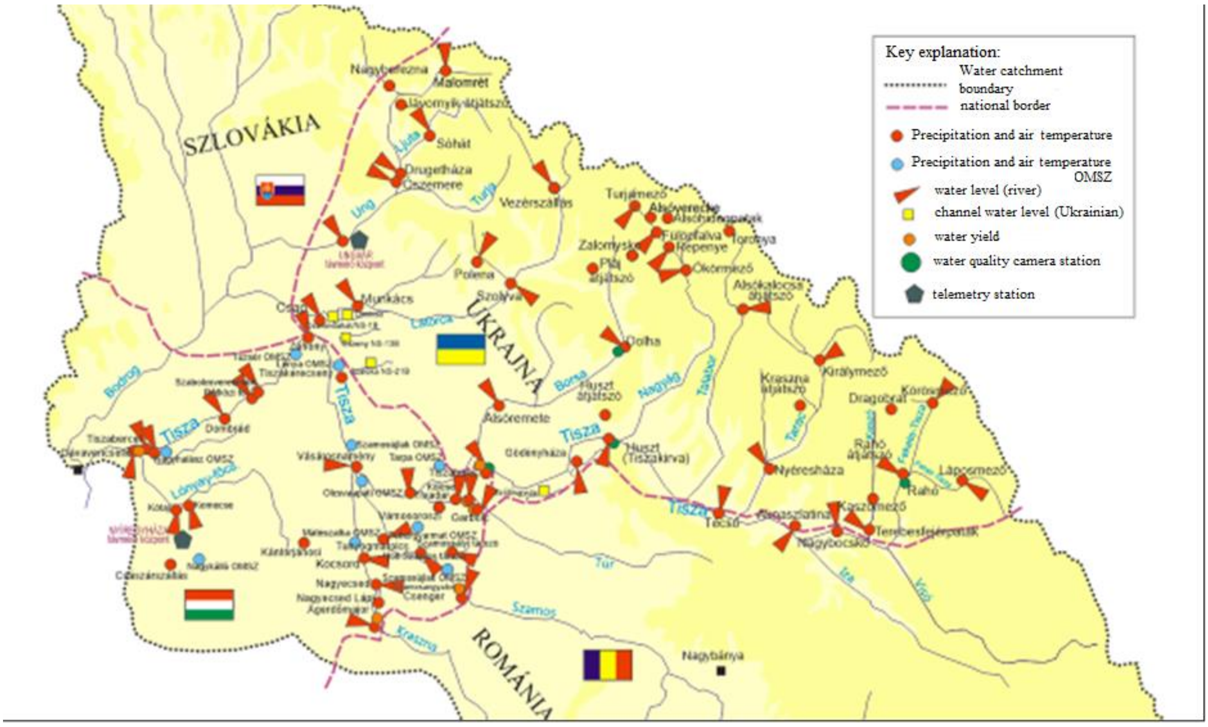
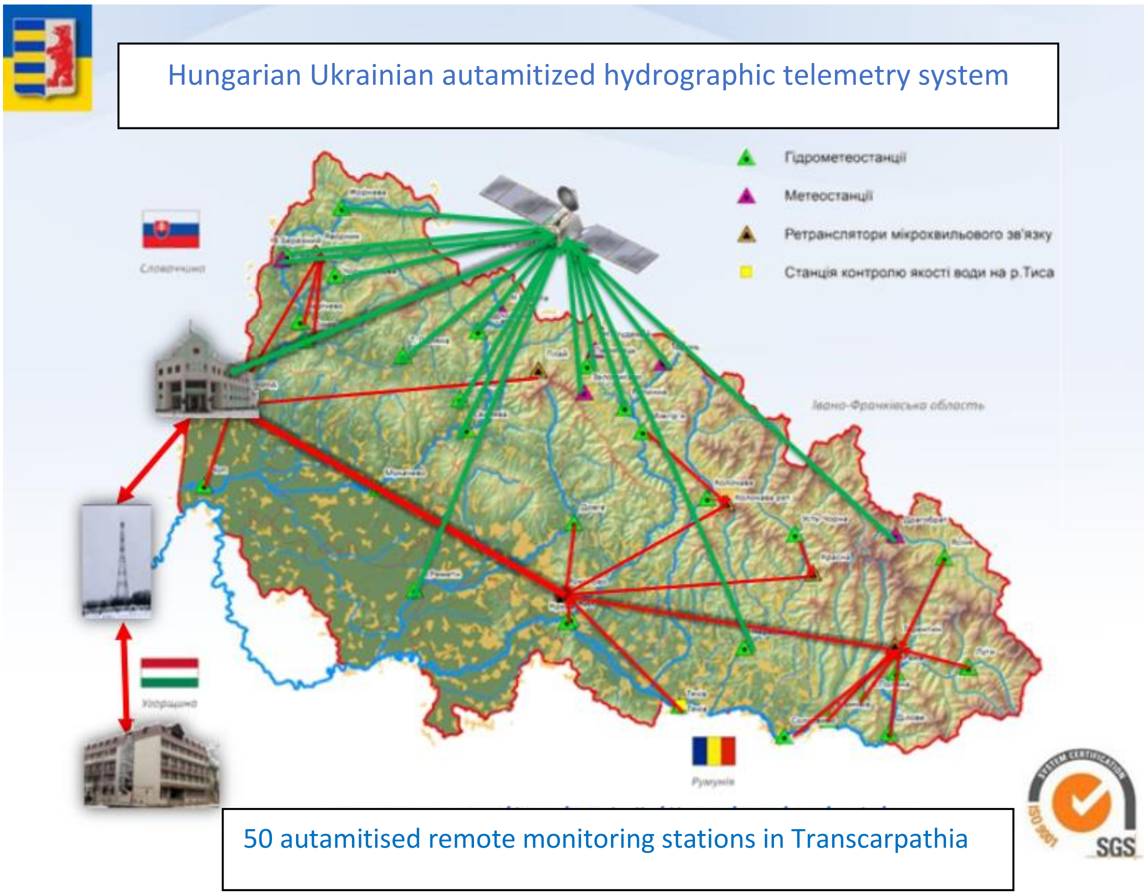


Figure 4.26: Site plan of the joint Hungarian-Ukrainian telemetry system consisting of 192 stations *Source: FETIVIZIG*

A new element is the measurement of the tidal reservoirs' table levels together with the associated water levels, which will help the hydrodynamic models. All in one system, an industrial-strength process control system (ClearScada) provides the complexity to perform almost any task.

The system is also the basis for the Tisza Valley Operations Management System, as a sufficient time advantage for opening tidal reservoirs can only be ensured by knowing the changes in the foreign part of the catchment.



Development of a common landscape and water management concept based on water retention, feasibility study and design of some elements in the Bodrogköz

A joint water management concept has been developed for the Hungarian and Slovakian border area of the Bodrogköz, under the leadership of the water management organisations of Hungary and Slovakia. In addition to surface watercourses and canals, this includes the examination of elements that directly influence water balance: the extent of surface cover, vegetation, and the examination of individual habitats, as well as the relationship between water use and water balance (evizig.hu).

Flood and inland water protection investments in Hungarian-Romanian cooperation

- Within the framework of the ERDF-based Central Europe Transnational Programme "Along the Szamos River on Water and on Two Wheels", a 40 km long embankment pavement was built along the Szamos River between Satu Mare (Romania) and Fehérgyarmat. The project will help both flood protection and tourism.
- Our projects "Development of the flood protection information system in the Upper Tisza river basin" and "Further development of the joint Hungarian-Ukrainian monitoring system for flood prevention at river basin level" have been completed to

upgrade and further develop the Upper Tisza flood warning and alert centre and the Hungarian-Ukrainian joint monitoring system.

- Complex monitoring stations will be set up in the Tiszabecs area on the Tisza and in the Csenger area on the Szamos, in the border sections, to provide a continuous picture of the quantity and important quality parameters of the water flowing into the Tisza and the Szamos. The implementation of the project was coordinated by the National Water Directorate General and was completed last year.
- FLOOD-WISE, "Sustainable flood management strategies in transboundary river basins", an INTERREG IVC project has prepared a flood risk management plan for specific Hungarian and Romanian areas of the Szamos River in cooperation with the Romanian side.
- In order to lay the foundation for further improvements, we submitted a joint tender with the Romanian Party for the "Design and construction of a filling crown pavement on the Túr-Palád-Batár (Братове / Bratove) embankment from Turulung (Túrterebes) to Dumbrava (Magosliget)". The construction works of the 22.6 km long crown lining were completed in 2014 (fetivizig.hu).

In the Upper Tisza river basin, the works carried out so far to increase inland and flood safety at national and cross-border level, the alarm and signalling systems installed and the well-established professional contacts have laid a solid foundation for the creation of a unified river basin management.

4.2.2. Flood risk in the Slovakian territory

In recent years, the Hornád (Hernád) River has been subject to major floods, causing considerable destruction in Slovakian areas (Figure 4.26, Figure 4.27). One of these should be mentioned is the flooding in early June 2010, which broke several previous records. The flooding and inundation affected more than 150 000 ha of arable land, which was 17 % of the total arable land in Slovakia. The damage caused could have reached €90 million. The Hornád (Hernád) river has received more rainfall than previously forecast, causing backwater in the Slovakian section and tributaries. The peak at the Hidasnémeti gauging station occurred at 30-50 cm above the LNV (record high water level).

On 14 October 2020, the 48-hour rainfall maximum of 123.1 mm was reached in the Kosice area, resulting in significant and rapidly rising floods on rivers.

Figure 4.27: The flooding Hernád / Hornád near Košice, June 2010 *Source: SITA.*

The reason for the extreme flooding is clearly explained by the extreme rainfall events of recent decades. A direct consequence of this is that the number of flooding days in the period 1990-2010, the study period, shows an increasing trend (Zelenakova 2011). In eastern

Slovakia, the number of flood days calculated for the whole country shows a complete co-movement (Figure 4.27).

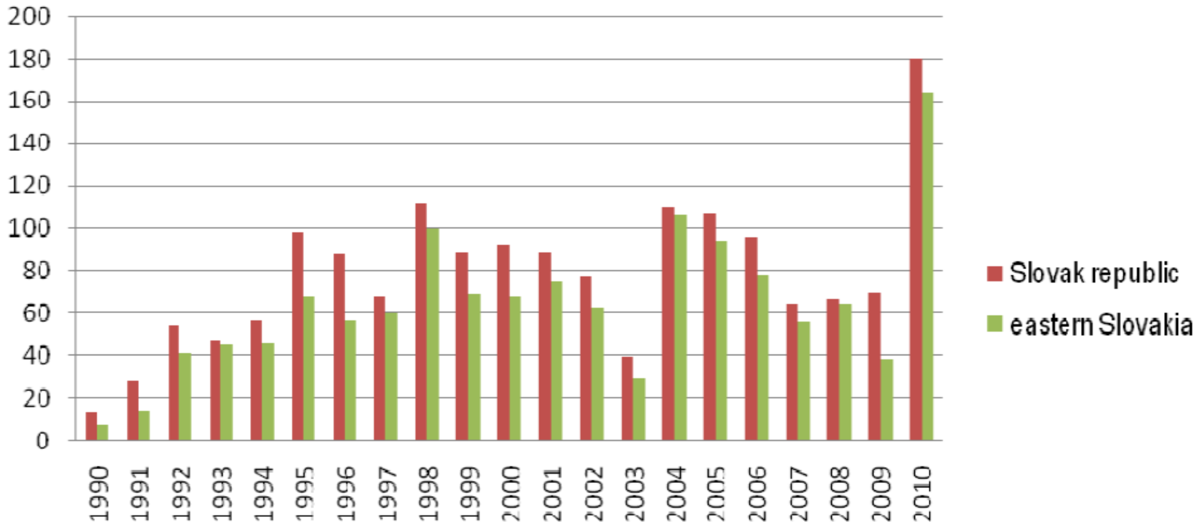


Figure 4.28: Increase in the number of flood days in eastern Slovakia and in the country as a whole in the period 1990-2010. *Source: Zelenakova, M. 2011.*

In contrast, the probability of flooding is higher in the eastern Slovakia region than in the rest of the country (Figure 4.28). Calculated on a five-point scale, the highest probability of flooding (very high) is expected along the Bodrog and its tributaries, especially along the lower reaches of the Ondava, Laborc, Latorca and Ung rivers, where flooding is concentrated due to the reduction in rainfall.

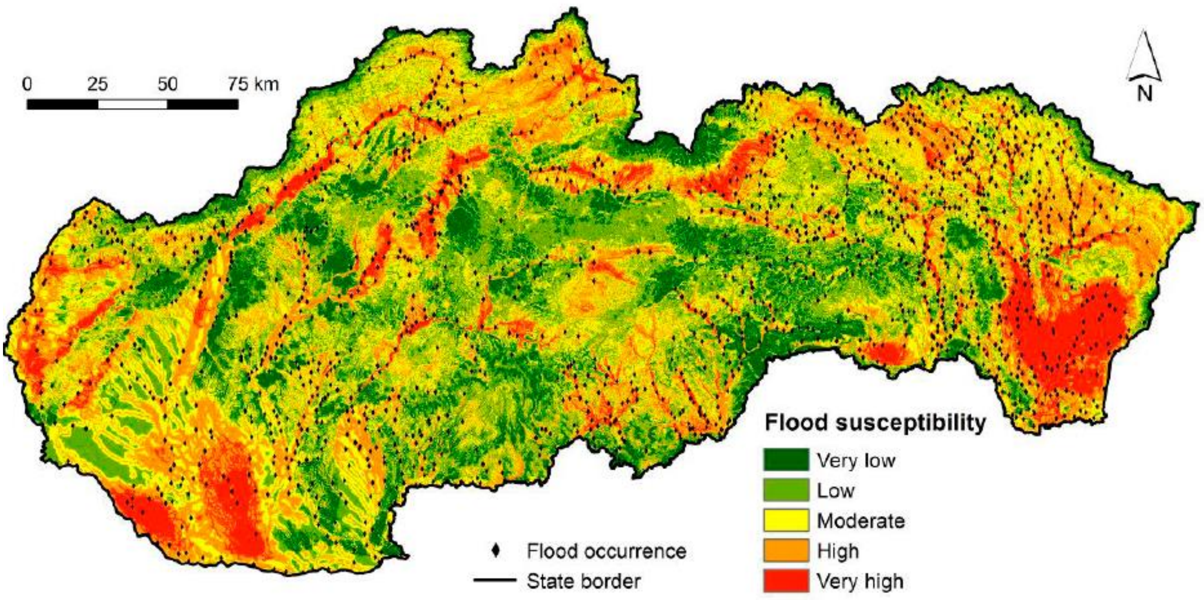


Figure 4.29: Flood probability in Slovakia and situation of flood-prone areas until 2019
Source: Vojtek, M., Vojtekova, J,. 2019.

Year	number of events (pcs)	type of event
2008	3	flood, inland water
2010	10	sludge spill, inland water
2013	9	sludge spill, inland water
2016	5	sludge spill, inland water
2018	17	sludge spill, inland water
2019	18	Floods, inland water, overloading of the sewerage system due to heavy rainfall, sludge spill

Table 4.31: Disaster management related incidents in the district of Kosice
Source: slovak.statistics.sk

Climate change will lead to much more extreme weather elements than ever before. From a flood protection perspective, the most serious problem will be the increasingly extreme distribution of precipitation. A marked decrease in the amount of precipitation in the form of snow is expected. The number of days of winter (daily maximum < 0 ºC) will decrease by 18-20 days compared to the 1960-2010 average. Consequently, the amount of precipitation stored in the form of snow will decrease and the effect of snow cover in delaying run-off will be reduced. This favours the development of flash floods caused by heavy rainfall. With a minimal decrease in precipitation, an increase in autumn and winter precipitation is expected, which will be accompanied by an increase in intensity of precipitation events. This will further increase the risk of floods and flash floods. The increase in runoff size contributes to their occurrence, partly due to the soaking effect of the runoff from the series of high intensity rainfalls. Hydrological research suggests that a rainfall event of at least 100 mm will soak the ground cover and the ground surface to such an extent that it will no longer have any retention effect (Konecsny 2002). The infiltration rate of a sudden heavy rainfall event is much lower than that of a rainfall event of the same magnitude but with a longer duration of rainfall.

Heavy and intermittent rainfall events increase the risk of soil erosion and landslides occurrence. Areas built up from loose sediments with a high relief are particularly affected.

The increase in flood risk threatens not only the built environment, but also transport infrastructure and utilities. Particularly dangerous public health situations can arise if technical installations in the drinking water network or sewage network are flooded.

The water yield data for the Tiszabecs section of the Tisza in the distant future (2071-2100) were modelled using the RCP 4.5 and RCP 8.5 discharge scenarios with data from the reference period 1981-2010 (Didovets et al. 2019). The RCP 4.5 scenario shows a small (4.5%) or large (62%) increase in water yields between 2071-2100. This is clearly due to an increase in precipitation in autumn and winter and rapid snow melt, which greatly reduces the flood safety of the area.

4.2.3. Main hydrogeoraphic trends of climate change in the Upper Tisza catchment

The exact course of climate change is difficult to predict due to the specific climatic conditions in the area, therefore climate models run with different GHG emission scenarios and different social and environmental input conditions produce different results. The model outputs show the change in temperature, precipitation and various climate indices over a past period (e.g. 1961-2010, or 1970-2000) for a more recent period 2021-2050 and a more distant period 2071-2100. The data projected for the period 2071-2100 have a higher uncertainty due to the longer time horizon (Figures 4.29, 4.30).

The results of each climate model point in the same direction on some key scales. All models show a clear increase in mean temperature. Between 2021 and 2050, the summer season is projected to warm by 1.2-2.5°C, but a similar increase is expected for winter. In the most pessimistic RCP8.5 scenario, the mean summer temperature could be as much as 4-4.5°C above the average between 1970 and 2000 (Figure 4.29). The RCP4.5 model, which is more optimistic on carbon dioxide emissions, predicts a warming of only 2-3°C. For winter, similar values of + 2-3°C (RCP4.5) and + 3-5°C (RCP8.5) can be expected.

Precipitation is projected to show a different trend in the summer and winter seasons (Figure 4.30). In the RCP4.5 scenario, a decrease in precipitation of 5-10 mm per month is expected in the summer season, while in the RCP8.5 scenario, an increase of up to 5 mm per month is expected in the lower areas, while the same decrease is expected in the higher parts of the catchment between 2021 and 2050. The total summer rainfall deficit could therefore reach 30 mm. Winter precipitation is also projected to show an upward trend with +10-20 mm per month. By the end of the century, the differences between the two seasons are expected to widen further. In the RCP4.5 scenario, winter precipitation could increase by 10-30 mm per month, which could mean an excess of up to 90 mm for the whole season. In contrast, summer precipitation could be 5 mm less per month (RCP4.5), but in extreme cases (RCP8.5), up to 30 mm less, which would mean a deficit of 90 mm for the whole season.

It is clear from the data that, although the amount of annual precipitation is practically unchanged, a significant part of it is clearly shifted to the winter period. The decrease in precipitation during the period of higher sunshine will clearly lead to an increase in drought periods, and more flooding, including flash flooding, is expected in winter due to increased runoff.

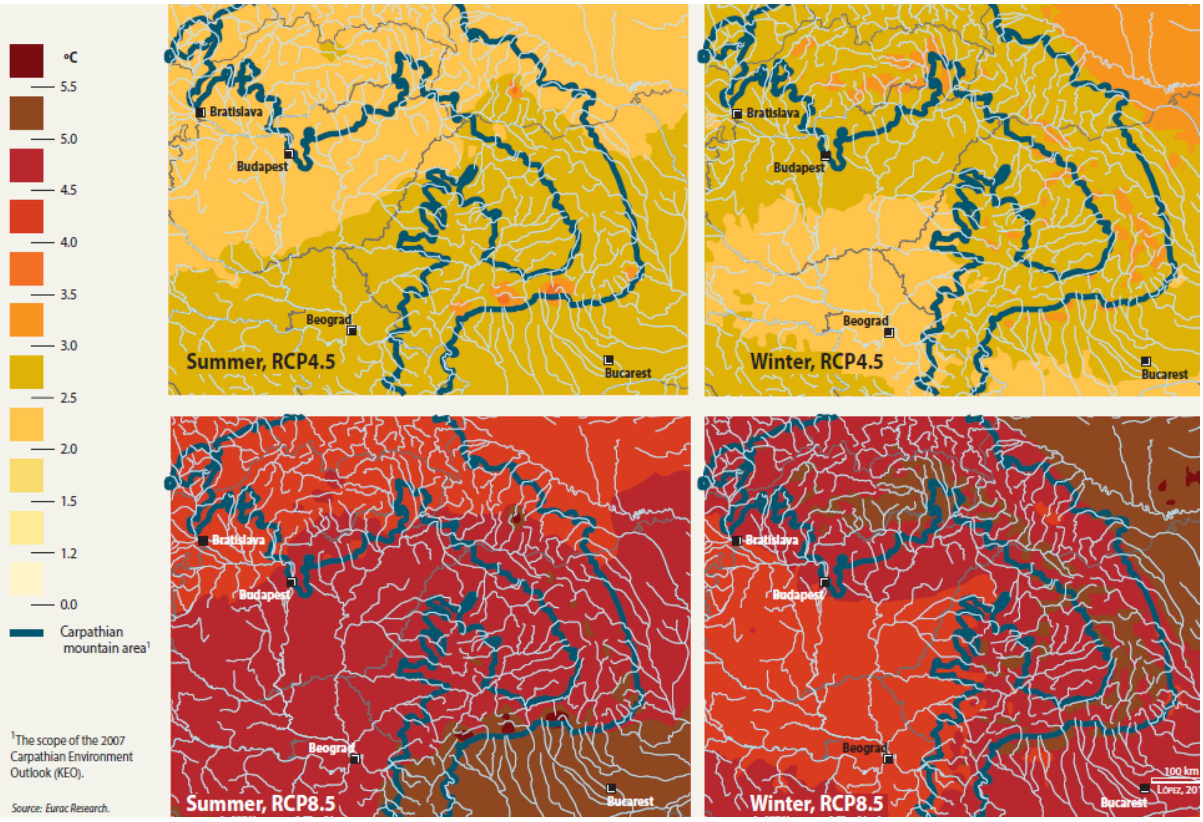


Figure 4.30: Change in average temperatures in summer and winter months under RCP 4.5 and RCP 8.5 scenarios for the period 2071-2100 compared to 1971-2000

Source: Eurac Research

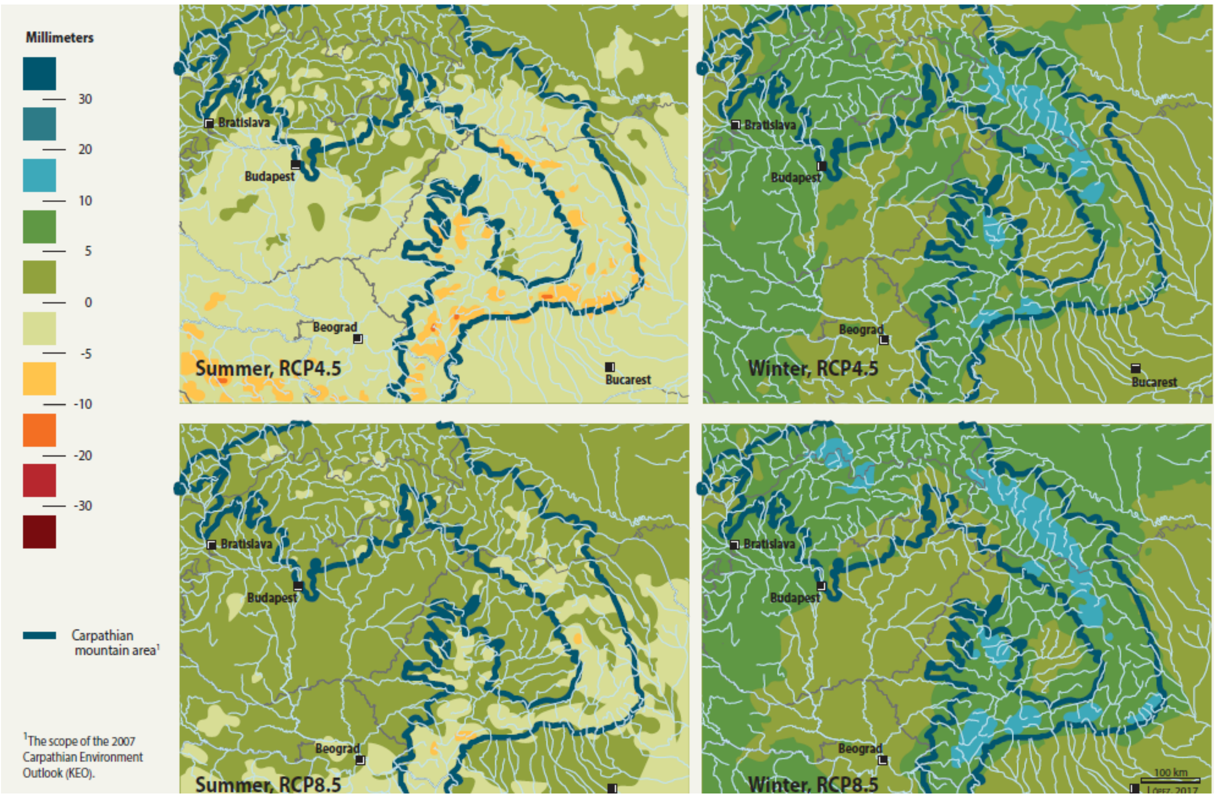


Figure 4.31: Changes in precipitation in summer and winter months under RCP 4.5 and RCP 8.5 scenarios for the period 2021-2050 compared to data from 1971-2000 *Source: Eurac Research*

In addition to the increase in the number of floods, the shift in precipitation to the winter and autumn half-years is directly linked to the drying of the summer half-year, which may show very extreme peaks by the end of the century (Figure 4.31). The water yield of rivers with lower headwaters will be severely reduced, while some rain-fed mountain streams may dry up, causing ecological damage and damaging tourism conditions in the area. The likelihood of drought will increase, which is accompanied by a subsidence of the groundwater table. Both the decline in river levels and the lowering of groundwater levels threaten drinking water sources, both in terms of quantity and quality.

The EU Member States in the Carpathian region have adopted a national target of 20% of their electricity generation to come from hydropower (European Commission 2009). Five hydropower plants are currently operating in the Upper Tisza river basin. Both falling water levels and extreme water flows threaten the safety of hydropower generation.

The greatest threats to natural surface and groundwater bodies are the current inappropriate water management and treatment processes. In addition to waste, water pollution is significant and inadequate water governance is a problem. Excessive fertiliser use leads to nitrate and nitrite leaching into surface and groundwater, upsetting nutrient balances and leading to eutrophication.

Due to the lack of water storage facilities and the low water levels in rivers, some areas are forced to rely on groundwater for irrigation. Over-abstraction leads to a number of environmental problems. On the one hand, the stability of sediment layers is significantly reduced, which can lead to subsidence. The lowering of water levels changes groundwater flow conditions, which can lead to additional areas becoming drought-prone or permanently water scarce. The groundwater from deeper layers contains very high levels of minerals and other dissolved substances which can trigger adverse processes in soils such as secondary salinisation. In addition to the vulnerability of agriculture, industry, tourism and human health will be under increased pressure.

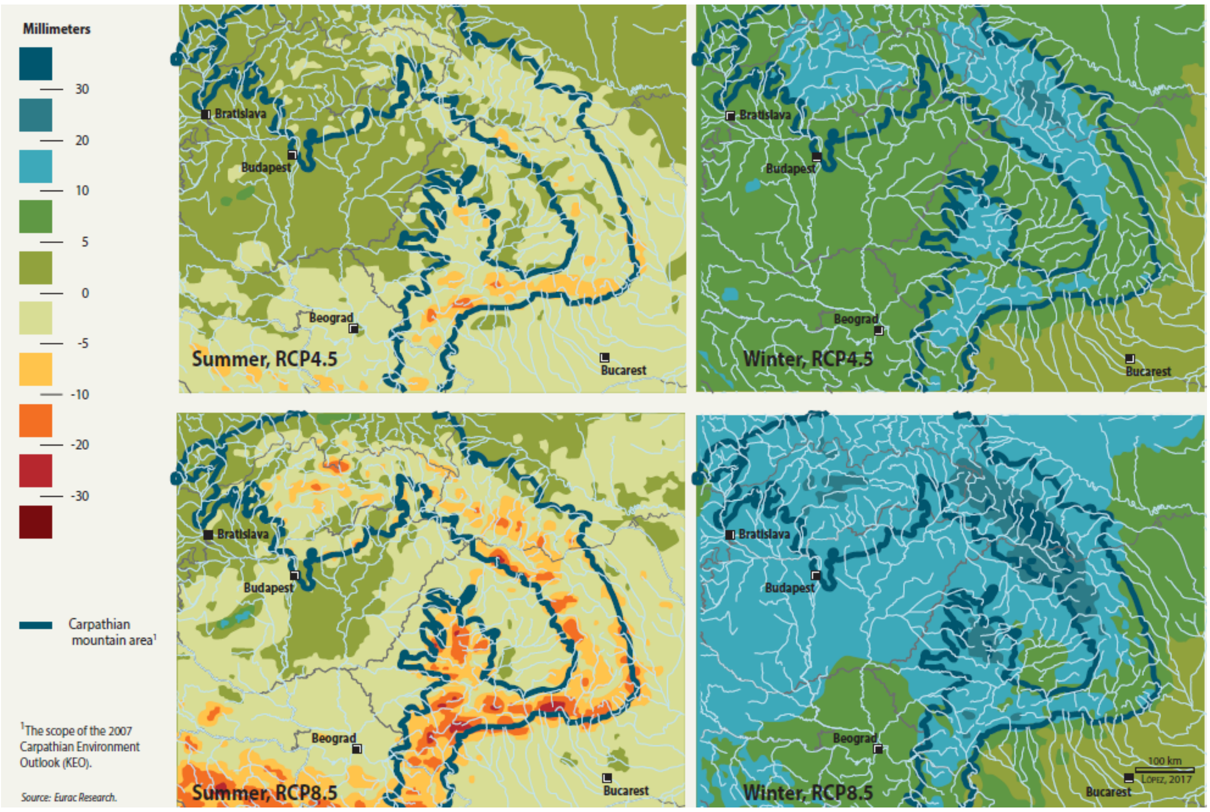


Figure 4.32: Changes in precipitation in summer and winter months under RCP 4.5 and RCP 8.5 scenarios for the period 2071-2100 compared to data for 1971-2000 *Source: Eurac Research*

4.2.4. Vulnerability due to drought

In meteorological terms, we talk about drought when a lack of rainfall results in water shortages that are significantly or persistently above average. The available water resources are insufficient to meet water needs or demands. In addition to precipitation, evapotranspiration is an important meteorological parameter, which is mainly a function of temperature, solar radiation and wind. The lack of precipitation causes the drying of the soil, which heats up more quickly, and the lack of moisture drastically reduces evaporation, making summer showers less frequent and thus exacerbating the drought. Drought is a complex phenomenon of several meteorological variables, so several metrics are used to characterise it.

Different metrics can be used in the analyses, which can be grouped as follows: precipitation indices: describe the relationship between the actual precipitation and the average amount, e.g. SPI (Standard Precipitation Index); balance (supply/demand) indices, which take into account evaporation as a main factor on the expenditure side, in addition to precipitation as an input; recursive indices, which also use data from the previous period in their calculation, being an integral value over a longer period.

Soil moisture indices: include more information on Ped's index, relative soil moisture, relative evapotranspiration, Palatine index (PAI).

The impact of drought can affect many different areas, so its definition can also be defined in sector-specific terms. In addition to drought in the meteorological sense, we distinguish between agricultural, hydrological and social and economic drought. Hydrological drought is defined as a shortage of surface and groundwater in terms of yields in watercourses, snowfall, and the level of lakes, reservoirs and groundwater bodies. Agricultural drought: insufficient soil moisture for the requirements of a given crop at a given time.

4.2.4.1 Drought vulnerability of the Hungarian river basin

The Hungarian catchment shows considerable variability in precipitation and temperature conditions as it moves north-eastwards. The average annual precipitation of 580-585 mm in Nyíregyháza increases to 680-700 mm in the Tiszabecs and Lónya area. The mean annual temperature shows the opposite trend. The eastern part of the Hungarian catchment is in the moderately arid zone, while the western part (the Western part of Felsőszabolcs and the Nyírség) is in the intermediate arid zone (Figure 4.66), while the areas between the Tisza and the Bodrog are in the drought-free zone.

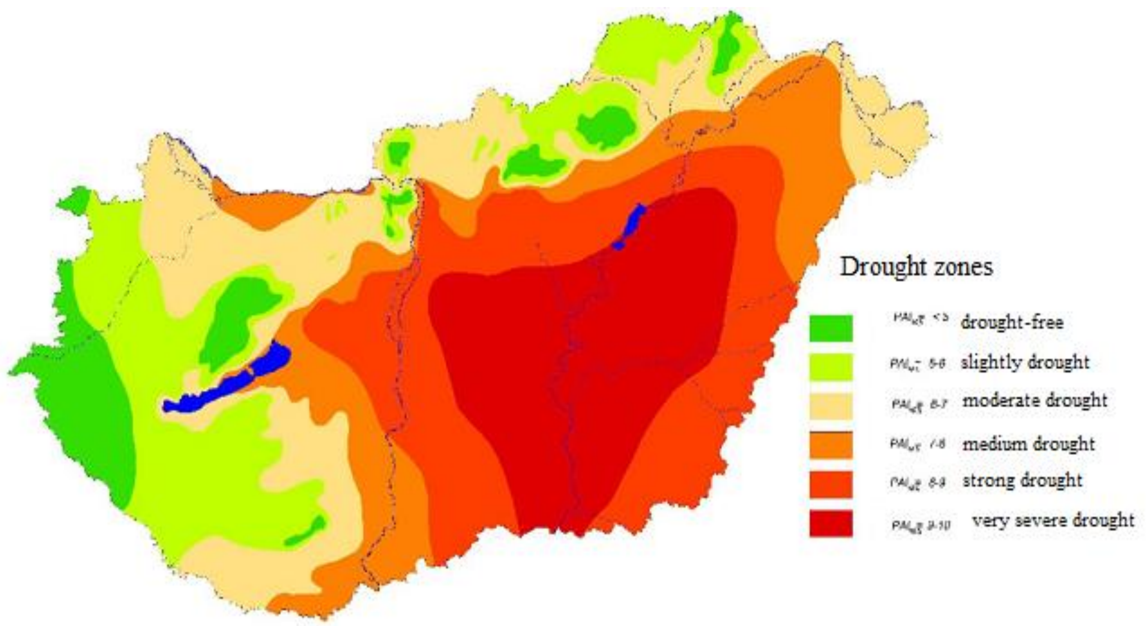


Figure 4.33.: Drought map of Hungary *Source: Dr. Imre Pálfai:Years of drought in the Great Plain between 1931-2010*

The vulnerability of the Hungarian catchment to drought is classified as a priority category, despite the fact that the vulnerability of its micro-regions varies considerably. Among the productive sectors, the agricultural sector, which is important for the economic life of the county, is the main one affected by climate change induced drought.

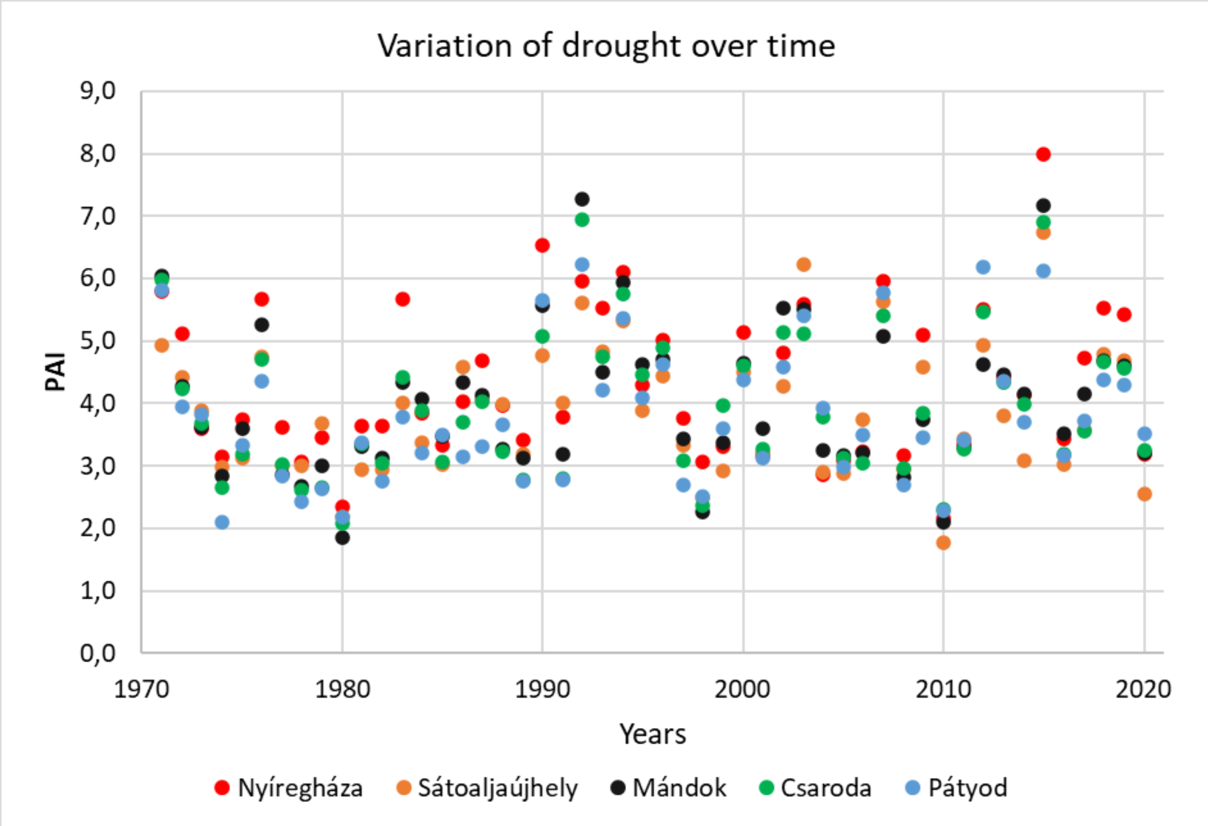


Figure 4.34: Temporal variation of drought in the Hungarian catchment area

In the Hungarian catchment municipalities, the PAI index shows clearly the periods when drought vulnerability was present in the area. The trend of the PAI index has slightly increased over the period 1971-2020, with more frequent years of moderate drought and more frequent periods of severe drought occurring. The PAI index values show a slight increase in drought vulnerability, which is in line with the trends observed in the region. Looking at the municipalities, it is clear that Nyíregyháza's drought exposure is significant, with a PAI index value of around 8 in 2015, a year of severe drought, while the other municipalities had lower values (6.1-7.2).

Crop simulation models are often used to estimate the likely agricultural impacts of climate change at local or global level. The model used in this study considers the impacts on agriculture as an increase in atmospheric CO_2 rates, shortened growing seasons and accelerated duff decomposition due to increased temperatures, reduced photosynthesis due to increased water stresses, and reduced pollination due to extreme temperatures during pollen dispersal. The crop simulation model is coupled with available climate change models. The analysis was carried out at high spatial resolution. At this scale, the climate may show only small variability, while the land cover may show significantly larger variability. The results obtained for the cells were mainly determined by the properties of the predominant soil type.

According to the model results, spring-sown crops (e.g. maize) are expected to show a severe yield decline in the more distant future (2071-2100), i.e. the yield security of these crops will decrease in the whole territory of Hungary. At the same time, autumn crops such as wheat, barley and rapeseed may yield significantly higher yields (30-50% higher) in the period under study. This suggests that the vulnerability of spring-sown crops is worth investigating.

On the basis of the model, it can be concluded that in terms of drought vulnerability, the Hungarian water catchment area in relation to the country as a whole, is one of the intermediate vulnerable counties in the country.

The county is divided into two parts in this respect, as there is no vulnerability in the western part of the county and moderately vulnerable areas in the eastern part. Farmers in drought-affected areas are already aware of the drought risk to their crops and the proportion of maize area sown to spring crops in their crop structure is decreasing.

4.2.4.2. Drought vulnerability of Romanian river basins

Droughts are analysed using the standardised precipitation index PAI on a monthly and annual scale. The period 1981-2020 is observed for years affected by moderate, severe and extreme drought. The 2000-2003 dry periods can be defined as the major drought events in terms of severity and spatial extent. In Romania, 60% of the territory was affected by extreme drought for more than 10 consecutive months. The results of the trend analysis underline the inhomogeneous spatial aspect of the drought/humidity trends. Statistically significant positive trends (wetter conditions) can be observed in small areas with inhomogeneous distribution within the country, such as the southernmost parts and the north-eastern part, and some small areas in the western part of the country. Statistically significant negative trends (drier/drier conditions) can be observed in the south-western and eastern parts of the country. The PAI trends generally follow the observed trends in monthly precipitation totals at the national level. Results show that there is no spatial consistency in drought occurrence at the national level.

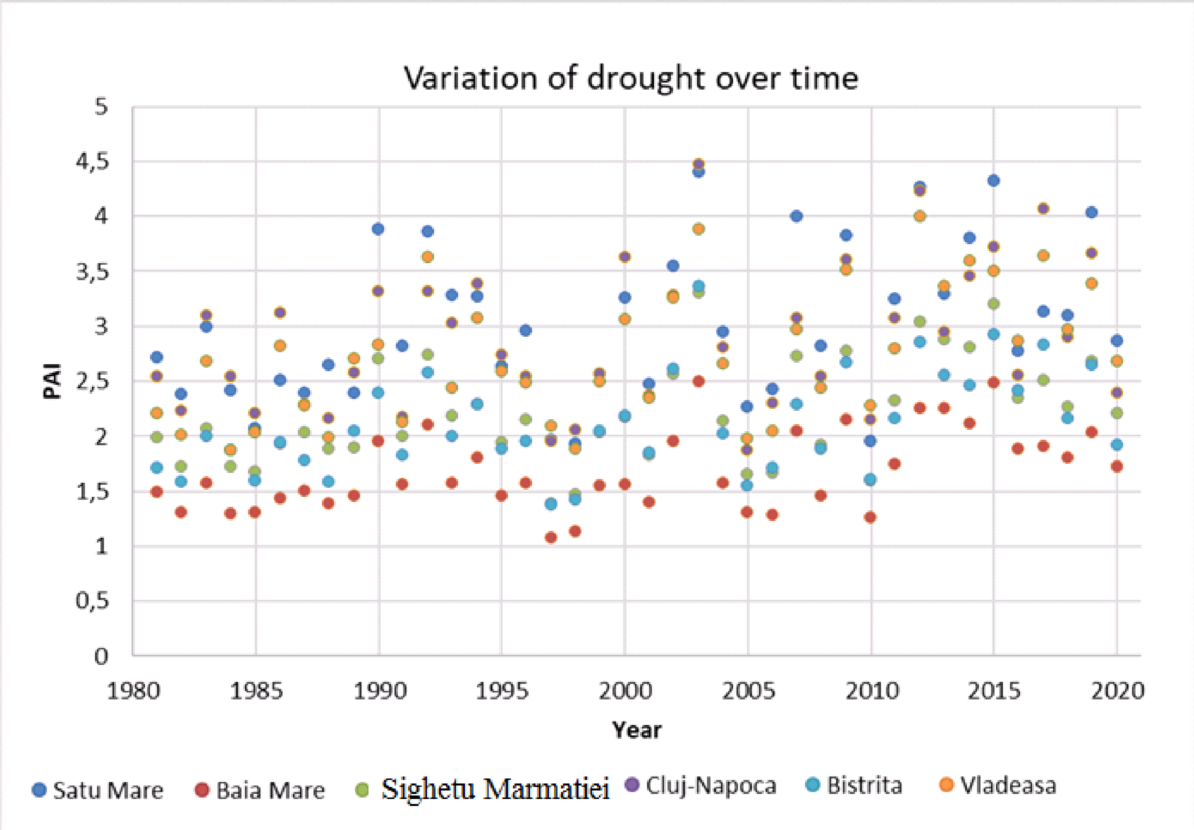


Figure 4.35: Temporal variation of drought in the Romanian catchment area

Figure 4.68 clearly shows that the PAI index value has increased in each municipality over the last period. The upward trends are significant in the municipalities studied and the pattern over time is similar. The municipalities of Satu Mare and Cluj Napoca stand out among the others, as the increase in PAI values is more significant among the others. This is due to the fact that the annual mean temperature is continuously increasing in the region, especially in the lowlands and basin, while the amount of precipitation shows a decreasing or stagnating trend. In the mountain valley municipalities, the time series clearly show that the drought risk is not significant, as it ranges between 1-2 PAI. It should be noted, however, that the time series follows the variations in the region, i.e. the mountain areas may be sensitive to longer drier periods. This is also indicated by the fact that the watch area has increased significantly over the last 20 years.

4.2.4.3. Drought vulnerability of the Slovak river basin

In Slovakia, the assessment of hydrological drought has been studied more often than meteorological drought. For estimation, mainly regionally developed methods were used, while internationally agreed indicators were rarely applied. The drought periods in the Slovakian catchment, which also caused yield losses in agriculture in 2015, have attracted the interest of the public and experts from different economic sectors regarding drought indicators. The widely known Palatine Area Index (PAI) methodology helps to characterise the vulnerability of the Slovakian catchment to drought.

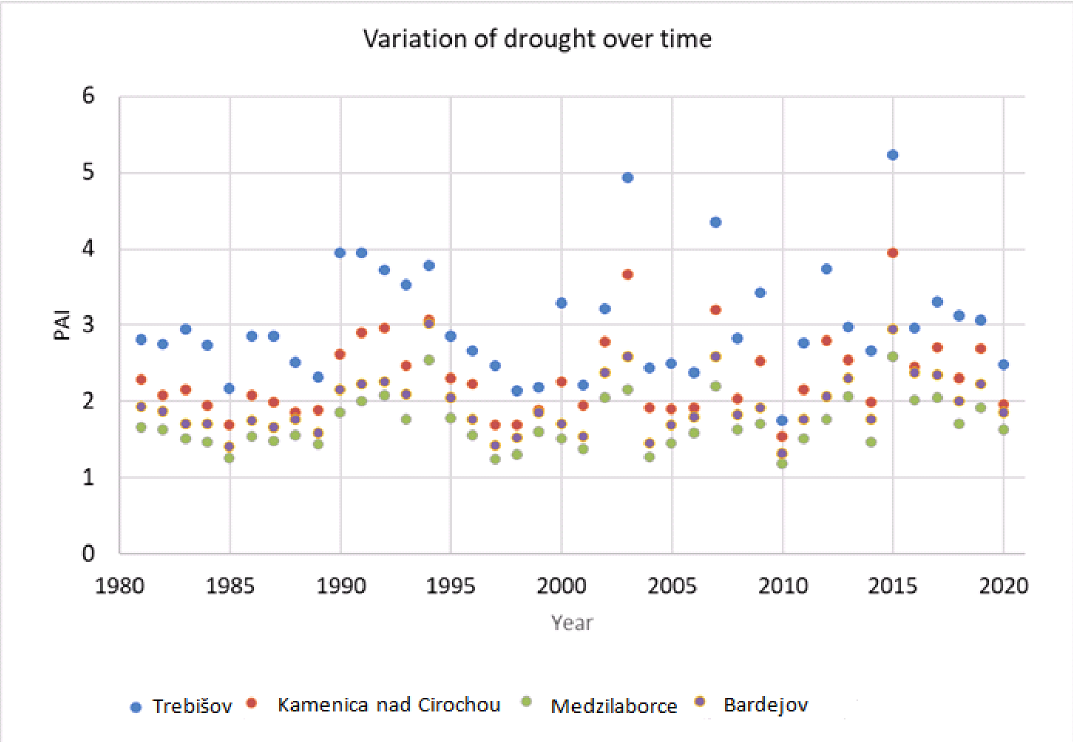


Figure 4.36: Temporal variation of drought in eastern Slovakia

Figure 4.70 clearly shows that the PAI index has increased slightly in the last period in each municipality, but overall the drought vulnerability is low in the region. In addition to the trends, spatial differences can also be observed, as the municipalities of Trebišov and Kamenica nad Cirochou had a mild drought period in 2015, while the municipalities of Medzilaborce and Bardejov did not have any outliers in PAI values, i.e. it was a drought-free year in these two municipalities. This phenomenon can be explained by the fact that the water supply was better in Medzilaborce and Bardejov than in the other two municipalities.

4.2.4.4 Drought vulnerability in Ukraine, Transcarpathia

Tracking the changes in drought indicators for Transcarpathia over the period 1981-2020, Figure 4.71 clearly shows that the PAI index has increased in the latter period based on observations. This can be attributed to the fact that the mean annual temperature in the region has been steadily increasing, especially in the lowland areas, while the amount of precipitation has been decreasing or stagnating. While in the mountain areas, the time series clearly show that the drought risk is not significant, ranging between 1-2 PAI. It should be noted, however, that the time series follows the changes in the region, i.e. the mountainous areas could be affected sensitively.

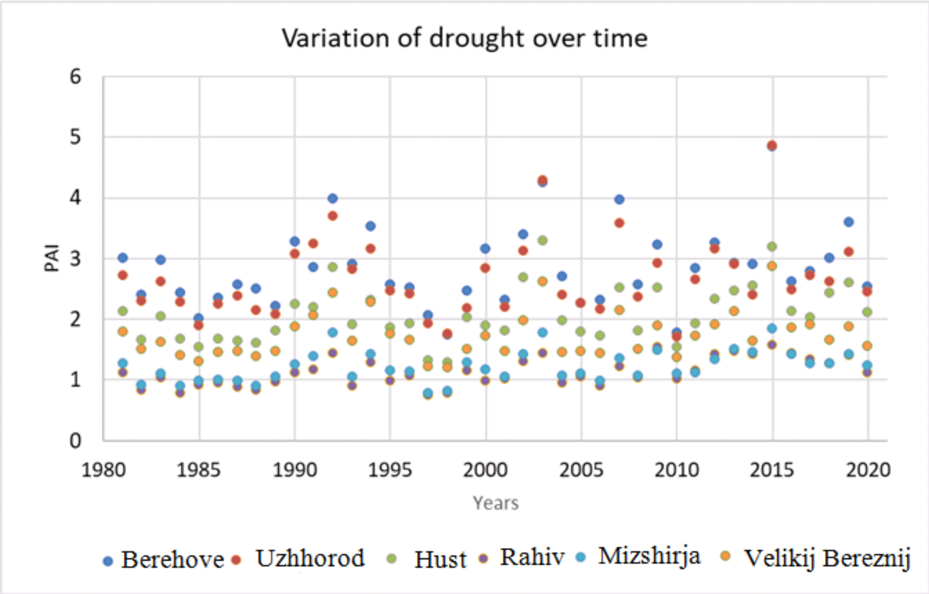


Figure 4.37: Temporal variation of drought in Transcarpathia

Future changes in drought in Transcarpathia based on climate projections

The spatial and temporal distribution of drought in Transcarpathia is determined by long-term projections for the period 2020-2050, temperature and precipitation conditions. Temperature and moisture conditions were analysed using CORDEX climate modelling data, using the results of the RCP4.5 and RCP8.5 climate scenarios. The results show that the annual mean air temperature increase at each station is mainly due to an increase in winter temperatures in both scenarios. The average annual precipitation increases insignificantly, but the opposite trend of winter and summer precipitation is observed. An assessment of the spatial and temporal distribution of drought using the drought index PAI showed that a general increase in regional aridity is expected over the period under study. A weak drought will be prevalent in both situations, with seven drought periods expected over the 31 years studied. However, under the relatively mild RCP4.5 scenario, droughts are predicted to be more intense, and both scenarios show an increase in the number of moderate and severe droughts over a period of more than one year. The temporal evolution of dry and wet periods is almost opposite between the scenarios, but in both scenarios the duration and intensity of drought episodes are projected to increase after the mid-2030s.

Thus, based on observed and projected data, the drought risk in Transcarpathia will increase in the future.

4.2.4.5. Assessment of drought vulnerability in the Upper Tisza catchment based on climate model results

The climate model results suggest an increase in the occurrence of summer droughts in central and southern Europe, particularly in the Carpathian Basin. In our narrower regions, an increase and persistence of droughts is also likely in the coming decades, especially in the summer period. This is because of the continuous increase in temperature, which promotes evaporation and thus soil drying. In the future, the distribution of precipitation will change both spatially and temporally, with a decrease expected in the summer period. Another important characteristic change in precipitation is that extreme precipitation activity, i.e. intensity and frequency, is expected to increase. This could have a number of consequences for the region, such as making it difficult to use the precipitation for agricultural purposes and even damaging crops. In addition, heavy rainfall, often accompanied by ice, will become more frequent in the future, which could further aggravate the situation by causing soil erosion and damage to soft parts of the crop. The operation and development of an anti-icing system is essential to mitigate agricultural damage.

4.2.5. Vulnerability of forest areas, presentation of locally specific problems

Climate change affects forests and forestry in complex ways, but forests also have a significant potential to mitigate its negative impacts, mainly by reducing the greenhouse effect through the sequestration of atmospheric carbon dioxide and particulate matter.

The sensitivity of forests to climate change depends on the species composition of the forest, the topography and rock composition, the soil conditions and the water network, but is also influenced by the silvicultural practices. In the lower regions of the catchment, forests are already exposed to increased drought risk at the present time. Where this is coupled with significant water abstraction, such as around the city of Nyíregyháza, old oak forests are experiencing peak drying. Increasing periods of drought lead to adverse physiological effects, such as reduced resistance of trees to pests or slow regeneration of wounds caused by storm damage.

Forest loss due to drought is expected in these regions, which will have a negative impact on both forest management and biodiversity. Increasing periods of drought and tree mortality caused by storm damage lead to soil erosion (Kazakova and Popp, 2009). The species most threatened by warming are spruce and European larch.

A significant part of the population in the catchment area relies heavily on firewood from forested areas, which results in increased carbon emissions, but as firewood is a renewable energy source, it is not directly part of the ecological footprint. In addition to legal logging, illegal logging is another common problem.

As a result of increasingly intensive forest management, the forest composition is moving in an unfavourable direction. Although there is no significant reduction in area, the amount of biomass is less due to recent planting. In the Carpathians, mature forests account for only 11% of the area, while young forests and new plantations account for over 50%, with much lower biodiversity than in older ecosystems. A further problem is the spread of invasive species that are better adapted to changing conditions, which typically become established on slopes with a milder climate and western exposure (Simpson, 2011). The figure below shows the forest areas felled between 2010 and 2015, mostly in the Upper Tisza catchment in Ukraine and to a lesser extent in the Maramures County (Figure 4.72).

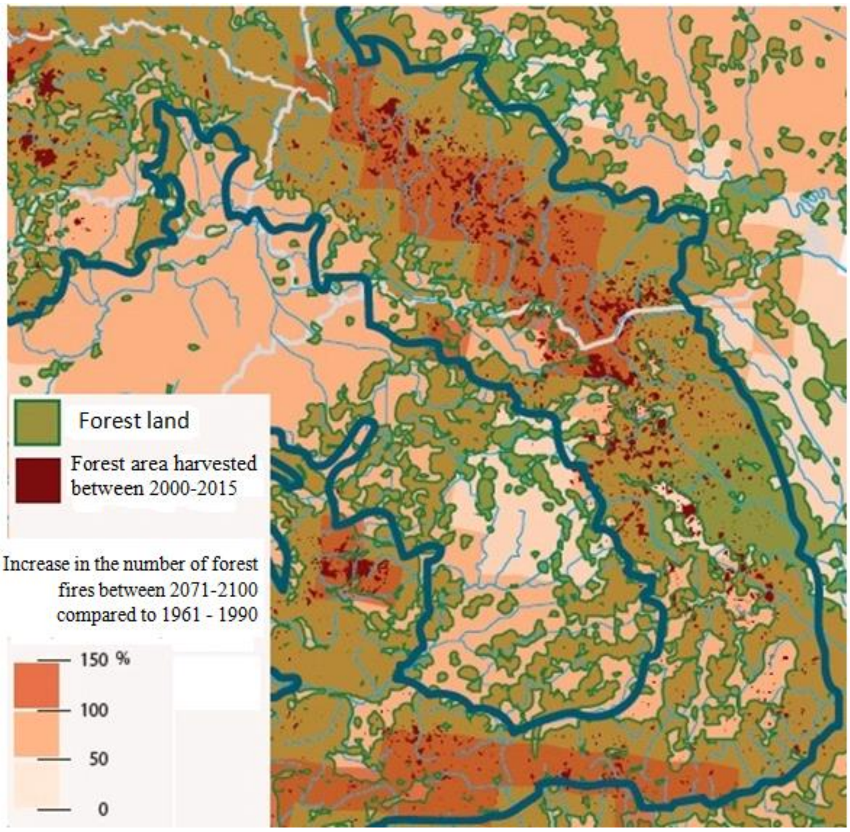


Figure 4.38. Status of deforested areas between 2000 and 2015 and projected increase in forest fires for the period between 2071 and 2100

Source: Joint Research Center, 2016, European Union; Borsa M. et al., 2009, VASICA: Visions and strategies 196nt he Carpathian Area, The Carpathian Project ; Hansen et al., 2016, Global Forest Change, University of Maryland

Some projections estimate that 14-50% of Europe's forest area will disappear by the end of the century. Countries do not currently have the economic capacity and coordinated institutions to effectively confront the challenges of climate change. Although forest protection strategies are being developed at national level, there is little emphasis on cooperation between sectors, among which there are many conflicts.

According to the geomorphological distribution of the Upper Tisza basin, the vulnerability of the forest areas of Slovakia and Ukraine will be low to medium by the end of the century, taking into account aspects of climatic exposure, forest climate and socio-economic adaptability (Figure 4.73). In contrast, the vulnerability of the Romanian part of the Szamos / Somes catchment will be high or very high by the end of the century.

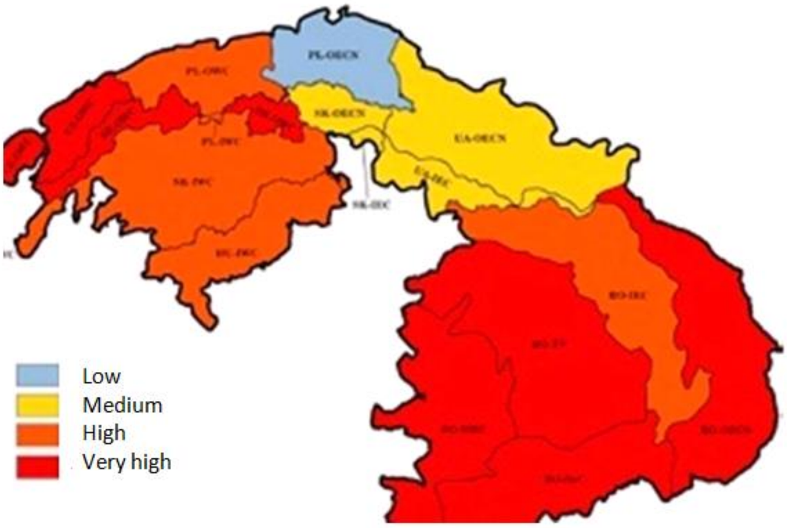
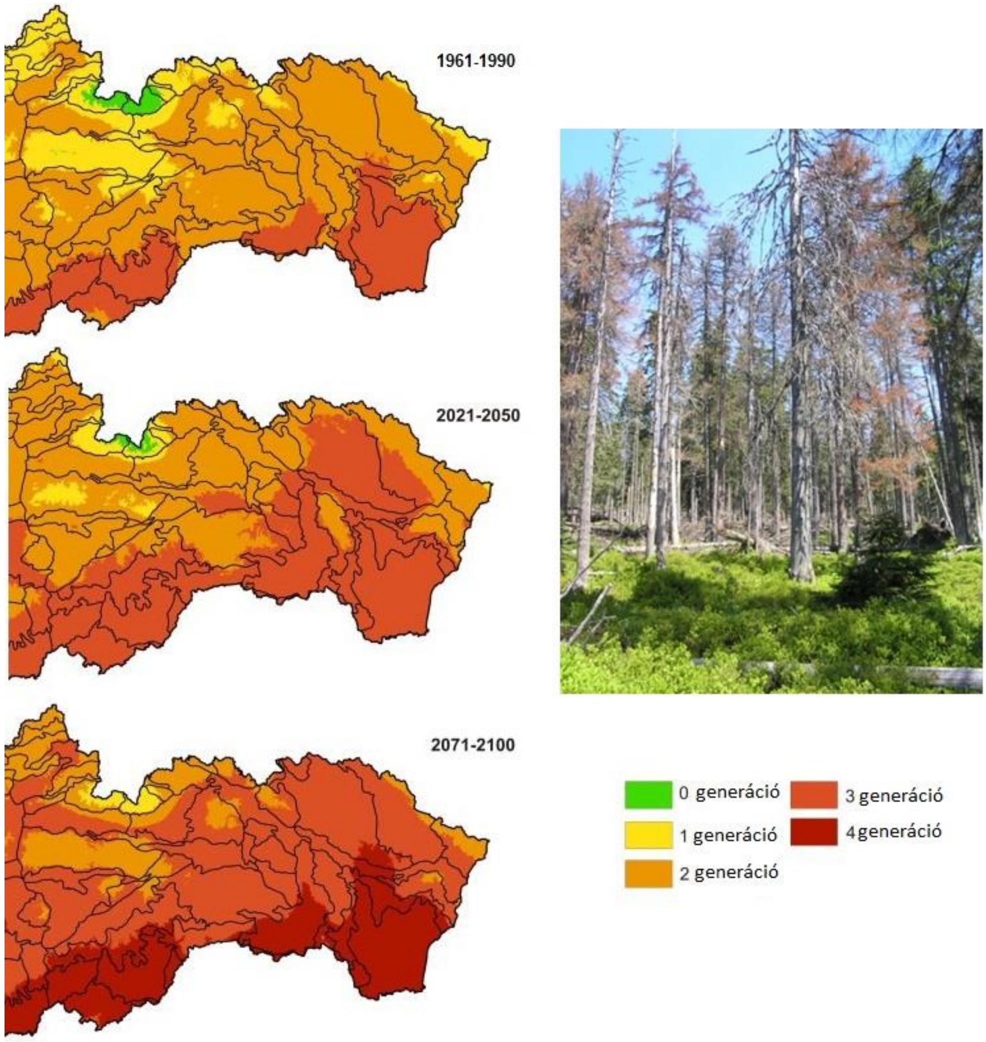


Figure 4.39: Vulnerability of forest areas to climate change assessed by geomorphological units, based on climate exposure, forest climate sensitivity and co-diversity/economic factors
Source: CarpathCC, http://www.carpathcc.eu/

The biggest enemy of immune-compromised trees weakened by drought and storm damage is the spruce bark beetle (Ips typographus), is a species of beetle in the weevil subfamily Scolytinae, the bark beetles. The amount of wood destroyed by the bark beetle pests in Europe is increasing rapidly, with almost 60 million cubic metres of pine trees falling victim to the pests in 2019. The most endangered species is the common spruce (Picea abies), especially stands over 60 years old (http://www.forestportal.sk/). The bark beetle mainly attacks weakened and damaged trees, but in recent years it has also been observed to cause considerable damage to healthy-looking stands. Due to the drought, spruce trees have weakened their overall resistance, producing less resin and thus less able to resist insect invasion. Research in Slovakia suggests that climate change will lead to a more intensive expansion of spruce bark beetle population. In our study area, the number of generations per year ranged from two to three in the period 1961-1990, and this number will not change in the period 2021-2050, but a larger area will be affected by such a high reproduction rate. In contrast, by the period 2071-2100, a significant proportion of the area will have seen the third to fourth generation, i.e. they will have become much more numerous (Figure 4.74).

Studies at the University of Natural Sciences in Vienna have shown that the species can reach altitudes of up to 1500 metres above sea level. At this altitude, warming is expected to be + 1-2°C by 2050 and + 3-4°C by 2071. This will not only increase the distribution of bark beetles over larger areas, but also the number of generations per year, which is in line with research in Slovakia. The pest, which is currently ravaging western and central Europe, is moving eastwards and has already reached Romania, where it is causing enormous damage.



4.40. Within-year increase in the number of generations of spruce bark beetle. The image shows the forest stand affected by the pest *Source:* *http://www.forestportal.sk/*

The dry spring and summer seasons mean that there is a real risk of an increase in the number of forest fires. Multi-criteria modelling studies at county level analysis in Romania show a high risk of forest fires in Maramures county on a four-point scale, whereas in Satu Mare county a medium risk should be expected (Figure 4.75, Barbu 2018). In Satu Mare County, more than 30 ha of forest burnt down between 2016 and 2019, with the highest number of burnt hectares in 2019 being 22 ha.

Figure 4.41. Forest fire risk in Romania, taking into account several modelled data *(Barbu 2018)*

Most of the forested areas in Transcarpathia are less vulnerable to the effects of climate change due to sufficient rainfall. One of the most important problems arising here is the illegal logging. In 2018, this amounted to 1536 m3. In 2018, a total of 1 million cubic metres of timber was felled in the region's state forestry departments. The region's total timber stock exceeds 270 million m3 , with an average volume of 350 m3/ha in Transcarpathia and 186 m3/ha in Ukraine, indicating favourable habitat conditions, also by European standards.

In 2017-2018, storm damage affected a total area of 5,297 hectares. Furthermore, 1306 hectares of diseased or damaged trees were felled. In 2018, there were 25 forest fires, which destroyed 49.3 hectares of forest.

In state-owned forests, 2,791 hectares were replanted in 2018, while 2,244 hectares were replanted in 2019.

Forest fire risk in Szabolcs-Szamár-Bereg county

More than 20% of Hungary is now covered by forest. Due to its vegetation geography, the country lies in a transition zone between closed forests and forest shrubs, which means that nearly half of our forested areas could be vulnerable to climate change. The living conditions and growth potential of forests are determined by the forest climate type, the soil and the potential for water inputs other than precipitation, to which they need to adapt. However, we must also be prepared for the fact that these conditions will be significantly altered by climate change in the longer or shorter term.

The national objective is to further increase forest cover, i.e. to have more than 25% of the country covered by forest.

The forested areas of the county belong to the less sensitive category in a national comparison. The forested areas of the Nyírség are in the most favourable situation, while the western parts, around Nyíregyháza and Tiszalök, are in a less favourable situation. The forest cover of these areas is currently minimal and the model does not recommend their future use for forestry.

4.2.6 Vulnerability of tourism

Tourism is affected not only by direct climate parameters (heat waves, changing water patterns, more frequent storms), but also by the natural impacts of climate change (biodegradation, spread of invasive species) and their socio-economic consequences (spread of infectious diseases, energy - and drinking water prices). Climate change can limit the capacity of tourism activities, eliminate a specific tourism product or even stimulate the development of new alternative tourism products. Climatic conditions are of particular importance for outdoor tourism, especially holiday, active and winter sports tourism. Climate change alters the basic resource of the tourism sector, the weather, thus affecting both the supply and demand side. Extreme weather events, changing seasons and the associated heating and cooling costs will fundamentally change the opportunities for the tourism service sector, and changing climatic conditions may lead to new business preferences and decisions.
The tourism offer of the Upper Tisza region is very complete, but it can be said that tourists arrive predominantly in the winter and summer season. The spa and health resorts can offer a

consistent level of service all year round, as this sector of tourism is not sensitive to the problems caused by climate change.

Ski tourism is at the heart of winter tourism. A total of thirty ski slopes are at the service of ski lovers. Several new ski slopes have been built in Slovakia, Romania and Ukraine since the change of regime. The construction of ski slopes has resulted in the clearing of significant areas of forest, increasing local run-off and soil erosion. The construction of the infrastructure (accommodation, electricity, natural gas, water and sewage systems) has also been a major intervention. The ecological footprint of tourists is not negligible, with significant additional point source consumption and emissions, as well as significant pollutant emissions from transport.

Based on modelled data, the higher average temperatures expected for the winter will lead to a reduction in the number of snow-covered days and the average thickness of the snowpack, which could lead to a shorter ski season and, to prevent this, it may lead to increased snowmaking with a negative impact on the environment.
The solution may be to create new ski slopes at higher altitudes or on colder slopes in the north and east, where sufficient snowfall is still occurring despite climate change, but this may raise conservation concerns. While the conditions for ski tourism are shrinking as a result of global warming, tourists fleeing the heat of the summer can compensate for the loss of revenue during the winter season. The adverse effects that occur, producing extreme events (increased flash floods, landslides, forest fires), all have a negative impact on tourism. The main adaptation policy for ski resorts is to continue the market diversification processes already under way.

The conditions for recreational tourism linked to rivers and still waters are also expected to deteriorate. Due to the decreasing low water yields of rivers, opportunities for bathing, swimming and water sports are shrinking. Rising average temperatures in stagnant waters will lead to increased eutrophication, which will cause a deterioration in water quality and a decline in angling tourism through fish mortality.

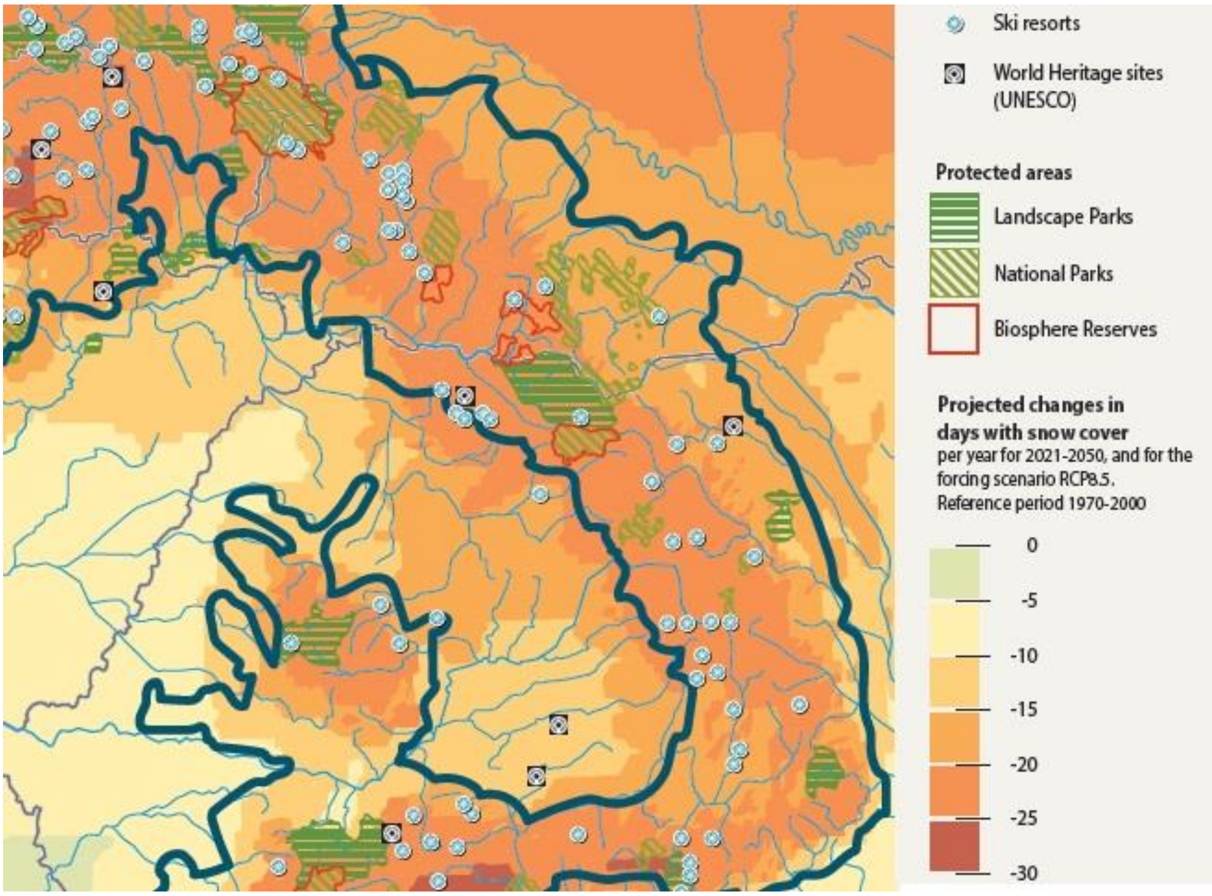


Figure 4.42: Change in the number of days with snow cover under scenario RCB8.5 for the period 2021-2050 compared to data between 1970 and 2000 *Source: Eurac Research*

Tourism vulnerability in Szabolcs-Szatmár Bereg county

Four tourist destination areas have been created in Szabolcs-Szatmár-Bereg county. The areas also form a well-defined geographical unit. They are: the Nyírség tourism ring, the Szatmár-Bergi cultural landscape, the Nyíri Mezőség tourism axis, and the Rétköz inter-regional tourism axis. The vulnerability of a given tourist area to climate change will be determined partly by the vulnerability of the surrounding natural environment.

The tourism vulnerability of Szabolcs-Szatmár-Bereg county is about 15% higher than the national average, mainly due to higher exposure and lower adaptive capacity (Csete et al. 2013).

Hunting tourism is very important in the county (Baktai-, Bockereki- Lónyai-, Ricsikai forests). According to research carried out by the Forestry Science Institute of the National Centre for Agricultural Research and Innovation, forests with significant hunting tourism are less vulnerable to the adverse effects of climate change. Among the built heritage of the county, it is mainly the adobe and adobe structures that may be damaged by high-intensity rainfall events, sometimes accompanied by hail. Among the tourist attractions elements, outdoor event tourism and waterfront tourism are at high risk, but also city tourism, cycling tourism and nature walks can be characterised by increased vulnerability.

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ДЕРЖАВНА СЛУЖБА СТАТИСТИКИ УКРАЇНИ ЧИСЕЛЬНІСТЬ НАЯВНОГО НАСЕЛЕННЯ УКРАЇНИ на 1 січня 2019 року.

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5. Climatic perspective SWOT analysis of the Upper Tisza river basin

Based on the mitigation and adaptation situation assessment chapters, a climate perspective SWOT analysis of the Upper Tisza river basin was carried out by country regions. Although we are talking about a single area in natural geographic terms, social, economic and administrative differences, as well as the different nature and severity of environmental problems, required that the assessment of each administrative unit be discussed separately.

With the help of a SWOT analysis, it is possible to structure the information gathered in a visual way to identify existing strengths and weaknesses, opportunities for adaptation as well as threats arising from adverse natural and social impacts.

The SWOT analysis has been prepared on the basis of the above situational analysis work packages, covering the following aspects:

- GHG emissions,
- Natural, landscape and built environment, environmental and disaster protection,
- Society and human health,
- Economy (Industry, Agriculture),
- Public Utilities (Water Utilities, Waste Management),
- Transport,
- Tourism.

5. 1. The Hungarian catchment area of the Upper Tisza

GHG emissions

Strengths	Weaknesses
• There are few large industrial emitters in the county. • GHG emissions have decreased as a result of the implementation of centralised waste management and the elimination of illegal landfills. • Orchards in the county sequester large amounts of carbon dioxide. • There are visible results from building energy upgrades and the use of renewable energy sources.	• The energy supply of the county's population depends on fossil fuels (natural gas use is significant). • Specific carbon emissions per capita are increasing. • GHG emissions from individual transport are increasing. • No central database of CO_2 savings of energy upgrades available.
Opportunities	**Threats**
• Increasing the use of renewable energy sources, e.g. by creating more solar parks, and increasing the energy efficiency of more residential buildings and public institutions. • Increasing the use of geothermal energy, which has significant potential. • Where economically justified: electrification of the rail network, procurement of electric city buses. • Increasing the area of carbon sinks: planting forests.	• GHG emissions from the transport sector may continue to increase. • Storm damage may lead to damage to forests, resulting in reduced CO_2 sequestration capacity. • The likelihood of forest and vegetation fires on hot days may increase. • Increased electricity demand from rising average summer temperatures will lead to increased GHG emissions.

Natural- and built environment

Strengths	Weaknesses
• The area has nationally outstanding natural values, rich in flora and fauna. • The number and extent of brownfield degraded areas is decreasing. • Flood safety in the county has increased through the construction of flood control structures, the creation of a flood warning system, the raising of flood protection embankments above the flood level and the construction of the Beregi, Szamos-Krasznaközi, Tisza-Túr and Cigándi tidal reservoirs. • The natural and landscape features to be protected are well defined.	• Vulnerable natural and built assets. • Large areas may be subject to inland flooding. • depletion of water resources. • Vulnerability to storm damage of old housing and public buildings or those built with inadequate materials and technologies. • Underutilised brownfield sites • Pollution of surface water from foreign sources (municipal waste, mining and industrial effluents). • Illegal waste disposal is a major problem, especially in rural areas.

Opportunities	Threats
• Establish a water retention management system. • Develop environmental information services to underpin local climate action. • Development of a spatial information management system, development of a database of endangered values, monitoring. • Increasing the proportion of urban green spaces, linking green spaces into a system. • Promoting value-based water management.	• Due to the increase in the number of days with extreme precipitation and the increase in the daily rainfall intensity index, the persistence of inland flooding is increasing. • Further depletion of water resources. • Changes in the costs of maintaining public parks (additional irrigation water use) due to the expected impacts of climate change. • Forest and vegetation fires will increase. • The vulnerability of monumental wooden buildings to forest and vegetation fires. • Fragmentation of natural habitats by new infrastructure investments.

Society and human health

Strengths	Weaknesses
• Rising income conditions. • Natural factors are highly favourable for ensuring a healthy and high quality of life. • At county level, significant efforts have been made in climate protection and public awareness. • Unemployment has fallen significantly in recent years. • Life expectancy at birth is higher than during the regime change. • There are five hospitals operating in the county. • Conditions for mass sports and recreational activities are ensured.	• The area is characterised by an ageing society. • The population is in constant decline. • Selective migration, mainly of young people, is significant. • A high proportion of commuting workers from the region. • A certain proportion of society is disadvantaged. • Combustion products of household solid mixed waste of uncertain composition used as fuel are harmful to human health. • Climate awareness among the population is not high enough.
Opportunities	**Threats**
• Continued landscaping of urban environments. Developing green space networks. • Organising health actions. Provision of drinking water during heatwave days, installation of mist arches and air-conditioned rooms. • Strengthening day care for the elderly and the medically needy residents. • Setting up an information, early warning and alert system. • Establish energy awareness centres in district headquarters. • Develop a heat alert plan for municipalities with a population of more than 10 000 inhabitants.	• Increasing excess deaths as a consequence of heatwave days. • Increased concentrations of particulate matter due to increased dry periods. • New subtropical pathogens are emerging as climate belts shift further north due to climate change. • Increased risk of contamination from illegal dumping. • Further population decline is probable. • Vulnerability of industrial plants to climate change poses a risk to public health. • Overloaded sewage systems due to increased run-off could lead to epidemics.

Economy (Industry, Agriculture)

Strengths	Weaknesses
• There are good opportunities for international economic relations. • The service sector is strong in the region. • Environmental pressures are moderate. • The emerging industrial park could attract additional capital-intensive, high employment businesses to the region. • The tourism base is strong and the area has marketable destinations. • The conditions are right for profitable agriculture. • The effective implementation of projects for the economic, nature conservation and mobility development of the four countries of the basin, as provided by the European Union. • The high proportion of agricultural land has considerable potential for biomass production.	• Underutilised brownfield sites. • The existence of rust belts is still a problem today. • There is a significant fertiliser load on the lands. • Agricultural land in the Nyírség region is at increased risk of soil erosion. • Groundwater aquifer exposed to agricultural pollution. • Low proportion of irrigated land. • Cultivation parallel to the contour lines is not practised, which is a problem in quicksand areas.
Opportunities	**Threats**
• Increasing funding sources for climate change objectives. • Encouraging industry to use renewable energy sources and energy-efficient production methods. • Widespread adoption of water-efficient industrial and agricultural technologies. • Establishment of cross-border transport corridors: extension of the M3 motorway to the Ukrainian border and then to Mukachevo, construction of the M34 motorway between Vásárosnamény and the Ukrainian border, construction of the M49 motorway between Vaja-Mátészalka-Szatmárnémeti-Nagybánya. • Marketing and community development supporting local economic development based on traditional agricultural production. • Expansion of irrigated areas. • Extension of the system of field protection forest strips. • Introduction of new drought-tolerant varieties of arable crops and forestry crops.	• The increase in drought periods, causing significant crop losses, increases water use in agriculture. • Drought increases the risk of wind erosion, which leads to soil degradation and crop failure. • Agricultural contamination of the soil may result in unsuitable groundwater for irrigation. • upsetting the balance of water resources and management. • New subtropical pests and pathogens are emerging as climate belts shift further north due to climate change. • Increased vulnerability of industrial installations to storm damage.

Utilities (water, waste management)

Strengths	Weaknesses
• The water supply network is 100% complete in most of the settlements in the county. • All settlements in the county have a natural gas network. • Inland stormwater drainage is provided in many places. • Municipal waste collection is well organised. • The amount of separately collected waste is steadily increasing.	• Part of the electricity is delivered by overhead cables on concrete and wooden support poles. • Despite efforts, the proportion of waste collected separately is not yet high enough. • The capacity of the waste water treatment plants in some municipalities of the county is insufficient. • The increase in the area of illegal landfills is a problem. • The maintenance and operation of regional and municipal water management infrastructure is underfunded.

Opportunities	Threats
• Developing a climate change resilient utility infrastructure. Mainly by eliminating overhead lines. • Promoting and further improving the conditions for selective waste collection. • Create conditions for biogas recovery in waste water treatment plants and livestock farms. • Expand the sewerage and stormwater drainage system to cope with increased run-off. • The use of treated waste water and sludge generated at waste water treatment plants	• Storms, strong gusts of wind and heavy rainfall can pose a threat to buildings and infrastructure. • Paved surfaces, roads and railway embankments are likely to be washed away underneath. • Overloading of drainage and sewerage systems due to sudden heavy rainfall. • upsetting the balance of water resources and management. • Increase in organic waste generation due to the decline of traditional household farming. • Increased water demand due to heat waves overloading the water supply network.

Transport

Strengths	Weaknesses
• The county has well-developed transport corridors. • Motorway construction up to the Ukrainian border, construction of express roads in the Záhony-Csap and Mátészalka-Szatmárnémeti-Nagybánya sections. • Part of the fixed rail transport is circular, most of its cross-border sections are electrified. • The proportion of paved surfaces is constantly increasing, improving transport conditions and quality of life. • The bypass road between Nyíregyháza and Nyírbátor is almost completed and has already been handed over in Kisvárda. • Public transport is well established in the larger cities.	• Low passenger numbers due to poor quality of rail sidings. • There is a lack of bypasses around major cities. • Traffic through the towns and cities puts pressure on the urban road network. • Many dirt roads cross the railways, creating a high risk of accidents.
Opportunities	**Threats**
• Improving the unpaved road network. • Modernisation of rail transport: extension of electrified lines. • Improving cycling infrastructure. • Develop green or low-emission local public transport. • Awareness campaigns to promote the use of public transport.	• The pavement of roads, railways, pavements and cycle paths are being washed underneath during periods of extreme rainfall. • Overhead power lines damaged by storm damage can obstruct traffic. • Asphalt surfaces melt and deform due to the increase in the number of hot days.

Tourism

Strengths	Weaknesses
• The conditions for recreational and health tourism are particularly favourable in the region. • Adequate quantity and quality of accommodation. • The conditions for ecotourism are good. • It is the richest county in watercourses in the country, so aquatic tourism is active. • Well developed tourist information network.	• Individual tourism businesses are undercapitalised. • Pollution of rivers and stagnant water has a negative impact on water sports and angling tourism. • Infrastructure conditions do not always meet the needs of tourists. • There are few destinations offering multi-day programmes.
Opportunities	**Threats**
• The conditions for recreational and health tourism are particularly favourable in the region. • Adequate quantity and quality of accommodation. • The conditions for ecotourism are good. • It is the richest county in watercourses in the country, so aquatic tourism is active. • Well developed tourist information network. .	• Conditions for water sports will deteriorate as drought periods increase. • The pavement of roads, railways, pavements and cycle paths are being washed underneath during periods of extreme rainfall, which may lead to a deterioration in accessibility to destinations. • Ecotourism destinations may be damaged by climate change.

5. 2. Romania, Maramures County and Satu Mare County

GHG emissions

Strengths	Weaknesses
• The counties of Maramures and Satu Mare have a medium-high potential (compared to the country as a whole) for renewable energy production from solar, wind, agricultural and forest biomass. • There are modest large industrial CO_2 emissions in the counties. • CO_2 emissions from agriculture decreased between 2016-2018. • GHG emissions have decreased as a result of the centralized waste management and the elimination of illegal landfills implemented so far. • Forest areas in the two counties sequester large amounts of carbon dioxide. • The potential of hydropower is high.	• The energy supply of the county's population depends on fossil fuels (significant use of wood and coal). • Specific carbon emissions per capita are increasing. • GHG emissions from individual transport are increasing. • Gross GHG emissions are basically stagnating with little variation over the period. • Energy efficiency upgrades and the use of renewable energy sources are still low.

Opportunities	Threats
• Expanding the use of renewable energy sources, e.g.: creating more solar parks, encouraging residential use. • Energy modernisation of public buildings. • Increasing the use of geothermal energy. • Increasing the use of hydropower through mobile micro power plants. • Increasing the area of carbon sinks: planting forests. • Developing urban electric public transport.	• GHG emissions from the transport sector may continue to increase. • Storm damage may damage forests, reducing their CO_2 sequestration capacity. • The likelihood of forest and vegetation fires on hot days may increase. • Increased GHG emissions from increased electricity demand due to increased average summer temperatures and heat wave frequency. • Capacity of hydropower plants may be reduced due to water shortages caused by drought.

Natural and built environment, disaster management

Strengths	Weaknesses
• The area has outstanding natural values, rich in flora and fauna, even at European level. • The number and extent of brownfield degraded areas is decreasing. • The range of natural and landscape features to be protected is well defined. • The proportion of newly built housing is high in the county capitals. • Monumental buildings of great importance. • Increasing urban green spaces. • Well developed hydrological monitoring and signalling system.	• There is a high proportion of housing with outdated technical standards and low comfort levels. • Risk of storm damage to housing and public institutions built in old buildings or with inadequately modern materials and technologies. • Illegal dumping of waste is a major problem, especially in rural areas. • The environmental monitoring system is poorly developed. • Risk of landslides, slides and mudflow in some stretches of river valleys (e.g. rasna river).
Opportunities	**Threats**
• Establish a water retention management system. • Developing an environmental information service to underpin local climate action. • Establishment of a spatial information-based management system, monitoring values at risk. • Further increase flood safety. • Fragmentation of natural habitats through new infrastructure investments.	• Due to the increase in the number of days with extreme precipitation and the increase in the daily rainfall intensity index, the persistence of inland flooding is increasing. • Changes in the costs of maintaining public parks (additional irrigation water use) due to the expected impacts of climate change. • Forest and vegetation fires will increase. • Risk of forest and vegetation fires in monumental wooden buildings.

Society and human health

Strengths	Weaknesses
• The population of counties is decreasing at a lower rate than the national average. • Many new homes have been built in the county seats recently. • Rising income conditions. • Natural factors are highly favourable for a healthy and high quality of life. • Maramures and Satu Mare counties have made significant investments in building energy efficiency. • Effective implementation of projects for the economic, nature conservation and mobility development of the four countries of the river basin, provided by the European Union. • Unemployment has decreased in recent years. • Life expectancy at birth is increasing. • Air quality has recently improved significantly.	• The area is characterised by an ageing society. • The age structure of Maramures County is less favourable than that of Satu Mare County. • Life expectancy at birth is the lowest in Satu Mare County. • Selective migration, mainly among young people, is significant. • The number of hospital beds in Maramures County has decreased. Both counties are characterised by an outflow of doctors. • The proportion of commuting workers from the region is high. • A certain part of society is disadvantaged. • Underfunded health care. • Climate awareness among the population is not high enough. • Part of the mountain areas are disadvantaged. • The network of public warning systems is outdated and underdeveloped.
Opportunities	**Threats**
• Organising health actions. Provision of drinking water during heatwave days, installation of mist arch and air-condistioned rooms. • Strengthening day care for the elderly and the medically needy residents. • Setting up an information, early warning and alert system. • In urban environments, installing heat-relieving devices in public spaces, e.g. mist arch. • Establish energy awareness centres in district headquarters • Develop a heat alert plan for municipalities with a population of more than 10 000 inhabitants.	•

Economy (Industry, Agriculture)

Strengths	Weaknesses
• There are good opportunities for international economic relations. • GDP growth is above the national average. • Growing manufacturing sector. • The economic structure of Satu Mare County is stable, with a high share of exports compared to the regional average. The four industrial parks are attractive to foreign investors. • Growing service sector. • Locally produced food is of national importance. • Strong tourism base, marketable destinations in the area, growing number of tourists. • Conditions for ecotourism are being built up. • Conditions for profitable agriculture are in a given state. • Mountain areas have significant wind energy potential.	• Non-ferrous metal mining, using cyanide technology, continues in the Maramures department, where it is a polluting activity. • The economy is concentrated in the county's capital cities • Low added value industrial production. • Decline in the industrial and agricultural sectors. • Low proportion of irrigated land. • The orchard population is ageing. • Lack of vegetable and fruit storage facilities. • Low share of tourism in the economy. • Lack of adequate industrial parks in the Maramures department. • The R&D&I sector is not strong enough.
Opportunities	**Threats**
• Increasing funding for climate change. • Encouraging industry to use renewable energy sources and energy efficient production methods. • Establishment of a cross-border transport corridor: the M49 motorway between Mátészalkaka and Satu Mare. • Marketing and community development supporting local economic development based on traditional forms of agricultural production. • Expansion of irrigated areas. • Planting forest strips to protect fields. • Introduction of new drought-tolerant varieties of arable crops and forestry crops.	• The increase in drought periods, causing significant crop losses, increases water use in agriculture. • Drought increases the risk of wind erosion, which leads to soil degradation and crop failure. • There is a risk of economic disconnection from the counties of Cluj and Bihor. • New subtropical pests and pathogens are emerging due to the northward shift of climate belts caused by climate change. • Increased vulnerability of industrial facilities to storm damage. • Increased concentration of the economy in the county seats.

Utilities (water, waste management)

Strengths	Weaknesses
• The drinking water sources in the counties are of satisfactory quality. • In urban areas, the proportion of dwellings connected to the drinking water network is high. • Waste and selective waste collection is organised and landfills are centralised. • There are several waste processing plants. • The urban areas of the counties have a high proportion of dwellings connected to the sewerage network.	• The number of natural and anthropogenic hazards is high. • Part of the electricity comes from overhead lines on wooden poles. • A significant proportion of dwellings are without water and sewerage connections. • The proportion of separately collected waste is not high enough. • Illegal dumping of waste and the discharge of waste water into watercourses is prevalent, especially in rural areas. • Some sections of the water supply system are outdated.

Opportunities	Threats
• Developing a climate-resilient utility infrastructure. Mainly by eliminating overhead lines. • Promoting and further improving the conditions for selective waste collection. • Create conditions for biogas recovery in waste water treatment plants and livestock farms. • Expand the sewerage and stormwater drainage system to cope with increased run-off.	• Storms, strong gusts of wind and heavy rainfall can pose a threat to buildings and infrastructure. • Paved surfaces, roads and railway embankments are likely to be washed away underneath. • Overloading of drainage and sewerage systems due to sudden heavy rainfall. • Increase in organic waste generation due to the decline of traditional household farming. • Increased water demand due to heat waves.

Transport

Strengths	Weaknesses
• The condition of the main roads is good. • The proportion of paved surfaces is steadily increasing, improving transport conditions and quality of life. • More than 75% of the road network in Satu Mare County is paved. • Conditions for international air traffic are good. • Public transport in major cities is well established. • Satu Mare Airport, which was modernised in 2015-16, has a capacity of 200 passengers per hour.	• The conditions for cross-border connections in the county of Maramures are poor, with only one road border crossing point in operation. • Rail traffic between the Maramures County and Ukraine is interrupted. • Some of the minor roads are in poor condition. • Lack of motorways and expressways. • Low passenger numbers due to poor rail infrastructure. • Lack of bypasses, poor condition of many level crossings. • Satu Mare's road junctions are congested.
Opportunities	**Threats**
• Improving the unpaved road network. • Modernisation of rail transport: extension of electrified lines. • Improving cycling infrastructure. • Develop green or low-emission local public transport. • Awareness campaigns to promote the use of public transport. • Introduction of a county road register. • The M3 motorway in Hungary will be built as an expressway between Mátészalka- Satu Mare - Baia Mare, .	• The pavement of roads, railways, pavements and cycle paths are being washed underneath during periods of extreme rainfall. • Overhead power lines damaged by storm damage can hamper transport and infrastructure. • Asphalt surfaces melt and deform due to an increase in the number of heat days. • Transportation improvements may be concentrated in southern counties.

Tourism

Strengths	Weaknesses
• Maramures County is one of the most popular tourist destinations in Romania. • A wide range of tourist destinations is typical of both counties. • There is a strong basis and tradition of spa tourism. • Both counties are rich in architectural heritage. • The conditions for ecotourism are good. • There is great potential for rural and agro-tourism. • Promotion of tourist destinations is ongoing.	• Individual tourism businesses are undercapitalised. • The tourist attractions of Satu Mare County are scattered throughout the county, and the utilisation of existing destinations is still low. • Some of the monuments are in poor condition. • Medical tourism does not build on spa tourism. • Pollution of rivers and stagnant water has a negative impact on water sports and angling tourism. • Infrastructure conditions do not always meet the needs of tourists.
Opportunities	**Threats**
• Tourism planning should take into account the expected impacts of climate change. • Diversification of tourism, e.g. ecotourism, cultural tourism, health tourism, conference tourism. • Further infrastructure development of ecotourism is justified. • Extension of the summer tourist season. • Secondary use of thermal water for heating buildings and greenhouses, which will be a priority in the future.	• Conditions for water sports will deteriorate as drought periods increase. • The pavement of roads, railways, pavements and cycle paths are being washed underneath during periods of extreme rainfall, which may lead to a deterioration in accessibility to destinations. • Ecotourism destinations may be damaged by climate change. • International competitive disadvantage for spa tourism.

5.3. Slovakia, Kosice District

GHG emissions

Strengths	Weaknesses
• The implementation of centralised waste management and the elimination of illegal landfills has reduced GHG emissions. • Significant investments in building energy upgrades and renewable energy sources. • Large industrial emissions decreased slightly between 2016 and 2018. • The district has a significant forest cover.	• The catchment area has the highest emissions of large industrial GHGs. • The county's population is dependent on fossil fuels for energy (significant use of natural gas). • Specific carbon emissions per capita are increasing. • GHG emissions from individual transport are increasing. • Large areas of forest in the district absorb only 5% of carbon dioxide due to high emissions.
Opportunities	**Threats**
• Increasing the use of renewable energy sources, e.g. creating more solar parks, increasing the energy efficiency of more public buildings. • The use of geothermal energy, which has significant potential, will increase. • Increased utilisation of biomass. • Increased use of hydropower, including mobile micro power plants.- Increasing the area of carbon sinks: planting forests.	• There is no chance of reducing emissions from large industry in the near future. • GHG emissions from the transport sector may continue to increase. • Storm damage may damage forests, reducing their CO2 sequestration capacity. • The likelihood of forest and vegetation fires on hot days may increase. • Increased GHG emissions from increased electricity demand due to increased average summer temperatures and heat wave frequency.

Natural and built environment, disaster management

Strengths	Weaknesses
• The area has outstanding natural values, rich in flora and fauna, also at European level. • The number and extent of brownfield degraded areas is decreasing. • Flood safety in the county has increased with the establishment of floodplain regulations and a flood warning system. • The range of natural and landscape features to be protected is well defined.	• There are significant risks from flash floods. • Vulnerable protected natural values. • Low floodplain areas are vulnerable to inland flooding. • Housing and public buildings of old construction or built with insufficiently modern materials and technologies are vulnerable to storm damage. • Illegal dumping of waste is a major problem, especially in rural areas. • Destruction by the spruce bark beetle (Ips typographus) affects significant areas of pine forest
Opportunities	**Threats**
• Establish a water retention management system. • Development of environmental information services to underpin local climate action. • Development of a geo-spatial information management system, development of a database of endangered values and monitoring.	• The vulnerability of karst areas may increase. • The increase in the number of days with extreme precipitation and the increase in the daily rainfall intensity index will increase the persistence of inland flooding. • Changes in the costs of maintaining public parks (additional irrigation water use) due to the expected impacts of climate change. • Forest and vegetation fires will increase. • Risk of forest and vegetation fires in monumental wooden buildings.

Society and human health

Strengths	**Weaknesses**
• Rising income conditions. • Natural factors are highly favourable for ensuring a healthy and high quality of life. • Unlike other administrative units in the catchment area, the population is increasing. • Income levels in society are increasing. • Unemployment has fallen significantly in recent years. • Life expectancy at birth is higher than during the regime change. • The climate awareness of the population is satisfactory.	• The area is characterised by an ageing society. • Income levels are lower than the national average. • The average age of doctors is high, and there are high waiting lists for medical care.
Opportunities	**Threats**
• Continued landscaping of urban environments. Developing green space networks. • Organising health protection actions (e.g. distribution of drinking water, mist arches, provision of air-conditioned rooms). • Strengthening day care for the elderly and the medically needy. • Setting up an information, early warning and alert system. • Installation of heat-relieving equipment in public spaces in urban areas, e.g. mist arches • . • Establish energy awareness centres in district headquarters. • Developing a heat alert plan for municipalities with a population of more than 10 000 inhabitants.	• Increasing excess deaths due to heatwave days. • Increased concentrations of particulate matter due to increased dry periods. • Drinking water crisis may occur due to drying up of groundwater wells during the dry season. • New subtropical pathogens are emerging as climate belts shift further north due to climate change. • Increased risk of contamination from illegal dumping. • Further population decline is likely. • The vulnerability of industrial plants to climate change is a threat to public health. • The gradual depopulation of rural areas. • Overloaded wastewater systems due to increasing run-off can lead to epidemics.

Economy (Industry, Agriculture)

Strengths	**Weaknesses**
• Good international economic relations. • Significant industrial tradition, skilled workforce. • A strong service sector in the region. • Environmental pressures are moderate. • The emerging industrial park could attract additional capital-intensive, high employment businesses to the area. • The tourism base is strong and the area has marketable destinations. • The conditions for ecotourism are being built up. • The conditions for profitable agriculture are in place. • Effective implementation of the projects for the economic, nature conservation and mobility development of the four countries of the basin, which are supported by the European Union. • There is considerable potential for the use of biomass because of the high proportion of agricultural land. • Favourable conditions for irrigation.	• Metallurgy has a significant environmental impact. • Underutilised brownfield sites. • The dominance of Kosice in the economic life of the county is significant. • Aquifer exposed to agricultural sources of pollution. • Low proportion of irrigated land.

Opportunities	Threats
• Expanding funding for climate change purposes. • Encouraging in the industrial sector the use of renewable energy sources and energy efficient production methods. • Marketing and community development to support local economic development based on traditional forms of agricultural production. • Expanding irrigated areas. • Establishment of forest strips to protect fields. • Introduction of new drought-tolerant varieties of arable crops and forestry crops. • Erection of runoff-slowing dams in mountain and hill forest areas using local timber. • Tillage parallel to the contour lines.	• The increase in drought periods causes significant crop losses and increases water use in agriculture. • Drought increases the risk of wind erosion, which leads to soil degradation and crop failure. • Agricultural contamination of the soil may lead to groundwater becoming unsuitable for irrigation. • New subtropical pests and pathogens are emerging as climate belts shift further north due to climate change. • Increased vulnerability of industrial installations to storm damage. • Extreme rainfall events will increase rutting erosion

Utilities (water, waste management)

Strengths	Weaknesses
• Well developed water supply network. • Waste and selective waste collection is organised. • High proportion of dwellings connected to the sewerage network in the most densely populated areas of the territory. • The natural gas network is well developed. • Municipal waste collection is well organised. • The volume of waste collected separately is steadily increasing and is significant.	• Part of the electricity is carried overhead on concrete and wooden support poles. • The proportion of waste collected separately is not high enough. • The capacity of the waste water treatment plants in some municipalities of the county is insufficient.
Opportunities	**Threats**
• Developing a climate-resilient utility infrastructure. Mainly by eliminating overhead lines. • Further improving the conditions for separate waste collection. • Create conditions for biogas recovery in waste water treatment plants and livestock farms. • Expand the sewerage and stormwater drainage system to cope with increased run-off.	• Storms, strong gusts of wind and heavy rainfall can pose a threat to buildings and infrastructure. • Paved surfaces, roads and railway embankments are likely to be washed away underneath. • Overloading of drainage and sewerage systems due to sudden heavy rainfall. • Increase in organic waste generation due to the decline of traditional backyard farming. • Increased water demand due to heat waves. • Increase in the number of flash floods.

Transport

Strengths	Weaknesses
• The international airport of Kosice has a significant passenger traffic. • Rail transport is of a good standard, with the vast majority of lines electrified. • Significant trade links with Ukraine and Russia through the rail transhipment area. • The condition of primary roads is good. • Public transport in the district is well established. • The D1 motorway under construction provides links to Bratislava and Ukraine.	• Air traffic noise is significant. • There is diesel haulage on the railway lines in the western part of the district. • Second and third class roads are in poor condition due to heavy traffic. • Traffic through the municipalities puts a strain on the urban road network.

Opportunities	Threats
• The construction of the R4 motorway will link the county with Poland and Hungary. • Modernisation of rail transport: extension of electrified lines. • Further development of cycling infrastructure. • Develop green or low-emission local public transport. • Awareness campaigns to promote the use of public transport.	• The pavement of roads, railways, pavements and cycle paths are being washed away underneath during periods of extreme rainfall. • Overhead power lines damaged by storm damage can hamper transport and infrastructure. • Asphalt surfaces melt and deform due to an increase in the number of heat days.

Tourism

Strengths	Weaknesses
• There are many historic sites in the district, UNESCO World Heritage destinations. • Development of a tourism mobile app. • Recreational and health tourism conditions are particularly favourable. • Adequate quantity and quality of accommodation. • Conditions for ecotourism are good. • It is the country's richest county in watercourses and therefore aquatic tourism is lively. • The length of cycle paths exceeds 1500 km	• Some tourism businesses are undercapitalised. • The number of multi-day tourism packages is small. • High vulnerability of karst areas. • Tourism is mainly limited to the summer season.
Opportunities	**Threats**
• Tourism planning should take into account the expected impacts of climate change. • Diversification of tourism, e.g. ecotourism, cultural tourism, health tourism, conference tourism. • Further infrastructure development of ecotourism is justified.	• Conditions for water sports will deteriorate as drought periods increase. • Risk of melting ice caves due to global warming. • Ecotourism destinations could be damaged by climate change.

5.4. Ukraine, Transcarpathian

GHG emissions

Strengths	Weaknesses
• There are few large industrial emitters in the county. • GHG emissions have decreased significantly since 1990 and stagnated between 2016 and 2018. • Due to the large forest area in the county, carbon dioxide sequestration is high (nearly 50% of total emissions). • The use of solar energy is developing. • Hydropower utilisation is significant within the catchment. • Electric taxi service in the county seat.	• The energy supply of the county's population depends on fossil fuels (significant use of natural gas, firewood and coal); • High emissions from energy consumption. • Energy efficiency of public institutions and residential buildings is low. • Low residential renewable energy use. • Poor road conditions contribute to high GHG emissions from transport. • High specific GHG emissions from waste due to inadequate management.
Opportunities	**Threats**
• Increasing the use of renewable energy sources, e.g. creating more solar parks, installing solar panels in public buildings. • Exploiting geothermal energy with significant potential. • There is a much wider potential for biomass utilisation • The wider use of hydropower, e.g. through mobile micro power plants. • Road upgrades could reduce GHG emissions from transport • Expanding the fleet of electric vehicles.	• GHG emissions from the transport sector may increase. • Storm damage may harm forest cover, resulting in reduced CO2 sequestration capacity. • The likelihood of forest and vegetation fires on hot days may increase. • Reduced summer precipitation may reduce hydropower production. • The volume of illegal logging may increase.

Natural and built environment, disaster management

Strengths	Weaknesses
• The area has outstanding natural values, rich in flora and fauna, also at European level. • The proportion of protected areas is steadily increasing. • Flood safety in the basin has increased with the development of river basin management and a flood warning system. • The range of natural and landscape features to be protected is well defined. • Local policy is committed to tackling environmental problems.	• Due to the former salt mining, there is a significant formation of salt deposits, collapse of areas, and risk of water pollution. • The remediation of contaminated industrial sites is not progressing at a sufficient pace. • There is a significant risk of landslides in mountain and hilly catchments. There is a risk of flooding and inundation in low-lying areas. • Risk of storm damage to old housing and public buildings, or housing built with inadequate materials and technologies. • Significant areas of underutilised brownfield sites. • Damage to nature caused by illegal dumping of waste. • Ineffective action by public authorities to tackle nature damage.

Opportunities	Threats
• International cooperation to tackle environmental damage from mining. • Establish a water retention management system. • Fixing unstable slopes. • Develop environmental information services to underpin local climate action. • Development of a geo-spatial management system, monitoring of vulnerable ore deposits. • Increasing the proportion of green areas in cities and towns.	• Flood and inland water risk is increasing due to the increase in the number of days with extreme precipitation. • The number of downhill mass movements increases. • Changes in the costs required to maintain public parks due to the expected impacts of climate change (additional use of irrigation water). • Forest and vegetation fires will increase. • Risk of forest and vegetation fires in monumental wooden buildings.

Society, human health

Strengths	Weaknesses
• Within the catchment area, Transcarpathia has the highest proportion of people under 15. • Natural factors are highly favourable for ensuring a healthy and high quality of life. • Unemployment has decreased significantly in recent years. • Life expectancy at birth is higher than during the regime change. • Multiculturalism characterises the county.	• The population is steadily declining. • Selective migration, mainly of young people, is significant. • There are also a number of segregated areas in the area. • Climate awareness among the population is not high enough. • The health status of the population is inadequate. • Untreated groundwater is consumed in large parts of rural areas and there is a lack of sanitation.
Opportunities	**Threats**
• Strengthening day care for the elderly and the medically needy. • Developing an information, early warning and alert system. • Installing heat-relieving devices in public spaces in urban environments, such as ste arch. • Setting up energy awareness centres in district headquarters. • Developing a heat alert plan for municipalities with a population of more than 10 000 inhabitants. • Ensure clean drinking water by eliminating groundwater wells. Complete the sewerage system in the county.	• Further population decline is likely. • Increasing excess deaths due to heatwave days. • Increased concentrations of particulate matter due to increased dry periods. • During the summer drought period, drinking water crises may occur due to the drying up of groundwater wells. • New subtropical pests and pathogens may emerge as climate belts shift further north due to climate change. • Risk of contamination from illegal dumping may increase.

Economy (Industry, Agriculture)

Strengths	Weaknesses
• There are good opportunities for international economic relations. • The tourism base is strong and the area has marketable destinations. • Conditions for profitable agriculture are in place. • Effective implementation of projects for the economic, nature conservation and mobility development of the four countries of the basin, provided by the European Union. • The high proportion of agricultural land has considerable potential for biomass production. • The mountain areas have considerable potential for wind energy.	• The county is economically peripheral in the country. • The volume of foreign investment is low. • Outflow of skilled labour. • The existence of rust belts is still a problem. • The proportion of irrigated land has fallen sharply. • Illegal logging is a problem.
Opportunities	**Threats**
• Increasing funding for climate change. • Encouraging industry to use renewable energy sources and energy efficient production methods. • Marketing and community development to support local economic development based on traditional forms of agricultural production. • Strengthening forestry with processing sectors. • Expansion of irrigated areas.	• The economic gap between the country's most developed regions and Transcarpathia could widen further. • Increasing periods of drought, causing significant crop losses, increase water use in agriculture. • Soil erosion caused by water is the most significant. • Soil contamination in agriculture can lead to groundwater becoming unsuitable for irrigation.

Utilities (water, waste management)

Erősség Strengths ek	Weaknesses
• High proportion of dwellings connected to the water network in the largest municipalities of the county • Gas supply is available in a significant area of the catchment. • Electricity networks cover almost the entire catchment area. • Inland stormwater drainage is available in many areas. • Municipal waste collection is well organised in the more developed regions of the catchment. • The amount of separately collected waste is steadily increasing. • The infrastructure for municipal waste collection in the territory of Transcarpathia is continuously being developed with the help of national and international funds.	• In rural areas, there is a low level of wastewater and stormwater drainage. • Rural areas have very low levels of piped drinking water supply, with drinking water being supplied from groundwater wells. • Much of the electricity is supplied by overhead lines on wooden poles. • In mountain areas, the lack of landfills or inadequate waste disposal is a major problem. This results in a high waste load to water courses, mainly in the form of PET bottles. • Legal and technical obstacles to landfilling in mountainous parts of the river basin. • The water supply network is ageing in some areas with an average water loss of around 20%.

Opportunities	Threats
• Changing the technical and legal requirements that prevent the establishment of landfills. • Developing a climate-resilient utility infrastructure. Mainly by eliminating overhead power lines. • Increasing the proportion of households participating in regular waste collection. • Develop a waste management system in Transcarpathia. • Promote selective waste collection. • Create conditions for selective waste collection. • Creating conditions for biogas utilisation in waste water treatment plants and livestock farms. • Extension of the sewerage and stormwater drainage system to cope with increased run-off. • Use of water from mountain streams for centralised supply to the population.	• Paved surfaces, roads, railway embankments are washed away underneath by an increase in the daily rainfall intensity index. • Storm damage can damage overhead power lines. • Overloading of storm drainage and sewerage systems due to sudden heavy rainfall. • Heavy rainfall events can damage water pipes due to underwater flooding. • Drinking water shortages may occur in mountainous areas with poor water management due to a drop in groundwater levels as a result of the lack of rainfall in summer. • Increased electricity and water demand due to heat wave.

Transport

Strengths	Weaknesses
• Continuation of the M3, M34 motorway to the Ukrainian-Hungarian border. • Existence of rail transport, most of the cross-border sections are electrified. • The proportion of paved surfaces is constantly increasing, improving transport conditions and quality of life. • The area is well served by airports and air traffic conditions are good.	• The condition of many roads is extremely poor. • Low passenger numbers due to poor quality of rail sidings. • The Ukrainian broad gauge railway makes international traffic and transport difficult. • Traffic through towns and cities puts a strain on the urban road network. • The cycle network in the municipalities needs further improvement. • The difficulty of crossing the Schengen borders is an obstacle to maintaining economic and people-to-people links and to developing new ones.
Opportunities	**Threats**
• Improving the unpaved road network. • Modernisation of rail transport: extension of electrified lines. • Modernise and increase the number of border crossings (local border traffic) • Construction and improvement of bypass roads to reduce traffic and noise • Improve cycling transport infrastructure. • Develop green or low emission local public transport. Preferably with electric buses. • Public awareness campaigns to promote the use of public transport.	• The pavement of roads, railways, pavements and cycle paths are being washed away underneath during periods of extreme rainfall. • Overhead power lines damaged by storm damage can hamper transport and infrastructure. • Asphalt surfaces melt and deform due to an increase in the number of heat days. • Broad railway gauge tracks in Ukraine slow down the flow of goods with other countries in the region.

Tourism

Strengths	Weaknesses
• Most tourism sectors in the area are present. • Conditions for recreational and health tourism are particularly favourable. • The conditions for ecotourism and white-water rafting are good, and further infrastructural development is justified. • Significant investments have been made in ski tourism.	• Some tourism businesses are undercapitalised. • Pollution of rivers and stagnant waters has a negative impact on water sports and angling tourism. • Infrastructure conditions do not always meet the needs of tourists. • The environmental impact of tourists is increased, and waste disposal is not addressed.
Opportunities	**Threats**
• Tourism planning should take into account the expected impacts of climate change. • Diversification of tourism, e.g. ecotourism, cultural tourism, health tourism, conference tourism dissemination. • The conditions for ecotourism and white water rafting are in place and further infrastructural development is justified. • The summer tourist season is expected to be extended due to global warming.	• Conditions for water sports will deteriorate as drought periods increase. • Ecotourism conditions will change due to the destruction of vegetation by insect pests. • Roads, railways, pavements and cycle paths being washed away underneath during periods of extreme rainfall, which may lead to a deterioration in accessibility. • Reduction in the number of days with snow cover will shorten the ski season, which could lead to losses for the sector. • Border crossing points are few and traffic is slow, which could reduce the number of foreign tourists and transit passengers.

One of the main characteristics of the Upper Tisza catchment area is that it lies within the territory of four countries. Among the countries in the basin, Slovakia and Hungary have been members of the European Union since 2004, while Romania joined in 2007. An Association Agreement between Ukraine and the EU has been concluded and entered into force on 1 September 2017. The regions are generally considered to be partially or completely peripheral, located far from the country's capital. The four administrative divisions all have a per capita gross domestic product and a net income per capita below the national average. In addition, all sub-regions are characterised by a dichotomy between the living standards of the rural and urban population. Of the 3.4 million inhabitants, 53 % live in rural areas, compared to a proportion of 63 % in Transcarpathia. It is generally true that for social groups in lower socio-economic positions, climate change issues are less important than other problems.

The population is steadily declining throughout the whole catchment, in line with European and national trends. At the same time, the aging of the population is observed, which has a very negative impact on the functioning of society in the context of the expected negative effects of climate change. It should be stressed that the urban population is steadily increasing in the area, leading to urbanisation, although the extent of this urbanisation varies from one part of the territory to another. The process of urbanisation is unfavourable because of the negative effects of the development that goes hand in hand with urbanisation: overheating of large paved areas, poor air circulation caused by tall, poorly sited buildings and concentrated point-source excess emissions, which create a specific urban climate. One of the effects of this is excess heat, which is particularly problematic in the summer season, when temperatures are an additional 2-5 °C above those of the surrounding areas. To address this problem, the last decade and a half or two decades have seen a rush to install air conditioning equipment, the energy demand of which contributes to the increase in GHG emissions. However, the increasing energy demand has been followed only slowly by the use of renewable energy sources. In the whole catchment area, heating with inappropriate materials (damp wood, furniture board, varnished wood, plastic, clothing) is a feature of the rural population, mainly of lower income. In addition to higher carbon dioxide emissions, heating with these materials releases a number of particularly harmful substances into the atmosphere.

GHG emissions from the large industrial sector are significant in the region, and there is no prospect of a decisive reduction in the near future. The high proportion of forested areas in the catchment area is encouraging. It is particularly noteworthy that it is close to 20 % in the lowland areas too. Due to the high proportion of forested areas, the CO_2 sequestered is about 13.5 % of total emissions. Taking into account the EU Council Decision of 21 April 2021 to reduce GHG emissions by at least 55% by 2030 compared to 1990 levels, while continuing to increase forest areas, further drastic steps need to be taken to reach the target.

The vulnerability of forest areas will increase due to increased storm damage, forest and vegetation fires, and shifting climate belts, as new insect and fungal pests emerge. A multi-sectoral approach is needed to protect forest areas.

Another negative consequence of climate change is that the reduction in summer rainfall will reduce the efficiency of hydroelectric power plants in the area, thus putting energy security at risk.

Agriculture, traditionally strong in the region and with a long tradition, will be hit hardest by the increase in drought periods. In addition to crop losses, drying of land may contribute to forest and vegetation fires and increased wind-induced soil erosion. Increasing the proportion of irrigated land is the best way to address this problem, but further drainage of soil and sheet water is not a long-term and environmentally sound solution, as it may lead to further groundwater subsidence and secondary salinisation. In addition to wind erosion, furrow erosion due to run-off water on slopes could cause significant problems as the number of extreme rainfall days increases.

Although GHG emissions from waste do not represent a large share of total emissions, their amount can be significantly reduced through appropriate collection and treatment technologies. In the district of Kosice, a reduction in municipal waste is already observed, which is a next target to be set. PET bottles and other plastic waste entering watercourses, in addition to damaging the environment, are also detrimental to tourism by spoiling the overall aesthetic image of the area.

In addition to waste collection, the availability of piped water and wastewater networks is a good indicator of a region's vulnerability to climate change. The whole catchment area is characterised by continuous network expansion, but there are also significant differences in this respect. The best performers in this respect are in the counties of Szabolcs-Szatmár-Bereg and the district of Kosice, while the counties of Satu Mare and Maramures are showing a steady catching-up trend. In Transcarpathia, there are significant shortcomings, mainly in rural areas. The main problems here are the high unit costs of installing and maintaining the systems and the lack of adequate funding. Efforts should be made to upgrade the technical condition of the existing systems, as the poor condition of the water pipelines is associated with significant leakage. The systems need to be prepared and the network expanded to meet the growing demand for water due to climate change. This is particularly important in areas where groundwater is currently the source of drinking water for the population, as its quality may worsen in the future.

In the 21st century, tourism income is becoming an increasingly important part of national economies. This is also true for the Upper Tisza basin. Spa tourism, with its long tradition, has developed significantly, with the addition of wellness and health services, but there are also significant regional differences. The development of this sector is also of particular importance because it is the least exposed to the risks of climate change. Sport and angling tourism linked to rivers is even more at risk, as the reduction in summer rainfall is likely to lead to a significant reduction in water yields, which could also lead to a deterioration in water quality. The operation of many ski resorts in the higher parts of the catchment could be threatened by the reduction in the number of winter days with frost and snow cover. In addition to the shortening of the ski season, the summer tourist season is expected to be extended, so that the overall reduction in revenue sources may be less significant. For particularly fragile mountain habitats, the increase in visitor numbers may cause additional environmental problems in addition to direct disturbance.

Overall, the strengths and weaknesses of the river basin are largely influenced by the spatial differences between administrative units. This is determined by the social, economic and environmental characteristics of the administrative unit concerned, as well as the state of the natural environment, the state of environmental protection and the environmental awareness of the population. The main strengths of the river basin are the substantial forest areas, the protected areas of high importance and the high density of watercourses. The strong agricultural tradition also provides a good basis. There is significant potential for solar, hydropower and geothermal energy. A large number of energy efficiency and climate and energy awareness projects have been implemented recently.

6. Awareness raising, situation assessment in the Upper Tisza river basin

The effects of global climate change are already being felt today and are having a major impact on the countries of the Upper Tisza basin. Public interventions and support are essential for Member States to meet their energy efficiency obligations under Directive 2012/27/EU and their renewable energy obligations under Directive 2009/28/EC. This chapter will describe their practice in each country, including good practices on awareness raising.

6.1. Hungary, Szabolcs-Szatmár-Bereg county

6.1.1. Awareness-raising projects

In recent years, several awareness-raising projects on climate change have been implemented in the county, using a variety of sources. These programmes have been funded through several types of grants:

1) KEOP 6.1.0 - Campaigns to promote sustainable lifestyles and related behaviours (awareness raising, information, training);
2) KEOP 6.2.0. - Exemplary projects to promote and disseminate more sustainable lifestyles and consumption options.
3) KEHOP-5.2.2-16 - Priority energy efficiency improvements in public buildings
4) TOP-3.2.1 - Energy efficiency upgrading of municipal buildings
5) GINOP-4.1.1 - Support for energy efficiency improvements in buildings using renewable energy sources and increasing energy efficiency

It is important to highlight one of the targeted projects, KEHOP-1.2.0-15 (Development of a Climate Strategy, Establishment of a Climate Change Platform in Szabolcs-Szatmár-Bereg County), which enabled the development of the County Climate Strategy.

Among the projects, it is important to highlight the KEHOP-1.2.0-15 (Development of a Climate Strategy, Establishment of a Climate Change Platform in Szabolcs-Szatmár-Bereg County) programme, which enabled the development of the County Climate Strategy, and the TOP-3.2.1-15-SB-2016-00062 programme, which enabled the development of the SECAP document (Sustainable Energy and Climate Action Plan for Szabolcs-Szatmár-Bereg County), which formulated the possibilities for the practical implementation of the development framework defined by the Climate Strategy.

A list of county projects implemented with different types of funding is given in Table 6.1.1.

Name of the project	Szabolcs-Szatmár-Bereg county	Borsod-Abaúj-Zemplén county Bodrogköz
GINOP-4.1.1-8-4-4-16 - Support for building energy improvements using renewable energy through a combined loan product	3	2
GINOP-4.1.2-18 - Support for building energy improvements using renewable energy	21	1
GINOP-4.1.4-19 - Support for building energy improvements to increase the use of renewable energy and energy efficiency	218	25
KEHOP-5.1.2-17 - Promoting renewable green electricity production	1	0
KEHOP-5.2.10-16 - Tendered building energy improvements for budgetary authorities	5	1
KEHOP-5.2.2-16 - Priority energy efficiency improvements in public buildings	7	0
KEHOP-5.2.3-16 - Churches' building energy improvements with the possibility of using renewable energy sources	9	0
KEHOP-5.2.5-16 - Establishing near-zero energy demand buildings	2	0
KEHOP-5.3.1-17 - Energy modernisation in the district heating sector	0	1
TOP-3.2.1-15-SB1 - Energy modernisation of municipal buildings	92	7
TOP-3.2.2-15-SB1 - Implementing a municipal-driven energy supply based on local conditions and exploiting renewable energy sources	8	0
TOP-6.5.1-16-NY1- Municipal buildings energy modernisation	13	0
VP-5.1.1-16 - Investments related to climate change and weather risk prevention	171	6
GINOP-8.4.1/A-17- Loan to increase energy efficiency and use of renewable energy in residential buildings	5	3

Table 6.1.1: Number of ongoing and completed projects promoting awareness-raising in Szabolcs-Szatmár-Bereg county and in the Bodrogközi municipalities of Borsod-Abaúj-Zemplén county

6.1.2. Good practices in awareness-raising

1. TOP-3.2.1-15-SB1 - Energy modernisation of municipal buildings
Energy upgrading of the Social Centre of Fehérgyarmat - thermal insulation of 3 buildings, boiler replacement, solar panel system.

Municipal Social Center Fehérgyarmat Tömöttvár u. 29-31. no. 3. residential home for the elderly: the building was built with 30cm thick brick masonry. The thermal insulation is inadequate.

The heating is provided by energy-saving condensing boilers and panel radiators. The external façade is insulated with 15cm of thermal insulation system, the plinth is insulated with 10cm of thermal insulation system with thin layer plaster. For renewable energy purposes, a grid-connected solar system was installed for central heating, hot water production and electricity generation.

2. TOP-3.2.1-15-SB1 - Energy modernisation of municipal buildings
Rakamaz, Ady Endre street Primary School building modernisation

The project aims at the energy efficiency-oriented improvement of a 100% municipality-owned building (façade insulation, replacement of windows and doors, heating modernisation, lighting modernisation), which will result in a reduction of greenhouse gas emissions from fossil fuels.

3. TOP-3.2.1-15-SB1 - Energy modernisation of municipal buildings
Development of sustainable energy and climate action programmes in Szabolcs-Szatmár-Bereg county
The aim of the project is to prepare a Sustainable Energy and Climate Action Plan (SECAP). As a result of the project, the municipalities in Szabolcs-Szatmár-Bereg county will have a SECAP document, which will result in climate adaptation and consequently climate change prevention aspects will apply. In addition to this, they will be able to make use of a professionally prepared document in the course of a future development and regulation, which will also take climate change and energy use into account.

4. KEHOP-5.2.2-16 - Priority energy improvements in public buildings

Energy improvement of the buildings of the Police Headquarters of Szabolcs-Szatmár-Bereg County

The immediate objective of the investment is to reduce the energy consumption of the buildings of the Police Headquarters of Szabolcs-Szatmár-Bereg County by increasing energy efficiency and using renewable energy sources, thus reducing greenhouse gas emissions and dependence on fossil fuels. The objectives of the project are to comply with the energy efficiency directives set by the European Union and to modernise the energy performance of the buildings concerned by the development, reducing their maintenance and operating costs.

5. GINOP-4.1.4-19 - Support for building energy improvements to increase the use of renewable energy and energy efficiency

Complex energy modernisation of the factory building of FRONTALIT Ltd. - Vásárosnamény, Nyíregyházi út (street)

The existing slab / ceiling will be covered with 2 x 15 cm thick polystyrene sheet insulation. On the masonry part of the building, a 15 cm thick polystyrene façade thermal insulation is applied with a smooth face plaster finish. The planned building will be fitted with insulated plastic windows and doors with increased air tightness. Metal gates will be replaced by insulated sectional industrial gates. Energy-saving upgrading of the entire heating system of the factory building (boiler, distribution lines, radiators, variable speed pump) Energy-saving upgrading of the lighting system of the factory building with ceiling-mounted LED luminaires.

6. GINOP-4.1.2-18 - Support for building energy improvements using renewable energy

Energy modernisation of a production hall in Nyíregyháza

The development consists of two main parts: firstly, the energy modernisation of the office and production hall where the company is located, and secondly, heating modernisation using renewable energy is carried out. The first aspect was justified by the need to significantly improve the thermal performance of the building. Its external insulation is inadequate and the nearly 40-year-old windows and doors are no longer of the required quality. Therefore, the external insulation of the building will be completed with a 10 cm sandwich panel system.

The insulation of the flat roof is a necessary and important element of the content, as it reflects the original state of the building when it was built. Another part of the improvement is the heating modernisation based on renewable energy. The previous heating system is completely outdated and has a high failure rate and is very expensive to run. The conversion of the heating plant will involve the installation of 3 Kroll MOS air heating boilers with Kroll KG/UB oil burners using rapeseed oil, thus significantly reducing the costs of the business. Overall, the above improvements will reduce the company's energy consumption by about a quarter.

7. KEHOP-5.2.5-16 - Construction of near-zero energy buildings as a pilot project

The aim of the development is to create a near-zero energy sports facility as a pilot project in Kisvárda. Planned public function: football and handball sports college. The building to be constructed has a net heated area of 3050 m2, with 60 residential units suitable for accommodating 120 people, and also has rooms for educational and community use.

8. GINOP-4.1.1-8-4-4-16 - Support for building energy improvements using renewable energy through a combined loan product

Building energy development at Sort Pack Kft. in Tiszakanyár

The building is not externally insulated, its windows and doors are partly outdated, the insulation of the slab is poor and incomplete, the heating system is energy-wasting and outdated, the lighting is traditional and not up-to-date. Investment planned: external insulation 15 cm thick, insulation of the slab with 12 cm thick sandwich panels, replacement of windows and doors where necessary, installation of a new energy-saving heating system with condensing boilers, LED lighting, solar panels.

Overall, the county has a number of projects that will help to develop and improve energy and climate conscious attitudes in society. In addition, it is important to highlight the usefulness of the future planned programme(s) in reinforcing energy and climate conscious attitudes.

6.2. Romania, Maramures and Satu Mare counties

6.2.1. Awareness-raising activities in the county of Maramures

The county of Maramures has a relatively high potential for energy production from renewable energy sources. In terms of solar energy, the county's potential in terms of solar radiation intensity varies between 1100 and 1300 kWh/m2/year. In terms of renewable energy sources, besides solar energy, hydropower is the most common in the county.

The following municipalities have solar parks installed in the county:
Nagybánya (Baia Mare) (0,72 MW), Koltó (Coltău) (0,98 MW), Kővárremete (Remetea-Chioarului) (0,224 MW), Nagynyíres (Mireșu Mare) (3,917 MW), Szilágyegerbegy (Tămășești) (3,522 MW) and the Lénárdfalva (Recea) (4,55 MW), as well as Farkasrév (Vadu Izei) (2,90 MW), Erzsébetbánya (Băiuț) (0,874 MW), Magyarberkesz (Berchez) (4,374 MW), Égerhát (Ariniș) (0,799 MW), Kővárhosszúfalu (Satulung) (0,565 MW), Koltó (Coltău) (2,5 MW), Lacfalu (Șișești) (0,15 MW)), Macskamező (Răzoare) (0,99 MW), the upper reaches of the Szőcs-stream (Suciu-Minghet) (0,98 MW), Nagysikárló (Cicârlău) (0,95 MW) and Szinérváralja (Seini) (0,315 MW).

In Maramures County there are 19 micro-hydroelectric power plants in operation, 15 of which are located in protected areas, on the waterways of Firiza, Chiuzbaia, Mara, Vişeu, Valea, Neagră, Săsar, Baicu, Șuior, Săpânța, and Suciu waterways.

In recent years, there have been investments in the use of renewable energy in the public sector, financed by the Environmental Fund administration, in Baia Mare (installation of heat pumps at the ANL block), in Călinești, and Cernești (installation of solar panels on public buildings). Several hundred households in the county have also been equipped with such equipment under the "Green House" programme. In Baia Mare and Kopalnic-Mănăștur, street lighting modernisation was carried out through tenders.

In addition, the Maramures County Council and the Energy Management Agency have developed a County Energy Action Plan for 2011-2020 in the framework of the "MORE4ENERGY" project, funded from the INTERREG IVC programme. Heating in the county is based on two main sources of energy: natural gas (mainly in urban areas) and wood (mainly in rural areas). In 2009, the county's energy consumption was estimated at 3.989

million GJ according to the CORINAIR inventory, of which 84.2% was wood, 14.1% natural gas and 1.7% fuel oil. Of the energy consumed in the Maramures department, 95.5% came from the national energy system and only 5.5% from the hydroelectric power plants in the Maramures.

The action lines set out in the 2011-2020 County Energy Action Plan aim to improve the energy efficiency of residential and public buildings, promoting investment in renewable energy, including street lighting, reducing emissions from transport and improving urban networks. These measures will mitigate the increasing dynamics of energy consumption in the county.

It is worth mentioning that the Energy Management Agency (AMEMM), set up within the framework of a project funded by the EACI and the Maramures County Council, is active at county level and promotes energy efficiency and management. In 2015, the Energy Management Agency and the Maramures County Council completed the project "Sustainable Energy Demonstration Education Centre - SEED", funded by the Joint Operational Programme for Cross-border Cooperation Hungary - Slovakia - Romania - Ukraine 2007-2013. This included the rehabilitation and modernisation of a building whose energy consumption is now close to zero. On the other hand, in the field of renewable energy, the county has been provided with educational equipment which will be used in education and training and applied in demonstration lessons.

6.2.2. Projects under implementation in Satu Mare County

Projects under implementation:
Regional management and recovery of urban waste in Satu Mare County

Financing scheme: the project is financed by the Romanian Ministry of Environment through the "Integrated Municipal Waste Management System" programme, with 75% of the total eligible expenditure. The project is implemented by Satu Mare County Council and the project is financed by the Romanian Ministry of Environment and Satu Mare County on the basis of the provisions of the agreement No. 5549/2006.10.26. It is based on the Financing Agreement with subsequent amendments and additions.

Financing agreement duration: 2006 - 2019, total project value: 117,049 thousand leu (RON). The main objective of the project is: implementation of a regional municipal waste management system in Satu Mare County by building basic infrastructure (regional landfill to ensure the reception and processing of waste generated in Satu Mare County - composting, sorting and final disposal for about 22 years), building supporting infrastructure, establishing waste transfer stations, closing non-organic landfills, and purchasing waste collection and transport equipment.

Deliverables: Satu Mare - Doba regional landfill, which started operations in August 2011.

Overall, the awareness-raising projects in the two counties require a gradual shift, as the use of climate-conscious technologies is not popular in the region and the private sector has a minimal involvement. However, the geographical conditions allow for the installation of more solar or even wind power plants in the region.

6.3. Slovakia, Kosice region

6.3.1. Awareness-raising projects

In the region of Kosice, several awareness-raising projects on climate protection have been implemented in recent years. The projects are co-financed by the Slovak Republic and/or the European Union.

The projects cover three main areas: preparing climate strategy and energy efficiency plans, modernising buildings and improving air quality.

Name of the project	**Time and place of project implementation**
Plan for the use of renewable energy sources in the region of Kosice for sustainability and energy efficiency	Place of implementation: Kosice, total cost: 66.500 EUR Completed in 2015
LIFE IP - Improving air quality	The total budget of the project is €15,000,000, with EU financial support of €9,000,000.The project is divided into four phases and will run for eight years (2020 - 2027).
Low carbon-dioxide-emission strategy for organisations in the municipality of Kosice	Total amount of eligible expenditure: EUR 299.897,50
Reconstruction, modernisation and increasing energy efficiency in the area of Trebisov	NFP amount: EUR 3.074.983,13

Plan for the use of renewable energy sources in the region of Kosice for sustainability and energy efficiency

The project aims to increase regional energy security and to create a tool for territorial planning and programming of regional energy system activities.

Specific objectives of the project:

- To establish the plan as a basic planning and information base to increase the use of renewable energy sources and accelerate energy security in the region

- To analyse the current energy situation in the region and to assess the feasibility of using the regional potential of renewable energies
- Preparation of a statutory SEA evironmental assessment
- Proposing measures to increase the region's energy security with regard to its sustainability, efficiency, for the parts and sectors of the territory

The main activities of the project are:

- Regional analysis of the current energy situation
- Assessment of the feasibility of using the regional potential of renewable energies
- Energy security of the region - development scenarios, solution models, proposals for types of renewable energies, measures to increase energy security and economic growth in the region, proposals for the use of renewable energies

Project results:

- preparation of the relevant basis for the preparation and updating of the spatial planning documentation necessary for the optimisation of the energy system of municipal facilities
- reducing the region's dependence on imports of fossil fuels and external energy, increasing the energy efficiency and thus the competitiveness of the regional economy
- reducing regional energy prices in the community and economic spheres, with a positive social impact on the population, depending on the local potential for renewable energy

LIFE IP - Improving air quality

Improving the implementation of air quality improvement programmes in Slovakia by strengthening the capacity and competence of regional and local authorities and supporting air quality measures. It will focus on the implementation of specific actions to improve air quality and will also support the education, communication and monitoring activities of the participating quality partners.

The total budget of the project is €15,000,000, with EU financial support of €9,000,000. The project is divided into four phases and will run for eight years (2020 - 2027).The project involves: the Ministry of Environment of the Slovak Republic, the Slovak Environment Protection Agency, the Banská Bystrica Region, the Trenčín Region, the Trnava Region, the

WrocBaw Region, the Severopovažský Region, the Prešov Region, the Kosice Region, the Slovak Hydrometeorological Institute, PEDAL Consulting sro, VŠB - Technical University of Ostrava.

The main objective of the project is to improve air quality and reduce exposure of the population to harmful air pollutants.

Specific objectives of the project:

- Improving effective air quality management and implementing air quality improvement programmes
- Promoting air quality measures and raising awareness of the importance of air quality
- Speed up the implementation of actions to minimise the negative impacts of domestic heating and transport on air quality
- Subsidy for the replacement of boilers for domestic heating purposes
- Improving air quality monitoring at regional and local level

To achieve the objectives of the project, each partner will carry out the following activities:

The employment of air quality-managers. As part of this task, the human capacity of regional and national authorities will be increased. Air quality managers will work in 7 municipal regions, in selected cities and towns where air quality needs to be improved. A coordination unit established at the Ministry of Environment of the Slovak Republic will manage the work of the air quality managers.

Awareness-raising campaigns and educational programmes to promote air quality actions and raise awareness of the importance of air quality. The aim of this action is to prepare and implement educational programmes and information activities that will raise awareness among local officials and the public of air pollution, its causes and consequences; and to support initiatives to improve air quality, involve the public and provide information on the support instruments offered. The education programmes are primarily aimed at representatives of local authorities, teachers, students and pupils.

Pilot projects with the aim of developing feasibility studies on transport solutions to improve air quality in selected cities.

The main objective of this activity is to encourage selected cities in the field of air quality management, where the main air quality problems are caused by transport, to ensure that feasibility studies are carried out on transport solutions to improve air quality, such as intelligent traffic management, the development of low emission zones or the introduction of charging for access to cities.

Low carbon-dioxide-emmision strategy for organisations in the municipality of Kosice district

Type of activity: development and implementation of low-carbon emission strategies for all types of areas, in particular for the urban areas, including the updating and implementation of municipal development concepts in the field of thermal energy

Duration of the main project activities: 18 months

Location:: Kosice - city districts: North, Old Town, Lorinčík, Myslava, Poľov, KVP settlement, Šaca, West, Dargovských hrdinov, Barca, South, Krásna, Nad jazerom, Šebastovce, Vyšné Opátske, Gelnica, Prakovce, Kráľovce, Kysak, Moldava nad Bodvou, Michalovce, Rakovec nad Ondavou, Strážske, Veľké Kapušany, Dobšiná, Rožňava, Sobrance, Krompachy, Spišská Nová Ves, Čierna nad Tisou, Kráľovský Chlmec, Pribeník, Sečovini, Trebiš

The main aim of the project is to create the conditions for activities aimed at reducing greenhouse gas emissions and thereby become the key document in the region's fight against climate change.

The strategy document assesses the state of the environment and suggests possible measures for low-carbon action. Energy efficiency and the use of renewable energy sources, with a particular focus on reducing greenhouse gas and air pollutant emissions. A regional low-carbon emissions strategy will be developed using the methodology of the Covenant of Mayors' Sustainable Energy Action Plan, for a minimum period of 5 years.

Reconstruction, modernisation and increasing energy efficiency in Trebisov (https://www.crp.gov.sk/50938-sk/rekonstrukcia-modernizacia-a-zvysenie-energetickej-ucinnosti-v-zps-a-dss-trebisov/)

The project aims to increase the availability and quality of civil infrastructure and facilities in the region, and to improve social services, and the infrastructure of social protection and social welfare services.

Specific objectives of the project:

- improving the quality of inadequate accommodation
- reducing energy intensity
- the creation of a universal data network

Project activities:

- improving the quality of accommodation and health facilities
- construction of lifts and implementation of accessibility
- replacement of old windows and balcony doors
- installation of solar panels
- expanding rehabilitation activities
- the creation of a universal data network
- the purchase of equipment for the renovated premises, including the purchase of new adjustable beds

Project results:

- separate bathroom for each room, the facility is handicapped accessible
- expansion of rehabilitation areas
- Internet access, installation of security and surveillance cameras, possibility to access telecommunication services

Several awareness-raising projects have been launched in the Kosice region, which can significantly encourage the population to adopt climate-conscious technologies. Overall, it can be said that a good number of awareness-raising projects should be launched in this region in the future in order to consolidate social awareness.

Source: https://web.vucke.sk/sk/uradna-tabula/projekty/implementovane-projekty/rekonstrukcia-modernizacia-zvysenie-energetickej-ucinnosti-zps-dss-trebisov.html

6.4. Ukraine, Transcarpathia

6.4.1. Awareness-raising activities

Environmental education and information in Transcarpathia is continuously organised by the Transcarpathian County Administration and its offices. In order to raise the awareness of the young generation about environmental problems, the development of environmental awareness and the importance of responsibility towards nature, the Government has conducted environmental information and educational activities for children.

In 2018, the environmental authority continued its cooperation with the media, especially with online publications Ukrinform, Uzhhorod. .Net, "Uzhhorod.in", "Time of Transcarpathia".

The Ministry of Environmental Resources is working with the media and regional representatives of the Ukrainian media to raise awareness of current environmental issues in the region, to provide information on the environment and to promote environmental education. Since the beginning of 2018, 208 pieces have been published in the media, including magazines, radio and television broadcasts. All materials are posted on the Ecology Department website (www.ecozakarpat.gov.ua). In addition, information can be found on Facebook social networking sites, providing an opportunity to disseminate environmental information and communicate online with the public in the region. 4 thematic regional conferences were organised and held in 2018 with the participation of a wide range of the public.

6.4.2. Examples of awareness-raising practices in Transcarpathia

Renewable energy projects

In Transcarpathia, developments in the renewable energy sector have taken place in the last five years. In the Unghuta (Гута) municipality in the Uzhhorod district, a 3.5 MW HUTA-2 solar power plant has been set up. The plant is located on a 5.73 hectare site in the mountains. During the construction of the solar power plant, a special SMS-211 mooring system was used to compensate for the unevenness of the terrain conditions.

The second phase of SES Veryatsya-1 and SES Veryatsya-2 were built in the village of Rákospatak (Горбки) in Transcarpathian region. The second phase of SES Veryatsya-1, which was commissioned by Interenergy LLC with a capacity of 1,062.6 kW, consists of almost 4,000 solar panels with a capacity of 275 W each. The second phase of the Veryatsya-2 solar power plant, sold by Aquanova Hydroresource LLC with a capacity of 1362.9 kW, consists of almost 5000 modules. The supplier of the panels for the SES Veryatsa-1 and SES Veryatsa-2 lines is the Chinese company Suzhou Talesun Solar Technologies CO. The supplier of the inverter is Photomates.r.o. which is the official representative of HUAWEI.

A solar power plant with a capacity of 2337 MW has been built near the village of Salanki (Шаланки) in the district of Nagyszőlős (*Виноградів* Vinohragyiv). The project was implemented by Solar Light LLC with its own funds and credit. The solar park consists of more than 22 thousand panels and covers an area of about 10 hectares. The plant produces about 7,300,000 kW/hour of electricity per year. The solar power plant will increase the reliability of electricity supply in the region.

picture 6.4.2. Solar power plant from above with Salank village behind,
Виноградів Vinohragyiv / Nagyszőlősi district
Source: https://ecotown.com.ua/news/Na-Zakarpatti-zbuduvaly-try-sonyachni-elektrostantsiyi

Overall, there is a lack of programmes in Transcarpathia that target energy efficiency and promote climate awareness. Renewable energy use has increased in some municipalities, especially the number and capacity of solar power plants. However, most of these investments are foreign-funded and do not directly affect local residents. In the future, a large number of climate-awareness projects need to be launched.

7. Identifying key strategic interfaces

From the 1990s to the present, three international climate treaties have been concluded and entered into force under the auspices of the UN. The first mandatory international document that directly dealt with the problem of climate change was the UN Framework Convention on Climate Change (UN Conference on Environment and Development, Rio de Janeiro, 1992). The main objective of the Convention is to stabilise atmospheric greenhouse gas concentrations at a level that will prevent dangerous human impacts on the climate system. Developed countries have committed that anthropogenic emissions of carbon dioxide and other greenhouse gases from their countries will be no higher by the end of the 2000s than they were in 1990. The 'transition economy' countries in our region could set an earlier baseline. This framework agreement is still the most fundamental framework for international climate policy negotiations and, through them, for global climate policy.

The Kyoto Protocol was adopted at the 3rd Conference of the Parties in December 1997, but due to a lack of sufficient ratifications, it did not enter into force until much later, in February 2005. It is the second climate policy document with international force, which is a stand-alone international agreement but linked to an existing treaty (the Framework Convention on Climate Change). The Kyoto Protocol required developed countries and countries with economies in transition to make mandatory emission reductions of at least 5.2 per cent per year averaged over the period 2008-2012 compared to the 1990 reference level. The then fifteen EU Member States collectively committed to an 8 per cent reduction (with varying levels of contributions from each Member State). Countries with 'transition economies' committed to average reductions of between 5 and 8 percent.

The third major climate policy document is the Paris Agreement, which was adopted at the 21st Conference in December 2015. The agreement recognises the principle of common but differentiated responsibilities and equity between the developed and developing countries. At the same time, it requires all countries to contribute to keeping the global average surface temperature increase to well below 2°C compared to the pre-industrial average - but preferably not exceeding 1.5°C - but does not set a numerical target for any country. These are the individual commitments, the so called Intended Nationally Determined Contributions (INDCs). Parties ratifying the Paris Agreement are required to declare their climate policy plans for emission reductions and adaptation every five years.

The European Union has been an active participant in climate policy cooperation from the very beginning. The current EU Member States have committed to emission reductions of 8 %, 20 % and at least 40 % under the Kyoto Protocol, the Doha Amendment and the Paris Agreement. The European Union Emissions Trading System (EU ETS) is a key element of the EU's climate change policy. The system covers 45% of EU emissions originating from the energy sector, industry and the civil aviation sector within the European Economic Area. Sectors outside the EU ETS (e.g. buildings, transport, agriculture, waste management) are decarbonised under the rules of the Effort Sharing Decision (ESD).

7.1. National level interfaces

Climate change affects a country's strategic vision at many points. In our view, the most important of these are:

- Climate elements that directly affect our lives, affecting an increasingly wide range of the population (e.g. unexpected and extreme heat waves, stormy winds, etc.).
- Flash floods and inland waterfalls, caused by precipitation falling in very short periods of time, seriously threaten the usability, condition and comfort of dwellings and their associated infrastructure.
- Damage caused by prolonged heat waves and drought, as well as atmospheric drought, is most damaging to traditional agricultural areas, but also poses a serious threat to users of gardens of houses, housing estates, green areas and holiday resorts.
- Extremely hot drought days increase the frequent occurrence of wildfires, which in extreme cases can pose an imminent threat to the lives of people living in the area. The rehabilitation process once these fires have been eliminated is extremely costly and time-consuming.
- The permanent damage caused by the extremes of climate change also seriously affects the infrastructure elements that have the greatest impact on the quality of life in a given area.

In recent years, the key elements of the complex problem of global climate change have been articulated in the formulation of international climate policy. The general formulations of international climate policy should and must be taken into account by all countries. The individual characteristics and potential of the region concerned must also be taken into account when formulating a country's climate policy. The formulation of climate policies in all these areas must also be clearly adapted to the climate strategy of the country, region or area concerned.

In the following, a brief overview of the most important climate policy strategies and regulations at national level in the countries concerned (Hungary, Romania, Ukraine, Slovakia) is presented.

7.1.1. Hungary

7.1.1.1. Second National Climate Change Strategy

The First Climate Change Strategy was adopted by Parliament in 2008. The latest version of the Second National Climate Change Strategy, approved by the Hungarian Parliament, was completed in 2018.

The revised strategy consists of two main pillars. The so-called domestic decarbonisation roadmap sets out the targets, priorities and courses of action for reducing greenhouse gas emissions. Hungary is in a favourable position within the European Union in terms of emissions of these gases, which is largely explained by its low per capita energy consumption, the dominance of nuclear power in energy production and the relatively low specific emissions of natural gas.

According to the strategy, achieving the transition to a low-carbon-economy is not a competitiveness barrier for the Hungarian economy, and can contribute to the modernisation of productive sectors and the re-industrialisation of Hungary through innovation and green economy development. In the medium term, increasing the capacity of the Paks nuclear power plant could be a decisive step in terms of the pollutant emissions of electricity generation.

The second main part of the document is the National Adaptation Strategy, which is based on an assessment of the expected impacts of climate change in Hungary, its natural and socio-economic consequences, and the climate vulnerability of ecosystems and sectors. In setting out the national framework and options for adaptation to climate change, the objectives include the protection of natural resources and stocks, support for the flexible and innovative adaptation of vulnerable areas and vulnerable sectors (including agriculture, forestry, tourism, energy, transport, buildings sector, telecommunications, communication systems) and the improvement of the adaptive capacity of society.

The public policy objective in the development of the second National Climate Change Strategy for the period between 2018 and 2030, which also looks ahead to 2050, was to develop a national climate change strategy that sets out the necessary objectives to manage the impacts of climate change in the long term. This can be achieved in two ways. In line with international efforts, we need to reduce greenhouse gas emissions and increase absorption capacity of carbon dioxide. These steps will contribute to international cooperation on climate protection, which, if successfully implemented, will reduce atmospheric concentrations of greenhouse gases in the long term, leading to a further reduction in the rate of increase in global atmospheric temperatures. In addition to reducing CO2 emissions and increasing absorption capacity, an objective assessment of the impact on the country's territory is needed. Adapting to the adverse consequences of climate change is also in our national interest, considering that climate change is a measurable process today, and will continue to be so, based on current atmospheric concentrations of greenhouse gases, future projected emissions and authoritative scientific projections.

7.1.1.2. National Energy Strategy 2030

The main message and goal of the Energy Strategy is " independence from energy dependence ". To achieve this goal, it proposes five instruments: energy saving, use of renewable energy as much as possible, safe nuclear energy and the electrification of transport based on it, the creation of a bipolar agriculture and connection to the European energy infrastructure. This will guarantee a market purchase price for natural gas, with the application of CO_2 capture and storage (CCS) technologies, allowing natural gas to maintain its dominant role, while domestic coal and lignite reserves (10.5 billion tonnes) will constitute a strategic reserve for the domestic energy sector, while maintaining current extraction capacity and infrastructure. During the energy transition, the following must be achieved:

1) energy efficiency measures throughout the entire supply and consumption chain;

2) increasing the proportion of electricity generated from low CO_2-intensive sources, primarily renewable energy sources;

3) the expansion of renewable and alternative heat production;

4) increasing the share of low CO_2 emission transport modes.

7.1.1.3. National Energy Strategy for Buildings

In Hungary, buildings account for approximately 40 % of the national primary energy consumption, which includes energy for heating, cooling and domestic hot water. This is broadly in line with the share observed in EU Member States with similar natural conditions. A significant proportion of domestic buildings are in an outdated technical and thermal condition, which means that there is considerable potential for energy savings in reducing the energy use of buildings. The share of natural gas in the energy use of the building sector is over 50%. Consequently, energy savings in buildings have a significant impact on the development of natural gas imports. The majority of energy use in buildings is for space heating, and therefore there is a strong seasonality of use. This is a key issue for both gas storage and power management. The objectives of the National Energy Strategy for Buildings are presented at three levels.

Overall strategic objectives:

1) Harmonisation with EU energy and environmental objectives;

2) Building modernisation, as one of the means to reduce household overheads;

3) Reducing budget expenditure;

4) Reducing energy poverty;

5) Employment creation;

6) Greenhouse gas (hereafter: GHG) emission reductions.

In addition, the strategy sets specific targets and energy performance targets for buildings.

7.1.1.4 Energy Strategy and National Energy and Climate Plan

The main objectives of the new Energy Strategy and the National Energy and Climate Plan (NECP) are to strengthen energy sovereignty and energy security, to maintain the results of the cuts in utility bills and to decarbonise energy production, which can only be achieved through the combined use of nuclear and renewable energy. For conventional energy-poor countries like Hungary, energy sovereignty is a matter of welfare, economy and national security. It is in Hungary's clear interest to reduce its energy import needs, while at the same time ensuring its wider connection to the regional electricity and gas networks, which is a guarantee of security of supply and effective import competition.

The cleanest energy is unused fossil energy. This can be achieved by using heating/cooling solutions based on renewable resources, by implementing the Green Thermal Programme and by reducing energy use in public institutions, industry and transport. Due to the high efficiency of electric motors, clear end-user energy savings will be achieved through the uptake of electromobility. And the Green Bus Programme for greening local transport will result in environmentally friendly electric buses in major cities. Energy independence for families can be promoted by supporting renewable energy production in the home for own use and promoting the uptake of smart meters. The Hungarian Government aims to ensure that the largest share of Hungary's electricity generation comes from two sources: nuclear and renewable energy, mainly from solar power. These technologies are not substitutes for each other or mutually exclusive, but mutually supportive solutions, and both can be considered as clean energy sources.

7.1.1.5. National Sustainable Development Framework Strategy

Between 2010 and 2012, the National Framework Strategy for Sustainable Development (NFSSD) was prepared after extensive professional and social consultation, and adopted by Parliament with a parliamentary resolution in March 2013. The objective of the Framework Strategy is to contribute to building a national consensus on sustainability. After all, sustainability is not just a political and governance issue; it is also a matter of individuals, families, businesses and civil society organisations pursuing goals and values, making day-to-day decisions and engaging in initiatives that can ensure a sustainable society. It sets out basic guidelines for the four main resource areas (economic, social, natural and human).

7.1.1.6. National Transport Infrastructure Development Strategy (NTIDS)

The strategy for the period 2014-2050 has its fundamental objective to ensure that transport infrastructure contributes as much as possible to increasing Hungary's competitiveness by efficiently serving economic processes. According to the document's objectives, an equivalent task to increasing competitiveness is to ensure the preservation of natural and human values and resources, the conditions for sustainable growth, and the coordination of environmental and economic, national and EU objectives, which sometimes conflict with each other. In this spirit, environmental considerations are also prominent among the main transport objectives, in the form of 'resource-efficient modes of transport' and the promotion of 'more socially beneficial passenger and freight transport'. In this context, the NTIDS encourages the development and promotion of non-motorised transport (on foot and by bicycle), the development of rail transport in socially justified cases, and the promotion and development of public transport in passenger transport by various means.

7.1.1.7. National Forest Strategy

The National Forestry Strategy mentions climate change as one of the main challenges for forests and forestry, and states that forestry's tasks should not only include adapting to a changing climate, but also contributing to climate change mitigation, because of the excellent carbon-absorbing capacity of forests. For this purpose, the strategy states that "methods and management practices that most effectively promote forest adaptation should be developed and introduced into forest management practices. Climate change considerations should be progressively integrated into forest planning, including site identification and tree species selection."

7.1.1.8. National Water Strategy - Jenő Kvassay Plan

The Kvassay Jenő Plan, i.e. the National Water Strategy, is the framework strategy for Hungarian water management until 2030, which is tasked with setting objectives for the management and status of water, identifying the measures and tasks required to achieve them, and defining the conditions and methods of implementation. To achieve this, the Water Strategy sets out seven key objectives:

1) Water retention and water allocation for better use of our water resources, to support economic water management.

2) Risk prevention water damage elimination

3) Progressively improve water status to achieve sustainable good status.

4) Quality water utility services and quality stormwater management at an affordable cost to consumers.

5) Improving the relationship between society and water (at individual, economic and decision-making levels

6) Renewing planning and management.

7) Reorganisation of the economic regulatory system for water management

7.1.2. Romania

7.1.2.1. Integrated National Energy and Climate Change Plan 2021-2030 (Planul Național Integrat în domeniul Energiei și Schimbărilor Climatice 2021-2030)

The document states that, as regards the share of renewable energy, the European Commission has recommended Romania to increase the level of commitments until 2030, with a minimum share of energy from renewable sources of 34%. Accordingly, the level of commitments for the share of energy from renewable sources has been revised from the initially proposed 27.9% to 30.7%. Thus, in order to reach the 2030 target of 30.7% share of renewable energy, Romania plans to develop an additional 6.9 GW of renewable capacity compared to 2015.

In the document, Romania has committed to a target of 32.3 Mtoe (Mtoe = million tonnes of oil equivalent) of primary energy consumption and 25.7 Mtoe of final energy consumption by 2030, thereby achieving energy savings of 45.1% compared to primary consumption, while reducing final energy consumption by 40.4% compared to 2007.

The decarbonisation targets will be achieved through a combination of emission reduction, energy efficiency improvement and energy security measures implemented partly through the energy sector, the industrial sector, the transport sector and the waste management sector. On the other hand, they intend to promote the use of renewable energy sources in transport (e.g. electric cars, electric buses in urban public transport) and it is also important to increase the use of biofuels as a proportion of total energy consumption.

In the area of energy efficiency, the targets are intended to be achieved through long-term building renovation and modernisation in the residential sector, energy efficiency improvements in the areas regulated by the EU ETS in the industrial sector, and the development and promotion of alternative mobility and the renewal of the vehicle fleet in the transport sector.

7.1.2.2. Romania's Energy Strategy for the period 2020-2030, looking ahead to 2050 (Strategia energetică a României 2020-2030, cu perspectiva anului 2050)

The document outlines Romania's vision for energy strategy, which is nothing less than the growth of the energy sector in conditions of sustainability and economic growth, taking into account the EU's 2030 targets and the European Ecological Agreement 2050. The development of the energy sector should be seen as part of Romania's development process.

On this basis, Romania's energy strategy vision is based on the implementation of eight strategic objectives and the implementation of a priority investment programme to meet the 2030 goals and targets.

The key strategic objectives set out in the document are:

1) Modernising corporate governance and institutional regulatory capacity. As an asset-owner, the state should improve the governance of companies in which it has a stake. State-owned energy companies need to become more efficient, professional and make their managment and operations more modern.
2) Modernising corporate governance and institutional regulatory capacity.
   As an asset-owner, the state should improve the governance of companies in which it has a stake. State-owned energy companies need to become more efficient, and must make their management and operations more professional and modernised.
3) Clean energy and energy efficiency.
   Within the strategy, the actions outlined in this chapter are most closely linked to climate action initiatives. In the development of the energy sector, In the energy sector, Romania is following best practices in environmental protection, while respecting the national targets it has undertaken as an EU Member State. This will require huge investments throughout the technology chain, from electricity generation to smart gas and electricity transmission and distribution networks, as well as the reform of the electricity and gas markets. The implementation of the National Long-Term Renewal Strategy 2050 (Strategiei Naţionale de Renovare pe Termen Lung) will also contribute significantly to improving energy efficiency, both in public buildings and private buildings, both residential and non-residential, as well as in the use of renewable energy sources, in particular in the heating and cooling sector and in decentralised energy production. In addition to the renovation of buildings to improve

their energy efficiency, this project also includes the use of renewable technologies such as the installation of solar panels and heat pumps. By 2030, the increased production of energy from renewable sources will be above 0.2 Mtoe. In Romania, many large industrial consumers will continue to invest in significant energy efficiency measures until 2024, based on commitments made as a result of energy audits. Consequently, by fulfilling the commitments on measures resulting from energy audits and/or good energy management practices, the industrial sector can achieve an annual energy demand reduction of about 0.6 Mtoe in the period 2021-2030. Similarly, annual savings of around 0.6 Mtoe are needed in the transport sector over this period. In order to achieve the annual targets, permanent measures are needed to modernise urban and rail public transport. In this context as required by the European Union directives and national legislation, the development of the energy system will ensure energy efficiency.

4) Ensuring access to electricity, heat and natural gas for all consumers.

   This identified objective sets the priority to complete the electrification of Romania and to maintain the electricity distribution systems, closely connected to the socio-economic development. It also aims to ensure access to natural gas resources by increasing the connection of household consumers to the natural gas distribution network.

5) Protecting vulnerable consumers and reducing energy poverty.The consumer should be at the centre of energy sector development policy, in particular by protecting the vulnerable consumer, by increasing access to energy for the population and by implementing appropriate environmental policies on energy. Access at fair prices is a key challenge and strategic responsibility of the energy system.

6) Competitive energy markets, the basis for a competitive economy.

   The energy system should operate on the basis of free market mechanisms, with the state's main role as policy maker, regulator and investor guaranteeing the stability of the energy system. The ambitious energy and climate goals to be achieved by 2030 call for the development of a new electricity market model aimed at increasing energy efficiency, renewable energy production, food security, sustainability, decarbonisation and innovation.

7) Improving the quality of education and innovation in the field of energy and the continuous training of human resources.

The success in achieving the country's energy vision and related objectives is directly proportional to the investment in the quality of energy education and training and in innovation based on scientific research and technological development.

8) Romania as a regional energy security provider.

   Romania aims to consolidate its regional energy status by developing its energy sector, taking into account the availability of resources and the stability provided by an effective transition to decarbonisation, as well as the maturity of new technologies.

9) Increasing Romania's energy contribution to regional and European markets.

   This objective expresses Romania's vision in the regional and European context and the vision of becoming a major player in the EU in this field.

7.1.2.3. Sustainable Development Strategy for Romania – 2030 (Romania's Sustainable Development Strategy – 2030)

The National Strategy for Sustainable Development of Romania was adopted by the Romanian Government on 9 November 2018 through Government Decision 877/2018. The main chapters of the document are:

1. Introduction (International background of sustainable development; European context of sustainable development; Perspectives of sustainable development in Romania).
2. Sustainable development goals.

In this chapter the strategic objectives are defined, which are:

- The eradication of poverty in all its forms (No Poverty)
- End hunger, achieve food security and improved nutrition, and promote sustainable agriculture (Zero Hunger)
- Ensuring healthy lives and well-being for all ages (Good Health And Well-Being)
- Ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for everyone (Quality Education)
- Gender Equality
- Ensure access to water and sanitation management and sustainable management for everyone (Clean Water And Sanitation)
- The key climate change objective is to significantly increase the efficiency of water use in industrial, commercial and agricultural activities and to ensure the rational reuse of treated and recycled water to meet the requirements of a circular economy. In addition,

water quality should be improved by reducing pollution, eliminating waste disposal and minimising chemical products and hazardous substances, thereby reducing the proportion of untreated wastewater and significantly increasing recycling and safe reuse.

- Ensure access to affordable, reliable, sustainable and modern energy for everybody (Affordable And Clean Energy).

  This objective is very closely linked to climate protection objectives, as follows: decoupling economic growth from resource depletion and environmental degradation by significantly increasing energy efficiency and widespread use of the EU ETS in stable and predictable market conditions. In addition, the share of renewable energy and low-carbon fuels in the transport sector (e.g. through the use of electric vehicles), including the use of alternative fuels, should be increased. In addition, a stable and transparent regulatory framework in the field of energy efficiency should be provided to attract investment.
- Achieving sustained, inclusive and sustainable economic growth, full and productive employment and ensuring decent work and economic growth for everybody (Decent Work And Economic Growth).
- The objective, which is partly linked to climate protection, is to maintain a GDP growth rate above the EU average in order to help reduce the gap between Romania and the more advanced European economies, while respecting the principles of sustainable development and continuously improving the living standards of the population.
- Building resilient infrastructure, supporting inclusive and sustainable industrialisation and stimulating innovation (Industry, Innovation And Infrastructure).

  An objective that is partially linked to climate protection is the restoration of the industrial sector to become sustainable through a more efficient use of resources and the increased use of clean and ecological industrial technologies and processes.
- Reducing inequalities within and among countries (Reduced Inequalities).
- Making cities and towns welcoming, safe, resilient and sustainable (Sustainable Cities And Communities).
- A sub-objective linked to climate protection is to significantly reduce economic losses caused by floods and landslides, improve collective resilience to them, enhance adaptation to the situation, and reduce the pollution caused by floods and landslides in the ecosystem. In addition, reduce the impact of air pollution on human health and the environment, in particular on air quality. Another important objective is to significantly reduce the number of deaths and illnesses caused by hazardous chemicals, pollution and

air-, water- and soil contamination. The protection of cultural and natural heritage and the landscape must be strengthened.

- A Ensuring Responsible Consumption And Production.
- The sub-targets set out here - which also include climate protection - are the following:

  Halve food waste per capita at retail and consumption level and to reduce food waste throughout the production and supply chain, including post-harvest losses.

  Another important sub-target is to recycle 55% of municipal waste by 2025 and by 2030 to recycle 60%. In parallel, 65% of packaging waste (including 50% of plastics, 25% of wood, 70% of metals, 50% of aluminium, 70% of glass, 75% of paper and cardboard) is recycled by 2025, and 70% by 2030 (55% of plastics, 30% of wood, 80% of metals, 60% of aluminium, 75% of glass, 85% of paper and cardboard). Achieve separate collection of household hazardous waste by 2022, of biological waste by 2023 and separate collection of textile waste by 2025.
- Steps to combat climate change and its impacts (Climate Action).

  The main sub-objectives are: to strengthen Romania's flexibility and adaptability to climate-related risks and to natural disasters. The ability to respond quickly to unexpected extreme weather incidents needs to be enhanced. Improve education, awareness, adaptation, human and institutional capacities related to climate change mitigation and reduce the impacts of climate change. Increase Romania's efforts to achieve the transition to a low carbon-dioxide emmission and to a green economy that is resilient to climate change, as well as implement integrated measures in accordance with EU policies in order to adapt to climate change in vulnerable economic, social and environmental sectors.
- Conservation and sustainable use of oceans, seas and marine resources for sustainable development (Life Below Water).

  Among the sub-objectives, the following should be highlighted: prevention and significant reduction of all forms of marine pollution, in particular that arising from land-based activities.
- Protecting and restoring the sustainable use of terrestrial ecosystems, managing forests sustainably, combating desertification, halting and reversing land degradation and halting biodiversity loss (Life On Land).

  A number of sub-objectives have been identified which are directly linked to climate protection: developing green infrastructure and exploiting the potential of natural ecosystems, conserving and protecting wetlands, and preserving mountain ecosystems and their biodiversity. In addition, an important sub-objective is to maintain sustainable forest management, eradicate illegal logging, develop an integrated digital system to monitor timber harvesting and transportation, reforestation of forest areas, afforestation of degraded or desertified areas and the planting of forest strips. Furthermore, the transition to a circular economy, the restoration/reconstruction of natural capital and the reduction of dependence on fertilisers and pesticides, protection against desertification, and halting soil degradation.

- Promoting peaceful and inclusive societies in order to achieve sustainable development, ensuring access to justice and building effective, accountable and inclusive institutions at all levels (Peace, Justice And Strong Institutions).
- Strengthening the means of implementation and revitalising the global partnership for sustainable development (Partnerships For The Goals).

3. Implementation and monitoring.

As can be seen from the above, several objectives and sub-objectives within them are intrinsically linked to climate protection and climate protection measures.

7.1.2.4. National Forest Strategy – 2018-2027 (Strategia Forestieră Națională 2018-2027)

The strategy adopted by the Romanian Government's Ministry of Water and Forests (Guvernul României Ministerul Apelor Şi Pădurilor) in 2017 consists of 9 chapters. The vision of the Forest Sector Development Strategy is "A developing Romania in which the forest sector contributes to the well-being of its people in an economically, socially and environmentally sustainable manner". The overall objective of the strategy is to align forest functions with the current and future requirements of Romanian society, in line with the sustainable management of national forest resources. The document identifies 5 main objectives:

1) Simplification of the institutional and regulatory framework for forestry activities.
2) Sustainable management of national forest assets.
3) Increasing the competitiveness and sustainability of forestry, bioenergy and bioeconomy.
4) Develop an effective awareness and communication system.
5) Improving scientific research and forestry education.

The National Forest Strategy for the period 2018 - 2027 sets out a long-term vision and medium-term strategic objectives. The document states that, according to the National Institute of Statistics, the total area of the national forest base in Romania is about 6.559 million ha, which represents 27.5% of the country's territory. 48% of the total forest area is state-owned, 33.9% private (natural or legal persons), 16% public territorial and 1.4% private territorial. Given the fact that the forest area in Romania covers a significant part of the country's territory, forests play an important role in the context of climate change, not only in carbon sequestration but also in biomass production and the production of renewable energy from them. Forests are also important from a social and cultural point of view: they are attractive to rural and urban populations, they allow the development of recreational activities and they represent an important cultural heritage. Rural development (including forest development) is a priority in Romania, which also contributes to job creation. The document states that the Romanian Government recognises the forestry sector as a strategic sector. On this basis, they also contribute directly to the achievement of climate change objectives. In the Objectives and Measures section, in relation to climate protection, the strategy sets out the following:

1) Adapting forest restoration practices to the needs of climate change (point 2.4.1);
2) Continued adaptation of the forest management system in order to improve resilience to climate change (point 2.4.2);
3) Restoring forests damaged by the consequences of climate change (point 2.4.6);
4) Selecting climate-resilient tree species as well as expanding their use in forest regeneration (point 2.4.7).

7.1.3. Slovakia

7.1.3.1. Integrated National Energy and Climate Protection Plan for 2021 - 2030 (Integrovaný národný energetický a klimatický plán na roky 2021 - 2030)

In November 2014, the Government of the Slovak Republic approved the country's energy policy for 2035 with a perspective to 2050. This document sets out the objectives and priorities for the energy sector, such as: creating competitive, low-carbon-dioxide emmission energies, ensuring secure, reliable and efficient energy supply at affordable prices, taking into account consumer protection and sustainable development. The Slovak Republic puts a strong emphasis on preserving air quality, reducing greenhouse gas emissions, mitigating climate change, security and affordability of energy supply of all types. In 2019, the Slovak Republic committed itself to achieving carbon dioxide neutrality by 2050.

The document sets out the priorities for Slovakia's energy policy:

- creating an optimal energy mix;
- increasing security of energy supply;
- the development of energy infrastructure;
- diversification of energy sources and transport routes;
- maximising the use of transmission networks and transit systems passing through the country;
- applying the principle of energy efficiency;
- reducing energy intensity;
- developing a market for energy in a competitive environment;
- ensuring the quality of energy supply at affordable prices;
- protecting vulnerable customers;
- addressing energy poverty;
- establishing an appropriate pro-export balance in the electricity sector;
- support for high-efficiency cogeneration;
- promoting the use of efficient district heating systems;
- promoting the use of renewable energy to produce electricity, hydrogen, cooling and heating;
- the use of nuclear energy as a low-carbon dioxide emmission source of electricity;
- improving the safety and reliability of nuclear power plants.

The main target is to reduce GHG emissions in the Slovak Republic by 20% in the non-ETS sectors by 2030 (the share has been increased from the initially declared 12%). The share of renewable energy in final energy consumption is set at 19.2% by 2030.

The document sets out measures to ensure environmental sustainability, which include:

- provide financial resources and use the revenues from the Slovak Republic's ETS quota auctions to support the energy and industrial sectors in harmony with the above-mentioned principles of sustainable development;
- increase activities undertaken to reduce CO_2 emissions, in particular in the transport sector;

- the creation of new energy conversion sources should be carefully analysed in the light of their potential negative impact on environmental sustainability and efficiency reduction;
- optimising the share of renewable energy sources, especially in the generation of heating and cooling;
- in the long term, promoting the use of natural gas, decarbonised gases and hydrogen;
- prepare measures for the transition to a low-carbon dioxide emission circular economy, as well as changing to more energy and material efficient economies;
- ensure the timely implementation of the Integrated National Energy and Climate Change Plan;
- the energy recovery of waste must be ensured.

7.1.3.2. Low-carbon dioxide emission development strategy of the Slovak Republic for 2030 with a view to 2050 (Nízkouhlíková stratégia rozvoja Slovenskej republiky do roku 2030 s výhľadom do roku 2050)

The strategy aims to identify all the measures to achieve climate neutrality in the Slovak Republic by 2050. The strategy envisages two scenarios:

- WEM – with existing measures;
- WAM – with additional measures.

The strategy states that if there are no additional measures beyond those applied in the WEM and WAM models and scenarios, Slovakia will not reach its climate neutrality target in 2050. The strategy is aiming at outlining the options for a comprehensive, long-term (30-year) strategic outlook for the transition to a low-carbon dioxide emissions economy and achieving climate neutrality by 2050.

Chapter 2.1 of the document deals with emission reductions and scaling up of the swallowing by 2050. The strategy states that even if the maximum possible removals by the LULUCF sector are taken into account, only a maximum reduction of 90% compared to the 1990 emissions level can be expected, which would still not be sufficient to achieve climate neutrality. This reduction will not happen automatically and will require significant investments and changes in the economy and by the population as well. This is illustrated by the WEM scenario, which models the total emission reductions in the case where only the measures in 2016-2018 are implemented. Under this scenario, without taking additional measures, emissions in 2050 are likely to remain at similar levels to 2015.

The projected emissions will be around 14 MtCO_2 equivalent, an 80% reduction compared to 1990 (excluding the LULUCF sector). Further reductions of this will require very difficult and expensive solutions. The final target is to reach an equivalent of 7 MtCO_2. This amount can most likely only be neutralised by sinks. Absorption is mainly a task for the LULUCF sector, which will be of great importance in reducing CO_2 emissions in addition to sustainable management.

The objective of the strategy is therefore to define all measures, including supplementary measures, to achieve climate neutrality in the Slovak Republic, which in practice means that in 2050 the maximum emissions volume will not exceed the above-mentioned emission residual.

Chapter 2.3 of the document deals with renewable energies. By 2030, the proportion of renewable energies in energy use is estimated at 19.2%. Chapter 2.4 deals with energy efficiency. The ambitious scenario foresees an energy efficiency index for final energy consumption of 30.32 % by 2030. Chapter 2.5 provides a detailed analysis of the different sectors.

The objectives and actions set out in the strategy are of great importance in relation to climate protection and mitigation of the effects of climate change. A number of objectives and measures have been formulated, the implementation and enforcement of which will contribute to the achievement of climate change objectives.

7.1.3.3. Climate Change Adaptation Strategy of the Slovak Republic (Stratégia Adaptácie Slovenskej Republiky Na Zmenu Klímy)

Chapter 1 of the Strategy presents the objectives of the Slovak Republic's climate change adaptation policy up to 2025 with a projection to 2030. The main objectives of the Strategy are to improve the country's preparedness to deal with the adverse impacts of climate change, to provide the widest possible information on current adaptation processes, and to establish an institutional framework and develop a coordination mechanism to ensure effective implementation of adaptation measures. The document identifies the following sub-objectives and framework actions in the area of adaptation, which contribute directly or indirectly to the main objective of the programme:

- Ensure the active development of national climate change adaptation policies.
- Effectively implementing adaptation measures and monitoring the effectiveness of these measures in practice.
- The translation of national climate change adaptation strategy objectives and recommendations into multi-level governance and business support should be strengthened.
- Increasing public awareness and the knowledge for more effective adaptation related to climate change.
- Creating synergies between adaptation and mitigation measures and applying an ecosystem approach while implementing adaptation measures.
- Promoting the objectives and recommendations of fundamental international legislative instruments to address climate change, in particular the agenda for sustainable development until the period 2030, the UN Framework Convention on Climate Change and the Paris Agreement.

7.1.3.4. Greener Slovakia - Strategy for the Environmental Policy of the Slovak Republic until 2030 (Zelenšie Slovensko - Stratégia environmentálnej politiky Slovenskej republiky do roku 2030)

The Strategy for the Environmental Policy of the Slovak Republic up to 2030 sets out a vision for the period up to 2030, taking into account possible, likely and desirable future developments, identifies key systemic problems, sets targets, proposes a framework for improving the current situation and includes key performance indicators that allow the results achieved to be monitored. The fundamental vision of the strategy is to achieve a better quality of the environment and a sustainable circular economy which is based on the strict protection of environmental elements and uses as few non-renewable natural resources and hazardous substances as possible. The environment protection and sustainable consumption will be part of the general awareness of citizens and policy makers. By preventing and adapting to climate change, the consequences of climate change in Slovakia will be minimised.

According to the document, the main environmental challenges in Slovakia are in the areas that are prioritised in the environmental policy up to 2030, such as waste management, air quality and the protection of habitats and species, especially forest, meadow and wetland ecosystems.

By 2030, the recycling rate of municipal waste, including preparation for reuse, will rise to 60% and by 2035 the landfill rate will be less than 25%.

In many elements and points, the strategy is aligned with climate protection, prevention and mitigation of climate change, and the development of nature and climate awareness.

Other strategy documents that are partly or tangentially connected to climate protection and to climate change mitigation:

- Action plan for the development of electromobility in the Slovak Republic (Návrh Akčného Plánu Rozvoja Elektromobility V Slovenskej Republike);
- National Forest Programme of the Slovak Republic (Národný Lesnícky Program Slovenskej Republiky);
- Waste prevention programme of the Slovak Republic for the years 2019 - 2025 (Program predchádzania vzniku odpadu Slovenskej republiky na roky 2019-2025).

7.1.4. Ukraine

7.1.4.1. Concept for the implementation of state policy on climate change up to the period 2030 (КОНЦЕПЦІЯ реалізації державної політики у сфері зміни клімату на період до 2030 року)

The document states that Ukraine is implementing its obligations under the UN Framework Convention on Climate Change and the related Kyoto Protocol, but that state policy on climate change is fragmented and is regarded as part of environmental policy. The lack of a systematic approach to climate change makes it generally impossible to take management decisions in order to ensure climate change prevention and adaptation throughout the whole economy. At the same time, the implementation of the new tasks that Ukraine has ratified in the Paris Agreement and its further implementation will require the development of a coherent and consistent state policy on climate change in line with international organisations, taking into account the world' leading technologies and priorities, as well as the specificities of national circumstances, opportunities, needs and priorities.

Aims and conditions for the implementation of the concept: the aim of the concept is to improve public policy on climate change in order to achieve sustainable development of the state, to create legal and institutional conditions for a gradual transition to low-carbon dioxide emission development in terms of economic, energy and environmental security, and to create well-being for citizens. The target date for the implementation of the concept is 2030.

The concept deals with the directions, ways and means of solving climate change problems, among which the following are highlighted:

- formulate and ensure the implementation of state policies on the climate change issue by strengthening institutional capacity;
- Prevent climate change by reducing anthropogenic emissions and increasing greenhouse gas sequestration and ensuring a gradual transition to low-carbon dioxide emission development of the state;
- adapting to climate change, strengthening the ability to adapt to resilience and reducing the risks associated with climate change.

In order to achieve the objectives set out in the concept, a number of steps and measures are also set out, of which the following are highlighted:

- defining and implementing effective mechanisms for integrating climate change policy elements into regional development strategies and their implementation action plans, taking into account the development priorities of the region's districts and towns and villages;
- enhancing the technical and technological capacity of the climate system observing system and implementing Ukraine's climate research programme;
- facilitating the creation and continuous updating of models for forecasting greenhouse gas emissions in economic development scenarios for the state and sectors;
- facilitating the ongoing assessment of actual projected climate change and its impacts, including regional distribution, identification of climate change risks and vulnerabilities at the level of local communities and at the level of economic sectors;
- ensuring public participation in climate change governance decisions;
- defining and implementing a public-private partnership mechanism on the climate change issue.

The concept also states that preventing climate change can be achieved by reducing anthropogenic emissions and by increasing greenhouse gas sequestration and by ensuring a gradual transition to low-carbon dioxide emission state development, together with the steps to be taken. It also states that adaptation to climate change, increasing resilience abilty and reducing risks associated with climate change is an important task, and sets out measures to achieve this.

The concept was accompanied by an action plan, which was approved by the Council of Ministers of Ukraine on 6 December 2017 under No 878. The action plan contains the necessary steps, the deadline for their implementation and the name of the organisation responsible for their implementation.

7.1.4.2. Ukraine's Low Carbon Dioxide Emissions Development Strategy until 2050 (Стратегія низьковуглецевого розвитку України до 2050 року)

Ukraine's Low Carbon Dioxide Emission Strategy aims to meet Ukraine's international commitments under Article 4.4 of the Paris Agreement. The strategy was developed by the Ministry of Environment with technical support from the United States Agency for International Development's Ukraine Municipal Energy Reform Project in the following sectors: energy supply, energy consumption in industry, energy consumption in residential and municipal services, transport, waste management, agriculture and forestry.

The first part of the strategy contains a brief description of the country's economic development problem and the ways to solve it, and defines the goals and objectives as follows:

1) Shift to an energy system that includes the use of low-carbon dioxide emission energy sources, the development of clean electricity and heat energy, the improvement of energy efficiency and energy savings in all sectors of the economy and in all areas of housing and municipal infrastructure, and the promotion of the use of alternative fuels to petroleum products in freight and passenger transport through cleaner means of transport.
2) Increase carbon dioxide sequestration and storage by applying best agricultural and forestry practices adapted to climate change.

3) Reduction of GHG emissions (e.g. methane, nitrous oxide), mainly from fossil fuel production, agricultural production and waste management.

The second section sets out the preconditions, while the third section, "Legislative and Institutional Framework", describes the legal framework to support low-carbon dioxide emission development and at the same time states that the central executive body empowered to formulate and implement state policy in the field of climate change is the Ministry of Ecology and Natural Resources of Ukraine.

The fourth section of the strategy is named "Decarbonisation of Ukraine's energy sector", which is a key part of the document, as the energy sector's share of total GHG emissions reaches 65% and, including the industrial process and product use (IPPU) sector, 82%. According to the document, in 2015, Ukraine's gross domestic product (GDP) has a carbon content 1.9 times higher than the world average, 2.4 times higher than OECD countries and 3.3 times higher than the EU average. Although the country's carbon dioxide intensity as a proportion of GDP fell between the 1990 and 2015 period, the rate of decline is not adequate. The baseline scenario assumes that GHG emissions from the use of energy resources by the population (including emissions from the technologies required for their use) and the production of goods and services in the "Energy" and "Industrial Processes" sectors will reach 455 $MtCO_2$ equivalent by 2030 (which is 54% of 1990 levels) while by 2050 they will reach 592 $MtCO_2$ equivalent (which is 70% of 1990 levels). The document also uses the 2015 value of 265 $MtCO_2$ equivalent (this is 31% of 1990 levels).

In order to achieve GHG emission reductions, the document groups and considers Ukraine's energy decarbonisation policies and measures according to sectoral principles. These are the following:

- energy efficiency,
- renewable energy production,
- modernisation and innovation,
- restructuring the market and institutions.

As presented in the Strategy, taking all these into account, the modelling calculations show that by 2050 GHG emissions in the Energy and Industrial Processes (Energy, IPPU) sector could be reduced to between 31-34% of 1990 levels, or 260-285 $MtCO_2$ in nominal terms.

The fifth section "Reducing greenhouse gas emissions other than CO_2" describes policies and measures to reduce emissions of methane and nitrous oxide in three areas, which are as follows:

- reducing leakage during extraction, processing, transport and storage of fossil fuels;
- improving waste management;
- reducing GHG emissions from agricultural activity.

The sixth section "Reducing carbon dioxide sequestration and greenhouse gas emissions from land use and forestry sector" provides a sectoral description for the LULUCF sector as follows:

- optimising the land use structure, increasing the area of forests, forest strips and green plantations;
- improving production practices in the agricultural and forestry sectors;
- developing and implementing a national forestry development programme;
- promoting the substitution of energy-intensive products (e.g. metal, concrete, plastic products, etc.) with wood products cultivated in sustainable forestry.

Due to the specific age structure of Ukraine's forests, their absorption capacity is expected to gradually decrease in the future. Depending on the increase in the country's forest area to 19.4% and the implementation of the gradual management decisions outlined in the strategy, the uptake of greenhouse gases by forests could reach up to 85% of 1990 levels in 2050.

7.1.4.3. Climate Change Adaptation Strategy 2030 for Ukraine's Agriculture, Forestry and Fisheries Sector (Стратегія адаптації до зміни клімату сільського, лісового та рибного господарств України до 2030 року)

The strategy was adopted by the Cabinet of Ministers of Ukraine on the basis of the Concept of the implementation of the state policy on climate change for the period up to 2030 (КОНЦЕПЦІЯ реалізації державної політики у сфері зміни клімату на період до 2030 року). The document states that, according to the Ukrainian Hydrometeorological Centre, the average annual temperature in Ukraine increased by 1.1°C in the period 1991-2017 (compared to the average temperature in the 1961-1990 reference period). According to scientists, total soil moisture could decrease by 15-20 % by 2030 compared to current levels, and by 20-30 % in the steppe zone.

The strategy takes into account the current and potential impacts of climate change affecting Ukraine's agriculture, forestry and fisheries, and states that agriculture is a major source of GHG emissions from land use and livestock production, accounting for about 14% of national emissions. However, agriculture is also affected by climate change and needs to adapt to these changes.

The strategy also reviews the main obstacles to adapting to climate change in agriculture, forestry and fisheries, and sets out objectives, principles and actions. It sets out the following main objectives:

1) Strengthening institutional capacity also strengthening legislative and regulatory support for adaptation to climate change for agriculture, forestry and fisheries.
2) Prevent climate change by reducing emissions and by increasing greenhouse gas sequestration.
3) Strengthening scientific support for climate change adaptation in agriculture, in forestry and in fisheries.
4) Raising awareness, strengthening education, training and scientific support in the area of climate change adaptation.
5) Developing and implementing climate change adaptation measures for territorial communities and for households in rural areas.

The document also identifies measures related to the objectives to achieve them. The main measures for implementing the strategy are summarised below:

1) Promoting climate-smart crop production, adapting to climate change.
2) Promoting livestock production adapted to climate change.
3) Adapting forestry to climate change by introducing "proactive adaptation".
4) Promoting climate resilient fisheries and aquaculture adapting to climate change.

7.1.4.4. Climate Change Adaptation Framework Strategy (Рамкова Стратегії з адаптації до зміни клімату в Україні)

In Ukraine, the development of a Framework Strategy for Adaptation to Climate Change started in November 2020, and this work has not been completed at the time of writing.

7.2. Link to territorial (regional) strategy documents

The preparation of territorial climate strategies is based on the necessary situation assessments, the so-called "problem map" that can be drawn on this basis, a vulnerability assessment taking into account the specificities of each territory, and a climate-related SWOT analysis that integrates the knowledge system into a complex whole.

7.2.1. Hungary – Szabolcs-Szatmár-Bereg county

7.2.1.1. Spatial Development Concept and Strategic Programme of Szabolcs-Szatmár-Bereg County

The Spatial Development Concept of Szabolcs-Szatmár-Bereg County is an integral part of the national operational programmes established by the objectives of the European Union and the objectives of the National Development 2030 - National Development and Spatial Development Concept. These objectives and priorities have defined the framework for the Szabolcs-Szatmár-Bereg County Concept, which contains the vision and development priorities of the county, in its Volume I (Situation Analysis, Situation Assessment) and Volume II (Proposing Phase). The County Concept, which has undergone extensive socialisation, was adopted by the Szabolcs-Szatmár-Bereg County Assembly by its resolution 14/2014 (20.II.20.).

According to Article 27 (1) paragraph of Act CLXXXIX of 2011 on Local Governments of Hungary, the Szabolcs-Szatmár-Bereg County Municipality performs spatial development, rural development, spatial planning and coordination tasks. Under the Act, spatial development became one of the most important tasks of the counties (county self-governments), which was further strengthened by the subsequent amendments to Act XXI of 1996 on Spatial Development and Spatial Planning.

The priority task for 2021 is to review and update the spatial development concept valid until 2030 in terms of its overall objectives, and to work out a new spatial development programme (strategic and operational programme sections) for the period 2021-2027. Socialisation was completed on 27 January 2021.

The vision of Szabolcs-Szatmár-Bereg county for 2030 sets out three overarching objectives, which reflect the county's choice of values and the main direction of its development objectives. In order to achieve the three overarching objectives, seven strategic objectives have been identified, four of which are thematic objectives and three are territorial objectives. The objectives set will be achieved in the context of smart, sustainable and inclusive growth ((as horizontal objectives) (Figure 7.1).

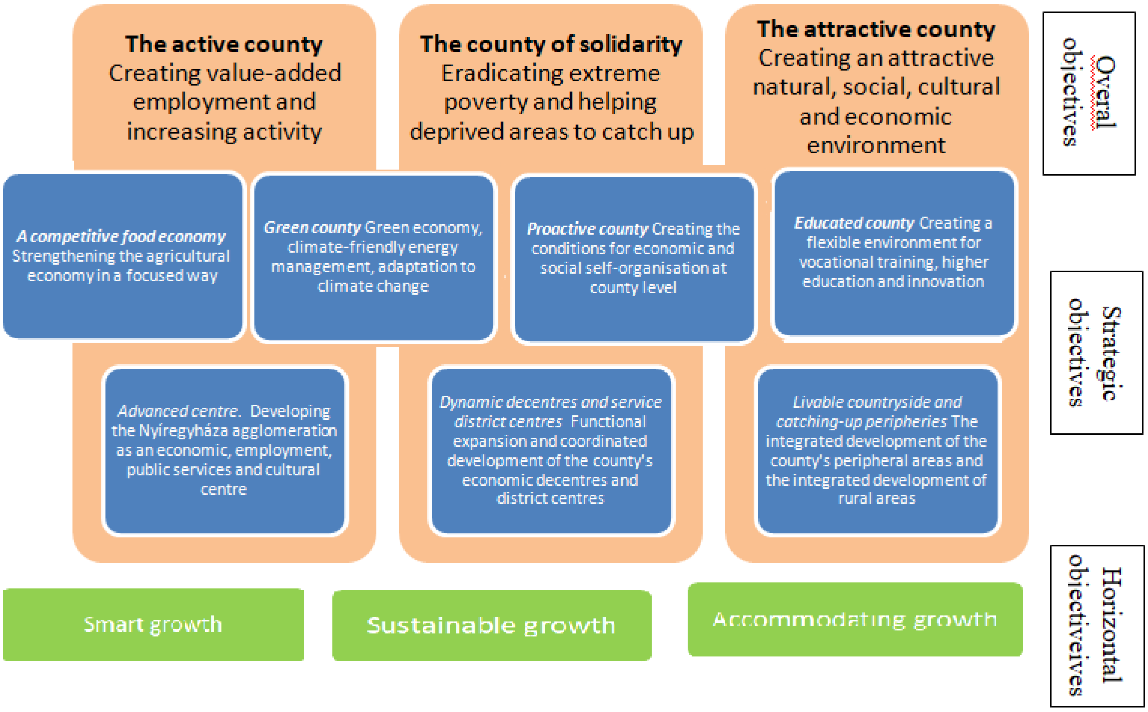

Figure 7.1. Spatial development objectives of Szabolcs-Szatmár-Bereg County

Source: Environmental and Spatial Impact Assessment of the Spatial Development Programme of Szabolcs-Szatmár-Bereg County

Among the thematic strategic goals, the chapter "Green County" is worth highlighting, which states that "In order to ensure the long-term development of the county and to create an attractive county environment, it is important to gradually switch the county's energy supply to renewable and alternative sources. This can on one hand reduce the County's external energy dependence and strengthen self-sufficiency in energy, reduce the County's direct and indirect carbon emissions, and on the other hand, encourage the strengthening of the green economy. The latter is of particular importance for Szabolcs-Szatmár-Bereg county, as the green economy can play an important role in the social economy, as it employs people with lower qualifications (integration of the green economy and the social economy). Climate change has negative impacts and risks that could have a major impact on the county. Preparations must be made to mitigate the negative impacts and to avert the risks. Given the specific situation of the county, water management (flood and inland water protection, drought) must be given priority and **a conscious climate strategy must be implemented**."

7.2.1.2. Operational Programme of Szabolcs-Szatmár-Bereg County

From the point of view of the climate strategy, priority 2 of the document, "Creating effective environmental management and adaptation to climate change" section is worth highlighting, which states that "The share of renewable energy sources still plays a minor role in the current energy carrier-structure of Szabolcs-Szatmár-Bereg county, but the county has relatively good potential for the use of renewable energy sources and the use of these energy carriers is increasing. In addition to the increase in average temperatures, the average annual precipitation in our country is expected to decrease and the distribution of precipitation to change in the coming decades, as well as an increase in the frequency and intensity of extreme weather events, drought and water abundance (floods, inland floods). The vulnerability of the county to floods and inland water is extremely high both nationally and internationally, and besides this, droughts cause significant economic, social and environmental damage. Climate change is also closely linked to water resources and water management." Specific objectives for Priority 2:

- Ensuring the planned management of water resources for the more efficient use of natural resources in Szabolcs-Szatmár-Bereg county;
- Reducing the area's vulnerability to flooding and inland water;
- Increasing renewable energy sources in the life of municipalities, increasing energy efficiency in municipalities, promoting sustainable and environmentally friendly transport development;
- Further development of the county's solid waste programme towards zero landfill, creating conditions for energy generation based on waste recovery, thus eliminating air pollution caused by landfilled waste and improving the sustainable and inclusive development of the region;

- Improving the conservation status and condition of protected natural values and sites of Community importance.

In order to achieve the objectives set, the programme considers it necessary to implement the following measures:

Measure 1: Complex environmental investments at municipal level;

Measure 2: Develop a complex water management programme;

Measure 3: Increase energy efficiency, promote the use of renewable energy sources;

Measure 4: Strengthening the conditions for environmentally friendly mobility;

Measure 5: Improving waste management in the county;

Measure 6: Nature and wildlife protection.

Achieving the objective will primarily have positive effects on the environment (soil, water, air, wildlife). The most important of these is undoubtedly to strengthen adaptation to climate change and reduce greenhouse gas emissions. On the other hand, its social benefits are also important in an indirect way: it contributes to improving the quality of life of the population, raising the quality of life and increasing employment, particularly in rural areas. Today, a healthy, environmentally aware lifestyle and environmental protection are important factors in social competitiveness. The strategic objective is to make the environment more liveable and more habitable for both urban and rural populations. The economic impact of the strategic objective is rather indirect. On the one hand, it contributes to the modernisation of the economic structure, to the region's energy dependency and to self-sufficiency. On the other hand, it directly supports the strengthening of the environmental industry as an alternative to industrial development.

7.2.1.3 Climate Strategy of Szabolcs-Szatmár-Bereg County and Sustainable Energy and Climate Action Plan of Szabolcs-Szatmár-Bereg County (SECAP)

The climate strategy prepared in 2018 identified the main development and action directions, which, if followed and implemented, would not result in a disproportionate burden for the population, institutions and various sectors, but especially for businesses and farmers in the agricultural sector in the coming decades, while Szabolcs-Szatmár-Bereg County would take its share in mitigating climate change in proportion to its own potential. The SECAP document approved by the General Assembly of Szabolcs-Szatmár-Bereg County with the Municipal Resolution No. 107/2019 (XII. 10.) contains the possibilities for the practical implementation of the development framework defined by the climate strategy, with which the county government intends to continue to play an incentive role in the county in the field of climate change-related investments, renovations and developments.

7.2.2. Romania - Maramures and Satu Mare counties (județul Maramureș, județul Satu Mare)

Given that the Sustainable Development Strategies for Maramures and Satu Mare counties for the period 2021-2027 are still being prepared at the time of writing, we cannot take them as a basis. However, the sustainable development strategies of the counties of Maramures and Satu Mare for the period 2014-2020 also address climate change, adaptation to its impacts and climate protection as important issues. An important element of the plans is to support climate change adaptation, prevention and risk management.

7.2.3. Slovakia - Kosice District (Košický kraj)

Due to the fact that the development strategy for the Kosice district for the period 2021-2027 is still being prepared at the time of writing, we cannot take it as a basis.

7.2.4. Ukraine - Transcarpathia county (Закарпатська область)

7.2.4.1. Regional Development Strategy of Transcarpathia 2021-2027 (Регіональна Стратегія Розвитку Закарпатської Області На Період 2021 – 2027 Років)

Climate change is a priority issue in the strategy. The SWOT analysis linked to the development of the region identifies the following as threats: the increasing impact of global climate change trends on natural and urban ecosystems and the unpredictable acceleration of global climate change. The document also states that there is a need to accelerate the creation of a competitive and innovative regional economy, one important step in which is to ensure sustainable energy development in all energy consuming sectors and to create climate change adaptation. In the context of climate protection, it is also an important task to establish natural, ecologically oriented, multifunctional forest management and to protect forests from the effects of climate change.

7.2.4.2. Report on the Ecological Assessment of the Regional Development Strategy of Transcarpathia County for the period 2021-2027 (ЗВІТ стратегічної екологічної оцінки Регіональної стратегії розвитку Закарпатської області на період 2021 – 2027 рр.)

The document provides a detailed analysis of the county's regional development strategy from an ecological perspective, with specific reference to the individual areas and the related climate change issues and impacts.

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8. Defining a vision for climate protection, setting targets

The climate change objectives have been set taking into account the main issues (high carbon emissions, pollution) and the bearers affected by climate changes (population, agriculture, forestry, tourism, etc.) identified in chapters 3 Mitigation assessment and 4 Adaptation assessment, identification of relevant climate change issues and impact agents.

8.1. Hungary: Climate protection vision of Szabolcs-Szatmár-Bereg county and the formulation of the target system to achieve it

As previously reported, Szabolcs-Szatmár-Bereg County already has its own climate strategy, which was approved and adopted by the Szabolcs-Szatmár-Bereg County Assembly in 2018. This climate strategy sets out the county's climate change vision and the climate change objectives that will achieve this vision. In light of this, the climate protection vision and objectives of Szabolcs-Szatmár-Bereg county are published here without any changes as set out in the climate strategy.

Climate protection vision of Szabolcs-Szatmár-Bereg county:

"In 2030, Szabolcs-Szatmár-Bereg county will be an area rich in natural values, able to adapt to the effects of climate change, where it is safe to live and to farm."

In order to achieve this common goal, it is necessary to set climate objectives.

8.1.1. County climate objectives

The main mitigation actions should be sought in the energy and sectors not based on direct energy use. The decarbonisation potential lies in the natural flora of our environment and in the planned and science-based management of waste management. The decarbonisation effect of forestry cannot compensate for the carbon emissions associated with the intensification of agricultural technologies, but its mitigating effect will be appreciated in the long term.

In order to achieve the detailed objectives, it is necessary to set up a climate protection institutional system and to generate the necessary funding for this (Figure 8.1).

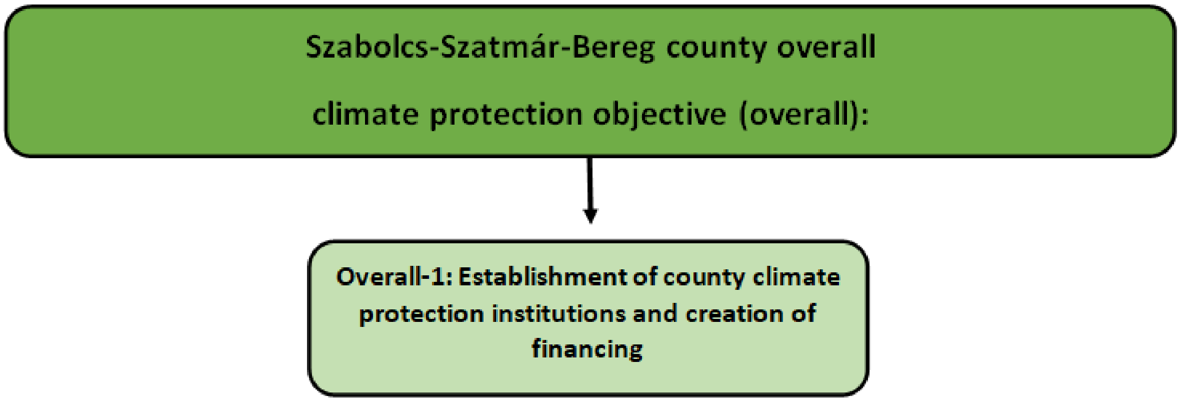

Figure 8.1: Overall climate protection objective of Szabolcs-Szatmár-Bereg county

Source: own editing

8.1.2. Mitigation objectives

The decarbonisation and mitigation targets of Szabolcs-Szatmár-Bereg county are closely linked to the national level strategic efforts, but also reflect the specificities of the county, due to its natural and economic characteristics. In the field of decarbonisation, the main priority is the replacement of fossil fuels. This will directly reduce GHG emissions. In general, efforts should be made to increase energy efficiency. There is considerable room for improvement not only in international comparison but also in comparison with other counties in Hungary. In addition, all aspects of green economy activity should be developed. Forestation, which has already achieved significant results in the county, deserves further development. Decarbonisation and mitigation activities cannot be envisaged without the involvement of research and innovation, which requires primarily public coordination and support.

The preparation and analysis of the countywide GHG inventory has identified those key problem areas that are critical at the county level and need to be addressed. The objectives were formulated on the basis of the share of emitters concerned, and the tasks were formulated on this basis. These decarbonisation and mitigation objectives are:

M-1: Increasing the use of energy efficiently by reducing emissions: the analysis carried out in this area showed that the overall energy consumption in the county shows a continuous upward trend. Energy use accounts for the largest proportion of GHG emissions. This proportion could be reduced through the use of more modern heating methods (e.g. condensing gas boilers instead of old ones), by reducing the energy consumption of residential and public buildings (e.g. insulation, replacement of windows, etc.), by replacing energy-intensive household appliances (e.g. old refrigerators, washing machines, etc.) with energy-saving ones, and by modernising lighting (energy-saving light bulbs, LED lamps). The support programmes launched at household level (e.g. the Home Warmth Programme) have achieved good results in this area and therefore their continuation is necessary. This will help to reduce energy consumption and make it more efficient, thus reducing the sector's GHG emissions.

M-2: Reducing CO2 emissions caused by transport: A critical point in Szabolcs-Szatmár-Bereg county is the significant increase in motorisation and the rise in emissions from transport. With the improvement of the road network, the distance between homes and workplaces, the declining role of public transport and changing consumer habits, this sector represents the greatest potential for growth with regard to emissions. It is important that the inhabitants of the county are made aware of the seriousness of the emissions caused by transport and unnecessary car use, while at the same time adopting environmentally friendly modes of transport. Promoting public transport, optimising routes, making public transport vehicles more convenient (internet, cleanliness, price, accessibility, routing) will help to reduce emissions from transport.

M-3: Increasing the share of renewable energy sources in the county's energy structure: increasing the share of renewable energy in the energy mix is one of the possible - and most desirable - ways to reduce GHG emissions. Szabolcs-Szatmár-Bereg county has excellent potential in this sector, whether we are talking about solar energy, geothermal energy or biomass. Environmentally sustainable growth means greener, more climate-friendly growth that makes more efficient use of existing resources. It is important that whatever development takes place, it should make a demonstrable contribution to sustainable development, reducing and certainly not increasing environmental pressures.

M-4: Increasing the proportion of afforestation (increasing CO2 capture): the analysis showed that forest cover in the county is broadly in line with the national average and has been increasing over the period. This is desirable, as the national objective is also to increase forest cover. It is important to create and introduce an incentive system that creates favourable conditions for private forest owners to maintain forests and to plant new forest areas.

As described above, the decarbonisation and mitigation target system is illustrated in Figure 8.2.

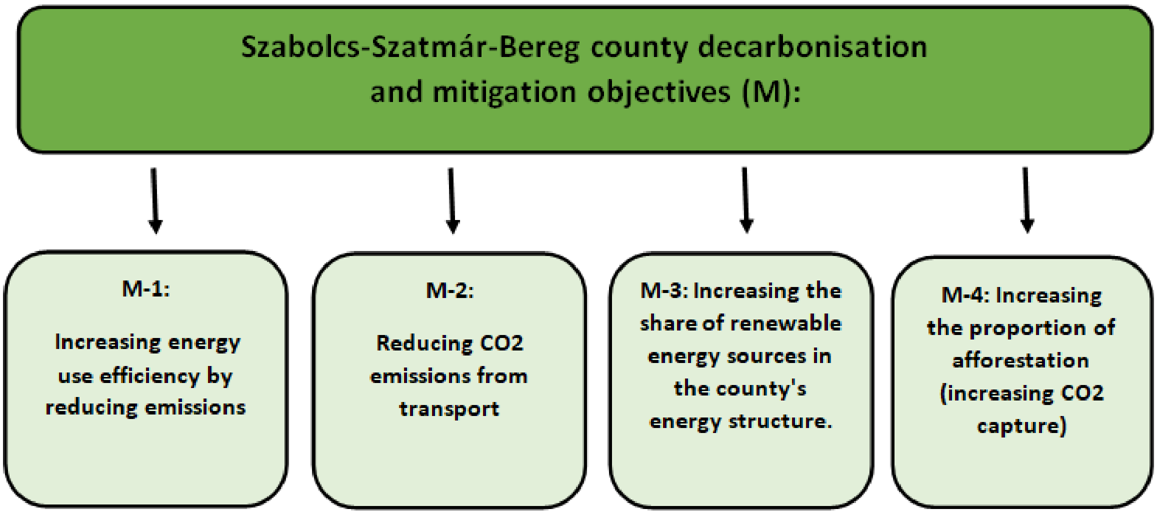

Figure 8.2.: Decarbonisation and mitigation target system of Szabolcs-Szatmár-Bereg county

Source: own editing

The quantified targets and the measures needed to achieve them can only be formulated in the light of currently known trends and expected economic development paths taking into account. The 2018 climate strategy of Szabolcs-Szatmár-Bereg county aims to achieve the targets presented in Figure 8.1. However, it should be noted that the European Green Deal (GreenDeal), adopted by EU Member States in 2020, aims to create the first climate neutral continent, which means that net GHG emissions should be zero by 2050. In line with this, an important sub-target is to reduce GHG emissions by 55% by 2030 compared to 1990 levels. This calls for a reconsideration of the targets set out in Figure 8.3.

	Base period (2015)	**2020**	**2030**	**2050**
Total countywide GHG emissions (t CO2 equivalent; including sinks)	**1.582.334**	**1.582.334**	**1.503.217**	**1.352.895**
	100 %	100 %	95 %	85,5 %
CO2 emissions per capita (t CO2 equivalent per person; including sinks)	**2,81**	**2,90**	**2,90**	**2,87**
	100 %	103,2 %	13,2 %	102,1 %

Figure 8.3: Projected future development of GHG emissions in Szabolcs-Szatmár-Bereg County Source: Climate Strategy of Szabolcs-Szatmár-Bereg County

8.1.3 Adaptation and preparedness objectives

Several of the climate change problems significantly affect Szabolcs-Szatmár-Bereg county, affecting the population, economy and agricultural production of the county. On the basis of the analysis, the following overall adaptation and preparedness objectives have been formulated for the county:

Aa-1: Increase the proportion of areas protected from drought: Drought and dryness is also an important issue in the opinion of the county's population, and the county-level analysis of its impact on daily life showed significant differences. Climate-induced drought primarily affects the agricultural sector. Accordingly, the primary objective and task is to create and further improve water retention conditions, the storage and use of surplus water in certain periods, to further develop the technical solutions already in place, and to create technical and economic opportunities for water recharge from rivers. Another important objective is to increase the proportion of irrigated land, to bring new areas under irrigation, to examine the possibilities of introducing new, more drought-tolerant crop varieties and to familiarise farmers with new cultivation techniques adapted to drought.

Aa-2: Reducing vulnerability to local water damage: to protect against sudden, extreme rainfall events at local level, especially in the late spring and summer. This can be done primarily at the municipal level, taking into account local specificities (e.g. proper maintenance of existing stormwater drainage systems, construction of new ditches and artificial structures where necessary). Local solutions should be used to achieve this objective. An important objective is to reduce sudden, high inland water loads on drainage systems.

Aa-3: Reinforcing protection against heat waves: the county of Szabolcs-Szatmár-Bereg is affected by a higher number of excess deaths caused by heat waves than the national average, partly due to the excess temperature on heat wave days, but also due to the unfavourable health and income situation of the population. In order to achieve the stated objective, it is important to increase the protective capacity of vulnerable target groups (young children, elderly and sick people, people of low status and living in modest financial circumstances). One of the means of doing this is to provide information and awareness-raising at the appropriate level and with the appropriate effectiveness. At the municipal level, the effectiveness of protection can be further increased by increasing the proportion of green and water areas and by installing mist arches where necessary.

Aa-4: Reducing the vulnerability of the built environment: the county, and its villages in particular, is characterised by a steady deterioration of the state of its buildings and an ageing building stock. These buildings are more vulnerable to storms. It is difficult to tackle this problem at local, municipal level alone, and it is important to launch county, regional or even national programmes to renovate and modernise buildings. In this respect, it is also essential to ensure that those concerned are properly informed in order to reduce the vulnerability to extreme weather events.

Aa-5: Maintain and improve flood and inland water protection: around 38% of the county's territory is at risk from floods (118 municipalities, 200,000 inhabitants). The situation analysis carried out on this subject has shown that the county is at a high risk of flooding, both nationally and internationally. Floods occurring here are characterised by rapid formation and run-off. The completed phases of the Vásárhelyi Plan (tidal reservoirs) play an important role in reducing the vulnerability, and further development of this programme will further reduce the county's flood vulnerability. In Szabolcs-Szatmár-Bereg County, among the climate change related issues, inland water vulnerability is one of the priority issues and is the second most important risk factor after flooding for the environmental security of the county. In order to reduce this risk, the existing inland water drainage system should be further improved and the elements of the existing system should be developed, both for the municipalities and for FETIVIZIG (Upper-Tisza Water Management). In addition to inland water, drought has been causing increasing economic damage in recent years. As the intensity and persistence of droughts is likely to increase in the coming period, it is important to improve the drainage systems in the area, which can also provide water retention if necessary.

It is also necessary to assess land improvement (melioration) systems (surface and groundwater drainage at the table level) that were previously implemented on a significant area of the county, but which have been abandoned due to the changed land structure, destroyed in places, but which can be reconstructed in most cases. These may be suitable for adaptive groundwater level control according to current approaches.

The specificity of the county is that water surplus must always be managed in conjunction with water deficit. Drought protection can be effective if water is retained in suitable areas and in the soil during flood and inland water events. Climate change will require the development of flexible water systems, the modification of existing water systems and changes in land use.

Aa-6: Increasing the green areas of settlements: In settlements, especially in larger cities, it is desirable to increase green areas, especially wooded areas. The benefits of this include: increasing shading, positive microclimate effects through evaporation, and reducing wind effects (through canopy cover). This can be achieved at relatively low cost and at local level, provided that suitable areas are available for planting trees.

Based on the above, the overall and preparedness objectives of Szabolcs-Szatmár-Bereg county are summarised in Figure 8.4.

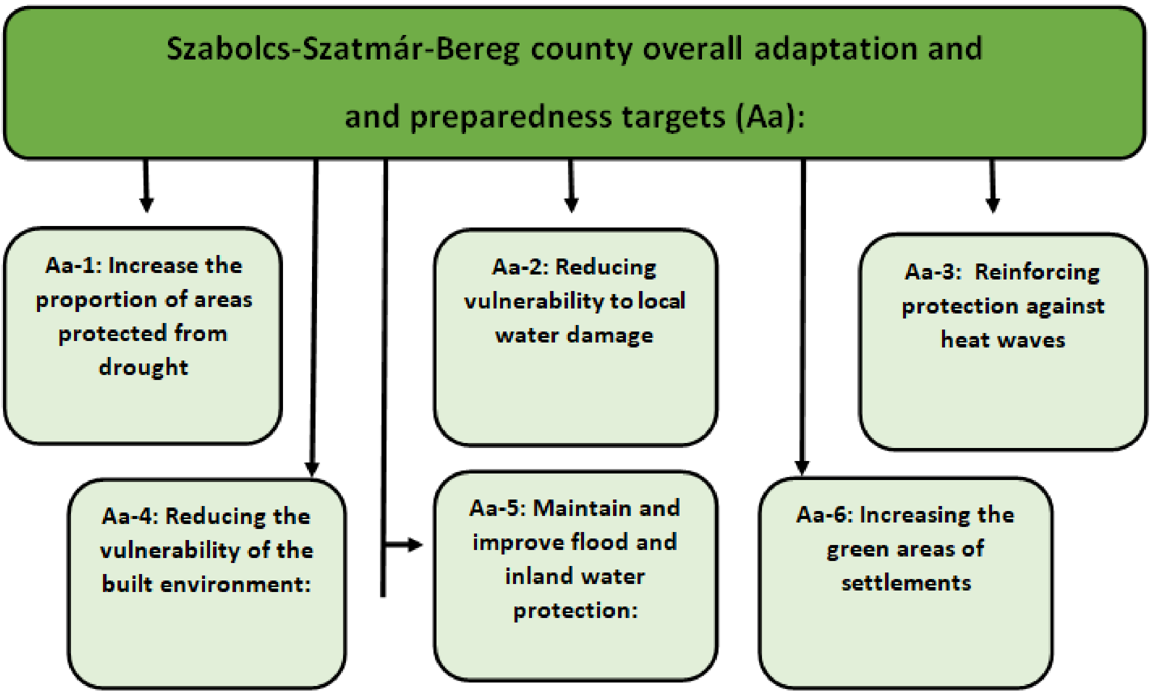

Figure 8.4: Overall adaptation and preparedness targets for Szabolcs-Szatmár-Bereg county

Source: own editing

8.1.4 Specific adaptation and preparedness objectives

Szabolcs-Szatmár-Bereg county has a number of local values and special areas, which are at risk of climate change and therefore the vulnerability of these areas to climate change must be reduced. These include natural and landscape values, protected cultural buildings, unique architectural values and ecotourism values. In order to reduce the vulnerability of these assets, the following specific adaptation and preparedness objectives have been identified (Figure 8.5):

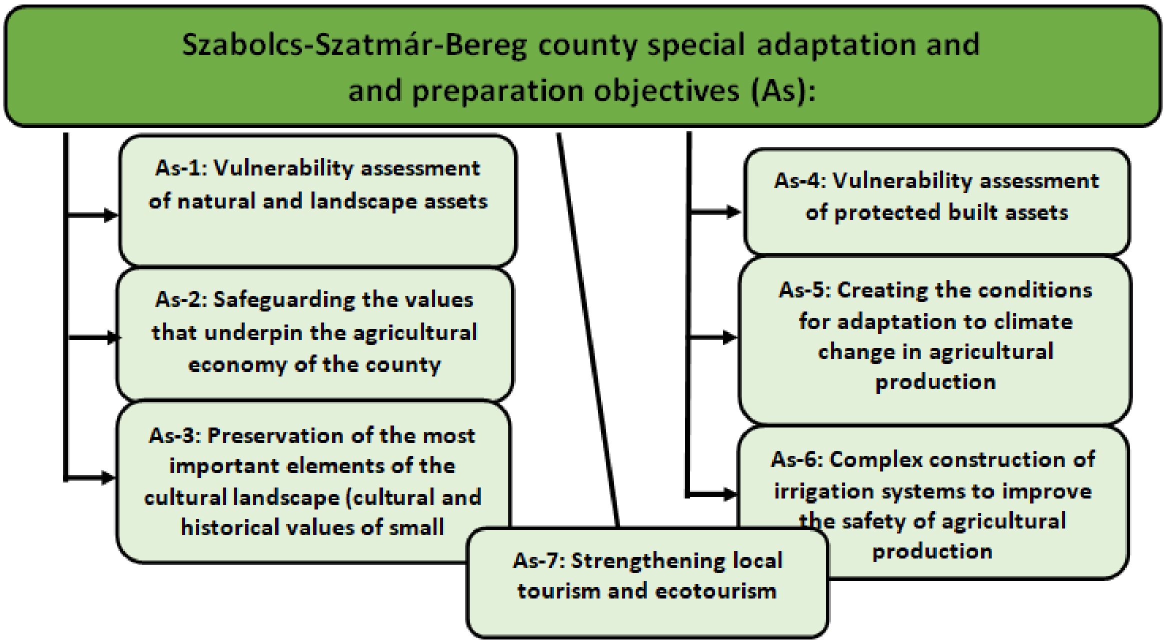

Figure 8.5. Specific adaptation and preparation targets of Szabolcs-Szatmár-Bereg county

Source: own editing

As-1: Assessment of the vulnerability of natural and landscape values: Szabolcs-Szatmár-Bereg county has a special value in terms of its natural and landscape features. From strictly protected areas to environmentally sensitive areas, values in need of conservation can be found in all parts of the county. Similarly, nature conservation areas of local importance also require protection. Among these, there are many castle parks, ancient grasslands and wetlands to be found. These cannot be protected solely by the financial resources of local authorities. A more complex management of officially registered landscape conservation areas and nature reserves would make a higher level of protection desirable, and even justify the creation of a national park, even in a cross-border context.

As-2: Preservation of the values that form the basis of the agricultural economy of the county: in place of the former mixed oak forests, the areas under cultivation are occupied by different types of forest soils. The above illustrates the diversity of soil conditions and the vulnerability and degradation of these landscapes to climate extremes. It is worthwhile and necessary to examine the risk of climate change and the options for protection (e.g. creation of forest strips to protect fields, physical and chemical soil improvement, artificial recharge, etc.) for each landscape unit and soil type. There are areas where agricultural production is not possible due to high frequency of inland flooding, and in these areas it is advisable to change the type of farming and create wetlands and retain water, thus improving the water management, plant life and economic benefits of the surrounding arable land.

As-3: Preserving the most important elements of the cultural landscape (cultural and historical values of small communities): climate change is already affecting all elements of the landscape in the short term. Prolonged heat and the resulting drought are drying out the soil's soil layer, destroying most of the soil life. Organic matter, including humus, which is more oxidised as a result of drought, is rapidly reduced. This triggers adverse chemical processes, resulting in soil acidification, loss of buffer capacity and adverse changes in the nutrient supply system. The dry soil surface is also vulnerable to the deflationary effects of increasing wind storms.

The soil-destroying effect of short rainfall events also causes severe damage. The water absorption capacity of the compacted soil is reduced, and the run-off from the soil surface creates erosion ditches and gullies, altering the living conditions of the biota.

As-4: Vulnerability assessment of protected built assets: the vulnerability assessment of protected built assets is essential to accurately assess their vulnerability to climate change. This is the purpose of this objective, which aims to assess the vulnerability of buildings listed in the Szabolcs-Szatmár-Bereg County Register of Historic Monuments.

As-5: Creating the conditions for adaptation to climate change in agricultural production: the agricultural activity of the county is outstanding in comparison with the rest of the country, especially in the field of horticultural crops. This fact alone justifies the need to address this issue seriously and responsibly. In this area, the primary objective is to inform and educate farmers and to provide them with the relevant information. However, the technical conditions for frost protection in orchards (e.g. the possibility of frost protection irrigation, frost protection by air mixing, etc.) and the technical conditions for reducing ice damage must also be created. An important step in this direction is that the National Chamber of Agriculture launched the operation of its national ice damage protection system (soil generator ice protection) in 2018. The role of farmers in agricultural water management should be emphasised. Soil is Hungary's largest reservoir - it is in the hands of farmers.

As-6: Complex development of irrigation systems to increase the security of agricultural production: the amount of irrigated land in Szabolcs-Szatmár-Bereg County is below the level of decades ago and from the currently is still existing possibilities. A significant increase in this area is expected in the near future. Increasing agricultural water demands, combined with the effects of climate change, will put considerable pressure on water resources, the use of which can only be supported to sustainable levels. Surface and groundwater resources are currently limited, with no freely exploitable supplies in many areas, and further water scarcity could be a source of conflict in the future.

In general, the use of surface water should be preferred to groundwater resources, which are difficult to renew on a human scale. Priority should be given to water conservation, river recharge, water management at table level, professional agrotechnology and precision farming. The aim is to ensure a professional water supply (surface and borehole) for intensive fruit and vegetable production.

As-7: Strengthening local tourism and ecotourism: Climate change may limit the capacity of tourism activities, eliminate a specific tourism offer or even encourage the development of new alternative tourism products. Climate conditions are of particular importance for outdoor tourism. Extreme weather events, changing seasons and the associated heating and cooling costs will fundamentally change the potential of the tourism service sector. The primary objective is to assess the climate vulnerability of tourist areas and their built elements at county level.

8.1.5 Climate awareness and awareness-raising objectives

The successful achievement of the objectives outlined in the previous sections can only be achieved if all relevant target groups are properly informed and involved in the implementation process.

Accordingly, the following climate awareness and awareness-raising objectives have been formulated:

Ca-1: Strengthening climate-aware consumer behaviour: There is still a lack of climate-aware attitudes among a significant part of the population in the county. Therefore, it is important to strengthen awareness-raising, awareness campaigns and actions, emphasising the conscious use of energy, energy efficiency, ways to reduce private transport and the reduction of the quantity of waste. Increase public awareness of the impact of their consumption habits on water resources (e.g. water footprint). This should be done by involving all relevant organisations, institutions and educational establishments that can be credible representatives of climate-aware behaviour.

Ca-2: Increase local adaptation knowledge: develop and communicate to people concerned the site-specific adaptation techniques to mitigate the negative impacts of climate change, especially in the area of agricultural production and cultivation. In addition, it is necessary to increase the general knowledge of the population of the county about climate protection and to pass on good practice. It is advisable to provide the people concerned with specific knowledge to improve their individual adaptability (e.g. how to reduce the heat sensation on hot days, rainwater management technologies, new methods, etc.).

Ca-3: Awareness-raising to reduce GHG emissions: the compilation of the GHG inventory and its analysis showed that energy use accounts for the largest share of GHG emissions in the county. To reduce this, awareness-raising campaigns should be launched in order to inform users, encourage investments in energy efficiency, and present the forms of support and the results achieved. It is also important to set up a public database to record and monitor savings from energy efficiency investments.

Ca-4: Strengthening climate-aware professional and public communication of the county government: the role of the county government in raising climate awareness among the population and economic actors is very important. It is particularly important that, as a founding member of the County Climate Change Platform, it sets a good example by informing and encouraging the relevant target groups. In addition, its main task is coordination in this field. In order to ensure successful awareness-raising and communication, it is advisable to involve cooperating organisations in this process (University of Nyíregyháza, Szabolcs-Szatmár-Bereg County Organisation of the National Chamber of Agriculture, Szabolcs-Szatmár-Bereg County Chamber of Commerce and Industry, etc.).

The system of horizontal climate awareness and awareness-raising objectives for Szabolcs-Szatmár-Bereg County is illustrated in Figure 8.6.

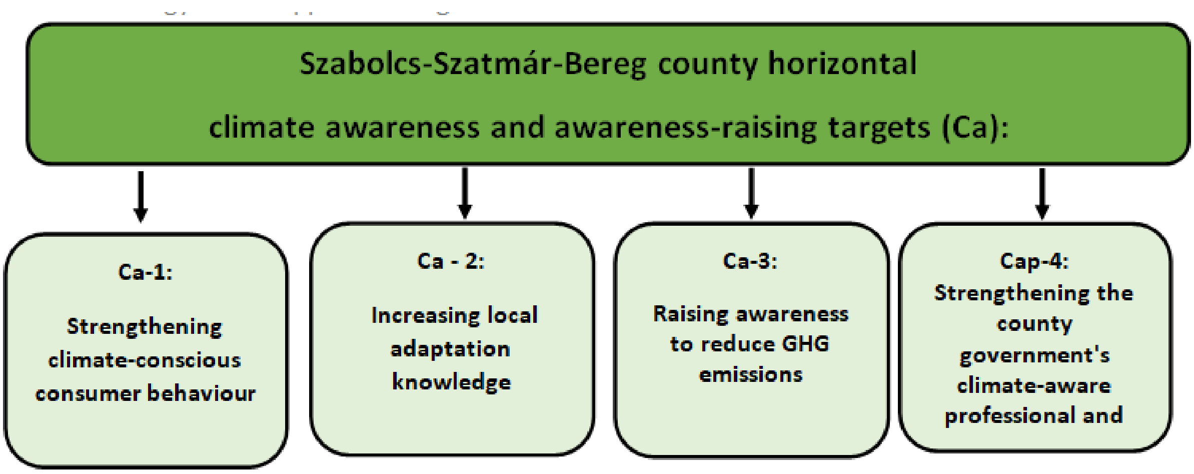

Figure 8.6: Specific adaptation and preparation targets for Szabolcs-Szatmár-Bereg county
Source: own editing

In summary it can be said that four mitigation, six adaptation, seven special adaptation and preparedness objectives and four awareness raising objectives have been formulated in order to achieve the climate vision of Szabolcs-Szatmár-Bereg county, with the implementation of which the planned climate objectives can be achieved.

8.2. Romania: Possible climate protection vision for the counties of Maramures and Satu Mare and the formulation of the target system to achieve it

In order for a country to achieve its commitments on climate change by 2050, it is necessary to formulate a climate change vision and the targets needed to achieve it not only at national level, but also at regional level. On this basis, the territory of the counties of Maramures and Satu Mare, as the Romanian part of the Upper Tisza river basin, can be considered as a single territory. As a unified territory, we define the possible climate change vision as follows:

" The counties of Maramures and Satu Mare will become a sustainable community able to adapt to the effects of climate change, and a tourist and business destination of European importance."

In order to achieve this potential climate vision, climate protection targets need to be defined. In the following, we outline the mitigation, adaptation and horizontal climate protection and awareness-raising objectives that are necessary to meet the climate vision set out above.

8.2.1. Mitigation objectives

A set of mitigation targets for a given area can only be effective if it is linked and integrated with national strategic efforts, but also takes into account the specific natural and economic characteristics of the area concerned. The data from the completed GHG inventory showed that one of the most important steps in decarbonisation is to replace fossil fuels and significantly reduce their use. In addition, efforts should be made to further increase energy efficiency in general. Afforestation also deserves further improvements. The preparation of the GHG inventory and its analysis have clearly identified the main areas of priority and importance for mitigation in the region. The mitigation target system was formulated on the basis of the share of relevant emitters and the targets were formulated on this basis. On this basis, the possible decarbonisation and mitigation targets can be summarised as follows:

M-1: Further increase energy efficiency and reduce GHG emissions: the analysis showed that overall energy use is on a slight downward trend, which should be maintained and further increased. GHG emissions from the energy used represent the largest share (over 50%). This share could be significantly reduced by using more modern heating methods (e.g. condensing gas boilers), reducing energy consumption in residential and public buildings (e.g. additional insulation, replacement of windows and doors, use of solar panels for domestic hot water, etc.), replacing energy-intensive household appliances (e.g. old refrigerators, washing machines, etc.) with energy-saving ones, and modernising lighting (e.g. LED lights).

M-2: Reducing CO2 emissions from public and private transport: according to the GHG inventory data, there is a clear increase in the growth of GHG emissions from transport. It is important to raise awareness among the inhabitants of the region of the impact of transport and of the emissions caused by the unnecessary use of cars, while at the same time promoting the use of environmentally friendly modes of transport, both for public and private transport. In public transport, local services (e.g. intra-community public transport) should replace diesel vehicles with CNG (compressed natural gas) or fully electric vehicles. In private transport, the purchase of electric vehicles and other alternative solutions (e.g. carpooling to work, car-sharing, etc.) should be promoted.

M-3: Continuously increasing the share of renewable energy sources in the regional energy supply: one of the most desirable ways to reduce GHG emissions from a climate perspective is to increase the share of renewable energy sources. As the analysis has shown, the region has excellent potential in this respect. It is very important that any development undertaken (e.g. solar, wind, biomass, hydro, etc.) should be a clear and demonstrable move towards sustainable development, reducing environmental pressures and the proportion of fossil energy sources used.

M-4: Further increase in the proportion of afforestation (increase CO2 capture): the analysis based on the GHG inventory clearly shows that it is imperative to increase the proportion of afforestation in the area. This is desirable not only for climate protection reasons but also for secondary purposes (e.g. tourism). In order to achieve climate neutrality, it is necessary to significantly increase the proportion of forested areas as sinks.

On this basis, the possible decarbonisation and mitigation target systems for the counties of Maramures and Satu Mare are illustrated in Figure 8.7.

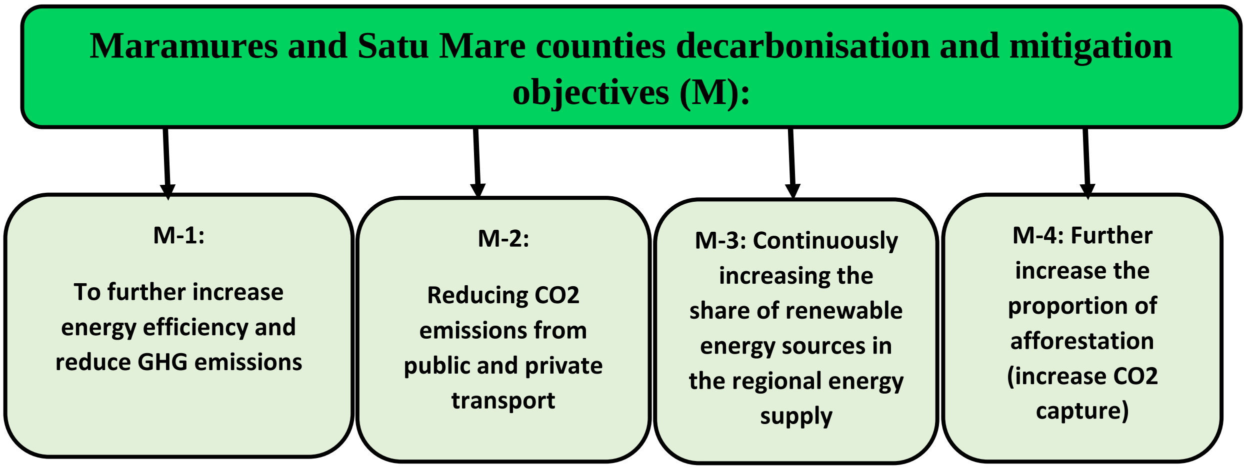

Figure 8.7: Possible decarbonisation and mitigation targets for the counties of Maramures and Satu Mare *Source: own edit*

8.2.2 Adaptation and preparedness objectives

Several of the climate change problems significantly affect the counties of Maramures and Satu Mare, affecting the population, economy and agricultural production of the county. Based on the analysis, the following overall adaptation and preparedness objectives have been formulated for the county:

Aa-1: Increase the proportion of areas protected from drought: Drought, dryness is one of the most visible signs of climate change for the population. In addition to metropolitan environments, the most severe negative impacts are felt in agriculture and forestry. Significant areas of the Maramures and Satu Mare and Satu Mare counties are exposed to drought. They are mainly located in the lower-lying areas of the counties, which are influenced by the more continental climate of the Hungarian Great Plain. The higher western exposed mountain and hill slopes are less vulnerable due to more precipitation, but also in these areas, which are mostly covered by forests, a decrease in summer precipitation can be expected. The agricultural and forestry sector is therefore the most vulnerable productive sector affected by climate-induced drought, and is of particular importance to the economy of the counties. Accordingly, the primary objective and task is to create and further improve water retention conditions and to further develop the solutions already in place. Particular attention should be paid to slowing down run-off in mountainous areas, in the case of smaller streams and intermittent watercourses, mainly by means of small temporary dams made of local timber. The aim is to increase the proportion of irrigated land in lower areas. Investigate the potential of new, more drought-tolerant crops, and introduce new cultivation and forest management techniques to farmers.

Aa-2: Strengthening protection against heat waves: Heat waves caused by climate change, which nowadays are becoming more frequent and longer in duration, are extremely stressful for the human body. According to several European Union and Hungarian measurements, the number of excess deaths caused by heat waves could be as much as 130-175% higher than recent figures. One of the unfortunate consequences of such high figures is the poor state of health of the population and the unfavourable income situation. To achieve this goal, it is important to increase the protective capacity of vulnerable target groups (young children, elderly and sick people, people of low status and living in modest financial circumstances). One means of doing this is to provide information and awareness-raising at the right level and with the right effectiveness. As the population of both counties is ageing, there is also a need to prepare for the provision of adequate health and social care for the elderly. At local level, increasing the proportion of green and water areas, opening up air-conditioned public buildings to the public on hot days and installing mist arches where necessary could improve the effectiveness of protection.

Aa-3: Reducing vulnerability of the built environment: As temperatures rise, the frequency of other weather extremes will also increase. One of the negative consequences of the shifting or changing, modification of climatic zones is the occurrence of extremely strong storms. Strong gusts of wind, frequent lightning strikes, hailstorms and extreme rainfall in 1 hour will put the built environment, including residential and historic buildings and infrastructure, under greater stress than ever before.

The counties, and in particular their villages, are characterised by a steady deterioration in the condition and ageing of their building stock, and these buildings are more vulnerable to the storms. The preparation of monuments is particularly important as they can suffer irreparable damage, even in their original form. In both counties, the large number of overhead power lines is a problem, since if they are damaged they can have the adverse effects of a power cut and also pose a fire risk, and the use of underground cables should be encouraged as far as possible. It is difficult to tackle these problems at local, municipal level alone; it is important to launch county, regional or even national programmes to renovate and modernise buildings. In this respect, it is also essential to ensure that those concerned are properly informed in order to reduce the risk of extreme weather events.

Aa-4: Maintain flood defences, develop protection against flash floods: the counties have a high density of valleys and watercourses due to their topography. Some of these are high gradient streams or rivers, which are generally characterized by the rapid collection and runoff of stormwater. Recent increases in runoff have resulted in flash floods and silt flows. This is partly due to extreme rainfall and uncovered slopes. Flash floods will continue to increase in the future, so preventing their adverse effects is the key objective. This can best be achieved by delaying run-off, partly by using temporary small dams made of organic materials on watercourses with lower flows to protect against drought. In agriculture, significant results can also be achieved by cultivating the soil parallel to the contour lines in hilly areas. In the case of larger rivers, it is important to continue to maintain and possibly raise flood protection embankments and to consider the possibility of creating tidal reservoir.

Aa-5: Vulnerability of natural assets: the natural and landscape assets of the counties are of particular value in many specificities, with the great advantage of the proximity of lowland, alluvial and high-mountain areas. Low-lying wetlands are at risk of drying out as a result of climate change, while in mountainous areas, warming temperatures and reduced soil moisture due to summer droughts weaken the immune system of pine trees, weakening their resistance to new emerging pests and potentially leading to catastrophic forest destruction. These problems can be actively combated by the use of water retention techniques. Some forestry organisations are seriously considering replacing beech stands harvested in the altitudinal zone of around 500-700 m with oak trees that are more resistant to climate change, less water-intensive and more tolerant of heat. This idea is also worth considering in the case of pine forests. It is very important to inform local farmers about the use of new forestry and water-saving technologies by showing them examples of good practice. A particular problem is the technical condition of the tailings ponds in non-ferrous metal mines and their resistance to extreme weather conditions caused by climate change.

Aa-6: Forest and vegetation at risk from fire: One of the greatest natural treasures of the Upper Tisza catchment area is the large forest areas. This is particularly true in the Romanian catchment areas of the counties of Maramures and Satu Mare, although the latter county has a much more modest forest cover. Besides their carbon sequestration role, forests also play an important economic and recreational role. Forests are, and will continue to be, under threat from drought caused by global warming and the proliferation of insect pests. This is also compounded by an increase in the frequency of lightning storms accompanying growing thunderstorms, which can be the cause of many fires. Lightning makes forest fires much easier to start if the forest understorey is dry or if some of the trees have been killed by drought or pests. In addition to the water retention solutions already mentioned in the previous adaptation objectives, it is very important to continue responsible forest management, which means first and foremost removing diseased or dead, dry trees as soon as possible, thus reducing the risk of vegetation fires. In addition to water retention, natural depressions should be filled with rainwater where possible, and small artificial reservoirs should be created in predetermined locations, preferably using natural materials. In lowland areas, it is very important to keep the undergrowth of forest patches and forest strips along roads and railways clear, as traffic may cause vegetation fires to occur more frequently than at present. In addition to training public authorities' staff, it is very important to train local farmers and entrepreneurs involved in forest management on the most appropriate adaptation options for the area concerned.

Aa-7: Aa-7: Vulnerability of water utilities (drinking water, wastewater): future droughts caused by global warming will significantly increase the use of drinking and irrigation water by the population and local farmers. The length of the drinking water and wastewater networks in the Maramures and Satu Mare and Satu Mare counties has increased significantly over the last decade and a half, as has the number of settlements and dwellings connected to the system. Despite the progress made, there is still considerable scope for improvement for both utilities. Groundwater consumption is very widespread, especially in small rural settlements, and its level could decline significantly in the future, with a consequent deterioration in quality. In rural areas, the first priority must therefore be to ensure the widest possible access to piped drinking water for the population, while the existing water supply networks must be prepared for the growing demand. In addition to increasing capacity in line with expected demand, the network must be able to cope with the potential for under-irrigation, minor landslides and soil erosion caused by.

Aa-8: Vulnerability of tourism: both Maramures and Satu Mare counties have attractive tourist destinations. The number of visitors is steadily increasing and further growth can be expected in this respect in the future. However, this is accompanied by a steady increase in the pressure on the natural environment, which is also becoming increasingly vulnerable to varying degrees due to the effects of climate change. Climate change may seriously limit the capacity of tourism activities, eliminate a specific tourism offer or even stimulate the development of new alternative tourism products. Climate conditions are of particular importance for outdoor tourism, especially for holiday, active and winter sports tourism. In the Maramures department, there is a shortening of the winter season, which means that operators in the sub-sector need to diversify their offer, which could be helped by the extension of the summer tourist season. In the case of water sports, forced breaks due to low water flows should be expected. Addressing this problem will require the involvement of other areas, in particular water authorities. Before problems arise, it is proposed that the climate vulnerability of tourist areas and their built elements should be assessed at county level as a priority objective.

Based on the above, the possible overall and preparedness objectives for the counties of Maramures and Satu Mare are summarised in Figure 8.8.

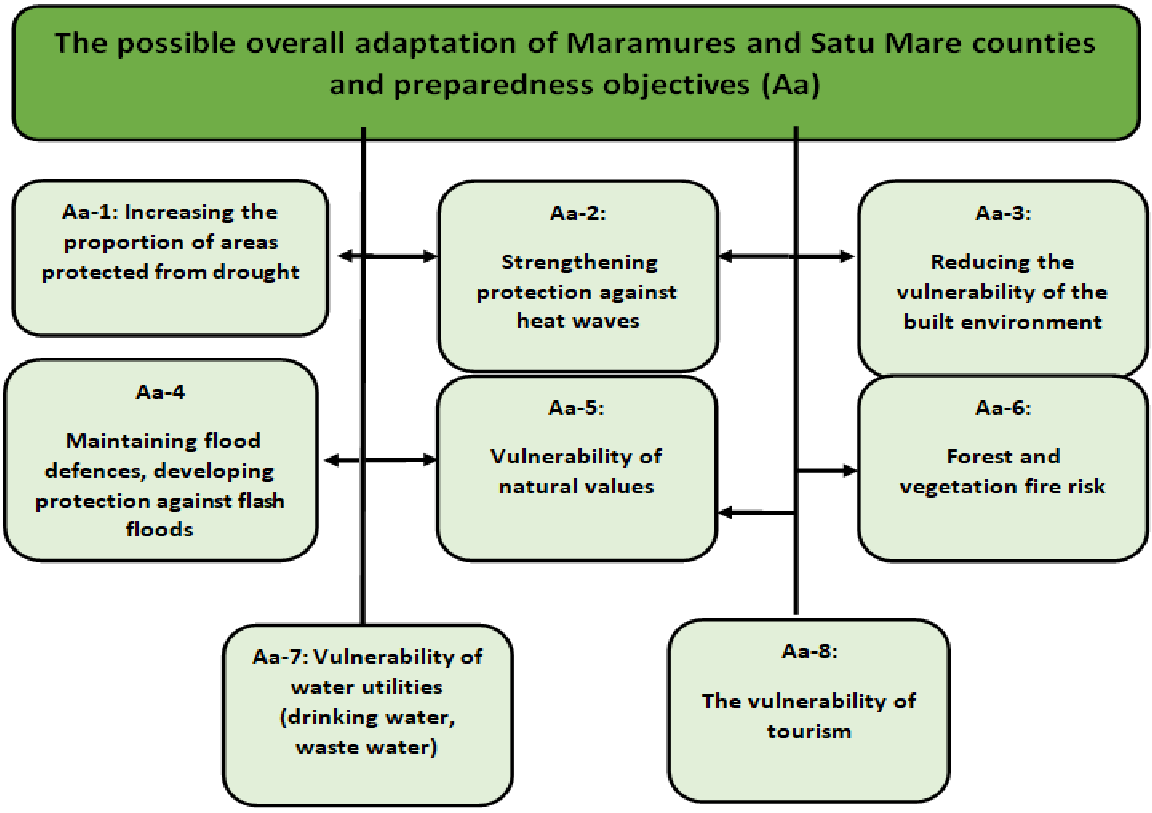

Figure 8.8.: overall adaptation of Maramures and Satu Mare counties and preparedness objectives *Source: own editing*

8.2.3. Climate awareness and awareness-raising objectives

The objectives outlined in the above points can only be successfully achieved if all relevant target groups are properly informed and involved in the implementation process.

Accordingly, the following climate awareness and awareness-raising objectives have been set for the counties of Maramures and Satu Mare:

Ca-1: Improving and further enhancing consumer behaviour towards climate awareness: a part of the population in the two counties is sufficiently climate-aware, while, based on experience abroad, climate-aware attitudes need to be developed among lower-income and more disadvantaged social groups. An important part of this is to strengthen awareness-raising campaigns and actions, emphasising the conscious use of energy, energy efficiency, water saving, possible ways of reducing private transport, and the proper disposal of waste and its separate collection in the largest possible proportion. Over time, further awareness-raising tools should then be used to reduce the amount of non-recyclable waste. It is important to make local products widely known to the public and to encourage their production and purchase. To achieve this, all relevant organisations, institutions, government and municipal offices, primary schools, secondary schools and higher education establishments that can credibly present and promote climate-conscious behaviour should be involved as far as possible.

Ca-2: Increasing local adaptation knowledge: develop and communicate to those involved about locally specific adaptation techniques, solutions and good practices to mitigate the negative impacts of climate change, especially in the area of agricultural production. In addition, it is necessary to increase the general knowledge of the population of the region about climate protection. It is important to make targeted adaptation proposals for specific areas and groups, e.g. specific proposals for mountain and lowland areas. Solutions to problems faced by representatives of the agricultural, productive and service sectors. This should also involve, as far as possible, all relevant organisations, institutions, government and local authorities, primary schools, secondary schools and higher education establishments that can credibly present and promote climate-aware behaviour.

Ca-3: Raising awareness to reduce GHG emissions: according to the GHG inventory data, the largest share of emissions in the counties of Maramures and Satu Mare comes from energy use, then followed by the transport sector, with a lower share of about 50%. Reducing these is an important task for the coming period. The aim is to encourage investments in energy efficiency in the residential, business and institutional sectors and to publicise the results of successful investments as good practice. It is important to start climate-aware education from a very early age, but only taking into account age-specific factors, because this is the only way to ensure that today's youth will become environmentally aware adults.

A possible horizontal set of climate awareness and education targets for the counties of Maramures and Satu Mare is illustrated in Figure 8.9.

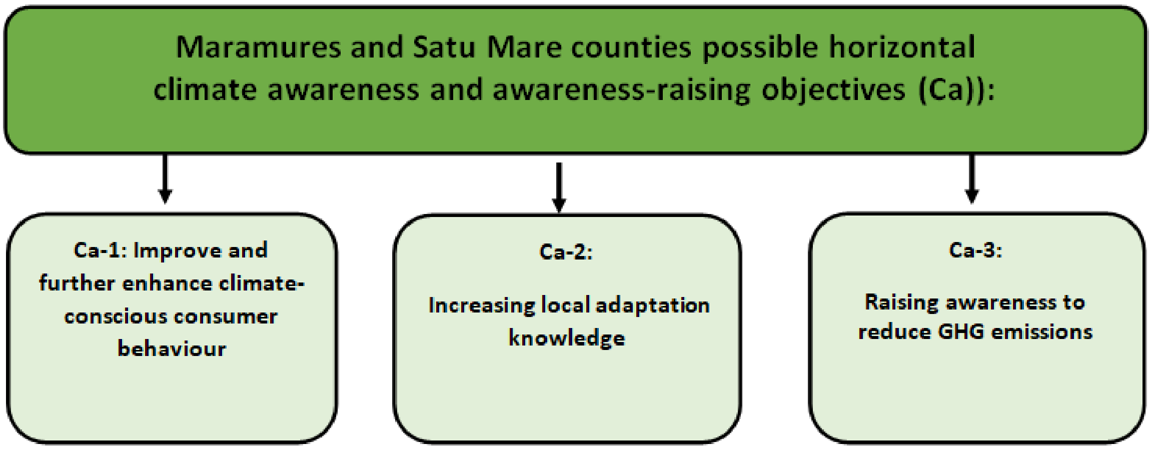

Figure 8.9: Possible horizontal climate awareness and awareness-raising targets for the counties of Maramures and Satu Mare *Source: own editing*

In summary it can be said that, four mitigation, eight adaptation and preparedness objectives and three awareness-raising objectives have been formulated to achieve the climate change vision for the counties of Maramures and Satu Mare.

8.3. Slovakia: a possible climate change vision for the Kosice region and a set of targets to achieve it

The possible climate change vision for the district of Kosice, as the Slovak part of the Upper Tisza river basin, is formulated as follows:

"The District of Kosice will be a competitive and climate-friendly area, where both urban and rural residents will have the opportunity to live, work and leisure activities of high quality, while preserving natural values."

This possible climate vision can only be realised if all the relevant participants (public administrations, citizens, economic operators, etc.) are aware of and accept a target system that can be a guarantee for its fulfilment of this future vision. To this end, it is therefore necessary to formulate a set of climate protection objectives. In the following, the mitigation, adaptation and horizontal climate protection and awareness-raising objectives needed to achieve the climate vision set out above are presented.

8.3.1. Mitigation objectives

The data and analysis of the GHG inventory for the Kosice district showed that one of the most important steps in decarbonisation is to reduce emissions from large industry. In addition, steps should be taken to reduce energy consumption and further increase energy efficiency in general. Further increasing afforestation is also an important target area. The mitigation targets were formulated on the basis of the share of relevant emitters, and defined on this basis the possible targets for the district of Kosice, which are summarised below:

M-1: Reducing energy use, further increasing energy efficiency: the analysis has shown that overall energy use is showing a slight upward trend, which is expected to be halted and a reduction achieved. If large industrial emissions are included, GHG emissions from energy use account for the largest share (around 15%). However, if large industrial emissions are not taken into account, this share is more than 80%. For this reason, it is also important to reduce energy use and at the same time increase energy efficiency, which together can lead to significant GHG emission reductions. The target set by Slovakia is to achieve energy savings of 30-32 % by 2030 as a result of increased energy efficiency. This value should also be targeted at regional level.

M-2: Reduction of large industrial emissions: It could be said that the region has significant large industrial emissions, which have been decreasing over the period under review. It is desirable to maintain this trend, but to accelerate its pace. According to 2016 data, metal production is responsible for 52% of GHG emissions in the industrial process sector. According to EUROSTAT data, energy intensity in Slovakia is still relatively higher compared to the EU average. This is due to the historical structure of industrial production. However, decarbonisation is weakening some sectors of heavy industry, such as chemicals, rubber and plastics, iron and steel. It is expected that the restructuring of the iron and steel industry will entail extra high investment costs, leading to significant price increases. On the other hand, energy costs, especially in the non-ferrous metals sector, will fall as a result of decarbonisation policies, leading to lower prices and increased production. According to the Low Carbon Development Strategy of the Slovak Republic 2030 with outlook to 2050 (Nízkouhlíková strategia rozvojaSlovenskejrepublikydoroku 2030 s výhľadomdoroku 2050), emissions from metal production should be reduced from 4,906 Gg CO2 equivalent (2017 data) to 4,043 Gg CO2 equivalent by 2040.

M-3: Continuous increase of the share of renewable energy in the regional energy supply: one of the most desirable ways to reduce GHG emissions from a climate perspective is to increase the use of renewable as much as possible. As the analysis has shown, the region has great conditions and excellent potential. It is important that any development implemented (e.g. solar panel, wind power, biomass power plant, hydroelectric power plant, etc.) should be a solution that clearly and demonstrably points towards sustainable development, reducing environmental pressures and the share of fossil energy use. The national target for the share of renewable energy is 19,2 % by 2030. This target should also be applied at regional level.

M-4: Further increasing the share of afforestation (increasing CO2 capture): analysis of the GHG inventory shows that it is essential to increase the proportion of forest cover in the area. This is desirable not only for climate protection reasons but also for secondary purposes (e.g. tourism). In order to achieve climate neutrality, it is important to increase the absorption in addition to mitigation measures.

Considering all this, the possible decarbonisation and mitigation target system for the district of Košice is illustrated in Figure 8.10.

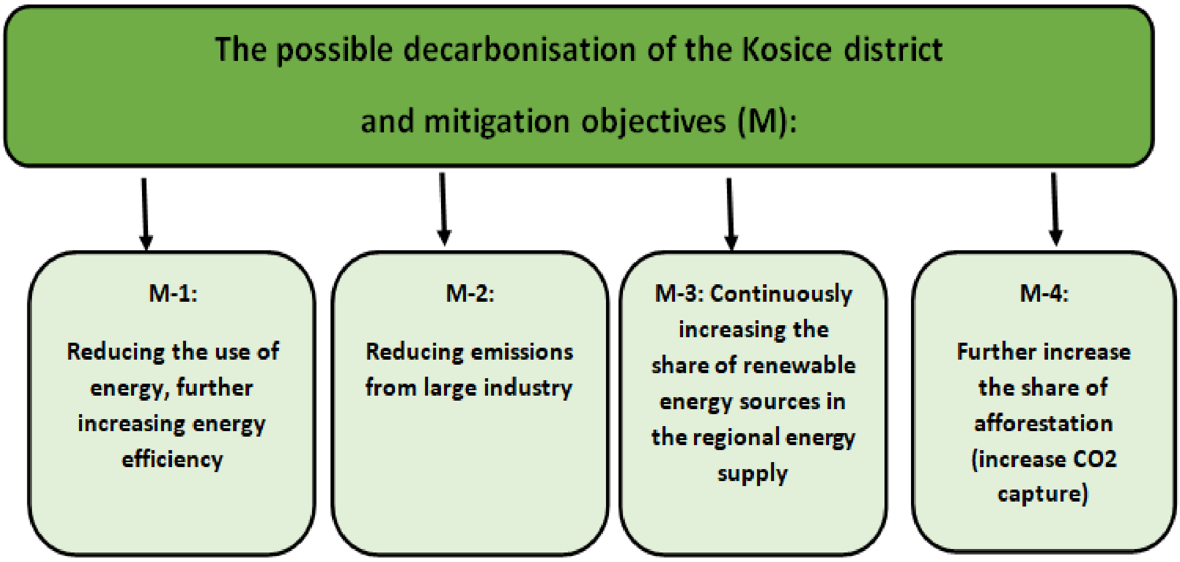

Figure 8.10: Possible decarbonisation and mitigation targeting for the Kosice district

Source: own editing

8.3.2. *Adaptation and preparedness objectives*

Several of the climate change problems significantly affect the Kosice area and have a major impact on the population and economy of the district. Based on the analysis, the following overall adaptation and preparedness objectives have been been formulated for the district:

Aa-1: Increasing the proportion of areas protected from drought: The Kosice area is exposed to the risk of drought due to climate change, which could threaten agricultural production and forestry. Drought vulnerability is more significant in lowland areas, where it could reduce agricultural production. While in mountainous areas, water supply shortages are a problem, rising temperatures and lack of moisture favour invasive species. As both regions of the Kosice area are affected, the main objective is to identify, analyse and present the need for water data. Evaluation of surface water and groundwater resources and of the interaction between surface water and groundwater.

Aa-2: Strengthening protection against heat waves: The lowland region of the Kosice area is affected by the effects of heat waves. These climatic effects influence the number of deaths in the region. An increase in the frequency of heat waves may also increase future health risks. Therefore, there is a need to continuously inform and educate the population to get involved in climate-conscious and health-promoting practices. At the municipal level, the effectiveness of protection can be increased by increasing the proportion of green areas and water surfaces, opening air-conditioned public buildings to the public during heatwave days and installing mist arches where necessary.

Aa-3: Reducing the vulnerability of the built environment: In the Kosice area, a significant proportion of buildings are in a state of continuous deterioration. The number of energy efficiency upgrades in buildings and the number of projects launched has increased recently. Energy upgrading of public institutions has started in the Kosice area. According to the GHG inventory, the majority of energy consumption is used for heating buildings. Therefore, it is proposed to increase the number of projects in which energy efficiency is prioritised.

Aa-4: Maintaining the flood protection system, developing protection against flash floods: The district has a high density of watercourses thanks to its topography. Some of the watercourses are streams and rivers, which are characterised by rapid flow in the mountainous areas, while in the lowland region there are intermediate rivers with significant flow. A slight increase in precipitation is observed in the catchment, which may be associated with higher runoff increases, causing floods and flash floods. Primarily by increasing the protection against sudden and extreme rainfall events, reducing the proportion of flooded areas. Due to the diversity of topography in the county, special attention should be paid to the different impacts on hilly and flat areas when designing measures, and thus to the different nature of the interventions required. Furthermore, the increased frequency of rainfall over a short period of time significantly increases the risk of flash floods. The objective propesed is to strengthen flood defences, develop a system of flash flood preparedness and the development of a monitoring system.

Aa-5: Vulnerability of natural values: the district has outstanding natural values at European level, with a rich flora and fauna, which can be divided into two distinctive regions, plain and mountain.The effects of climate change, the future of habitats and the biodiversity of the area are significantly affected, with the emergence of invasive alien species and the increase in the number of areas at risk from extreme weather events, such as water damage and drought.

Aa-6: Vulnerability to forest and vegetation fires: The proportion of forested land in the Kosice district is well over forty percent. In addition to their carbon sequestration role, forests also play an important economic and recreational role. Forests are under increasing threat from drought and fluctuating water supplies. Forest fires can be caused by lightning storms accompanying more frequent storms and can be a precursor to major fires. Pine forests are at high risk from climate change. The insect pest, spruce bark beetle (Ipstypographus) is causing significant damage. It attacks weakened and damaged trees, but in recent years it has also been observed that it attacks healthy and intact looking trees. Similar to previous adaptation objectives, the occurrence of flash floods should be prevented. The creation of small artificial reservoirs could be a goal, which could also reduce forest fires over larger areas. Increasing the proportion of forested areas in the Kosice area could promote decarbonisation.

Aa-7: Vulnerability to tourism: the Kosice district has many sites of historical importance that are part of the UNESCO World Heritage. Recreational tourism is one of the main tourism profiles, with favourable conditions and adequate accommodation. Most sectors of tourism are present in the area, and it would be worth diversifying further into other sub-sectors, as this could reduce the vulnerability of tourism. In the case of aquatic sports, it should be kept in mind that the climate is changing, leading to rapid changes in water flows, while winter sports should be expected to have a change in the number of days with snow cover. As a priority objective, it is proposed to assess the climate vulnerability of each sector in the tourism sector.

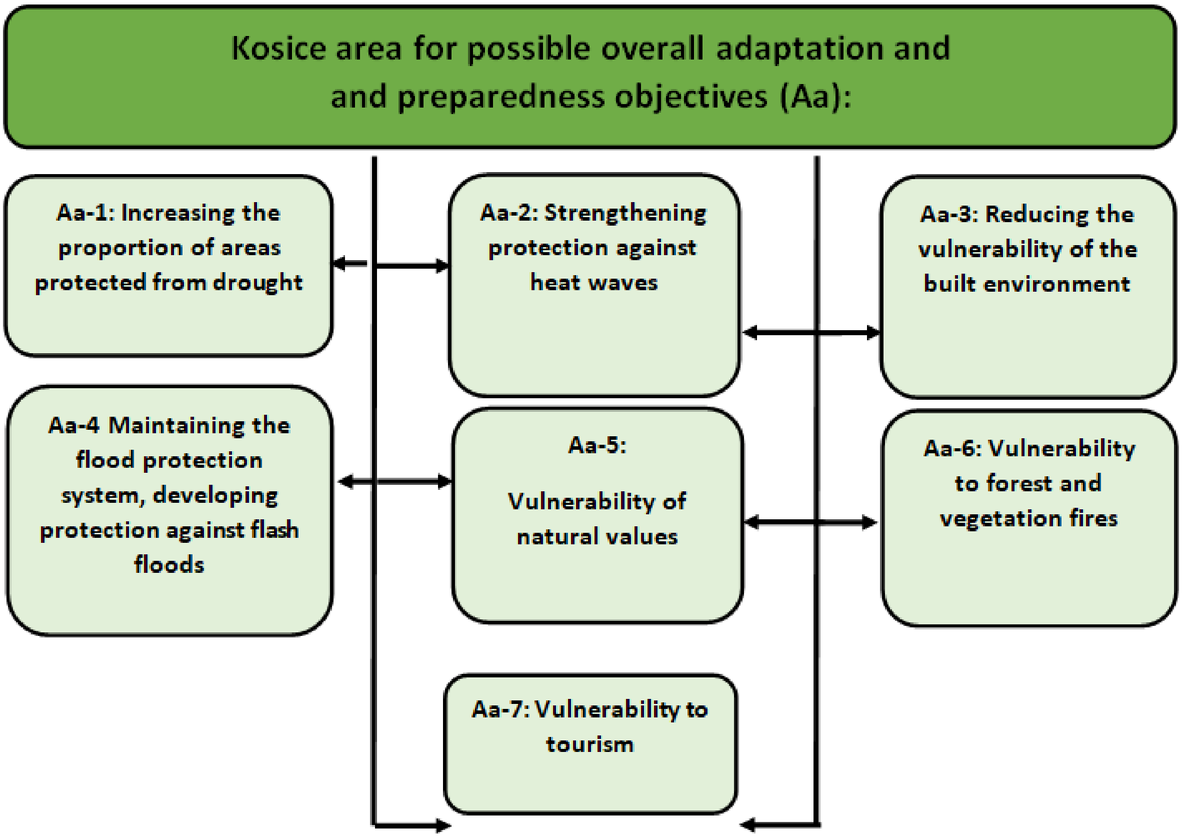

Figure 8.11: Adaptation and preparedness objectives of the Kosice spatial network
Source: own editing

8.3.3. Climate awareness and awareness-raising objectives

The successful achievement of the objectives outlined in the previous points can only be achieved if all relevant target groups are properly informed and involved in the implementation process. Accordingly, the following climate awareness and awareness-raising objectives have been formulated for the district of Kosice:

Ca-1: Further increase climate-conscious consumer behaviour: further develop climate-aware attitudes among a significant part of the population in the area. An important part of this is to strengthen awareness-raising, awareness campaigns and actions, emphasising the conscious use of energy, energy efficiency, possible ways of reducing private transport and further reducing waste. In order to achieve this, it should involve as many relevant organisations, institutions, government and local authorities, primary schools, secondary schools and higher education establishments as possible, which can credibly present and promote climate-conscious behaviour.

Ca-2: Further increase local adaptation knowledge: develop and communicate to those involved about locally specific adaptation techniques, solutions and good practices to mitigate the negative impacts of climate change, especially in the area of agricultural production. In addition, it is necessary to increase the general knowledge of the population of the region about climate protection. As it is primarily the population at regional level that can do most to combat climate change, it is very important that those concerned are aware of the problems this poses at local level and is also important that they are able to adapt to the upcoming changes and challenges.

Szh-3: Raising awareness to reduce GHG emissions: according to the GHG inventory data, the largest share of emissions in the Kosice region, energy use accounts for the largest share of GHG emissions after large industrial emissions. Reducing this is an important task for the coming period, which will require awareness-raising campaigns to inform the public, further encourage energy efficiency investments, promote and adapt support schemes and the results achieved, as well as good practices. It is important to start climate-aware awareness-raising from an early age among children, but only in an age-appropriate way, as this is the only way to ensure that today's youth become environmentally aware adults. A possible horizontal set of climate-awareness and awareness-raising objectives for the district of Kosice is illustrated in Figure 8.12

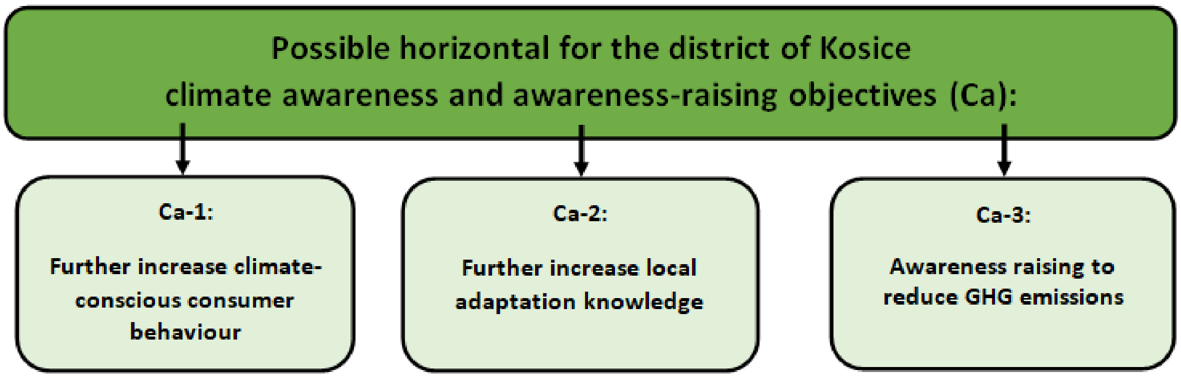

Figure 8.12: Possible horizontal climate awareness and awareness-raising target system for the district of Kosice. *Source: own editing*

8.4. Ukraine: a possible climate change vision for Transcarpathian region and the formulation of a set of objectives to achieve it

The possible climate change vision for the Carpathian region, as the Ukrainian part of the Upper Tisza river basin, is formulated as follows:

Transcarpathia will be a region where climate protection is balanced with industrial development and the preservation of unique natural resources, a region where everyone is happy to live and work.

This possible climate vision can only be realised if all the relevant participles (public administrations, citizens, economic operators, etc.) are aware of and accept a set of objectives that can guarantee its realisation. To this end, it is therefore necessary to formulate a set of climate protection objectives. In the following, to achieve the climate vision formulated above, we present the mitigation, adaptation and horizontal climate protection and awareness-raising objectives.

8.4.1. Mitigation objectives

Ukraine is committed to mitigating climate change, and this commitment needs to be taken forward at the regional level as well. This means doing everything possible to reduce GHG emissions in the region and to maximise carbon absorption capacity, using the instruments at its disposal.

However, in setting targets, the economic strengths and potential of the area, the interests and quality of life of the people living there must always be taken into account. Industry is present in the life of the county and is reflected in CO2 emissions, although these are not recorded in the EU ETS. However, the county administration currently has much less room for manoeuvre in this area than it does in the area of residential and municipal emissions.

The completed GHG inventory data for the region of Transcarpathia shows that one of the most important steps in decarbonisation and mitigation is to replace fossil fuels and to significantly reduce their use. In addition, there is significant decarbonisation potential in increasing energy efficiency. In formulating the mitigation target system, we have taken as a starting point the share of emitters concerned and have used this as a basis for formulating possible targets, which can be summarised as follows:

M-1: Reducing energy use-related GHG emissions, increasing energy efficiency: the analysis has shown that the overall energy consumption in the county is slightly showing a declining tendency, which should be maintained and further increased. GHG emissions from the energy used represent the largest share (almost 50%). The most effective way to reduce this is to increase energy efficiency, therefore significant investments in energy efficiency are needed in the county, both in the residential and municipal sectors and in the public and local government sectors. There is also a need for economic operators to increase their energy efficiency.

M-2: Reducing CO2 emissions from transport: according to the GHG inventory, there is a downward trend can be observed in GHG emissions from transport. This reduction is desirable to maintain, but the rate of decrease needs to be increased. However, it should be stressed that the county is located on an important pan-European transport corridor (TEN-T Corridor V: Venice - Trieste/Copper - Ljubljana - Maribor - Budapest - Uzhhorod - Lviv - Kiev), which carries significant passenger and freight traffic. Its economic role is very important, so a reduction in this traffic is unlikely. However, it is an important local objective to raise awareness among the inhabitants of the region of the impact of transport and of the emissions caused by unnecessary car use, while at the same time creating the conditions for environmentally friendly modes of transport (e.g. electric charging stations). It is then desirable to promote the purchase of electric vehicles for private transport and other alternative solutions (e.g. carpooling to work, car-sharing, etc.).

M-3: A steady increase in the share of energy from renewable sources in the regional energy supply: one of the most desirable ways to reduce GHG emissions from a climate perspective is to increase the share of renewable energy as much as possible. Transcarpathia has a significant potential in the field of hydropower due to its mountain rivers. Increasing the use of this potential and, at the same time, the use of solar systems and the use of solar collectors for the production of domestic hot water (especially in lowland areas) are also important areas for development. Any development of renewable energy sources (e.g. solar panels, wind power plants, biomass power plants, hydroelectric power plants, etc.) should only be undertaken in a way that is clearly and demonstrably oriented towards sustainable development, reduces environmental pressures and decreases the proportion of fossil energy use.

M-4: Maintain and possibly increase the proportion of forest cover (increase CO2 capture): the forest cover in Transcarpathia can be considered outstanding (more than 50% of its territory is forest), which should be maintained and possibly further increasing preferable. This is important not only for climate protection reasons but also for secondary objectives (e.g. ecotourism). The county can thus make a significant contribution to achieving climate neutrality objectives.

On this basis, the potential decarbonisation and mitigation targeting system for the Carpathian region is illustrated in Figure 8.13.

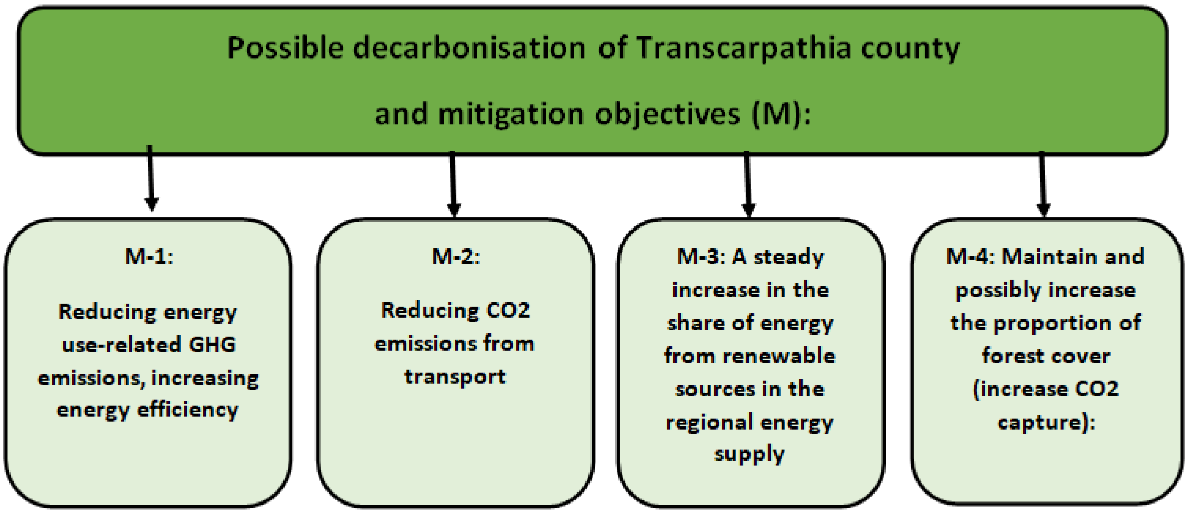

Figure 8.13: Possible decarbonisation and mitigation target system for Transcarpathia County
Source: own editing

8.4.2 . Adaptation and preparedness objectives

Several of the climate change problems significantly affect the Transcarpathian region, affecting its population, economy and agricultural production.

Based on the analysis, the following overall adaptation and preparedness objectives have been formulated for the county:

Aa-1: Increase the proportion of areas protected from drought: According to the climatic scenarios, drought may cause problems in agricultural production in the plain areas of Transcarpathian region, as it may generate significant yield losses for farmers. While in the mountainous areas the impact of drought is not significant for forestry. Overall, the risk of drought in the lowland region affects the agricultural sector, hence the main objective and task is to develop a water management system to improve agricultural production. To retain water for agricultural areas through technical solutions, of which the main sources are surface water and rivers. In addition to these, it is a very important objective to increase the proportion of irrigated land and to encourage farmers to use drought-tolerant plant varieties. Review and improvement of agricultural drainage systems.

Aa-2: Strengthening protection against heat waves: The lowland areas of Transcarpathia county are significantly affected by the effects of heat waves. These effects may be associated with an increase in the number of deaths, these weather situations put a significant strain on the body systems of the population, which can be mainly explained by the excess temperature. However, the unfavourable health and income situation of the population is not conducive to health protection. In the county, it may be important to achieve the following objective, in order to improve the ability of vulnerable age groups in society to protect themselves, both in urban and rural areas. One way to protect is to organise and implement awareness-raising programmes at the right level and with the right effectiveness. In municipalities, the creation of green corridors, parks and open water surfaces can be key to reducing temperatures in the city centre.

Aa-3: Reducing the vulnerability of the built environment: In Transcarpathia County, the condition of its buildings is constantly deteriorating as a result of extreme hydrological and meteorological conditions (wind gusts, lightning, floods, groundwater table). In rural settlements, the age composition of buildings is ageing, making them more vulnerable. Heavy rainfall can overload the roof structure of buildings (hail, heavy precipitation) and the lack of drainage systems accelerates the deterioration of buildings at a higher than average rate. These problems may be important to address in the future, which could be implemented through national programmes and municipal improvements, i.e. modernising buildings, improving energy efficiency.

Aa-4: Maintaining the flood protection system, developing protection against flash floods: The county has a high density of watercourses due to its topography. Some of the watercourses are streams and rivers, which are characterised by rapid flow in the mountainous areas, while in the lowland region there are intermediate rivers with significant flow. A slight increase in precipitation can be observed in the catchment, which can be associated with higher runoff increases, causing floods and flash floods. Furthermore, the increased frequency of rainfall over a short period of time significantly increases the risk of flash floods. The main objective may be to protect against and prevent flooding. Prevention could include the use of such technical solution(s) that could prevent flash flooding and store surplus water in lowland areas for use in irrigation. In the case of larger rivers, it is important to continuously maintain and possibly heighten flood protection embankments and to consider the creation of tidal reservoirs.

Aa-5: Vulnerability of natural values: the county has a rich natural fauna, which can be divided into two distinctive regions: plains and mountains. The lowland areas are highly vulnerable to drought conditions, especially wetlands, while in the uplands sudden precipitation can cause natural damage. Climate change is a major factor determining the loss of species diversity in the region. To mitigate this process, an objective can be formulated to increase the proportion of protected areas in the lowlands, furthermore, an increase in the proportion of lowland forest area could help to maintain the biodiversity and preserve the wildlife.

Landforms of anthropogenic origin and underground mines can pose a risk to wildlife, the Tisza River and the lowland areas. Increasing precipitation due to climate change will accelerate the number of collapsed sinkholes and areas of subsidence, which could have a significant impact on infrastructure and public buildings. A possible objective is to develop a stormwater drainage system of sufficient capacity on abandoned mine sites.

Aa-6: Vulnerability to forest and vegetation fires: In Transcarpathia, the proportion of forested land is well over forty percent, but in the lowlands it is only fifteen percent. Besides their carbon sequestration role, forests also play an important economic and recreational role. Forests are under increasing threat from drought and fluctuating water supplies. Forest fires can be triggered by lightning storms accompanying more frequent storms and can be a precursor to major fires. In line with previous adaptation objectives, water retention solutions could help prevent forest fires and the introduction of conscious management of resources would also contribute significantly to minimising risks. The creation of small artificial reservoirs near more vulnerable areas could reduce forest fires over larger areas. In lowland areas, it is important to improve the proportion of forest cover and to keep the forest belt undergrowth clear.

Aa-7: Managing the waste situation: As a result of consumer behaviour, there is a significant amount of waste generated in the county which needs to be managed, as the challenges posed by climate change require efficient waste management from collection to disposal/recycling. There are some good examples in the county, such as the use of selective waste collection, and in some municipalities the number of waste collection and landfill sites has increased in the last period. Waste storage and processing is a problem in mountainous regions, while smaller municipalities in the lowlands have not solved the problem of waste transport and processing yet, either. The establishment and development of a waste management system and the construction of waste processing plants in both lowland and mountain areas could be an important objective for the region.

Aa-8: Vulnerability of water utilities (drinking water, waste water): Future droughts caused by global warming will significantly increase the use of drinking and irrigation water by the population and local farmers. In the rural areas of Transcarpathia, there is a low level of coverage of piped drinking water supply and of sewage and stormwater drainage

While more improvements have been made in urban areas, despite the progress made, significant development targets have yet to be set for both utilities. In rural areas, it is important to ensure the widest possible access to piped drinking water for the population. In addition, existing utilities and networks need to be upgraded to cope with growing water consumption.

Aa-9: The vulnerability of tourism: Transcarpathia has attractive tourist destinations. The number of tourists is steadily increasing and is expected to grow further in the future. This, however, is accompanied by a steady increase in the pressure on the natural environment, which is also becoming increasingly vulnerable to varying degrees due to the effects of climate change. Climate change may limit the capacity of tourism activities, such as outdoor events and leisure activities, or lead to the closure of more drastic sectors. In Transcarpathia, winter and summer tourist seasons can be separated. Most tourism sectors are present in the county, but there is a need to diversify into additional sub-sectors, as this could reduce the vulnerability of tourism. For water sports, rapid changes in water flows due to climate change should be expected, while for winter sports, a reduction in the number of days with snow cover should be expected. As a priority objective, it is proposed to assess the climate vulnerability of the tourism sector.

On the basis of the above, the overall and preparedness objectives for Transcarpathia County are summarised in Figure 8.14.

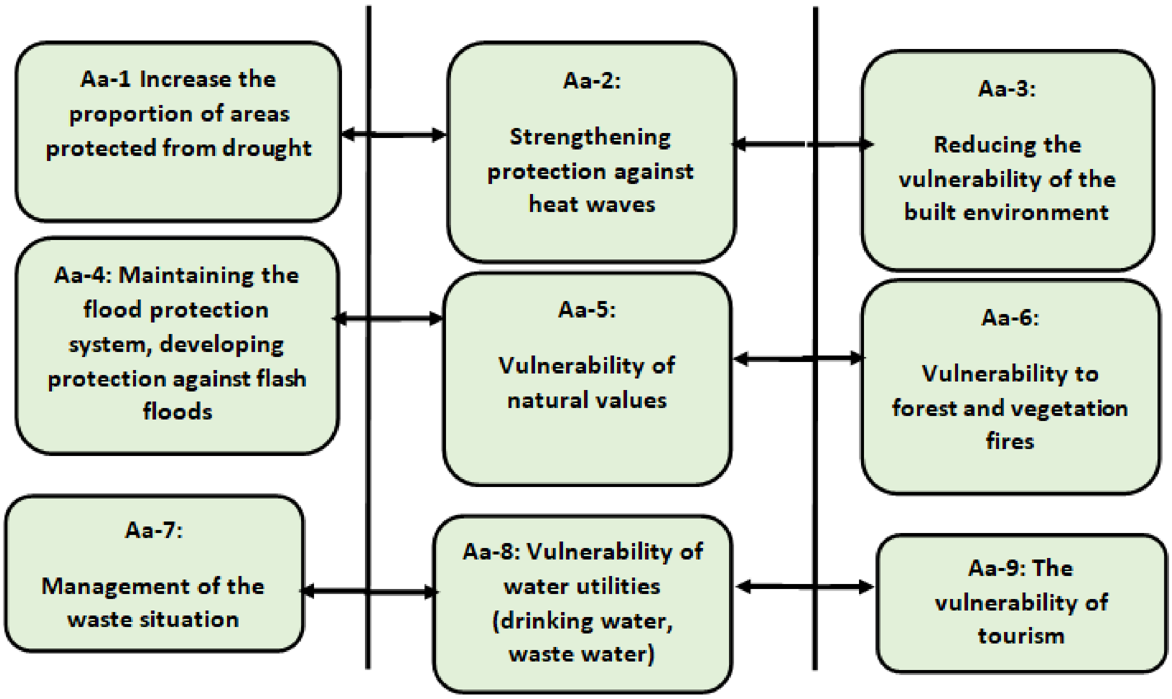

Figure 8.14: Transcarpathia's overall adaptation and preparedness objectives.
Source: own editing

8.4.3. Climate awareness and awareness-raising objectives

The successful achievement of the objectives outlined in the above points can only be achieved if all relevant target groups are properly informed and involved in the implementation process. Accordingly, the following climate awareness and awareness-raising objectives have been formulated for the Transcarpathian region:

Ca-1: **Developing and improving climate-aware consumer behaviour:** it is important to develop climate-aware attitudes among a significant part of the population of the county. One way to do this is to develop and implement awareness-raising projects. Another is to implement awareness-raising campaigns and actions, emphasising the concepts of energy efficiency and energy awareness. In addition, it is important to highlight possible modes of transport and ways of reducing waste. In order to implement the projects, all relevant organisations, institutions, government and local authorities, primary schools, secondary schools and higher education establishments that can credibly present and promote climate-aware behaviour should be involved as far as possible.

Ca-2: Further develop local adaptation knowledge: the development and implementation of adaptation techniques can only be achieved through climate-aware thinking, education and awareness-raising of the importance of individual responsibility. Local adaptation techniques, solutions and good practices that can help to mitigate the negative effects of climate change, particularly in the areas of agriculture and forestry, should be communicated to the target groups concerned. This could include, for example, providing garden owners and farmers with information on new soil cultivation and rainwater management technologies, sharing good practices, or providing information on how to improve thermal comfort on heat days.

Ca-3: Raising awareness to reduce GHG emissions: the GHG inventory and its analysis showed that energy use accounts for half of the GHG emissions in the county. The trend of GHG is decreasing, and it is desirable to further increase it, which can be achieved most effectively by increasing energy efficiency. Therefore, it is necessary to launch awareness-raising projects and campaigns aimed at informing users, encouraging investments in energy efficiency, presenting the forms of support and the results achieved. In addition, it is important to develop a public database to record and monitor savings from energy efficiency investments.

A possible set of horizontal climate awareness and awareness raising targets for Carpathians is illustrated in Figure 8.15.

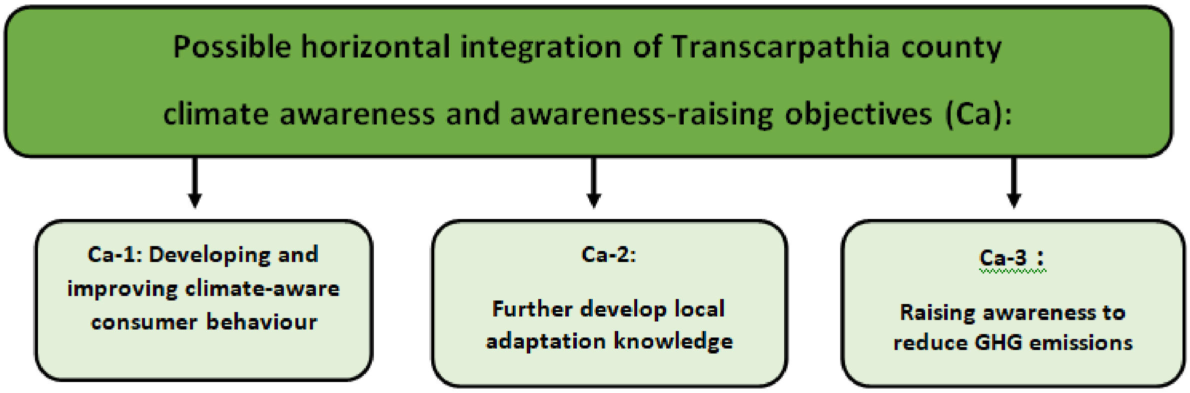

Figure 8.15: Possible horizontal climate awareness and awareness-raising target system for Carpathians

9. Identification of possible areas for intervention and related proposals for action

In the following, measures related to the objectives set out in the previous chapter (8. Defining a vision for climate protection, setting targets) are presented in summarised form for the entire Upper Tisza River basin. As there are unique objectives for mitigation, adaptation and awareness-raising for each administrative unit of the river basin, in addition to the overall objectives for the whole area, these are highlighted separately. Specific, detailed proposals for action are also presented separately for each administrative unit as an annex to Chapter 9.

9.1. Proposals for mitigation measures

The most important future challenge for decarbonisation is to replace fossil fuels with renewable energy sources. This will directly reduce GHG emissions. In general, efforts should be made to increase energy efficiency. The preparation of the GHG inventories and their analysis have revealed the main problem areas that are dominant in the Upper Tisza River basin and need to be dealt with. The formulation of the objectives was based on the proportion of emitters concerned, and on this basis, we formulated the mitigation measures that we consider appropriate to implement in all four countries. These decarbonisation and mitigation targets are:

9.1.1. Increasing energy efficiency by reducing emissions

Based on the GHG inventories, it was found that energy use accounts for the largest share of GHG emissions, typically around 50% of emissions (with the exception of the district of Kosice, where large industrial emissions are significant. Without taking into account large industrial emissions, the share is 80%). This share could be reduced by using more modern heating methods (e.g. using condensing gas boilers instead of the old ones), by reducing the energy consumption of residential and public buildings (e.g. replacing insulation, windows, etc.), by replacing energy-intensive household appliances (e.g. old refrigerators, washing machines, etc.) with energy-efficient ones, and by modernising lighting (energy-saving light bulbs, LED lamps). In parallel to reducing energy use, it is also important to increase energy efficiency, which together can lead to significant GHG emission reductions. This also requires significant energy efficiency investments in the areas concerned, in the residential, municipal, public and local government sectors. Energy efficiency also needs to be improved by economic operators.

9.1.2. Reducing CO2 emissions from transport

The analysis shows an increase in motorisation in the Upper Tisza River basin and a corresponding increase in transport emissions. With the improvement of the road network, homes and workplaces becoming more distant from one another, the decline of public transport and changing consumer habits, this sector has the greatest potential for growth in emissions. The GHG inventory data show a clear increase in GHG emissions from transport (with the exception of the Transcarpathian region, where a slight decrease was observed). It is important that people in the region are made aware of the impact of transport and the emissions caused by unnecessary car use, while at the same time efforts should be made to use environmentally friendly modes of transport, both for public and private transport. In public transport, local services (e.g. intra-community public transport) should replace diesel vehicles with CNG (compressed natural gas) or fully electric vehicles. In private transport, the purchase of electric vehicles and other alternative solutions (e.g. carpooling to work, car-sharing, etc.) should be promoted. At the same time, efforts should be made to create the conditions for environmentally friendly modes of transport (e.g. electric charging stations).

9.1.3. Continuously increasing the share of renewable energy sources in the regional energy supply

One possible way to reduce GHG emissions - and perhaps the most desirable from a climate perspective - is to increase the proportion of renewable energy in the energy mix. The Upper Tisza catchment area is basically well endowed and has great potential in this sector, whether we are talking about solar energy, wind energy, geothermal energy, biomass or hydropower. It is important that whatever development takes place, it must make a demonstrable contribution to sustainable development, reducing, but certainly not increasing, the environmental burden and the current rate of fossil fuel use.

9.1.4. Further increase the forest cover in the area (increase CO2 absorption)

The preparation of GHG inventories and their analysis showed that in the Upper Tisza River basin, the amount of forest cover and thus the share of carbon sequestration in total GHG emissions varies from country to country. Basically, in all the countries concerned, forest cover is slowly but steadily increasing. This is desirable, as the overall aim is also to increase the amount of forest area. This is desirable not only for climate protection reasons, but also for secondary purposes (e.g. tourism). Achieving climate neutrality requires a significant increase in the extent of forested areas as sinks. The forest cover of Transcarpathia County is outstanding (more than 50% of its territory is forest), and it is desirable to maintain and, if possible, further increase it.

9.2. Proposals for mitigation measures

Adaptation interventions aim to achieve some of the climate change adaptation and preparedness objectives set out in Chapter 8 as thoroughly as possible, in order to reduce the risks posed by climate change. As with the formulation of mitigation objectives, the adaptation and preparedness objectives for each part of the river basin differ on only a few points.

9.2.1. Increasing the proportion of areas protected from drought

Due to the changed atmospheric situation resulting from climate change, must prepare simultaneously for sudden, extreme rainfall as well as for a long period without rainfall, for possible drought even within the same year. To achieve this, it has become necessary to retain rainfall and use it for irrigation during the drier periods. This planned measure aims to increase the security of agricultural production by encouraging local farmers to conserve water and improve their irrigation technology.

In mountain and hilly areas, it is also important to create opportunities for water retention. The best way to achieve this is to partially block the beds of small streams or intermittent watercourses with temporary dams made of local timber that can be easily dismantled if possible. This intervention can delay run-off and thus allow higher groundwater levels to be expected during periods of no rainfall. Smaller dams in several places along the watercourse will improve groundwater balance and create a fresher microclimate.

9.2.2. Strengthening protection against heat waves

Heat waves caused by climate change, which are becoming more frequent and longer in duration, are extremely stressful for the human body. According to several European Union and Hungarian measurements, the number of excess deaths caused by heat waves could be as much as 130-175% higher than recent figures. As the population of the catchment area is ageing, there is also a need to prepare for adequate health and social care for the elderly. At the municipal level, increasing the proportion of green and water areas can increase the effectiveness of protection. For settlements with a population of more than ten thousand people, a heat alert plan should be developed if the settlement does not already have one. With a specific emphasis on the protection of vulnerable groups. This must include opening air-conditioned public buildings to the public during heat waves, as well as installing mist arches, water distribution at busy traffic junctions. An important measure is to inform the public on how to deal with heat waves and extreme weather situations The measure supports target-specific communication and the use of information tools.

9.2.3. Built environment and infrastructure vulnerability assessment

The measure aims to create a database of buildings which will include buildings of a certain age or in a certain technical condition. Each building is given a weighted score according to its vulnerability to climate change. In addition to buildings, a similar inventory of linear infrastructure is recommended.

9.2.4. Maintenance of flood and inland water protection system, protection against flash floods

In recent years and decades, the flood protection system and flood safety of the Upper Tisza water system have improved significantly. It is therefore important that the protection structures and other technical installations are able to fulfil their function in the long term. In the hilly and mountainous areas flash floods are a real threat and the risk of their occurrence will increase in the future. The proposed solution to reduce flood damage is to use run-off slowing solutions. Significant results can be achieved by cultivating the land parallel to the contour lines, by temporarily blocking small watercourses and by planting forests on critical slopes. Especially in lowland areas, to prevent flood damage, it is important to improve local drainage and retention systems and to renovate and modernise existing ones.

9.2.5. Vulnerability assessment of protected values

The aim of the action is to assess the climate-specific vulnerability of protected natural, landscape, built and other special values, with a particular focus on mapping the negative impacts of climate change.

9.2.6. Preparation and monitoring of facilities related to mining

Salt and non-ferrous metal mining over the centuries has left behind mines, former and still in use tailings storage facilities as potential hazards are present. These sites are particularly vulnerable to the adverse effects of climate change. These sites are particularly vulnerable to the adverse effects of climate change. For this reason, it is important to carry out an annual assessment of the technical state of the cyanide and heavy metal slurry reservoirs in Mara Mures County, and if necessary, to technically upgrade their dams. In the case of the karsts of the Szolotvino (Aknaszlatina) salt mine, it is recommended to continue monitoring them, both in terms of their technical condition and their extent. The technical aspects of the rainwater drainage potential of the mine area should be investigated. The technical aspects of the rainwater drainage potential of the mine area should be investigated.

9.2.7. Vulnerability of forest and vegetation to fire

Forest and vegetation fires are also becoming more frequent due to the increasing likelihood of lightning strikes and the intensifying drought. To prevent these as effectively as possible, it is important to remove diseased and dead trees as soon as possible, as they are more likely to catch fire. In the case of lowland areas, it is very important to keep the undergrowth of forest patches and forest strips along roads and railways clear, as in their absence, traffic can cause vegetation fires to occur more frequently than at present. In addition to training public authorities, it is very important to train local farmers and entrepreneurs in the forestry sector on the best adaptation options for their area.

9.2.8. Vulnerability of water utilities (drinking water, waste water)

Climate change is expected to lead to a significant increase in demand for drinking water in the summer, for which the drinking water supply system needs to be prepared in time. The measures will include both the preparation of a revision plan for the drinking water network and the necessary reconstruction works, which will also include the construction of a larger diameter backbone.

Methane from wastewater is a non-negligible item in the GHG inventory, so it is a top priority to ensure that the maximum, i.e.,100%, is reached by homes connected to the wastewater network. The intervention would protect the environment (surface water, groundwater, soils) while allowing wastewater to be used in biogas power plants. This would minimise methane emissions and significantly improve the GHG balance. In Transcarpathia, the wastewater network system in most of the cities requires reconstruction works. In rural areas, where they are lacking, sewerage and drainage networks need to be constructed.

9.2.9. Strengthening local tourism and ecotourism

It is important to assess the climate vulnerability of tourism and ecotourism destinations. The sector must be prepared for climate adaptation based on the changed circumstances. In hilly areas it should be kept in mind that, as a consequence of global warming, the summer tourist season is expected to be extended, putting increased pressure on the natural environment. It is therefore essential that a detailed cadastral survey of the most vulnerable areas is carried out to identify the most vulnerable areas, where only limited numbers of tourists will be allowed to enter.

9.3. Proposals for awareness-raising measures

9.3.1. Raising public awareness to improve climate conscious behaviour, to expand knowledge on mitigation and adaptation

The measure includes the organisation of the following climate-awareness raising activities, which will showcase energy saving solutions, increasing the energy efficiency of buildings; the potential of renewable energy sources; ways to build resilience to extreme weather situations; ways to protect against heat waves; and the promotion and popularisation of public transport.

9.3.2. Complex awareness-raising programme for local farmers and agricultural producers

The measure takes a complex approach and includes awareness-raising objectives to help local farmers prepare for the negative impacts of climate change. Particular importance of these are the threats of drought, the phenomena caused by deflation and erosion, and flood protection. Farmers can also find out about mitigation options related to their activities. The programmes include the following points: 1. develop a database for farmers and agricultural producers on the varieties that can be grown under changed or extreme weather conditions with less risk; 2. to prepare the farmers of the county for precision farming, with particular emphasis on reducing the environmental burden; 3. awareness-raising campaigns on the arrival of new, previously non-native or invasive species and possible control methods; 4. promoting and strengthening the role of organic farming; 5. transfer of knowledge on agricultural water management; 6. reducing the amount of waste generated during production, striving for zero waste.

9.3.3. Climate action programme for local schools

Complex climate-aware awareness-raising programmes should be introduced in public education, specifically designed to increase the knowledge of pupils under 18. The programme aims to achieve the following objectives: 1. developing students' energy awareness; 2. promoting knowledge of renewable energy sources and strengthening their role; 3. reinforcing education on selective waste collection; 4. raising awareness of the impacts of climate change in the county.

9.3.4. Awareness-raising programme for local businesses and other economic participants

The measure will include complex awareness-raising and knowledge transfer programmes for businesses and economic operators in the region, presenting climate conscious good practices related to different economic activities and mitigation opportunities in different sectors of the economy.

9.3.5. Organisation and implementation of climate change awareness-raising activities for public authorities

The measure aims to raise the climate change awareness of groups in the public administration who are involved in the running of a municipality, so that they can explore the local context. Their awareness-raising will help to increase local community knowledge and communication about climate change and local environmental problems.

9.3.6. Collecting good practices on climate and energy efficiency

The measure includes exploring climate conscious good practices and presenting them in the local press and on TV channels. Where possible, visiting energy-efficient demonstration houses and organising residential study tours.

10. Annexes

Proposals for action - Hungary - Szabolcs-Szatmár-Bereg county

Comprehensive proposals for action

Establishment of the Szabolcs-Szatmár-Bereg County Climate Office and Climate Fund			**Code of action**
The establishment of an appropriate institutional framework is an essential prerequisite for the achievement of the county's climate objectives. A possible solution is to set up a County Climate Office and to secure a Climate Fund to finance it. Its main activity is to provide professional support, coordination and advice. The University of Nyíregyháza (formerly Nyíregyháza College) has already established a local climate office in 2010, with the cooperation of Szent István University. Based on this experience, the County Climate Office will be able to provide assistance to the population of the county, institutions, business organisations and municipalities in the field of climate protection, and to coordinate the implementation of the county's climate protection goals. **Due to its specific geographical location (bordering Slovakia, Ukraine and Romania), the county can also play a cross-border coordination role in the implementation of a regional climate strategy.** The climate advisers working here can inform relevant target groups and other interested parties about what is currently being done, the funding available and help those concerned by collecting good practice. The purpose of the Climate Fund to be set up is to operate the Climate Office, providing a financial resource for small-scale activities that are not supported by national or Community funds. The financial backing of the fund would be provided by voluntary contributions from local governments, businesses and other public and county institutions.			M-0 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-0	-	-
Timeframe:	Operating continuously from 2021		
Responsible:	Hungarian State, Szabolcs-Szatmár-Bereg County Municipality, municipal governments		
Target Group:	The entire population of Szabolcs-Szatmár-Bereg County, institutions, business organisations, municipal governments		

Proposals for mitigation measures

Validation of the decarbonisation objectives of the Szabolcs-Szatmár-Bereg County Climate Strategy in the county's strategic, development and tender documents			**Code of action**
A key aspect in the preparation of future county development documents should be the implementation of the objectives of the Climate Strategy. For this purpose, the decarbonisation objectives outlined in the climate strategy should be taken into account and integrated into the document when preparing future county development and other strategic documents. It is also important to ensure that decarbonisation commitments are taken forward in the preparation and implementation of development activities.			M-1 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1	-	Ca; Ca-1; Ca-2; Ca-3; Ca-4;
Timeframe:	Continuously from 2021		
Responsible:	The organisations, consultative bodies and authorities responsible for drawing up developments and strategies.		

Target Group:	Szabolcs-Szatmár-Bereg County Municipality; Total population of Szabolcs-Szatmár-Bereg County

Measures related to Objective M1

Encouraging residential energy efficiency investments			**Code of action**
In Szabolcs-Szatmár-Bereg county, the renewal of the housing stock is one of the most important tasks. For this purpose, efforts should be made to modernise the energy efficiency of the county's housing stock (e.g. replacement of windows and doors, insulation, replacement of outdated gas boilers, replacement of old, energy-intensive household appliances, etc.). It is important to inform the public about the related funding sources, in which the future County Climate Office can play an active role.			M-2 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1	-	Ca; Ca-1; Ca-2; Ca-3; Ca-4;
Timeframe:	2021-2027		
Responsible:	Szabolcs-Szatmár-Bereg County Climate Office		
Target Group:	Total population of Szabolcs-Szatmár-Bereg County		
Energy upgrading of enterprises			**Code of action**
County businesses play an important role in keeping jobs and creating new jobs. It is therefore very important to ensure their long-term economic sustainability. One way to do this is to reduce energy use and thus costs, which is also a climate protection requirement. Within the framework of the measure, industrial and agricultural operators will be informed about current sources of funding and other programmes to promote energy efficiency.			M-3 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1; M-3	-	Ca; Ca-1; Ca-2; Ca-3; Ca-4;
Timeframe:	2021-2027		
Responsible:	Szabolcs-Szatmár-Bereg County Chamber of Commerce and Industry; Szabolcs-Szatmár-Bereg County Organisation of the National Chamber of Agriculture		
Target Group:	Farming organisations, farmers		
Energy upgrading of Public institutions			**Code of action**
The energy modernisation of some of the county's public buildings has been completed or is underway. It is essential to continue this work, which has the overall climate protection objective of reducing GHG emissions and, on the economic side, reducing energy costs for the Community.			M-4 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1; M-3	-	Ca; Ca-1; Ca-2; Ca-3; Ca-4;
Timeframe:	2021-2027		
Responsible:	Szabolcs-Szatmár-Bereg County Climate Office; Owners and operators of the institutions concerned		
Target Group:	Municipal governments; operators of social, health, educational and training institutions; operators of public administration institutions.		
Collecting, monitoring and making public the energy efficiency results of energy developments and investments through the creation of a database (monitoring the reduction of GHG emissions)			**Code of action**
Through this measure, energy savings (GHG emission reduction) data on energy efficiency investments made by institutions, municipalities and business organisations will be collected and recorded in a central database. This also provides an opportunity to summarise and make the data public.			M-5 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1	-	Ca; Ca-1; Ca-2; Ca-3; Ca-4;

Timeframe:	Continuously from 2021
Responsible:	Szabolcs-Szatmár-Bereg County Climate Office
Target Group:	Institutions, municipalities, economic operators involved in the investments

Measures related to Objective M2

Strengthening the role of cycling			**Code of action**
The aim of the measure is to further develop the county's network of cycling paths and related infrastructure, thereby reducing GHG emissions from transport and increasing the role of cycling tourism. In this context, the implementation of awareness-raising activities, such as the Car Free Day or the Cycle to Work programme, and the promotion of cycling in general, are also important.			M-6 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-2	-	Ca; Ca-1; Ca-2; Ca-3; Ca-4;
Timeframe:	2021-2027		
Responsible:	Hungarian State; municipal governments; Szabolcs-Szatmár-Bereg County Climate Office; national and local civil cycling organisations		
Target Group:	Local residents and tourists		
Encouraging the creation of Workplace Mobility Plans			**Code of action**
Encourage major county employers (businesses, public institutions) to develop workplace mobility plans to increase the role of sustainable transport modes. This could be an exemplary solution not only for commuting but also for business travel. Typically, neither companies nor public institutions have such plans yet. The role of the county council and the Climate Office would be important in this, helping the various partners involved to work together.			M-7 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-2	-	Ca; Ca-1; Ca-2; Ca-3; Ca-4;
Timeframe:	Continuously involving larger employers from 2021		
Responsible:	The person responsible for the development of the plans is the relevant employer; Szabolcs-Szatmár-Bereg County Climate Office.		
Target Group:	Major employers in Szabolcs-Szatmár-Bereg county (e.g. LEGO, MICHELIN, Unilever, etc.);		
Strengthening the role of public transport			**Code of action**
Increasing the role and share of public transport is essential for reducing GHG emissions. For this purpose, it is important to continuously improve the public transport fleet, both local and interurban modes. One element of making it more attractive could be the development of a modern passenger information system. The spread of electric buses in urban public transport.			M-8 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-2	-	Ca; Ca-1; Ca-2; Ca-3; Ca-4;
Timeframe:	Continuously from 2021		
Responsible:	The State of Hungary		
Target Group:	Volánbusz Ltd; municipalities; the population of the county		
Encouraging the improvement of the car fleet and the uptake of zero-emission vehicles			**Code of action**
GHG emissions from private transport in the county and the ageing vehicle fleet justify the need for intervention. County residents and businesses should be encouraged to modernise their vehicles. This also means increasing the uptake of electric vehicles, notably through public subsidies.			M-9 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-2	-	Ca; Ca-1; Ca-2; Ca-3; Ca-4;
Timeframe:	Continuously from 2018		

Responsible:	The State of Hungary
Target Group:	Residents and business organisations of Szabolcs-Szatmár-Bereg County;

Measures related to Objective M3

Increasing the renewable energy use of the population			**Code of action**
In addition to energy modernisation in the residential sector, in Szabolcs-Szatmár-Bereg County it is advisable to increase the use of solar panels and biomass based on local conditions. However, the latter should be supported only in a limited way and area. For this reason, it would be advisable to implement a broad information campaign covering all details, in the framework of which the use of renewable energy sources can be tailored to the individual households.			M-10 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-3	-	Ca; Ca-1; Ca-2; Ca-3; Ca-4;
Timeframe:	Continuously from 2021		
Responsible:	Szabolcs-Szatmár-Bereg County Municipality; Szabolcs-Szatmár-Bereg County Climate Office; Szabolcs-Szatmár-Bereg County Chamber of Commerce and Industry; Szabolcs-Szatmár-Bereg County Organisation of the National Chamber of Agriculture; other relevant civil and professional organisations.		
Target Group:	Residents of Szabolcs-Szatmár-Bereg County		
Increasing the renewable energy use of public institutes			**Code of action**
The use of renewable energy sources also represents an opportunity for public institutions to reduce costs and to introduce and establish an environmentally conscious approach. Encourage the use of renewable energies based on local conditions.			M-11 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-3	-	Ca; Ca-1; Ca-2; Ca-3; Ca-4;
Timeframe:	Continuously from 2021		
Responsible:	Szabolcs-Szatmár-Bereg County Climate Office; operators of the institutions concerned		
Target Group:	Szabolcs-Szatmár-Bereg County Municipality; local municipalities		
Increasing the use of renewable energy of economic operators			**Code of action**
The use of renewable energy sources not only reduces costs for economic operators, but also increases environmental awareness throughout their business activities. This action will make it possible to promote climate-friendly production and contribute directly to reducing GHG emissions.			M-12 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-2	-	Ca; Ca-1; Ca-2; Ca-3; Ca-4;
Timeframe:	Continuously from 2021		
Responsible:	Szabolcs-Szatmár-Bereg County Chamber of Commerce and Industry; Szabolcs-Szatmár-Bereg County Organisation of the National Chamber of Agriculture; The County Climate Office as coordinator		
Target Group:	Business organisations of Szabolcs-Szatmár-Bereg County		
Collecting, monitoring and making public the energy efficiency results of energy developments and investments through the creation of a database (monitoring the reduction of GHG emissions)			**Code of action**
This action will help to summarise the results of renewable energy use implemented by institutions, municipalities and business organisations. Currently no such database is available.			M-13 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-4	-	Ca; Ca-1; Ca-2; Ca-3; Ca-4;

Timeframe:	Continuously from 2021
Responsible:	Szabolcs-Szatmár-Bereg County Climate Office
Target Group:	Institutional managers, municipalities, economic operators involved in the investments

Measures related to Objective M4

Increasing the forest cover in the county, assessing the potential areas (increasing CO2 uptake)			**Code of action**
This measure will help to increase the share of forested areas in Szabolcs-Szatmár-Bereg county, which will directly contribute to GHG reduction (through carbon sequestration) and directly serve rural development and nature objectives. For this purpose, agricultural areas in the county should be assessed, whose long-term utilisation can be most economically achieved by planting forest areas there.			M-14 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-4	-	Ca; Ca-1; Ca-2; Ca-3; Ca-4;
Timeframe:	Continuously from 2021		
Responsible:	Szabolcs-Szatmár-Bereg County Organisation of the National Chamber of Agriculture; The County Climate Office as coordinator		
Target Group:	Farmers involved in the planting; indirectly the entire population of the county.		

Adaptation measures

Measures related to Objective Aa1 and Aa2

Preparation of a county irrigation and water conservation plan			**Code of action**
Due to the changed situation resulting from climate change, Szabolcs-Szatmár-Bereg county - like other counties - has to prepare simultaneously for sudden, extreme rainfall as well as for a long period without rainfall, possible drought even within the same year. To achieve this, it has become necessary to retain rainfall and use it for irrigation during the drier periods. For this to be possible, an irrigation and water conservation plan for the county must be drawn up with the involvement of the relevant professionals (water experts, agricultural experts). This may also be replaced by the part of the Irrigation Strategy for the county, which is being prepared on the basis of Government Decision 1744/2017 (X.17.). In order to improve the ecological status of the Nyírség and to meet irrigation needs, the study on the 'Water Replenishment of the Nyírség' should be implemented as soon as possible.			Aa-1 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
		Aa-1; Aa-2	Ca-2
Timeframe:	Continuously from 2021		
Responsible:	Szabolcs-Szatmár-Bereg County Organisation of the National Chamber of Agriculture; FETIVIZIG, Upper Tisza Region Water Management Council, General Directorate of Water Management (OVF)		
Target Group:	Farmers, landowners; indirectly the entire population of the county.		
Encouraging local farmers to engage in sustainable water management			**Code of action**
This planned measure aims to increase the security of agricultural production by encouraging local farmers to conserve water and improve their irrigation technology. This should increase the size and thus the proportion of irrigated land in the county. The County Climate Office or the county organisation of the NAK (National Chamber of Agriculture) can provide professional assistance to the farmers.			Aa-2 intervention
Link to the objectives of	**Mitigation objective**	**Adaptation objective**	**Awareness-raising**

the county's climate strategy:	**code**	**code**	**objective code**
	-	Aa-1; Aa-2	Ca-2
Timeframe:	2021-2027		
Responsible:	Szabolcs-Szatmár-Bereg County Organisation of the National Chamber of Agriculture; Szabolcs-Szatmár-Bereg County Climate Office		
Target Group:	Szabolcs-Szatmár-Bereg county farmers, producer groups.		
Promoting measures to improve soil quality			**Code of action**
Preserving and improving the condition of Szabolcs-Szatmár-Bereg county's farmland is an important task. This means increasing the humus content of soils, reducing their acidity, introducing good practices, reducing the use of fertilisers and other chemicals to the minimum necessary, and using environmentally friendly pesticides. The measure is designed to support these actions.			Aa-3 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	Aa-1; Aa-2	Ca-2
Timeframe:	Continuously from 2021		
Responsible:	National Chamber of Agriculture of Szabolcs-Szatmár-Bereg County; Szabolcs-Szatmár-Bereg County Climate Office; companies producing and distributing fertilizers and pesticides.		
Target Group:	Szabolcs-Szatmár-Bereg county farmers, producer groups.		

Measures related to Objective Aa-3

Encourage the development of municipal heat alert plans			**Code of action**
Szabolcs-Szatmár-Bereg county is more affected by this problem than the national average. Thus, this measure is necessary to encourage the municipalities and the institutions concerned to draw up heat alert plans, with special emphasis on the protection of vulnerable groups.			Aa-4 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	Aa-3	Ca; Ca-2; Ca-4;
Timeframe:	Continuously from 2021		
Responsible:	Szabolcs-Szatmár-Bereg County Climate Office; municipal governments; Szabolcs-Szatmár-Bereg County Government Office; other relevant institutions.		
Target Group:	Residents of Szabolcs-Szatmár-Bereg County		
Public information on managing heat waves and extreme weather situations			**Code of action**
The measure will support the use of target-specific communication and information tools to provide relevant information to the target groups concerned.			Aa-5 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	Aa-2; Aa-3	Ca; Ca-2; Ca-4;
Timeframe:	Continuously from 2021		
Responsible:	Szabolcs-Szatmár-Bereg County Climate Office; municipal governments; Szabolcs-Szatmár-Bereg County Government Office; other relevant institutions; other relevant NGOS		
Target Group:	Residents of Szabolcs-Szatmár-Bereg County		

Measures related to Objective Aa-4

Built environment and infrastructure vulnerability assessment			**Code of action**
The measure will support the use of target-specific communication and information tools to provide relevant information to the target groups concerned.			Aa-6 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	Aa -2; Aa-3; Aa-6	Ca; Ca-2; Ca-4;
Timeframe:	Continuously from 2021		
Responsible:	Szabolcs-Szatmár-Bereg County Climate Office; Regional Chamber of Architecture; County Organisation of Disaster Management		
Target Group:	Residents and public institutions of Szabolcs-Szatmár-Bereg County		

Measures related to Objective Aa-5

Improving local stormwater drainage and retention systems, reducing the risk of water damage			**Code of action**
Protecting the county's municipalities against water damage and avoiding critical situations is important for economic, social and water-related reasons. The aim of this measure is to build local stormwater drainage systems, renovate and modernise existing ones, and create water conservation. In addition, the transfer, adaptation and dissemination of good practices.			Aa-7 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	Aa-1; Aa-2; Aa-4; Aa-5; Aa-6	Ca; Ca-2; Ca-4;
Timespan:	Continuously from 2021		
Person in charge:	Municipalities; Szabolcs-Szatmár-Bereg County Climate Office;		
Target Group:	Residents and settlements of Szabolcs-Szatmár-Bereg county		
Preservation and maintenance of the county flood protection system			**Code of action**
The flood protection system of Szabolcs-Szatmár-Bereg county has recently reached a high level of completion with the help of major developments. The aim of the measure is to ensure the ongoing maintenance of this system and to ensure that further improvements are made as necessary.			Aa-8 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	Aa-5	
Timeframe:	Continuously from 2021		
Responsible:	FETIVIZIG - Upper-Tisza-Region Water Management Directorate		
Target Group:	Residents and settlements of Szabolcs-Szatmár-Bereg county		

Measures related to Objective Aa-6

Maintaining and increasing urban green spaces			**Code of action**
The general aim of the measure is to provide information to the public, municipalities, farmers and producers on the importance of and opportunities for increasing green spaces. In addition to providing information, this includes the development of green space plans, providing information on the species to be considered, compiling the best alternative.			Aa-9 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	Aa-6	
Timeframe:	Continuously from 2021		
Responsible:	Szabolcs-Szatmár-Bereg County Climate; Nyírerdő Ltd.(Forestry Company); concerned NGOs; concerned public organisations.		
Target Group:	Residents and municipal governments of Szabolcs-Szatmár-Bereg County		

Measures related to Objective As-1-4

Vulnerability assessment of protected values in the county			**Code of action**
The aim of the measure is to examine the climate-specific vulnerability of the natural, landscape, built and other special county values included in the Szabolcs-Szatmár-Bereg County Repository of Values, with a special focus on mapping the negative impacts of climate change.			As-1 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	As-1-4	Ca

Timeframe:	Continuously from 2021
Responsible:	Szabolcs-Szatmár-Bereg County Repository of Values Committee; County Climate Office; County Disaster Management Department; other relevant authorities and public organisations.
Target Group:	Municipal governments; owners and managers of protected values

Measures related to Objective As-5-6

Development of agricultural production systems			**Code of action**
The aim of the measure is to provide farmers in the county with information, special knowledge and training on the factors caused by climate change, to prepare them for the expected impacts and to present good practices for dealing with the changed situation.			As-2 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	As-5-6	Ca
Timeframe:	Continuously from 2021		
Responsible:	Szabolcs-Szatmár-Bereg County Climate Office; University of Nyíregyháza		
Target Group:	Agriculture producers; municipalities.		

Measures related to Objective As-7

SZABOLCS-SZATMÁR-BEREG COUNTY DEVELOPMENT OF ECOTOURISM			**Code of action**
The aim of the measure is to assess the climate vulnerability of the county's ecotourism destinations and to prepare the sector for climate adaptation based on the changed circumstances. The medium-term goal is to develop a county ecotourism trademark system, coordinated and managed by the County Climate Office.			As-3 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	As-7	Ca
Timeframe:	2021-2024		
Responsible:	Szabolcs-Szatmár-Bereg County Climate Office; TDM office (Touristic Destination Management NGO; tourist accommodations		
Target Group:	Local tourism operators and incoming tourists.		

Awareness-raising measures

Measures related to Objective Ca-1

Raising public awareness to improve climate conscious behaviour, to expand knowledge on mitigation and adaptation			**Code of action**
The measure aims to spread the following climate-conscious awareness-raising activities: – energy saving solutions, increasing the energy efficiency of buildings, – promoting the use of renewable energy sources, – improving resilience to extreme weather related events – information on how to protect against heat waves, – promoting means of sustainable transport			Ca-1 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	-	Ca
Timeframe:	Continuously from 2021		
Responsible:	Szabolcs-Szatmár-Bereg County Climate Office; Municipalities educational institutes (University of Nyíregyháza)		
Target Group:	Residents of Szabolcs-Szatmár-Bereg County		

Measures related to Objective Ca-2

Complex awareness-raising programme for local farmers and agricultural producers			Code of action
The objectives of the measure include the implementation of complex awareness-raising activities which will help them to prepare for the negative impacts of climate change, in particular the phenomena caused by deflation and erosion, and to become informed about mitigation options for their own activities. Accordingly, the programmes include the following priorities: – develop a database for farmers and agricultural producers on the varieties that can be grown under changed or extreme weather conditions with less risk; – to prepare farmers in the county for precision farming, with particular emphasis on reducing the environmental burden (e.g. rational use of fertilisers and pesticides, water-saving irrigation systems, combined agrotechnical practices, etc.); – awareness-raising campaigns on the arrival of new, previously non-native or invasive species and possible control methods; – promoting and strengthening the role of organic farming; – transfer of knowledge on agricultural water management; – reducing the amount of waste generated during production, striving for zero waste. Presentations on the topics identified in the programme series are organised according to the farmers' annual activities (typically 3-5 lectures and or practical demonstrations/year).			Ca-2 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1; M-3	Aa -1; Aa-2; Aa-5	Ca; Ca-1-4;
Timeframe:	Continuously from 2021		
Responsible:	Szabolcs-Szatmár-Bereg County Organisation of the National Chamber of Agriculture; FETIVIZIG (Upper-Tisza-Region Water Management)		
Target Group:	The agricultural producers and farmers of the county, indirectly the entire population.		
Climate action programme for local schools			**Code of action**
A series of complex climate awareness programmes for primary and secondary schools in the county, specifically targeting the under-18 age group, with the following main themes: – developing students' energy awareness; – raising awareness of renewable energy sources and strengthening their role; – reinforcing education on selective waste collection; – raising awareness of the impacts of climate change in the county.			Ca-3 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1; M-3	Aa-1-6	Ca; Ca-1-3;
Timeframe:	Continuously from 2021		
Responsible:	School operators; municipalities; educational institutions; County Climate Office		
Target Group:	Primary and secondary school students of Szabolcs-Szatmár-Bereg county, indirectly the whole population		
Awareness-raising programme for local businesses and other economic participants			**Code of action**
The aim of the measure is to launch complex awareness-raising programmes for businesses and other economic participates in the county, with a particular focus on raising climate awareness in their activities and identifying mitigation opportunities.			Ca-4 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1; M-3	Aa -1; Aa-2; Aa-5	Ca; Ca-1-4;
Timeframe:	Continuously from 2021		
Responsible:	Szabolcs-Szatmár-Bereg County Chamber of Commerce and Industry; County		

	Climate Office
Target Group:	Business organisations of Szabolcs-Szatmár-Bereg County

Measures related to Objective Ca-3

Collecting good practices on climate and energy efficiency			**Code of action**
The continuous collection of good practices implemented in the county and the surrounding counties, their systematisation and communication to the participants.			Ca-5 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1; M-3	Aa -1; Aa-2; Aa-5	Ca; Ca-1-4;
Timeframe:	Continuously from 2021		
Responsible:	Szabolcs-Szatmár-Bereg County Climate Office		
Target Group:	Residents and business organisations of Szabolcs-Szatmár-Bereg County;		

Measures related to Objective Ca-4

Climate and environmental awareness for public institutions and municipal staff			**Code of action**
Within the framework of this measure, information presentations, demonstrations and training sessions will be held for the workers concerned, with the aim of raising awareness of the local impacts of climate change, and presenting mitigation and adaptation options.			Ca-6 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1; M-3	Aa -1; Aa-2; Aa-5	Ca; Ca-1-4;
Timeframe:	Continuously from 2021		
Responsible:	Szabolcs-Szatmár-Bereg County Climate Office		
Target Group:	The local government of Szabolcs-Szatmár-Bereg County, the senior and middle managers of the local governments of the settlements, the relevant decision-makers of the public institutions.		
Creation of a County Climate Protection Network (CCN)			**Code of action**
The basic aim of the establishment of the CCA is to bring together the actors actively involved in the field of climate protection in the county and to coordinate their activities.			M-7 intervention
Link to the objectives of the county's climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1; M-3	Aa-1-6	Ca; Ca-1-4;
Timeframe:	Preparation from 2021, operation from 2022		
Responsible:	Szabolcs-Szatmár-Bereg County Municipality;		
Target Group:	Municipalities of Szabolcs-Szatmár-Bereg County and other concerned organisations		

Proposals for action - Romania - Maramures and Satu Mare counties

Proposals for mitigation measures

Mainstreaming decarbonisation objectives in local strategy, development and planning documents in the counties of Maramures and Satu Mare			**Code of action**
The objectives set out in the mitigation and decarbonisation target framework should be a key consideration in the design of future regional development documents. For this purpose, these objectives should be integrated into future regional and local development and other strategic documents. It is also important to ensure that decarbonisation commitments are taken forward in the preparation and implementation of development activities.			M-0 intervention
Link to the objectives of	**Mitigation objective**	**Adaptation objective**	**Awareness-raising**

the proposed regional climate strategy:	**code**	**code**	**objective code**
	M-1, M-2, M-3, M4	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	The organisations, consultative bodies and authorities responsible for drawing up developments and strategies.		
Target Group:	The County Governments of the counties of Maramures and Satu Mare; the entire population of the two counties concerned		

Measures related to Objective M1

Encouraging residential energy efficiency investments			**Code of action**
The renewal and energy modernisation of the housing stock is one of the most important tasks in the region. This should include the replacement of opening shutters, insulation, possibly replacement of insulation, replacement of energy-intensive household appliances, replacement of lighting fixtures, replacement of conventional gas boilers with energy-saving (condensing) boilers.			M-1 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	2021-2027		
Proposed responsibility:	the local governments of the counties and municipalities concerned		
Target Group:	total population of the counties concerned		
Energy upgrading of enterprises			**Code of action**
Businesses play an important role in keeping jobs and creating new jobs. Ensuring their long-term economic sustainability must therefore be a priority One possible way to achieve this is to reduce energy use and increase energy efficiency, which, in addition to reducing costs, will also fully contribute to meeting climate protection requirements. Renewable energy production by businesses should also be encouraged. Within the framework of the complex measure, in addition to investment support, industrial and agricultural sectors will be informed about current sources of funding and other programmes to promote energy efficiency.			M-2 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1; M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	2021-2027		
Proposed responsibility:	chamber organisations;		
Target Group:	Farming organisations, farmers		
Energy upgrading of Public institutions, public buildings			**Code of action**
The energy modernisation of some public buildings and institutions in the region has already been partially or fully completed or is currently in progress. It is essential to continue this desirable work, with the overall climate protection objective of reducing GHG emissions and, on the economic side, reducing energy costs for the Community.			M-3 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1; M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	2021-2027		
Proposed responsibility:	owners and operators of the institutions concerned		
Target Group:	Municipal governments; operators of social, health, educational and training institutions; operators of public administration institutions.		

Measures related to Objective M2

Promoting the uptake of electric vehicles, developing zero-emission public transport			**Code of action**
In the region, after energy use, GHG emissions from transport are the most significant, largely due to an ageing vehicle fleet and significant private transport. This justifies the need for the above-mentioned intervention. County residents and businesses should be encouraged to modernise their vehicles. Support programmes should be launched to encourage the uptake of electric vehicles. In local urban transport, electric solutions should be preferred to non-tracked solutions.			M-4 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-2	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	government;		
Target Group:	residents and business organisations of the region		
Strengthening the role of cycling			**Code of action**
The aim of the measure is to further develop the county's network of cycling paths and expand the related infrastructure, thereby reducing GHG emissions from transport and increasing the role of cycling tourism. In this context, the expansion of awareness-raising activities is also an important objective.			M-5 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-2	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	2021-2027		
Proposed responsibility:	government; municipal governments; county governments; national and local civil cycling organisations		
Target Group:	Local residents and tourists arriving here		
Developing and strengthening the role of public transport			**Code of action**
An important objective is the continuous improvement of the public transport fleet, in both local and interurban terms. This must apply not only to road but also to rail transport. Increasing the role and share of public transport is essential for reducing GHG emissions. One of the elements to make it more attractive could be the development of a modern passenger information system and the introduction of other amenities such as free Wi-Fi.			M-6 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-2	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	government;		
Target Group:	municipalities; the population of the county; companies involved in the implementation of public transport		

Measures related to Objective M3

Increasing renewable energy use in public institutions and buildings			**Code of action**
The use of renewable energy sources is also an opportunity for public institutions and buildings to reduce costs and to introduce and promote an environmentally conscious approach. Encourage the use of renewable energies based on local conditions. This could mainly mean the use of solar panels, solar collectors.			M-7 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	operators of the institutions concerned		
Target Group:	the local governments of the counties and municipalities		
Increasing the renewable energy use of the population			**Code of action**
Encourage and support the use of solar panels and solar collectors in residential energy modernisation. For this purpose, it would be advisable to implement a broad information campaign covering all the details, in order to develop the most efficient use of renewable energy sources for each household according to local conditions.			M-8 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	county and municipal governments; chamber organisations; other relevant civil and professional organisations.		
Target Group:	total population of the counties concerned		
Increasing the use of the renewable energy resources among economic participants			**Code of action**
The use of renewable energy sources not only reduces costs for economic operators, but also increases environmental awareness throughout their business activities. Because of this, to encourage and support investments in renewable energy by economic operators. This action will make it possible to promote climate-friendly production and contribute directly to reducing GHG emissions.			M-9 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	chamber organisations; economic participants		
Target Group:	economic participants of the counties concerned		

Measures related to Objective M4

Further increase the forest cover in the area (increase CO2 absorption), assess areas suitable for planting			**Code of action**
The intervention and the measure will increase the forest area of the Maramures and Satu Mare counties, which will directly contribute to GHG reduction (through carbon sequestration). It also serves rural development, nature and tourism purposes. For this purpose, it is advisable to assess the areas of the counties whose long-term use can be most economically achieved by planting forest areas there. This is the measure that can make the biggest contribution to meeting climate change targets.			M-10 intervention
Link to the objectives of the proposed regional	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**

climate strategy:	M-4	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	forest companies concerned; landowners; county governments as coordinators		
Target Group:	agricultural participants involved in the planting; indirectly the entire population of the county.		

Overall proposals for adaptation and preparedness measures

Measures related to Objective Aa-1

Providing water retention in hilly and low-mid mountain areas			**Code of action**
The planned measure will protect fields and forestry operations from drought by blocking the beds of small streams or intermittent watercourses with temporary dams made of local timber that can be easily dismantled to delay run-off during drier periods. Smaller water bodies in several places downstream improve groundwater balance and create a fresher microclimate.			Aa-1 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	Aa-1; Aa-6	Ca-2
Timeframe:	2022 onwards		
Responsible:	County Chambers of Agriculture, Local forestry authorities		
Target Group:	Local producer groups, forestry organisations		
Encouraging local farmers to engage in sustainable water management			**Code of action**
This planned measure is intended to increase the security of agricultural production by creating conditions for irrigation, and to train farmers in water-saving irrigation techniques in the conditions already in place. As a result, the share of irrigated land in the departments will increase and production security and exposure to drought will be reduced.			Aa-2 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	Aa-1	Ca-2
Timeframe:	2022 onwards		
Responsible:	County Chambers of Agriculture,		
Target Group:	local producer groups.		

Measures related to Objective Aa-2

Encourage the development of municipal heat alert plans			**Code of action**
In large areas of Maramures and Satu Mare counties, an increase in the frequency of heat waves will be a serious problem. Therefore, for settlements with more than ten thousand inhabitants, it is recommended that a heat alert plan is developed, with special emphasis on the protection of vulnerable groups. This will include opening air-conditioned public buildings to the public during heat waves, as well as installing mist arches and water distribution at busy traffic junctions.			Aa-3 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	Aa-2	Ca-2
Timeframe:	2022 onwards		
Responsible:	Local authorities		
Target Group:	Local and working citizens, tourists		
Public information on managing heat waves and extreme weather situations			**Code of action**
The measure will support the use of target-specific communication and information tools to provide relevant information to the target groups concerned.			Aa-4 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	Aa-2	Ca-2
Timeframe:	2022 onwards		

Responsible:	Local authorities
Target Group:	Resident population

Measures related to Objective Aa-3

Built environment and infrastructure vulnerability assessment			**Code of action**
The measure aims to create a database of buildings which will include buildings of a certain age or in a certain technical condition. Each building is given a weighted score according to its vulnerability to climate change. In addition to buildings, a similar inventory of linear infrastructure is recommended.			Aa-5 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	Aa-3	Ca-2
Timeframe:	Continuously from 2022		
Responsible:	Regional Chamber of Architecture; County Organisation of Disaster Management Public utilities		
Target Group:	Residents and public institutions of the counties		

Measures related to Objective Aa-4

Preservation and maintenance of the county flood protection system			**Code of action**
The flood protection system in the counties of Maramures and Satu Mare has undergone significant development in recent years, and it is therefore important that the protection structures and other technical installations are able to fulfil their function in the long term.			Aa-6 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	Aa-4	Ca-2
Timeframe:	Continuously from 2022		
Responsible:	County water authorities.		
Target Group:	Residents and settlements of the county		
Reducing the risk of flash floods			**Code of action**
In the hilly and mountainous areas of Maramures and Satu Mare counties, flash floods are a real threat and the risk of their occurrence will increase in the future. The proposed solution to reduce flood damage is to use run-off slowing solutions. Significant results can be achieved by cultivating the land parallel to the contour lines, by temporarily blocking small watercourses and by planting forests on critical slopes.			Aa-7 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-4	Aa-1; Aa-4	Ca-2
Timeframe:	Continuously from 2022		
Responsible:	County water authorities.		
Target Group:	Residents and settlements of the county		

Measures related to Objective Aa-5

Vulnerability assessment of protected values in the county			**Code of action**
The aim of the measure is to examine the climate-specific vulnerability of the natural, landscape, built and other special county values included in Maramures and Satu Mare counties with a special focus on mapping the negative impacts of climate change.			Aa-8 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	Aa-3; Aa-5	Ca-2
Timeframe:	Continuously from 2022		

Responsible:	The relevant bodies of the county municipalities; the county organisation of the Civil Protection; other relevant authorities and public organisations.		
Target Group:	Municipalities; owners and managers of protected sites.		
Assessment of the state of the tailings ponds associated with non-ferrous mining			**Code of action**
The aim of the measure is to carry out an annual assessment of the technical condition of the cyanide and heavy metal slurry reservoirs in the Maramures region and, if necessary, to reinforce the technical barriers.			Aa-9 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	Aa-5; Aa-8	Ca-2
Timeframe:	Continuously from 2022		
Responsible:	County authorities of the disaster management; other relevant authorities, mining companies		
Target Group:	The population living along the affected river systems.		
Protecting forest areas by creating small water bodies			**Code of action**
As a result of climate change, plant geographic belts are continuously moving to higher regions than they are today. Because the rate of change is faster than the rate at which trees regenerate, the destruction of some forests is inevitable. To alleviate the situation, natural depressions can be continuously replenished with water, or artificially created pools can be filled.			Aa-10 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-4	Aa-1; Aa-5; Aa-6	Ca-2
Timeframe:	Continuously from 2022		
Responsible:	Forest Authorities		
Target Group:	Residents of the counties; forest managers		

Measures related to Objective Aa-6

Reducing the likelihood of forest and vegetation fires			**Code of action**
With the increasing likelihood of lightning, forest and vegetation fires are also becoming more frequent. To prevent these as effectively as possible, it is important to remove diseased and dead trees as soon as possible, as they are more likely to catch fire. In the case of lowland areas, it is very important to keep the undergrowth of forest patches and forest strips along roads and railways clear, as in their absence, traffic can cause vegetation fires to occur more frequently than at present. In addition to training public authorities, it is very important to train local farmers and entrepreneurs in the forestry sector on the best adaptation options for their area.			Aa-11 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-4	Aa-1; Aa-5; Aa-6	Ca-2
Timeframe:	Continuously from 2022		
Responsible:	Forest Authorities		
Target Group:	Residents of the counties; forest managers		

Measures related to Objective Aa-7

Preparing the drinking water supply system to meet the additional demand for water during heat waves and droughts, and expanding the public network	**Code of action**
Climate change is expected to lead to a significant increase in demand for drinking water in the summer, for which the drinking water supply system needs to be prepared in time. The measure includes both the preparation of a revision plan for the drinking water network and the necessary reconstruction works, which will also involve the construction of a larger diameter backbone. It is also	Aa-12 intervention

necessary to ensure that piped water reaches as many people as possible in rural villages in the counties.			
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
		Aa-2; Aa-7	Ca-2
Timeframe:	Continuously from 2022		
Responsible:	The local governments of the counties and municipalities		
Target Group:	Residents of the county		
Complete the wastewater network and increase the number of connected households			**Code of action**
Methane from wastewater is a non-negligible item in the GHG inventory, so it is a top priority to ensure that the maximum is reached by homes connected to the wastewater network. The intervention would protect the environment (surface water, groundwater, soils) while allowing wastewater to be used in biogas power plants. This would minimise methane emissions and significantly improve the GHG balance.			Aa-13 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1	Aa-7	Ca-2
Timeframe:	Continuously from 2022		
Responsible:	The local governments of the counties and municipalities		
Target Group:	Residents of the county		

Measures related to Objective Aa-8

Assessing the condition of ecotourism sites and preparing them for the extended summer tourist season			**Code of action**
As a consequence of global warming, the summer tourist season is expected to be extended, putting increased pressure on the natural environment. It is therefore essential that a detailed cadastral survey of the most vulnerable areas is carried out to identify the most vulnerable areas, where only limited numbers of tourists will be allowed to enter during the extended season.			Aa-14 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
		Aa-5; Aa-8	Ca-2
Timeframe:	Continuously from 2022		
Responsible:	County government, bodies and authorities managing nature conservation areas		
Target Group:	Tourists visiting the region		

Awareness-raising measures

Measures related to Objective Ca-1

Improving and further enhancing climate-conscious consumer behaviour			**Code of action**
The most effective way to "fight" climate change is through grassroots initiatives. However, it is essential that the public is aware of climate change and its effects on them and on their environment, so it is crucial to inform the public as widely as possible and increase their capacity to adapt. Therefore, it is appropriate to include climate change education in the programmes of local traditional events. Information programmes should take into account both the social and financial situation of the population			Ca-1 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	-	Ca-1
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	municipalities; educational institutions (secondary and higher)		
Target Group:	Residents of the county		

Measures related to Objective Ca-2

Complex awareness-raising programme for local farmers and agricultural producers			**Code of action**
The objectives of the measure include the implementation of such complex awareness-raising activities which will help them to prepare for the negative impacts of climate change, in particular the phenomena caused by erosion and downslope mass movements, and to inform them of the mitigation options related to their own activities. Accordingly, we recommend the programmes include the following priorities: – develop a database for farmers and agricultural producers on the varieties that can be grown under changed or extreme weather conditions with less risk; – to prepare farmers in the county for precision farming, with particular emphasis on reducing the environmental burden (e.g. rational use of fertilisers and pesticides, water-saving irrigation systems, combined agrotechnical practices, etc.); – awareness-raising campaigns on the arrival of new, previously non-native or invasive species and possible control methods; – promoting and strengthening the role of organic farming; – reducing the amount of waste generated during production, striving for zero waste.			Ca-2 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1; M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	The county chambers of agriculture		
Target Group:	the agricultural producers, indirectly the entire population.		
Organisation and implementation of climate change awareness-raising activities for public authorities			**Code of action**
The measure is designed to raise awareness of climate change among groups of people who work in public institutions in a given municipality and who come into daily contact with dozens of local residents. They should also be trained in the correct, clear and comprehensible ways of communicating about climate change, taking into account age and educational background.			Ca-3 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1; M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	School operators; municipalities; educational institutions;		
Target Group:	primary and secondary school students of settlements, indirectly the whole population		

Measures related to Objective Ca-3

Collecting best practices on climate and energy efficiency	**Code of action**
Continuous collection of good practices implemented in the counties of Maramures and Satu Mare and in the North-Western Romanian Development Region, as well as the wider implementations, their systematisation and communication to the relevant persons.	Ca-4 intervention

Link to the objectives of the proposed regional climate strategy:	Mitigation objective code	Adaptation objective code	Awareness-raising objective code
	M-1; M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	The units responsible for climate protection in county governments		
Target Group:	Residents of the county; farmers' and farmers' organisations		

Proposals for action - Slovakia - Kosice District

Proposals for mitigation measures

Mainstreaming the mitigation and decarbonisation objectives of the Kosice District into local strategy, development and planning documents			**Code of action**
The objectives set out in the mitigation and decarbonisation target framework should be a key consideration in the design of future regional development documents. For this purpose, these objectives should be integrated into future regional and local development and other strategic documents. It is also important to ensure that decarbonisation commitments are taken forward in the preparation and implementation of development activities.			M-0 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1, M-2, M-3, M4	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	The organisations, consultative bodies and authorities responsible for drawing up developments and strategies.		
Target Group:	the municipalities concerned; the entire population of the area concerned		

Measures related to Objective M1

Encouraging and supporting residential energy efficiency investments			**Code of action**
The energy modernisation of the housing stock owned by the public should be continued. For this purpose, the efforts of the population should be encouraged and supported (e.g. replacement of windows and doors, additional insulation, replacement of outdated gas boilers, replacement of old, energy-intensive household appliances, use of alternative energy-saving heating methods, etc.). It is important to inform the public about the sources of support available, and it is also important to raise awareness of the importance of energy certification and its purpose must be made clear to the relevant people.			M-1 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	2021-2027		
Proposed responsibility:	the residents; municipalities as coordinators		
Target Group:	total population of the area concerned		
Energy upgrading of Public institutions and public buildings			**Code of action**
Further energy modernisation of public institutions and buildings in the region is an important task. There is a strong case for continuing this process, which on the one hand from an economic point of view aims to reduce the Community's energy use and thus reduce energy costs, and on the other hand to reduce GHG emissions as a general climate protection requirement.			M-2 intervention

Link to the objectives of the proposed regional climate strategy:	Mitigation objective code	Adaptation objective code	Awareness-raising objective code
	M-1; M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	2021-2027		
Proposed responsibility:	owners and operators of the institutions, public buildings concerned		
Target Group:	municipal governments; operators of social, health, educational and training institutions; operators of public administration institutions.		
Energy upgrading of enterprises			**Code of action**
Maintaining and increasing the competitiveness of businesses is an important objective, and one possible and desirable way to achieve this is to improve their energy efficiency. This can also ensure their long-term economic sustainability. Increasing energy efficiency and reducing energy use is also an important climate protection objective and requirement. Intervention should encourage and support businesses in their efforts to reduce their energy use and increase their energy efficiency. The intervention should also be accompanied by measures to raise awareness and inform businesses in the field of energy.			M-3 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1; M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	2021-2027		
Proposed responsibility:	professional chambers; the companies concerned		
Target Group:	farming organisations, farmers		
Collect, monitor and make public the energy efficiency results of energy developments and investments, create a database (record GHG emission savings)			**Code of action**
Through this measure, energy savings (GHG emission reduction) data on energy efficiency investments made by institutions, municipalities and business organisations will be collected and recorded in a central database. This also provides an opportunity to summarise and make the data public. Residents can also join the system on a voluntary basis.			M-4 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2022		
Proposed responsibility:	government body responsible for climate protection		
Target Group:	Those involved in the investments are institutional operators, local authorities, economic operators and, on a voluntary basis, the general public.		

Measures related to Objective M2

Promoting technological change in the large industrial segment			**Code of action**
The region has significant large industrial output, but these companies also make a significant economic contribution to local GDP. Reducing emissions from large industry is an important area for intervention, and one of the possible steps is to ensure a shift to more modern technologies. To achieve this, these industrial players should be supported and encouraged to adopt new, greener, more climate-friendly technologies.			M-5 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-2	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2022		
Proposed responsibility:	the government body(ies) responsible for regulating industrial processes		
Target Group:	large industrial operators; indirectly, the entire population of the region		
Reducing energy consumption in large industrial companies			**Code of action**
Large industrial companies in the region also have significant energy consumption. In addition to technology change, reducing energy consumption is			M-6 intervention

also an important area for intervention. Within the framework of this intervention, measures should be implemented to reduce direct energy use and improve energy efficiency. Therefore, these industrial actors should be supported and encouraged to operate in a more economical and energy efficient way.			
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1, M-2, M-3,	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2022		
Proposed responsibility:	the government body(ies) responsible for regulating industrial processes		
Target Group:	large industrial operators; indirectly, the entire population of the region		

Measures related to Objective M3

Increasing the renewable energy use of the population			**Code of action**
In the residential sector, further increasing the share of renewable energies is an important area for intervention, alongside and in parallel with energy upgrades. A wide-ranging, comprehensive information and awareness-raising campaign should be launched and implemented in order to develop the use of locally available renewable energy sources (e.g. solar panels, solar collectors, wind, etc.) according to the specificities of each household.			M-7 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2022		
Proposed responsibility:	district government together with the government body responsible for climate investment; professional chambers; other relevant civil and professional organisations.		
Target Group:	total population of the area		
Increasing the use of renewable energy of economic operators			**Code of action**
The use of renewable energy sources not only reduces costs for economic operators, but also increases environmental awareness throughout their business activities. This action will make it possible to promote climate-friendly production and contribute directly to reducing GHG emissions.			M-8 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2022		
Proposed responsibility:	professional chambers; the companies concerned		
Target Group:	economic operators		
Increasing the renewable energy use of public institutes			**Code of action**
The use of renewable energy sources also represents an opportunity for public institutions to reduce costs and to introduce and establish an environmentally conscious approach. Encourage the use of renewable energies based on local conditions.			M-9 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2022		
Proposed responsibility:	operators of the institutions concerned		
Target Group:	the local authorities of the municipalities concerned; the operators of public institutions		

Measures related to Objective M4

Increasing the forest cover in the county, assessing the potential areas (increasing CO2 uptake)	**Code of action**

Based on the identification of the area of intervention, there is a need to implement measures that will increase the amount of forest area in the Kosice district. The rate of increase in forest cover is in itself a desirable climate protection objective, which also contributes directly to GHG reductions. Within the framework of this measure, the areas that could be considered for further afforestation should be examined and assessed. Rural development and the development of ecotourism are not negligible secondary objectives.	M-10 intervention

Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-4	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	government agency responsible for forestry; the district government as coordinator		
Target Group:	Farmers involved in the planting; indirectly the entire population of the area.		

Awareness-raising measures

Measures related to Objective Ca-1

Raising public awareness to improve climate conscious behaviour, to expand knowledge on mitigation and adaptation			**Code of action**
The objectives of the action in the intervention area include the dissemination of the following climate conscious awareness raising activities: – energy saving solutions, increasing the energy efficiency of buildings, – promoting the use of renewable energy sources, – improving resilience to extreme weather related events – information on how to protect against heat waves, – promoting means of sustainable transport			Ca-1 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	-	-	Ca-1
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	municipalities; educational institutions (secondary and higher)		
Target Group:	entire population of the area of Kosice		

Measures related to Objective Ca-2

Complex awareness-raising programme for local farmers and agricultural producers	**Code of action**
The objectives of the measure include the implementation of complex awareness-raising activities which will help them to prepare for the negative impacts of climate change, in particular the phenomena caused by deflation and erosion, and to become informed about mitigation options for their own activities. Accordingly, the programmes include the following priorities: – develop a database for farmers and agricultural producers on the varieties that can be grown under changed or extreme weather conditions with less risk; – to prepare farmers in the county for precision farming, with particular emphasis on reducing the environmental burden (e.g., rational use of fertilisers and pesticides, water-saving irrigation systems, combined agrotechnical practices, etc.); – awareness-raising campaigns on the arrival of new, previously non-native or invasive species and possible control methods; – promoting and strengthening the role of organic farming; – transfer of knowledge on agricultural water management (water	Ca-2 intervention

management at table level, farmers' tasks for inland water protection, improving soil water management, etc.). – reducing the amount of waste generated during production, striving for zero waste. Presentations on the topics identified in the programme series are organised according to the farmers' annual activities (typically 3-5 lectures and or practical demonstrations/year).			
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1; M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	Slovakian Chamber of Agriculture		
Target Group:	the agricultural producers, indirectly the entire population.		
Local climate programme for local educational institutions			**Code of action**
The implementation of a complex series of climate-awareness programmes, with the involvement of primary and secondary schools in the municipalities, specifically targeting the under-18 age group, with the following main themes: – developing students' energy awareness; – raising awareness of renewable energy sources and strengthening their role; – reinforcing education on selective waste collection; – raising awareness of the local impacts of climate change.			Ca-3 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1; M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	School operators; municipalities; educational institutions;		
Target Group:	primary and secondary school students of settlements, indirectly the whole population		

Measures related to Objective Ca-3

Collecting best practices on climate and energy efficiency			**Code of action**
To continuously collect, organise and communicate the good practices implemented in the district of Kosice, in neighbouring districts, in other districts of the country and in the neighbouring countries towards those concerned.			Ca-4 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1; M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	the district council's climate protection unit		
Target Group:	residents of the district of Kosice; farmers' and farmers' organisations		

Proposals for action - Ukraine - Transcarpathian region

Proposals for mitigation measures

Mainstreaming the mitigation and decarbonisation objectives of the Transcarpathia into local strategy, development and planning documents			**Code of action**
In the future, the objectives of the mitigation and decarbonisation targets should be taken into account in the preparation of development documents for the county and municipalities. For this purpose, these objectives should be integrated into future regional and local development and other strategic documents.			M-0 intervention
Link to the objectives of	**Mitigation objective**	**Adaptation objective**	**Awareness-raising**

the proposed regional climate strategy:	**code**	**code**	**objective code**
	M-1, M-2, M-3, M-4	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	The organisations, consultative bodies and authorities responsible for drawing up developments and strategies.		
Target Group:	the municipalities concerned; the entire population of the area concerned		

Measures related to Objective M1

Encouraging residential energy efficiency investments			**Code of action**
Much of the county's housing stock is in need of renewal, which is one of the most important and urgent tasks for the near future. In all cases, renovation should include energy upgrades, to reduce energy use and thus increase energy efficiency. Experience in recent years has shown that energy prices have increased significantly, making energy upgrades important not only from an economic point of view, but also for meeting climate change objectives. Energy modernisation should aim not only at increasing energy efficiency (e.g. replacing windows and doors, insulation, replacing outdated gas boilers, etc.), but also at boosting renewable energy production (e.g. solar panels, solar collectors).			M-1 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	2021-2030		
Proposed responsibility:	the unit responsible for energy modernisation in the county administration		
Target Group:	total population of the area		
Energy modernisation of buildings in state and municipal institutions			**Code of action**
A relatively small proportion of public buildings in the county, both state and municipal, have undergone significant energy modernisation. The proposed action in the area of intervention relates to the need to carry out an energy assessment of these buildings and the necessary calculations for the energy savings. On this basis, the necessary and urgent upgrades should be implemented. This measure will not only increase energy efficiency, but will also help to achieve the climate protection targets.			M-2 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1; M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	2021-2030		
Proposed responsibility:	Owners and operators of the institutions concerned		
Target Group:	municipal governments; operators of social, health, educational and training institutions; operators of public administration institutions.		

Energy upgrading of enterprises			**Code of action**
County businesses play an important role in keeping jobs and creating new jobs. It is therefore very important to ensure their long-term economic sustainability. One way to do this is to reduce energy use and thus costs, which is also a climate protection requirement. Under the measure, industrial and agricultural operators can on the one hand receive information on current sources of funding and other programmes to promote energy efficiency, and on the other hand apply for grants for their investments to increase energy efficiency.			M-3 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-1; M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	2021-2030		
Proposed responsibility:	Chamber of Commerce and Industry of Transcarpathia coordinated by the County Municipality		
Target Group:	Farming organisations, farmers		

Measures related to Objective M2

Strengthening the role of local and interurban public transport			**Code of action**
Increasing the role and share of public transport is essential for reducing GHG emissions. The county has significant transit traffic for both passengers and freight (TEN-T Corridor V). In order to strengthen the role of public transport, it is important to continuously improve the low-emission public transport fleet, both locally and inter-city. In addition, preference should be given to electric vehicles. One element of making it more attractive could be the development of a modern passenger information system. In urban public transport, electric buses should be encouraged.			M-4 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-2	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2012		
Proposed responsibility:	state body responsible for public transport; urban transport companies; state railway company		
Target Group:	urban transport companies; municipalities; the population of the county		

Rejuvenating the county's vehicle fleet, encouraging the uptake of zero-emission vehicles			**Code of action**
GHG emissions from private transport in the county and the ageing vehicle fleet justify the need for intervention. County residents and businesses should be encouraged to modernise their vehicles. This also means increasing the uptake of electric vehicles, notably through public subsidies.			M-5 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-2	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2022		
Proposed responsibility:	public bodies responsible for transport policy;		
Target Group:	The population and farming organisations of Transcarpathia county;		

Measures related to Objective M3

Increasing the use of renewable energy in public institutions run by the state and municipalities			**Code of action**
The use of renewable energy sources also represents an opportunity for public institutions to reduce costs and to introduce and establish an environmentally conscious approach. Encourage the use of renewable energies based on local conditions. This measure will also directly contribute to the achievement of the climate change targets.			M-6 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2022		
Proposed responsibility:	operators of the institutions concerned		
Target Group:	County government; municipalities; public bodies		
Increasing the renewable energy use of the population			**Code of action**

In addition to energy modernisation in the residential sector, in Transcarpathian county the use of solar panels and solar collectors in particular is proving to be the most effective. For this reason, it would be advisable to implement a broad awareness raising information campaign for the residents covering all details, in the framework of which the use of renewable energy sources can be tailored to the individual households. Financial support should also be provided to encourage their uptake.			M-7 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2022		
Proposed responsibility:	County Municipality; Transcarpathian Chamber of Commerce and Industry; other relevant civil and professional organisations.		
Target Group:	Residents of Transcarpathia County		
Increasing the use of renewable energy of economic operators			**Code of action**
The use of renewable energy sources not only reduces costs for economic operators, but also generates economic benefits. Under this measure, environmental awareness will also be increased in their farming activities. This measure will allow the uptake of climate-friendly production and will directly contribute to the reduction of GHG emissions and the achievement of the climate targets.			M-8 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-3	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2022		
Proposed responsibility:	Chamber of Commerce and Industry of Transcarpathia coordinated by the County Municipality		
Target Group:	Economic operators of the Transcarpathian region		

Measures related to Objective M4

Maintaining and, where possible, increasing the forest cover ratio in the county, creating sustainable forest management			**Code of action**
With the help of this measure, the percentage of forest cover in Transcarpathia will not decrease but will probably increase. Maintaining this outstanding value (more than 50% of the area is forest) is of paramount importance and desirable. Forest areas also contribute directly to GHG reductions (through carbon sequestration) while serving rural, natural and economic purposes. Creating sustainable forest management is also a priority.			M-9 intervention
Link to the objectives of the proposed regional climate strategy:	**Mitigation objective code**	**Adaptation objective code**	**Awareness-raising objective code**
	M-4	-	Ca-1; Ca-2; Ca-3;
Suggested timespan:	Continuously from 2021		
Proposed responsibility:	forest holdings		
Target Group:	forest holdings; total population of the county		

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