Pilot Study of the “Tisza River Basin”

EXECUTIVE SUMMARY

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Task Leader VITUKI Kht.

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RELATED DOCUMENTS
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Executive Summary for Task 22

1. Scope of the research in Task 22

The objective of Task 22 of the FLOODsite programme is to develop river basin based, precautionary and sustainable flood management strategies, to investigate and analyse previous floods, to foster international co-operation and to apply the outcome of other tasks by preparing vulnerability analysis.

Task 22 is executed by three partners: VITUKI, H-EURAqua and UFZ. Input is obtained from FLOODsite Sub-Task 1.3 on “Risk analysis: Scientific knowledge and understanding the vulnerability and sensitivity of the receptors of risk”.

Task 22 provides 6 research outputs (RO):

1. Inventory of pollution sources, fate of pollutants, need for further research (D22.1.d)
2. Report on the scenario analysis of intervention options to raise the flood conveyance capacity of the flood bed (D22.1.e)
3. Report on the analysis of the impact of extreme precipitation patterns on the flood peaks along the Tisza River (derived from different historical hydro-meteorological conditions) (D22.1.b)
4. Report on the scenario analysis of partial floodplain reactivation with controlled inundation (D22.1.f)
5. Report on the development the basin wide integrated system of monitoring, flood forecasting and warning (D22.2)
6. Report on the pilot study application of general vulnerability analysis developed in sub-theme 1.3, in one of the flood cells to identify the effectiveness of flood management strategies (D22.3)

The first RO was delivered by the end of month 24, the 2nd to 5th ROs were delivered by the end of month 36 and the last one will be delivered by month 52 (there is a four months delay due to the serious illness of the sub-task leader).

1.1 Inventory of pollution sources, fate of pollutants, need for further research

In early 2000, two major mining-related accidents occurred in the Maramureș County in Romania (See Figure 1.1) which caused the release of large amounts of cyanide and heavy metals into the rivers Szamos and Tisza (a major tributary of the Danube).

The Hungarian sections of the Tisza River and the Szamos River form the investigation area. The Tisza basin is the largest sub-basin (157,186 km²) of the Danube basin (801,463 km²). Samples of sediment and water were taken starting downstream of the eastern border to Romania at Csenger and ending at Szeged in the south of Hungary close to the Serbian border (See Figure 1.2).

The Tisza and three of its tributaries (Szamos, Körös, Maros) were investigated. The Szamos and the Maros can be seen as its most polluted tributaries due to the influence of industrial and domestic sewage from towns at the end of the Carpathian Mountains. As a result the water quality decreased drastically (WWF, 2002).

Following a period of heavy rainfall (30 L/m²) and snowmelt, a dam breach occurred on January 30, 2000 at the Aurul S. A. gold processing plant in Baia Mare (Maramureș County, Romania) releasing ca. 100,000 m³ tailings waters. The water contained ca. 1,000 t cyanides and 1,000 t heavy metals. The polluted waters flowed over small rivers from the dam into the Szamos, which enters the Tisza at Vasárosnamény in Hungary.

Shortly after the Baia Mare accident (March 10, 2000), another accidental spill occurred at the Novat tailing dam¹ near Baia Borsa (Maramureș County, Romania) again triggered by heavy rainfall (37 L/m²) and snowmelt. Polluted water flowed through the Vaser River into the

¹ at the Preparation Enterprise for processing complex ores of Pb and Zn
Upper Tisza. The total load was estimated at 40,000 t² solid waste (containing heavy metals, e.g. Cu, Pb, Zn) and 100,000 m³ water.

The high concentrations of cyanides killed almost immediately more than 1,000 t of fish on the Hungarian side. Cyanides pose a short-term threat to the environment due to their degradability. In contrast, heavy metals deposit in the river catchment area and can accumulate in the food web due to their lack of degradability, which results in a long-term threat to the ecosystem and to humans.

To assess the contamination, sediments were sampled along Szamos and Tisza in Hungary (See Figure 1.2) from 2000 to 2005. Concentration of arsenic, cadmium, cobalt, copper, molybdenum, nickel, lead and zinc was investigated both in surface sediment and in vertical sediment profiles. The aqua-regia soluble element contents and the bonding forms of selected elements were analyzed in the grain size fraction < 20 µm.

Heavy metal concentrations in sediments were initially high at the Szamos (≤ 3,000 mg/kg Zn) and decreased with increasing distance from the mining accident (ca. 500 µg/g Zn in the middle section of the Tisza). In 2005, the trace element concentrations in the Szamos have decreased to a level slightly higher than in the Tisza. The concentration decline is probably caused by dilution with “uncontaminated” sediment, transport of contaminated substrate further downriver as well as transport out of the river onto the floodplains. Most of the sediment profiles do not reflect the mining accidents of the year 2000, which indicates a long history of heavy metal contamination in the Tisza catchment. Cluster analysis discriminates three sections of the research area: (1) Szamos, (2) middle Tisza and (3) lower Tisza. This pattern is based on the contamination level ranking from high to low. Over the observed years the element pattern changed only marginally: (1) Cd–Pb–Zn, (2) As–Cu, (3) Cr and (4) Co–Ni.

Although the decrease of the sedimentary heavy metal concentration gives a positive impression regarding the sediment quality, potential sinks of the contaminants should be determined. Therefore further research is needed to assess the effect on floodplains, because they are due to their agricultural use integrated in the human food web.

Figure 1.1 Location of the accidental spills (Baia Mare and Baia Borsa) in the catchment area of the Danube

2 other sources: 20,000 t of mineral waste
Overall it can be concluded that the contamination level of the sediments in Tisza and Szamos has decreased. The concentrations of heavy metals and As declined significantly since the mining spills in early 2000. The decrease is especially pronounced at the extremely contaminated locations at the Szamos. But still most of the investigated elements exceed target values recommended for sediments and soils.

Since heavy metals are not biodegradable other mechanisms must have caused the decrease. These could be the redistribution of contaminated sediment during subsequent floods, which is connected to an increase in the contaminant concentration in adjacent floodplains and sediments downriver. Mixing with non-contaminated sediment could also be responsible for some of the concentration decline since the spill. This material can be derived from tributaries of the Tisza from non-mineralized regions. Dissolution can also play a role in the contaminant decrease, although the data from the performed bonding form analysis do not give a consistent picture.

Based on the results of the sediment analyses, an estimation of the potential input of contaminants bound on sediments into floodplains and adjacent areas of the Tisza and Szamos was made. This first rough assessment showed that the soil element content increased strongly during repeated flooding; in a few cases the increase was extremely high. This first assessment of the risk potential of heavy metal contamination for soils in floodplains demonstrates their high contamination threat and the need for further research.

1.2 Report on the scenario analysis of intervention options to raise the flood conveyance capacity of the flood bed

After a relatively long dry period unprecedented series of extreme floods hit the Upper- and Middle Tisza River between November 1998 and March 2001. During the 28 month period four extreme floods occurred, as a consequence of which the total duration of flood alerts reached 24 month. Within this, extraordinary alerts lasted 9 month. The November flood in 1998 as well as the March flood in 2001 brought new records in flood peaks along the Upper-Tisza, the latter caused even dike breach.
there. However, these floods due to the attenuation of the single flood waves resulted in a high, but not extreme flood on the Middle-Tisza section which is subject of our investigation, being the selected pilot site downstream Szolnok. The location of the Tisza River Basin in Europe is illustrated in Fig. 1.3, also evidencing the above mentioned frequent extreme flood events, while orientation on the Middle-Tisza region and the pilot site itself is given in Fig. 1.4.

Figure 1.3 Location of the Tisza River Basin

Analysis of the time series of annual maximal, mean and minimal water stages of the past century at the Szolnok gauging station (Figure 1.5) shows a trend of increasing high water levels, slightly decreasing mean water levels and decreasing low water levels. The decrease in the mean and low water levels is the result of the deepening and narrowing of the mean river bed as it will be seen on the evaluation of the changes of the cross sections. The reason of the increasing maxima is also partly connectable to the above changes but is more complex and will be explained by the evaluation of the discharge measurements.

Evidences of river capacity reduction along the Middle-Tisza has been demonstrated by the analysis of the trends of characteristic water stages as well as of the Q-H loops of significant floods of the past hundred years (Figure 1.6).

To discover the main causes of the problem data collection has been organised and performed including the analysis of sets of maps of the past 220 years (including the first military survey in 1782-85, the second military survey in 1826-66, a study on the changes of the river between 1830 and 1890 titled ‘The Tisza River long ago and now’, the Tisza Atlas made in 1930 and in 1976, finally ortophotos made in 2001). Data collection and analysis concentrated on the reduction of the area of the flood bed (floodway), on the artificial structures erected in the floodway, especially summer dikes, on the changes in the mean riverbed (Figure 1.7) and in the land use of the floodway with special regards to the floodplain forests.
Figure 1.4 Location of the Middle Tisza Region and the pilot site

Figure 1.5 Trend in maximal, mean and minimal water stages at Szolnok gauging station

\[
y = 1.5754x - 2389.8
\]

\[
y = -0.2108x + 561.68
\]

\[
y = -1.1246x + 2037.7
\]
Figure 1.6 Results of flood discharge measurements at Szolnok at different floods

Figure 1.7 Characteristics of the flood bed

Using the HEC-RAS 1D hydrodynamic model, after successful calibration and verification, analysis has been made on major intervention options to raise the flood conveyance capacity of the flood bed along the Middle-Tisza section, notably demolition of summer dikes, and creation of a ‘hydraulic
corridor’ in the floodway cleaned from man made obstacles of flow and from dense vegetation (rehabilitation of pastures and mosaic type floodplain forests in the floodway). Individual and integrated effects were also determined and proved to be very efficient in lowering flood crests (up to 40, 50 and 90 cm, respectively; Figure 1.8).

EFFECTS OF DEMOLITION OF SUMMER DIKES AND FLOODWAY REGULATION ON THE FLOODWAVE OF 2000. ALONG THE SZOLNOK - CSONGRÁD SECTION

1.3 Report on the analysis of the impact of extreme precipitation patterns on the flood peaks along the Tisza River (derived from different historical hydro-meteorological conditions)

Following the almost three decades’ time elapsing without any major event after the by now legendary great flood in the Tisza Valley of 1970, involving almost the whole river system and characterized in most sections of the latter by water levels surpassing all former records, during the last ten years there were as many as five outstanding flood waves in the Tisza River system (in the years 1998, 1999, 2000, 2001 and 2006) resulting along a number of various shorter or longer river stretches of the system in water levels surpassing all the previously observed maxima.

On the basis of a detailed analysis of the hydro-meteorological scenarios leading to the various flood situations, one may conclude that — although these flood peaks in a number of places substantially surpassed the former maximum values — in most cases both the hydro-meteorological scenario preceding the flood and that following it, were far from being the potentially worst ones. This fact, of course, is involving the sinister perception that there is a realistic chance for the future occurrence of flood waves characterized by even more extreme hydrological parameters than those observed in the past.

A detailed investigation on the effects of flood-triggering meteorological processes was started around 1970 by E. Bodolai-Jakus (BJE), identifying the types of weather patterns triggering floods, determining the frequencies of occurrence of these patterns and the role of each of them in creating the various types of flood waves. When classifying weather patterns, the investigation was based on the actually observed precipitation cycles producing flood waves. Thus the flood wave periods were not connected to the types of a pre-existing catalogue, but inversely: the types of weather patterns providing large amounts of precipitation were identified for the catchment area of the Danube and Tisza, in accordance with the hydrological goal of the investigation. To put it more concretely, the
quasi stable objects were identified, for the theoretically significant period of classification, for about 800 rainy days triggering flood waves in the area investigated, on the 500 hPa absolute and the 500/1000 hPa relative topographic maps. The seven types of floodwave-triggering weather patterns (See 6 of them on Figure 1.9) were identified on the basis of the characteristic geographical positions of three objects: the near-to-surface centre of the cyclon, the depression- and the crest line of orographic maps.

![Figure 1.9 Flood inducing weather patterns: a - West (W); b - West with peripheric storm (Wp); c - Zonal (Z); d - Moving Mediterranean Cyclone (M); e - Central Type (C); f - Western Cyclone (CW)](image)

The results of the meteorological investigations indicated that the frequency of weather scenarios leading to flood waves is changing with time and that there is an increasing tendency of their absolute frequencies within the range of all typical weather situations. It is also obvious that in the lowland part of an extended catchment area like that of the Tisza Basin with its strongly ramified river system, flood waves propagate only very slowly, so that the genesis of the latter is predominantly determined by the weather conditions of longer periods, generally characterized by an accumulation of weather types. All the same, the attempts to maximize such weather type accumulations did not provide acceptable results: since their completion, even more disadvantageous weather combinations were observed over the catchment. Therefore the hydrological investigations carried out in the framework of the present work were aiming at the determination and analysis of the potential changes caused by certain modifications of the flood scenarios already occurred in the past.

It was investigated, what would have been the effect exerted on the water levels of situations in which the meteorological and/or hydrological/flood defence conditions during and before the floods had been slightly more unfavourable than they were actually. Thus various hydro-meteorological scenarios were generated by modifying one or more selected parameters of any of the selected actual (observed)
meteorological and/or hydrological/flood defence situations and then the effect of such a modification was determined. According to the type of the modified hydro-meteorological parameters, the scenarios generated may by classified into the following four types:

- On the upstream river stretches, the height of flood levees differs from the actual value, resulting in the non-occurrence of real dike failures (See **Figure 1.10**);
- Modification of the extension and the progress direction of the precipitation zone causing flood waves, i.e., of the areal distribution of precipitation as compared with the real one (meteorological scenario);
- Modification of the actual progress velocity of the flood-generating precipitation zone, leading to a modified timing of coincidence of flood waves of the various tributaries (meteorological scenario);
- Modification of the actual precipitation conditions of the various sub-basins of the river system (Figure 1.11)

![Figure 1.10 Observed, adjusted for dike failures and simulated hydrographs of the 1998 flood](TISZA_TISZABECS.png)

**Figure 1.10** Observed, adjusted for dike failures and simulated hydrographs of the 1998 flood

![Figure 1.11 Stage hydrographs of the 1998 flood at Tiszabecs](TISZA_TISZABECS.png)

**Figure 1.11** Stage hydrographs of the 1998 flood at Tiszabecs
1.4 Report on the scenario analysis of partial floodplain reactivation with controlled inundation

The concept of increasing flood safety against the increasing flood risks in the Tisza Valley in Hungary, the so called “Update of the Vásárhelyi Plan (UVP)” has determined the below main goals:

- heightening and reinforcement of the primary flood embankments where their parameters do not meet the prescribed parameters yet, to provide protection against the 1 in 100 years’ floods;
- decreasing flood peaks/crests by:
  - the improvement of the flood conveyance capacity of the high water bed (we have just discussed);
  - partial reactivation of the flood plain with controlled inundation, e.g. creation of a system of flood detention basins in the protected floodplain to reduce flood volumes passing down the river.

The aim concerning reduction of flood crests was to find a solution by creating an appropriate system of flood detention basins which is capable of lowering the flood crests of the 1 in 100 years’ floods by 1.0 m. In fact, such a solution would provide safety against the 1 in 1000 years floods as well, taking into consideration the expectable impacts of climate change.

To reach the above aim, a preliminary study estimated the total volume of flood detention to be in the range of 1.5 billion m$^3$ and included an overall investigation of 30 potential locations of flood detention basins along the River Tisza. Out of these potential locations 11 were selected for construction (See Figure 1.12).

Effect of partial floodplain reactivation on flood crest reduction has been investigated using the 1D HEC-RAS model. Results (See Figure 1.13) are in similar range than those of the improvement of river capacity (Sub-Chapter 1.2). The combined effects will result in the desired lowering of the flood crests in case of flood discharges equalling with that of in the year 2000 by min. 1.0 m.
Figure 1.12 Selected flood detention basins along the River Tisza – version of 11 basins
1.5 Report on the development the basin wide integrated system of monitoring, flood forecasting and warning

The basic aim of this action is to provide timely the necessary hydrological and meteorological information derived from monitoring networks together with the warnings and forecasts related to the future behaviour flood inducing processes and to transfer these data and information to those responsible for flood defence.

This part of research focuses on three main topics:
- the inventory of existing monitoring systems (See Figure 1.14),
- the inventory of existing (in the Tisza Basin) flood forecasting systems and
- a proposal to create WEB based “virtual” forecasting centre (See Figure 1.15).

During the latest years many new, up-to-date, automated hydro-meteorological stations have been deployed in the Tisza Basin. They report to local forecasting centres. These centres are again connected to each other. The major advance in the co-operation of the Tisza Basin countries that some of the data collection centres are connected to each other across the state borders, thus the information can be easily transferred from one centre/country to the other. Though in many cases the data are collected hierarchically to a national centre and the international data transfer is initiated from there. Thus data transfer from country to another one can still be slow and during flooding situation the vital information might arrive late.

The range of hydrological forecasting models use in the Tisza Basin range from the simple correlation models, through linear routing routines and hydrodynamic modelling to grid based distributed parameter hydrological models. The more complex a model is the more data needed to run it.
Figure 1.14 Joint Hungarian-Ukrainian Hydrological Telemetry System

To meet the data requirements of the different models a central, “virtual” database is proposed. The NET based information centre can easily be accessed by each countries. The raw data and the product (the forecasts) will be publicly available, while the private part serves for the communication of the national forecasting centres and for storage and exchange of internal data and information. A draft version of this “virtual” database has also been prepared.

Figure 1.15 WEB based „virtual forecasting centre”
1.6 Report on the pilot study application of general vulnerability analysis developed in sub-theme 1.3, in one of the flood cells to identify the effectiveness of flood management strategies

The objective of this report is a pilot study application of general vulnerability analysis techniques developed in FLOODsite sub-theme 1.3, in one of the flood cells to identify the effectiveness of flood management strategies.

During the preparation for this analysis, to enable a realistic objective setting, first we had to review and evaluate data availability along the Tisza pilot site from Szolnok to Csongrád. The floodplain of this 88.4 km long river section consist of 6 separate flood area (floodplain basin) with a total extension of 563.42 km²s accommodating some 110 thousand inhabitants in 15 settlements, including Szolnok itself, an industrialised town.

In Hungary there are flood plain maps available produced in 1976-77 in scales of 1:50 000 and 1:100 000, (later in 1:500 000 as well) showing the extent of inundation of 1 in 100 as well as 1 in 1000 year floods. However, these flood plain maps do not provide any information on elements of hazard like flood depth, duration or velocity. The maps are available in paper format only.

Lack of data related to flood depth prevented us from undertaking the whole pilot area, therefore a smaller separate flood basin must be selected within it, for which DEM can be produced within the timeframe and budget conditions of this project. Further CORINE land use data were used while values of assets at risk were developed from Hungarian Statistical Yearbook, Regional and County Statistical Yearbooks, etc. Flood damage data of historical descriptions and records were also used, though no valid conclusion can be drawn for future measures from the existing unreliable and contradictory historical damage data.

The selected flood area (Fig. 1.16 and 1.17) is situated in a rural environment at the confluence of Tisza and Hármas-Körös rivers. It covers the inner area of four settlements (Tiszaug, Tiszasas, Csépa and Szelevény) and the outer area of Tiszainoka, Tiszakürt and Kunszentmárton. Population of the flood area is in the range of 5,000 capita while the endangered assets in the settlements are in the magnitude of 100 million Euros, in the agriculture 20 million Euros.

Land use patterns based on Corine Land Cover 1:50,000 (CLC 50) are shown in Fig. 1.18. Prevailing land use category or type of activity at the lower elevations is agricultural, mainly arable land but there are also some complex cultivation patterns, orchards and pastures as well. Forests are rather rare in the protected flood area but are dominant in the floodway of the rivers. These forests are composed of broad-leaved trees with rather dense under vegetation. There are also some wetlands and lakes, mainly the oxbows of the River Tisza and Körös.

Industrial activity is restricted to the eastern edge of the flood area and is situated on rather higher elevation in the periphery of Kunszentmárton but still in the risk zone of potential inundation in case of failure of the defences. Commercial (retail, catering and hotel trade) units are placed on higher ground mainly in the inner area of the settlements. Hotel trade is developing in the area, mainly in Tiszaug, where not only guest houses but a three-star hotel with broad selection of leisure facilities and services are available.

The urban fabric of the settlements shows discontinuous rural character and is composed by detached houses with gardens. The average plot size is 655 m². Along the banks of the larger two oxbows recreation houses have been erected. These are also detached houses, sometimes bungalows. Several farm houses can also be found in the agricultural land.

Inundation modelling has been performed by using the HEC-RAS model. Flood extent and distribution of flood depth is illustrated in Fig. 1.19. It is clearly seen that properties in the fringes of municipalities Tiszaug, Tiszasas and Csépa will be covered in the range of <1m to max. 1-2 m, while Szelevény, which is intersected by the depressions of an ancient, silted up oxbow will suffer more serious inundation both in the share of inundated area and in flood depth. Industrial plant in the outer area of Kunszentmárton will be affected by ~1m flood depth.
Fig. 1.16 Location of the 2.86 Körös corner flood area

Fig. 1.17 Topographical map of the 2.86 Körös corner flood area
Fig. 1.18 Land use map of the 2.86 Körös corner flood area based on CLC 50 images

Fig. 1.19 Flood hazard map of the Körös corner flood area in case of p=0,5% flood
For the evaluation of the economic risk a macro scale approach was used since neither the available DEM, nor the rather coarse land use information and the level of economic data enabled us to apply a meso-scale method resulting in more detailed analysis.

To evaluate the damages relative damage functions were developed for residential buildings (**Fig. 1.20**), for industrial, commercial and agricultural units.

**Relative damage functions for residential buildings**

Finally damages were calculated for different return period flood events (**Fig. 1.21**).
Results of the work performed are demonstrated in Chapter 4 of this report,
- we developed the flood hazard map of the Körös corner flood area, indicating the distribution of flood depth,
- determined the extension of land use categories and the distribution of the value of assets at risk in the Körös corner flood area (mean estimation),
- developed relative damage functions,
- calculated and determined the distribution of flood event damages for three different scenarios, the floods of 200 year, 100 year and 50 year recurrence period (or 0.5% - 1.0% and 2.0% probability),
- calculated the annual average damage
- documented the uncertainties.

2. Principal results

In the following the major outcomes of the project are listed briefly sub-task by sub-task.

2.1 Inventory of pollution sources, fate of pollutants
- Contamination level of the sediments decreased since the spills (Szamos)
- High potential mobility of toxic elements was found
- Repeated contamination threatens the use of floodplain (risk to agriculture!)

2.2 Scenario analysis of intervention options to raise the flood conveyance capacity of the flood bed

The creation and maintenance of a hydraulic corridor (relocation of levees, removal of obstacles) has a positive effect which can attain 1-1.5 m decrease of extreme flood levels (with the partial floodplain reactivation and flood detention).

2.3 Report on the analysis of the impact of extreme precipitation patterns on the flood peaks along the Tisza River
- The importance of the antecedent precipitation and the water content of the snow cover is higher than we have thought it previously,
- The run-off is very sensitive to the path of the frontal zones; minor deviation in geographical location of the precipitation field can produce extreme floods,
- The most dangerous situations for the lower Hungarian Tisza reach are the precipitation events on the Upper-Tisza followed by 8-10 days with a precipitation on the Körös-Maros catchment.

2.4 Report on the scenario analysis of partial floodplain reactivation with controlled inundation

The partial floodplain reactivation and flood detention have a positive effect (1-1.5 m) on the water levels (with a combined effort as shown in sub-chapter 2.2).

2.5 Report on the development the basin wide integrated system of monitoring, flood forecasting and warning

The increase of lead time requires large amount of data in due time. A WEB based joint database seems to be a solution.

2.6 Report on the pilot study application of general vulnerability analysis developed in sub-theme 1.3, in one of the flood cells to identify the effectiveness of flood management strategies

Results of the work performed are demonstrated in Chapter 4 of the report,
- we developed the flood hazard map of the Körös corner flood area, indicating the distribution of flood depth,
- determined the extension of land use categories and the distribution of the value of assets at risk in the Körös corner flood area (mean estimation),
- developed relative damage functions,
- calculated and determined the distribution of flood event damages for three different scenarios, the floods of 200 year, 100 year and 50 year recurrence period (or 0.5% - 1.0% and 2.0% probability),
- calculated the annual average damage,
- documented the uncertainties.

3. Relevance to practice

In the table below the projects identified in FLOODsite’s project links database are listed.

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<td>VTT</td>
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<td>EFFS</td>
<td>A European Flood Forecasting System</td>
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<tr>
<td>EFAS</td>
<td>A European Flood Alert System</td>
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The research in progress is closely linked to the domestic research activities related to the Update of the Vásárhelyi Plan, a complex flood risk management and regional development project, flood risk management component of which consist of
- improvement of the flood conveyance capacity of the Tisza River,
- reduction of flood crests by giving more space for the river by local dike relocations and partial floodplain reactivation, as well as by creating flood detention basins, finally
- development of the dike profiles to meet the standard.

Though the Tisza pilot is not directly connected to the EFFS and EFAS projects the same team members participate in those projects too, so the exchange of information, knowledge and experience comes through their contribution.

The five countries joined efforts to improve flood management condition in the Tisza Basin. One of the topics of analysis is to find an efficient way of forecasting and dissemination of results. The idea WEB based “virtual forecasting centre” was welcome by the working groups.

4. Remaining gaps in knowledge

4.1 Inventory of pollution sources, fate of pollutants
- Continue to monitor the decrease of contaminants
- Investigate the transfer of contaminants to the protected floodplain
- Contaminants in flood detention reservoirs require further studies.

4.2 Report on the scenario analysis of intervention options to raise the flood conveyance capacity of the flood bed
- Maintenance of the hydraulic corridor
- The involvement of stakeholder requires further improvement and development of new methodologies.

4.3 Report on the analysis of the impact of extreme precipitation patterns on the flood peaks along the Tisza River
- More realistic scenarios (breaches)
- Benefit to cost analysis of flood development
- Risk analysis
4.4 *Report on the scenario analysis of partial floodplain reactivation with controlled inundation*
- Optimization of the operation of reservoirs (synchronization; DSS)

4.5 *Report on the development the basin wide integrated system of monitoring, flood forecasting and warning*
- Implementation of the virtual forecasting centre
- Harmonisation of forecasting models
- Definition of data needs