2010 Floods in the Danube River Basin

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International Commission for the Protection of the Danube River

Internationale Kommission zum Schutz der Donau

Brief overview of key events and lessons learned

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Foreword

According to climatic data, the 2009 – 2010 hydrological year (measured from November to November) produced the largest amount of precipitation ever observed in many parts of the Danube region.

The layer of snow and rain along the central Danube exceeded the multiannual average by 1.5 to 2.0 times, a maximum never observed since systematic instrumental weather observations have been available. Contrary to the massive single flood events on the Danube as occurred in 2002 or 2006 due to high precipitation volume in a short time, in 2010 the scattered character of the rainfall throughout the whole year and throughout the most of the Danube River Basin led to a high number of damaging flood events at the local level. Except of German and Austrian part of the Danube River Basin, where only minor floods occurred, all other countries suffered from considerable flooding causing casualties and massive damages.

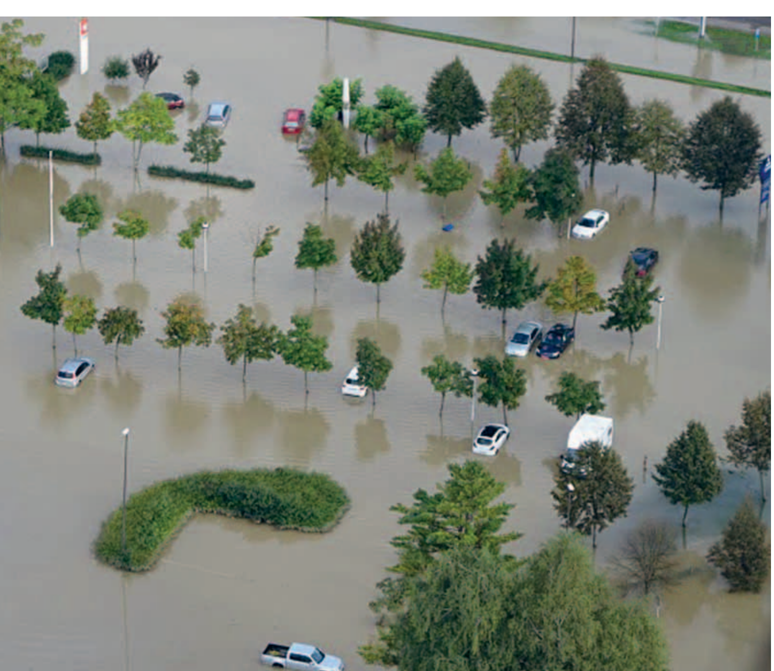
This report gives a brief overview of the flood events in the basin in 2010, reviews the responses of the countries and the damages registered and brings forward the lessons learned.

1. Meteorological situation / precipitation in 2010

Meteorological situation in 2011 in most parts of the Danube River Basin (especially the central and lower part) can be characterized by precipitation high above the long-term annual averages leading to a number of flood events.

There were some specific situations like that in the second half of May and the beginning of June when pressure lows and front systems moving along the southern trajectory across Mediterranean and Black Sea into the Central Europe, and from Northern Atlantic to Eastern Europe, brought along unusually strong precipitation. However, the extensive precipitation events (amplified in spring months by snowmelt) were recorded in the most part of the Danube river basin during the whole year leading to a high number of significant local floods scatteredly distributed in space and time.

The period from 30 April to 3 June was extremely rich in precipitation in the Czech part of the Morava river basin. The month precipitation total reached the level of 240% of the long-term mean for the period 1961 – 90 and was the highest since the 1997 July catastrophic flood. Two precipitation events hit a part of the Morava river basin in the second half of May and at the beginning of June.



During the first event between 16 – 20 May precipitation total of 200 mm fell in Beskydy mountain, during the second event from 30 May to 3 June almost 100 mm of precipitation fell again in the Beskydy mountains and in Vsetínské vrchy area. The highest precipitation intensities reached up to 180 mm in 24 hours on 16 May and up to 115 mm in 24 hours on 17 May. Soil saturation was above normal already in the mid May in most of the area of the Czech Republic. During the second flood episode due to this high initial saturation the water level in streams increased dramatically and reached up to 100-years flood levels in a number of river profiles.

Following the above-average precipitation in the end of 2009 the rainfalls intensified in Slovakia from March 2010 and reached critical level in May. Precipitation total in May 2010 exceeded long term average value for this month three to four times in the individual regions of Slovakia. These wet conditions caused, that the mean annual precipitation total in Slovakia was already exceeded in the beginning of June.

The entire hydrological year in Hungary produced large surplus of precipitation. Already the autumn rainfall in 2009 was above the average. Starting from December 2009 each month (except March) the precipitation was higher than the average. The influx of wet air masses to the territory of the country was most intensive during May 2010. The monthly layer of precipitation exceeded seasonal values twice and most of the rainfall took place within a short period with atmospheric low pressure on 15 – 18 May. Storms caused not only heavy rain leading to flash floods and inundation but record breaking strong winds removed or destroyed the roofs of hundreds of family houses in southern and central Transdanubian parts of Hungary. Similar extreme events followed within a surprisingly short period in late May and on the first days of June when torrential rains generated new flood waves on the catchment of rivers entering into Hungary and in the country itself.

In the period between 16 and 20 September an extreme precipitation was recorded in south-western Slovenia with more than 500 l/m^2 in individual locations, while several other areas in central and western Slovenia received around 200 l/m^2. In few locations the two day precipitation exceeded 100 years return period.

According to the Croatian Meteorological and Hydrological Service, the year 2010 was defined in terms of precipitation as an extremely wet, very wet or wet year in 99% of the area of Croatia. Hydro-meteorological conditions were particularly unfavourable between 30 May and 2 June. In the greater area of Slavonia, precipitation reached record quantities of up to 180 mm. In the period between 20 June and 23 June, additional 90 – 100 mm of precipitation fell again in Slavonia. On 22 June, the highest daily precipitation quantity of 107.2 mm was measured in Osijek, which is the highest daily precipitation quantity in the available time series (1899 – 2010). The next wave of high precipitation was observed in the period from 16 to 19 September. Apart from large precipitation quantities, snow cover melting due to sudden warming at the end of December 2009 and beginning of January 2010 played a significant role in the formation of two large water waves in Croatia.

In Bosnia and Herzegovina the annual precipitation amounts in 2010 were far above average ranging from 951 mm in Bugojno to 1836 mm in Bihać. Extremely heavy precipitation was frequently observed in the southern part of the country, especially in December 2009 and January 2010.

In Serbia between December 2009 and February 2010, there were three periods of rapid snowmelt, in both mountain and low-lying areas, accompanied by moderate to heavy rainfalls. In the second half of April, a heavy rainfall was recorded in southeastern, central and southwestern Serbia (40 – 60 mm in the Južna Morava Basin, 30 – 50 mm in the Velika Morava Basin, and 20 – 40 mm in the Zapadna Morava Basin). In June, the weather was extremely unstable, with massive precipitation. Western Serbia received 90 – 130 mm rain from 17 to 25 June, and 20 – 110 mm rain between 26 June and 1 July.

In the end of November and the beginning of December, a strong cyclone activity enveloped Montenegro and East Herzegovina, causing heavy rainfall, strong southerly winds, and very high temperatures for this time of year. Snowmelt and abundant rainfall (100 – 200 mm) led to a flood situation in the Upper Drina Basin.

In Romania the average precipitation was exceeded by 33% in 2010 due to an excess rainfall in nearly all months of the year. The extreme events occurred in May to August. From 20 June to 14 July, very heavy rainfall that accompanied storms caused severe flooding on the rivers Siret, Prut and Jijia. In the first half of August, heavy rainfall caused flash floods in Harghita, Covasna, Prahova and Suceava county. In the Siret basin at Itcani 86.4 mm were recorded on 22 June, at Campulung 83.2 mm on 20 May, at Bogdanesti 91.4 mm on 20 May. In the Constanta county (Dobrogea region) 116 mm were recorded on 9 July at Cernavoda.

Precipitation combined with a heavy snowmelt in February / March cause floods in Bulgaria. Few months later, in June, the heavy rainfalls were recorded and the hydrological situation was intensified by strong precipitation in the headwaters of the Tisa, Sava and Velika Morava outside Bulgaria.

In Ukraine major flood events occurred in Zakarpattia region (Ukrainian part of Tisza River basin) in January, May, June and December with the peak floods occurring in May and June.
At Borzhava, Latorytsa and Uzh catchments within two decades of May the precipitation quantity reached 541% of the average value.

In Moldova several consecutive floods occurred on the Prut and Nistru rivers in 2010 starting in the second half of May. The most significant floods were recorded in June – July. As a result of torrential rains, the total amount of precipitation on the territory of Ukraine in the Prut River Basin, from 16 to 30 June amounted to 232 mm, which is equal to 6 months average. From 1 to 21 July, the amount of precipitation fallen in the Prut River Basin reached 165 mm, being equal to 4 months average.

2. Key flood events

In Czech Republic the largest floods in May were on the Morava tributaries with return periods between 10 – 50 years. After this first precipitation wave the elevated soil saturation caused the second flood event in the beginning of June despite the rainfall in that time was not so strong. These floods had return periods between 10 – 100 years and were evaluated as the second most significant summer flood event in the Morava basin during the last 100 years.

The extreme floods were recorded in Slovakia mostly in May and June. Altogether there were 206 days of flood alerts until the end of August (85% of the time) and the floods affected the whole territory of the Slovak Republic. High saturation of the Nitra river basin in June 2010 caused flood with the estimated peak discharges Q20 – Q50 in Nitrianska Streda and Nove Zamky. Extreme flood events, which resulted from long-lasting rainfalls in the beginning of June, occurred in several river basins of the Central Slovakia. The return period of floods in the Slana and Rimava river basins was estimated to 50 years. In the Litava at Plastovce (the Ipel River tributary) the flood peak discharge was estimated to Q100. Eastern Slovakia has been continuously affected by floods since the mid May. Extreme rainfalls in the beginning of June, combined with high saturation of river basins in this region, caused floods with return periods 50 – 100 years in several river reaches.

Hungarian river reaches experienced several significant flood waves resulting from the intensive rainfall events directly or as the superposition of a number of floods following subsequently. Multiple floods on the tributaries resulted in a significant Danube flood wave upstream of Budapest, equal to the third largest one of the last century causing serious transport limitations within the city of Budapest. The Vienna – Budapest railway line was also endangered while the motorway M1 was cut by a flash flood induced damage for a couple of days. Extreme character of the events was manifested on streams of the Slana / Sajo river network together with Hornád / Hernád and Bodva where two or three subsequent flood peaks in May – June exceeded historical flood crest (water level) or peak discharge maxima of the year 1974. Lower Hernad Valley was mostly saved by intensive flood protection works constructing a temporary dike of 40 km length. Water levels reaching historical maximum levels occurred on the River Tisza at Tiszaujváros and the recently completed emergency reservoir (detention basin or polder) of Tiszaroff was opened reducing the flood peak by 15 – 20 cm easing the load on the flood protection of the city of Szolnok. The year 2010 was denoted in Hungary with the highest number flash flood type of events (510) since such statistics are available (1980).

In Slovenia fluvial foods, flash floods and karst phenomena floods occurred accompanied by landslides. Floods reached their peak between 18 to 22 September. The discharge return period varied from less than 5 years to more than 50 years.

Flood events on the Croatian rivers were caused not only by an extreme precipitation in the territory of Croatia but also due to the large inflow from the upstream parts of the river basin in the neighbouring countries. At many hydrological stations, maximum water levels which occurred during 2010 exceeded or were only slightly below those recorded during the previous 35 years. This period was chosen because in 1975 the flood relief structures for the Sava and Kupa rivers were either constructed or put into operation. In the Sava upstream of Sisak and in the western left-bank Sava tributaries, extremes occurred during the large water wave in September 2010. The eastern left-bank tributaries achieved their maximums in June, and the largest right-bank tributaries, the Kupa and the Una, during December 2010. Preliminary statistical analyses showed that the large water wave in the upper section of the Sava river basin in September was the occurrence of a 100-year return period. The flood maximums which occurred in June had occurrences between 25- and 100-year return periods, and those in December between 10- and 50-year return periods.

In Bosnia and Herzegovina the key flood events were registered at the beginning of January 2010 on Una, Sana, Vrbas and Bosna river with the recurrence period ranging from 5 to 100 years. Main floods in the Drina basin were caused by the extreme precipitation in Montenegro's and Serbian's part of river basins. Flow rate of the Drina river, at the confluence to the Sava river, was over 4000 m^3/s what is the highest flow recorded in the last 50 years. The recurrence period of the Sava river flow downstream the confluence with Drina, almost reached 100 years (6000 m^3/s).

The hydrological situation in Serbia was highly unfavourable throughout the whole year with repeated floods on nearly all national and international rivers. The best example is the Sava River, where floods occurred at the very beginning of the year, in the summer, and in December 2010. Flood defence activities lasted in Serbia for 185 days, during most of these days emergency flood defence was in force. Rapid snowmelt and rainfalls generated flood waves on many rivers in Serbia already in December 2009 and this situation continued in January and February 2010. The most serious events exceeding emergency flood defence stages occurred on the Sava River, the Timok River, and the rivers in Banat. The most adversely affected was the Timok River Basin, where the soil was already saturated by snowmelts and rainfalls in the previous year and an exceptional runoff occurred in the second half of February and in the second half of April with absolute maximum levels recorded at many gauge stations, with return periods estimated at 20 – 100 years. Frequent and abundant rainfalls induced flood waves in the Velika Morava River Basin in April. The most dangerous situation was recorded along the most downstream section of the Juzna Morava River, where the historical maxima were exceeded (at Aleksinac and Mojsinje gauge stations on 21 April). At the end of June a flood event occurred in the Kolubara River Basin (a right tributary of the Sava, near Belgrade) caused by abundant rainfall, reaching the soil already saturated by previous rains. New extremes were recorded on many tributaries and the Kolubara River itself, where the return period of peaks was estimated at 50 – 100 years.

In the Drina River Basin the most extreme flood event occurred at the end of November and the beginning of December. Flood waves on the Drina and its tributaries were induced by extreme rainfalls in Montenegro and East Herzegovina, where 100 – 200 mm of rain fell in 3 days. Flood waves on the Drina tributaries (Piva, Tara, Cehotina, Lim and Jadar) and the main course were exceptional, such that hydropower reservoirs could not retain them. A new maximum was recorded on 3 December at Radalj, the most downstream gauge station on the Drina River. As a result, a flood wave also occurred on the Sava River in Serbia, where emergency flood defence was declared at the beginning of December.

In Romania the major flood events have been registered between June and August. In June danger and inundation water levels were exceed on Crasna and Tur (both in Somes-Tisa basin) and on Timis, Barzava and Moravita river (Banat region). On 1 – 3 July danger water levels have been recorded on the Upper Olt at Tomesti, on the middle Siret (Lespezi-Dragesti sector) and on the Prut river (Oroftiana – downstream Stanca sector) while the inundation level was observed on Olt and on several Siret tributaries. In the second half of June and beginning of July the whole North-Eastern Romania has been affected by continuous significant precipitation which induced successive massive floods especially on the Siret and Prut rivers, reaching historical values recorded in 2005 and 2008.

The hydrological situation in February / March in Bulgaria (high water in the Timok combined with groundwater floods) caused floods in Bregovo. In June high water levels were observed on the Orshova River.

In Ukraine in May the high flood levels were recorded at the lower Tisza and Latorytsa. On 20 May Latorytsa at Chop reached 701 cm (the historical maximum being 750 cm) while in December at the same station the historical maximum was reached.

The major pluvial floods on the Prut in Moldova occurred in June – July. In the first decade of June, upstream the Costeşti-Stînca reservoir the pluvial flood led to the rise of water level by approx. 2.0 m and to inundation of the floodplain of Briceni district. In the beginning of July, the inundation of floodplains from Briceni and Edineţ districts and of the railway embankment of the Bălţi-Cernăuţi districts occurred. Few days later a flood wave on the Prut increased the water level near Şirăuţi village by 5.10 m and the maximal discharge reached 2020 m^3/s. This led to inundation of floodplains and of some localities of Briceni district. In the sector Costeşti-river mouth, floodplains and farm lands were inundated and the water supply for the Ungheni district was jeopardized.

The geographical overview of the significant flood events in 2010 is shown in the Figure 1 and can be viewed on: http://www.icpdr.org/danubis2/flood_events

Danube River Basin District: Flood Events in 2010

FIGURE 1

www.icpdr.org

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This ICPDR product is based on national information provided by Contracting Parties to the ICPDR (BA, BG, CZ, HR, HU, MD, RO, RS, SI, SK, UA). National borders data provided by the Contracting Parties to the ICPDR (AT, BA, BG, CZ, DE, HR, HU, MD, RO, RS, SI, SK, UA) and CH was used; ESRI data was used for national borders of AL, ME, MK; Shuttle Radar Topography Mission (SRTM) from USGS Seamless Data Distribution System was used as topographic layer; data from the European Commission (Joint Research Center) was used for the outer border of the DRBD of AL, IT, ME and PL.

Vienna, September 2011

3. Flood warning and monitoring

3.1 National systems

During floods in the Czech Republic the forecasting offices of the Czech Hydrometeorological Institute (CHMI) regularly issued forecasts, warnings and information reports. The first warning alerted with the lead-time of 48 hours on a high probability of the extreme rainfall and significant rises of water levels. During the extreme flood events communication with River Basin Authorities and with the regional flood control authorities as well as with the crisis management was fully ensured. Updated information and forecasts were published on CHMI´s website. The meteorological and hydrological forecasts and flood warnings were in most cases successful and they served as a significant information basis for crisis management bodies, flood protection management authorities, media and public. The regional forecasting office in Brno calculated hydrological forecasts for the Morava river several times a day. This included forecasts for the profile Hohenau / Moravský Svätý Ján, located both in Austria and Slovakia. Forecasting for the profile Hohenau is in the test operation within an international project with Austria.

Flood forecasting and warning service in Slovakia is ensured by the Centre of forecasting and warnings in the Department of hydrological forecasting and warnings of the Slovak Hydrometeorological Institute (SHMI) in Bratislava and its branch offices in Zilina, Banska Bystrica and Kosice. Currently, SHMI operates 260 operative discharge gauging stations. Data from this network provide hydrologists with a good overview of the hydrological situation and trends in specific regions. During flood events data and information are provided to water management operators and water management authorities responsible for flood protection via phone or e-mail. SHMI regularly (every hour) updates information for the public on its web page. 2,256 hydrological warnings were issued by the SHMI in during flood events in 2010. Operational data from gauging stations were updated every hour.

Flood events in Hungary were closely monitored and regularly predicted by the National Hydrological Forecasting Service (NHFS) at VITUKI Institute in close cooperation with Regional Water Directorates. One or two hourly observation of water levels, current flood alert and excess water alert maps together with forecasts and warnings were published on the Web sites of the Water Directorates and VITUKI NHFS. In 2010 the forecast service was at alert for 92 days, out of those the extreme alert status lasted 38 days. At least twice a day a summary of the flood situation was produced together with medium range (6 days ahead) water level forecast for 96 stations (i.e. key stations on all major and medium streams). During the period of alert the experimental flash flood advisory map was produced for the Hungarian Emergency / Civil Defense and water services.

Based on the forecast of intensive precipitation by Slovenian Environmental Agency declaring red flood alert for threatened catchments, Civil Protection Commander of the Republic of Slovenia issued a readiness order for the Republic of Slovenia's Civil Protection Staff and regional Civil Protection Staffs on 16 September. Moreover, support services and other capabilities, in particular fire fighters and logistic centres, were also requested to be on duty. The mayors received recommendations for setting alerts based on precipitation and water level situation in their relevant areas to ensure the required preparedness of fire fighters and other emergency services, and to continuously update the potentially threatened population on the risks. The Administration of the Republic of Slovenia for Civil Protection and Disaster Relief (ACPDR) provided routine information to the national and other authorities, media, responsible institutions and organizations, protection, rescue and relief forces, and local communities.

In the Republic of Croatia, the Main Flood Defence Centre was established in the Hrvatske vode as a central organizational unit for the purpose of management, coordination and information on flood defence status. For organization of management in case of disasters, all necessary measures are carried out by the National Protection and Rescue Directorate. The Main Flood Defence Centre is in a direct contact with the State Meteorological and Hydrological Service which prepares reports on the quantity and type of precipitation as well as weather forecasts (using ALADIN and ECMWF models). The Main Flood Defense Centre operates a system for an up-to-date monitoring of hydrological regime on watercourses and other waters in the Republic of Croatia. In the Danube river basin, water level status is monitored on more than 140 automatic water stations and other water stations relevant for immediate flood defence with data collected in real time. Using the Internet, hydrometeorological conditions and forecasts are monitored also in parts of the basin which are located in the neighbouring countries. As soon as the hydrometeorological forecasts indicated a possibility of flood danger occurrence, warnings were issued to all county flood defence centres, Hrvatske vode as well as to chief flood defence managers, and 24 hour duty was established at the Main Centre. The Main Centre regularly informed the National Protection and Rescue Directorate on the development of the status and forecast situation as well as on undertaken flood defence measures. During regular flood defence, daily reports were prepared on the status and undertaken flood defence measures and also forecasts on the magnitude and time of water wave appearance. During flood alerts, updating reports were prepared several times a day.

In Bosnia and Herzegovina hydrometeorological institutes conduct regular measurements of meteorological data at their meteorological stations. Based on this monitoring, daily and 3-days weather forecasts are provided. Data on flood waves are exchanged and delivered to civil protection units which are responsible for protection of people and property. Continuous reporting on the water level status at reference water measuring stations is performed at least every two hours.

During flood events along Serbia's rivers in 2010, information, early warnings and forecasts were disseminated to all relevant actors on a daily basis. Information included river stage status and trends, dates of anticipated threshold exceedance, dates on which regular and emergency flood defence measures had to be undertaken, flood wave peak dates and predicted levels, weather forecasts, and expected precipitation levels. Warning and short-term forecast information is believed to have been good, while in the case of the flood waves on the Drina and the June flood wave on the Sava it has been considered as satisfactory, in view of the fact that warnings and water level forecasts were not available from Montenegro, Bosnia & Herzegovina, and Croatia. Hydrological data, forecasts and information were posted on the website of the Hydrometeorological Service of Serbia and relevant information and reports were given to media as well.

In Romania 171 hydrometeorological warnings and 1949 now-casting warnings were issued in 2010, and have been transmitted to the responsible institutions. Due to the meteorological and hydrological warnings, the territorial branches of the “Romanian Waters” decreased water levels in reservoirs such at Stanca-Costeşti on Prut river in order to flatten peak flow.

Warnings on floods were issued in Bulgaria using standard routing procedures, which involve Ministry of Interior / Civil protection, Ministry of Transport and Danube River Basin Directorate.

In Ukraine in the territory of Transcarpathia (Zakarpattia) region a joint Ukrainian – Hungarian automated information measuring system AIMS Tysa is in operation. It provides data from automated stations (44 units) to the database centre in Transcarpathian Water Management (Uzhgorod) every 5 to 15 minutes.

During the 2010 summer floods in Moldova the State Hydrometeorological Service issued timely forecasts, warnings and informative bulletins, that were disseminated according to the “Scheme of dissemination of the hydrological information” approved by the Ministry of Environment. Warnings and forecasts were also uploaded on the website of the State Hydrometeorological Service (www.meteo.md) and provided to the media.

3.2 Danube EFAS response

Table 1 illustrates the major flood events for the Danube river basin as forecasted by EFAS and / or reported by international online news media for 2010. Almost all major events which concerned flooding at a large scale were forecasted by EFAS and either flood alerts or flood watches have been sent out to the EFAS partners in the Danube countries. The civil protection centre (MIC) of the European Commission was informed as well about the forecasts when the alerts were sent out to the national authorities.

Due to a prevailing local character of floods in 2010 (often being flash floods) some countries reported that EFAS information did not match fully the outcomes of the national forecasting & warning services. It is however necessary to emphasize that the scope of the Danube EFAS is to provide early large scale and cross-border flood information for the whole Danube River Basin. The EFAS system was not designed to predict local flash flooding, which at maximum can be predicted up to 24 hours before. At those scales, the national services have a leading role.

Overview of main flood events for the Danube river basin in 2010, as forecasted by EFAS and/or reported in international on-line news media.

TABLE 1

From	To	River Basin Affected	Country Affected	EFAS Alert sent?	Date EFAS Alert Sent	Confirmed?	Comment
20 February	4 March	Sava	HR / RS	Yes (Flood Watch)	24 Feb	Yes	Severe flooding in Central & E. Serbia, and in Sava & Morava river systems.
21 February	28 February	Velika Morava	RS	Yes (Flood Watch)	16 Feb	Yes	Severe flooding in eastern Serbia
February	February	Koeroes	RO / HU	Yes (Flood Watch)	16 Feb	No	(No reports found on on-line news media). Events to be confirmed by partners in next annual EFAS meeting
1 March	5 March	Danube	RO / BG	Yes (Flood Alert)	3 Mar	Yes	Severe flooding in S. Romania and in N.W. & N. Bulgaria.
March	March	Somes / Mures / Koeroes	RO / HU	Yes (Flood Alert)	18 Mar	No	No reports found on on-line news media. Events to be confirmed by partners in next annual EFAS meeting
15 May	30 May	Danube / Oder	SK, PL, CZ, HU	Yes (Flood Alert)	12 May	Yes	Extensive flooding in central & eastern Europe, esp. Poland, Czech Republic, Slovakia, Hungary and Serbia.
Late June	July	Siret / Prut / Moldova / Bistrita	RO / MD	No	-	Yes	Severe flooding in N.E. Romania kill 25 people, also some counties in Moldova.
15 July	15 July	Prut / Olt	RO	Yes (Flood Alert)	7 July	Yes	Maximum flood alert on Prut river in E. Romania, along border with Moldova.
17 September	19 September	Sava / Soca	HR / SI	Yes (Flood Alert)	18 Sep	Yes	Severe flooding in Slovenia kill 3 people. Croatia also affected.
Late November	Early December	Drina	RS	Yes (Flood Alert)	29 Nov	Yes	Severe flooding in Bosnia, Serbia and Montenegro, with river Drina at highest level in 100 years.
3 December	8 December	Sava	HR	Yes (Flood Alert)	5 Dec	Yes	Heavy rain causes devastating flooding in the Balkans, esp. Bosnia and Herzegovina, Croatia, Montenegro, & Serbia.
9 December	9 December	Tisza	HU / RS	No	-	Yes	Snow-melt and swollen rivers flood 3000 km^2 of arable land, esp. near Szeged, on Tisza river, in S.E. Hungary.
December	December	Koeroes	HU / RO	Yes (Flood Alert)	3 Dec	No	(No reports found on on-line news media. Event to be confirmed by local authorities in annual EFAS meeting)

4. Flood interventions and affected area

In the Czech Republic Fire Rescue Corps and other parts of the Integrated Rescue System were involved in the response. Army of the Czech Republic was helping during reconstruction works. National state reserves were used to manage the flood situations and reconstruction works. 164 people were rescued and 472 people were evacuated.

In Slovakia flood safeguarding works were organized and mostly performed by the Slovak Water Management Enterprise in collaboration with the municipalities and units of the fire and safeguarding brigades. Fire brigades of the Department of Interior were involved in the rescue works ensuring water pumping, removal of fallen trees, rescue of inhabitants, evacuation, etc. Since May to August the fire brigades made 1954 interventions. Altogether 85,349 persons were actively involved in the flood mitigation activities out of which 34,235 were professionals (members of flood protection authorities, crisis staff, water management authorities, firemen and rescue brigades, police and other parts of integrated rescue system and military forces). 7,729 Slovak citizens were evacuated during flood events in 2010.

Flood defence activity in Hungary required mobilization of major work force, many thousands people were involved. At the peak of defence works in early June 18,669 persons took part in flood mitigation, out of those 9,985 professionals from the water and emergency services, 2,960 Army forces and 5,724 public workforce and civilians. 1,473 units of major equipment including transportation facilities were in use. The estimated number of sand sacks used exceeds 7 million. The cost of flood defence activity within state water services exceeded 20 million €.

In Slovenia almost 300 persons were evacuated. At the request of municipalities, more than 100,000 flood bags, 17,000 m^2 of foil, several dozens of boats, 50 pumps and power generators, and other items were released from the national civil protection logistic centre.

In addition to works on elevation and stabilization of dykes and development of temporary embankments (in the total length of about 50 km), sand bags were used in Croatia for protection of family residences and industrial facilities in endangered areas. In several places, new counter-pressure wells were constructed, and planks were driven to strengthen embankments. Simultaneously, sluices were operated to relieve and strengthen individual culverts, protective walls and revetments. Plugs were closed and discharge profiles were cleaned. The cut-offs were built, pipe culverts removed, and for drainage of hinterland, seepage and flood waters all active pumping stations were used, with additional mobile pumps of higher capacities, which prevented larger damages to hydrotechnical facilities and to the population. The top of the large water wave was relieved several times through the Prevlaka dam into the Lonja-Strug canal and the retention areas of Lonjsko polje. In total, 750,000 bags were used for flood defence in Croatia as well as 60,000 m^3 of materials such as sand, gravel, earth and stone. 200 excavators, 40 bulldozers and 250 other machines for transportation and installation of materials were applied.

In the Bosnian Federation 2,514 households with 6,317 inhabitants were endangered. Evacuation of 836 persons was carried out.
In the Republic of Srpska 3,473 households were endangered and 956 families evacuated.

The main interventions in Romania have been organized in the area of Siret, Prut and Dobrogea-Litoral basins as well as along the Danube, especially in the Galati city area. These interventions included informing public on mitigation measures; rescue and evacuation of people, animals and goods; restricting traffic on the roads affected by flooding and on damaged bridges and culverts; securing accommodation, food supply, water and providing medical care for affected population; disinfection of affected areas; consolidation of dikes and water removal from inundated enclosures.

In Serbia responsible public water management companies took all necessary flood defence measures, including declaration of the beginning and end of flood defence, status monitoring, strengthening of defence lines, and engagement of machinery and manpower. In case of large-scale floods (such as those on the Sava, on the Timok, and in the Kolubara, Drina and Morava river basins), the Sector for emergency management of the Ministry of Interior took part in mitigation efforts and in the evacuation of the threatened population. However, critical situation occurred south of the Sava and the Danube, where exceptionally high stages were recorded at nearly all watercourses. Overtopping and flooding were recorded solely along untrained river sections, while man-made protection systems sustained considerable damage.

During the February / March floods in Bulgaria activities towards an upgrade of the critical sections of the dike near Bregovo and towards water level decrease in the Timok were made. In June, a protective dike with a height of 70 cm and length of 20 m was constructed near the Port of Lom.

In Ukraine in May, Uzhgorod, Mukachevo and Beregovo rayons were most affected by flooding. The total volume of the water pumped out of the flooded area was 83 mil m^3. In December 12 rayons suffered by the floods (Rakhiv, Tyachiv, Khust, Mizhgirja and Irshava rayons being the most affected) and the total volume of the water pumped out of the flooded area was 200,5 mil m^3 (the historical maximum).

In Moldova, as result of the high water discharge from the Costeşti-Stanca reservoir and due to a bad state of the dykes, several locations were flooded. The most affected district was Hincesti, particularly the Nemteni, Cotul Morii, Obileni and Sarateni villages. In order to mitigate the consequences of the disaster, works were carried out to strengthen the dykes involving the forces of the Civil Protection Service, the National Army and the local authorities of the riverside areas.

5. Casualties and assessment of damages

5.1 Casualties

In 2010 three flood victims were registered in the Czech Republic, two victims in Slovakia, two victims in Moldova and four victims in Slovenia. Floods caused 24 casualties in Romania.

5.2 Damages

In the Czech Republic floods in May and June 2010 caused damages amounting to 2.6 billion CZK. Major damages were recorded in water management infrastructures (28.2%, 738.8 million CZK) and transport infrastructure (25.7%, 673.4 million CZK). 199 bridges and 550 km of roads were damaged. In 187 affected municipalities 1,287 houses were destroyed.

In Slovakia 27,521 residential and 6,700 non-residential buildings were damaged by floods in 2010. The extent of flooded area was 97,290 hectares out of which there were 6,680 hectares of urban area, 87,370 hectares of agricultural land and 3,240 hectares of forest land. 733 bridges, over 100 km intercity roads and over 500 km of local roads were destroyed. Total cost of flood damages in 2010 was 337 million €.

Flood related damage in Hungary accounted 989 homes destroyed or seriously damaged. The Vienna-Budapest railway line was also endangered while the motorway M1 was cut by a flash flood induced damage for a couple of days. Right-hand tributaries of the Tisza inundated their banks. Temporary closure and damages occurred on roads and railway lines were cut in the Sajó, Bódva Hernád and Ipoly valleys. Records show that 510 communities reported flash flood induced damage. Massive floods impacted not only houses and infrastructure but tens of thousands of hectares of arable land have been affected and the damage to cereal crops led to further economic losses. The maximum extent of excess water effected territory in Hungary reached 198,000 hectares. Together with infrastructure losses the bill of the extreme events in Hungary is above 147 million €.

In Slovenia during flood events in September 8241 buildings and more than 30,000 hectares of agricultural land were flooded. Excessive water caused 868 land slides, slumps and trench collapses, primarily in Subalpine areas. Damage occurred on 91 bridges and on a number of local and national roads. Total costs of direct damages caused by floods are 207 million € out of which the damages in 137 municipalities reached 48 million €. The structure of other damages was as follows: river network 116 million €, economy 20 million €, cultural heritage 2 million €, state roads 440,000 € and railroads 2.94 million €.

The catastrophic floods in May / June caused great damages to agriculture, fruit and vegetable growing, livestock production, infrastructure, personal property and property of local self-government units in eastern and central parts of Croatia. 427 houses, cellars and yards were flooded; 682 houses were directly threatened and damaged; 112 families were evacuated, and, where appropriate, also movables and domestic animals (poultry, pigs, cattle). The evacuated population (and animals) were cared for and provided with temporary accommodation. The total damage of flooding in May / June in Croatia has been estimated at almost 153 million €. During floods in September 900 residential buildings were flooded, 257 people were evacuated from flood-affected areas. From the area of the Nature Park “Lonjsko polje” 600 cattle were evacuated, mostly native horse species. As Zagreb belongs to key traffic nodes in the country, closing down of the roads caused enormous losses. The total damage caused by flooding in Croatia in September has been estimated at almost 32 million €.

In Bosnia and Herzegovina / Bosnian Federation over 140,100 hectares of land were flooded out of which approx. 91,360 hectares were agricultural land / surfaces. In the Republic Srpska about 100,649 hectares of land were flooded, 48 houses were destroyed, 1,513 objects were damaged. Moreover, 15 bridges were destroyed and 40 bridges were damaged. Excessive saturation by water caused 1261 landslides in the Bosnian Federation, and 156 landslides in Republic Srpska. According to the data collected so far, the damages on the land, construction structures, equipment, cultural goods and other properties in the Bosnian Federation exceed 50 million €, and those in Republic Srpska exceed 26 million €.

In Serbia the flood wave in February threatened unprotected riparian lands of the Beli Timok River and the City of Zaječar sustained the greatest damage. Following the declaration of an emergency situation, evacuation and rescue measures were undertaken to protect people and property. Some 600 residential and public buildings, as well as roads and municipal infrastructures, were flooded, as were entire complexes of high quality agricultural land. One hundred and fifty households were evacuated. Total damage was estimated to 4.5 million €. In the Južna Morava River Basin, a number of rural and parts of urban settlements were flooded (e.g. Leskovac, 500 houses and more than 1,000 ha of arable land and greenhouses with spring vegetables). In June 2010, flood was recorded in the Kolubara River Basin, mainly in the Ub Municipality, where 315 buildings sustained damage. Following the declaration of an emergency situation, 120 people were evacuated. Extraordinarily high stages of the Lim, the Drina, and their tributaries in the beginning of December 2010 caused overtopping and flooding of residential areas of the Town of Prijepolje on the Lim, where an emergency situation was declared. Additionally, some 3,000 buildings were flooded in parts of the towns of Ljubovija and Banja Koviljača, from which more than 1,400 people were evacuated.

In Romania the major flood damages were registered during June–August, the total cost being about 3.7 billion Lei (870 million €). Over 3,936 houses were affected, out of which 863 were completely destroyed. About 110,000 ha agricultural field, 707 bridges and 2,729 small bridges, 31 km of water supply, 147 social and economic objects, out of which 87 schools, 3 hospitals and 33 churches and over 5,200 km national and regional roads have been affected by flood events.

In Ukraine in May, 28 settlements were flooded (750 households), as well as 12,000 ha of agricultural land. The infrastructure damages amount to 2.3 million UAH (0.21 million €). The approximate estimation of total damages in the region is 17.63 million UAH (1.16 million €). Floods in December affected 1,911 households, as well as 3,200 ha of agricultural land and damaged 18 km of roads, 5 km of bank reinforcement and 15 bridges. 671 persons were evacuated. The infrastructure damages amount to 4.2 million UAH (0.4 million €). Approximate total damages in the region were 71.3 million UAH (7 million €).

In Moldova in the districts around the Prut river floodplain the floods damaged houses, roads, farm land as well as wells and water collection systems. The floods caused long term impact on large areas of farm lands and pastures. Overall 13,000 persons were affected by flood. 1,105 houses and 4,308 ha of farm lands, 4,800 ha of pastures and 930 ha of forests were damaged. More than 4,000 citizens were evacuated. The total estimation of economic losses amounts 41.75 million USD.

Based on the cost estimation reported by the countries the total damages of the 2010 floods in the Danube River Basin reached about two billions €.

6. Lessons learned

6.1 Land Use and Spatial Planning

Proper regulation of land use and spatial planning is a key factor for minimizing the adverse impacts of future floods. Spatial planning has to ensure that the land is used in the most efficient way to serve society in achieving its economic, social and environmental goals. The urban and country planning has to respect the needs of flood risk management and the spatial planning has also to consider the possibilities of reactivation of former, or creation of new, retention and detention capacities to give rivers more space.

Management of floodplains in the frame of land use planning proved to be a critical factor for minimizing damages by floods. The following issues were highlighted as significant during floods in 2010:

- Improper land use in floodplains;
- Need of elimination of illegal structures in the floodplains;
- Proper maintenance of structures in the floodplains to ensure their stability against flood flows;
- Integration of flood management experience into urban and other development planning;
- Urbanization of the floodplain areas along watercourses leading to a significant reduction of space for free flow of high waters increasing flood risks;
- Extensive and unplanned deforestation in upper parts of the river basins leading to significantly increased outflow coefficient and thus to higher flood risks downstream;
- Planning works on torrential sectors of the basins (headwaters) should be given high priority;
- There is a need for an improved support by the local actors (municipalities, local authorities, land owners, population) to implement flood protection measures.

The recently completed emergency reservoir (detention basin or polder) of Tiszaroff was opened during the June 2010 flood reducing the flood peak by 15–20 cm and easing thus the load on the flood protection of the city of Szolnok. **This flood event proved the efficiency of the system, however recalled the importance of proper planning and forecasting for decision making and reservoir operation.**

6.2 Structural measures

Floods in 2010 confirmed that structural measures remain an important part of flood management. Emphasis was given primarily to a proper maintenance of the existing structures focusing on:

- Reconstruction of the dykes to ensure their stability during excessive load in the time of floods;
- Increase of capacity of pumping stations to improve flood protection against internal water;
- Sustaining the designed flow capacities of river channels;
- Avoiding insufficient flow capacity (profile) of bridges and removing other bottlenecks in water courses;
- regular maintenance of flood bed to remove the vegetation, sediments and all kinds of debris to ensure the transit capacity of high waters;
- Harmonization of design criteria.

Several flash flood events in Hungary called attention on the importance of proper handling of small dams, reservoirs and fish ponds. The impact of flash floods was further enhanced and aggravated by the failure of such structures either not licensed properly, abandoned or poorly maintained.

The experience in Ukraine showed that the existing and reconstructed objects provided an effective flood protection against extreme water levels and prevented economic losses. The ongoing programme in Ukraine foresees in addition to dike construction and reinforcement also creating of dry mountain reservoirs and lowland polders for surplus water accumulation. Similarly in Romania there is a need for constructing reservoirs for flood retention in headwaters of Jijia, Moldova and Suceava River.

6.3 Non-structural measures

An important role among non-structural measures belongs to meteorological and hydrological forecasting and flood warning and monitoring systems. Timely delivery to flood defence units of meteorological and hydrological warnings, data and forecasts, sufficient accuracy of the data and well organized cooperation between key actors contributed substantially to an efficient reduction of damages. It was however concluded that meteorological and hydrological forecasting and warning systems have to be enhanced and the international data and forecast exchange between the neighbouring countries needs to be improved.

Availability of flood maps and plans proved to be a key element of flood risk management. In some of the affected areas the recently published hazard maps showed good accordance with the flood extent of the events in 2010. In any case it is recommended that future revisions of the current flood plans, evacuation plans and land use plans would take into account the experience and lessons learned from the floods in 2010.

6.4 Preparedness and mitigation

Well structured emergency organization is vital in order to be able to cope with flood emergencies. Timely and effective interventions and rescue actions are essential for protecting lives, property and environment and require a properly organized crisis management. Comprehensive contingency plans to respond to flood events should be properly prepared in due time and maintained in operational status. The level of preparedness of individuals as well as flood-fighting professionals must be continuously kept at the high level. "Crisis plans" (flood emergency plans) at all levels of flood and crisis management have to be regularly updated using the experience from the recent flood events. Adequate funds have to be allocated for establishing emergency structures and crisis management.

The experience from the 2010 floods in Hungary demonstrated a clear need for more centralized approaches when the state takes most of the responsibility for flood defence. There were situations when the local communities were found unable to organize and conduct flood defence works at the necessary level.

As a reaction to 2010 floods Slovenia reported well organised and coordinated performance of different rescue services, police, Slovenian Army and other public service institutions. Effective contribution was provided by different voluntary organisations (fire brigades, Red Cross). As regards concrete actions Slovenia reported

- First operational use of mobile heavy capacity water pumps;
- First operational activation of teams for First Aid organised by the Slovenian Red Cross;
- First activation of the new (updated) system of public alarming;
- First use of satellite images of the flooded areas

6.5 Financing aspects

Availability of financial instruments for prevention, preparedness and protection as well as for recovery and reconstruction works after floods at local, national and EU level is crucial. Fast adoption of specific national recovery programmes after extreme flood events causing massive damages is highly recommended. Insufficient financing of flood protection increases the risk of casualties, damages and losses by floods. Possibility of obtaining financial support for flood prevention (dike reinforcement) from other actors (land owners, municipalities, fisheries) should be considered as well.

The importance was underlined of the European Union Solidarity Fund being a specific financial instrument to give immediate financial assistance in the event of a major disaster to help people, regions and countries concerned to return to living conditions.

In Serbia it is estimated that considerable funds will be needed to repair the damage to the existing protection systems as well as to raise the level of protection, especially in densely populated areas which were flooded in 2010.

6.6 Climate change impacts

Climate change will affect the hydrological cycles, precipitation patterns and thus also the probability of flooding. The impacts of climate change have to be addressed in the flood risk management plans.

General analyses of precipitation in the area of Bosnia and Herzegovina during the last thirty years show that there are no changes in average annual quantities of precipitation, however, there is a change in the intra-annual distribution of precipitation bringing short periods with very high intensity of precipitation leading to increased flood risks.

7. Conclusions

A high number of flood events occurred in the Danube River Basin in 2010 and led to 35 casualties and the total damages reaching about two billions €.

The lessons learned from 2010 floods showed that while reliable forecasting of flash floods is rather complicated, an efficient application of structural and non-structural measures such as providing sufficient space to rivers by creating dry polders and revitalization of floodplains, or regular maintenance of river channels ensuring unhindered flow during extreme hydrological conditions can remarkably decrease the risk of flood damages.

Emergency services and agencies responsible for the management of water infrastructure were put on high alert during the whole year of 2010. National efforts were sufficient to cope with rising emergencies; however, the economic losses were vast. Studies on the impact of climate change show it is very likely that there will be massive floods or flash floods in the future, so we must be prepared to cope with them. Therefore the preparation of flood risk maps by 2013 and flood risk management plans by 2015, in accordance with EU legislation, are important steps to live with the flood risks and to address them with appropriately targeted measures.

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