Integrated Flood Risk Analysis
and Management Methodologies

FLOODsite

Scenario Analysis

THE DEVELOPMENT OF THE BASIN WIDE SYSTEM OF FLOOD WARNING

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Authors	**Péter Bartha**
Contributors	**Péter Bakonyi, Gábor Bálint, Balázs Gauzer, Károly Konecsny**
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DISCLAIMER

SUMMARY

An effective and reliable system of flood forecasting and warning dissemination should be set up to inform, at respective level, authorities responsible for flood defence and citizens in threatened areas. Classical and new media such as sirens, formal warnings, state and private broadcasting services, satellite-based communication system, alarm calls on the radio (switching on radios by remote control), mobile telephones, the Internet and teletext etc should be used, tested and performed according to technological progress. Alarm and action plan must be adapted to local conditions.

Such secondary services and channels of information fed regularly by the responsible authorities may also separate them from direct inquiries of the public enabling them to concentrate on the mitigation activities.

CONTENTS

1. Introduction

1.1 General

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 hydrometeorological 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 hydrometeorological 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.

1.2 Short description of the Tisza Basin

The largest sub-basin of the Danube is that of one of its left-bank tributaries, the Tisza River, having a share of 19.5% (157,200 km^2) in the Danube Basin). It reaches its recipient near to the town Titel in Yugoslavia with a multi-annual mean discharge of 830 m^3 /s, thus contributing only 5.6% to the total runoff of the Danube Basin. The considerable gap between the Tisza River's shares in the areal extension (19.5%) and in the mean total runoff (5.6%) of the Danube Basin is due to the typical lowland-character of about 25% of the Tisza Basin, lying in the Great Hungarian Plain, with a multi-annual specific runoff of only 10-20 mm/a. The drainage basins of the tributaries of the Tisza River are rather different from each other not only as far as their shape, situation, size, hydrography and sloping are concerned, but also with regard to their soil composition and vegetation cover. In 2007, five countries share the catchment area of the Tisza River: Ukraine, Romania, Slovakia, Hungary and Serbia. The orography of the Basin is displayed in Fig. 1. It can be seen that with the shape of an arching semi-circle, the towering ridge of the Carpathians (in Slovakia, Ukraine and Romania) is the northern, eastern and southern boundary of the Tisza Catchment. The western – south-western part of the watershed is comparatively low, on its Hungarian and Serbian section, it is totally flat.

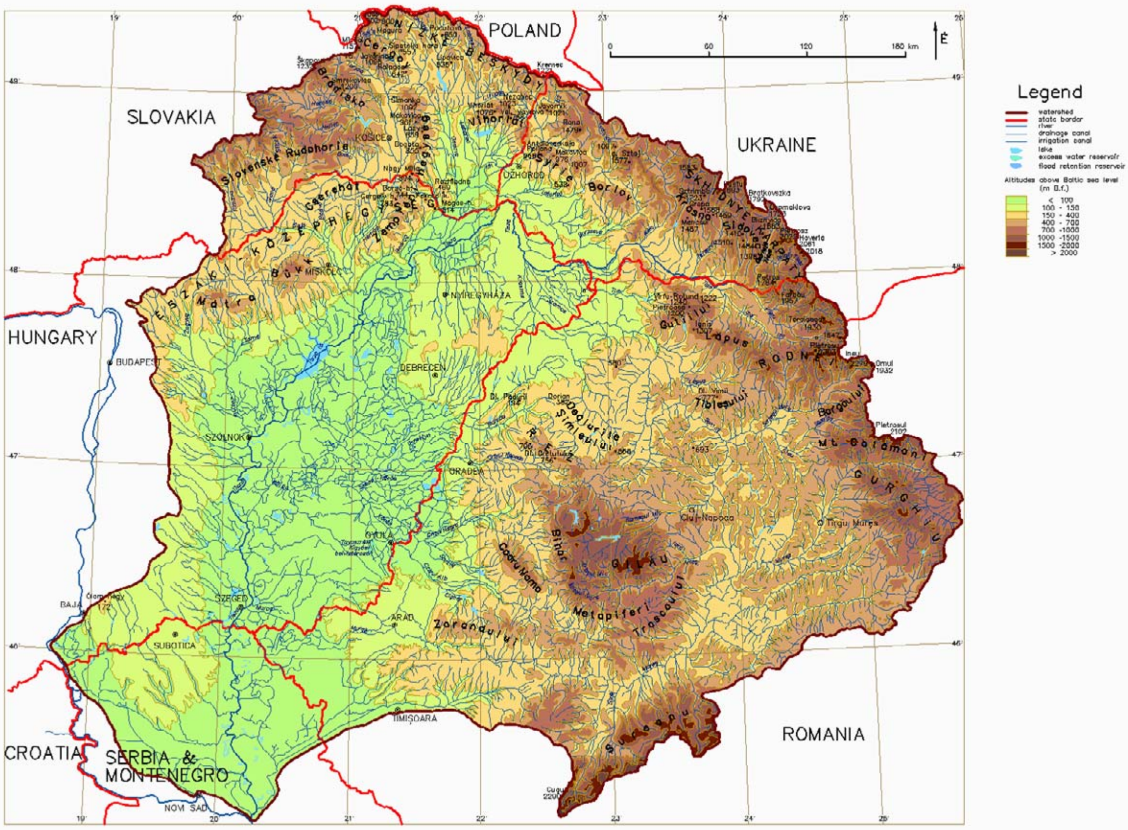


Fig.1. Orography and river network of the Tisza Basin

The hydrographic structure of the Tisza River Basin is displayed in Fig. 2, showing the lengths and catchment areas of the main tributaries.

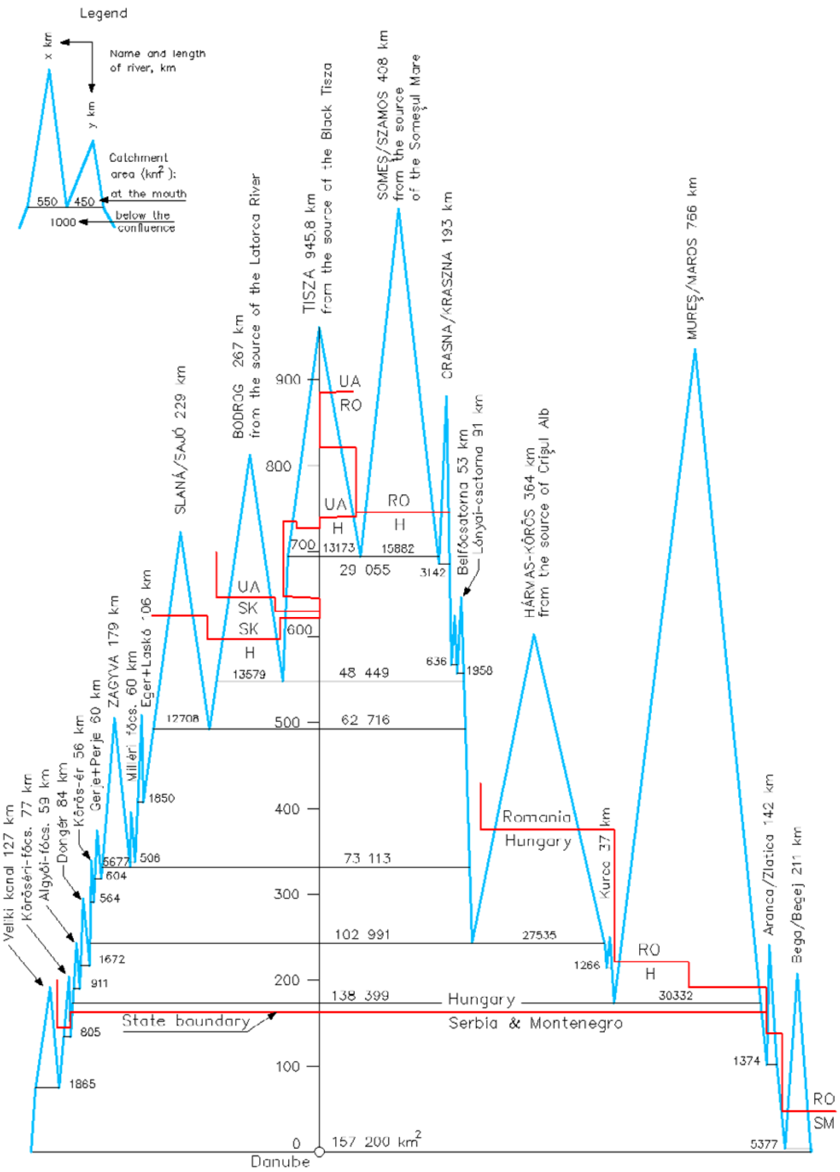


Fig.2. Hydrographic structure of the Tisza River Basin
(Upstream from the mouth of Someş/Szamos without details)

The original length of the Tisza, with its heavily meandering riverbed along its lowland stretch, from its springs in the North-eastern Carpathians (Ukraine) to its embouchure into the Danube, used to be, around the middle of the XIXth century, about 1,400 km. During the second half of the XIXth century, very extensive measures of river training and flood control (including more than one hundred cut-offs) were taken along the river (situated at that time completely in Hungary). As a result of these works, the river's total length was shortened by 453 km (32%) and is today between the springs and the mouth 946 km, and between Vilok (at the Ukrainian/Hungarian border) and the mouth 761 km.

Traditionally, based on the hydrogeographical characteristics, the Tisza River and its Basin are being divided into three main sections: the mountainous Upper Tisza in the Ukraine (upstream from the Ukrainian/Hungarian border), the Middle Tisza in Hungary, receiving the three most well-watered tributaries: the Bodrog collecting the waters of the Carpathians in Slovakia and the Ukraine as well as the Someş/Szamos and Mureş/Maros, both draining the Transylvanian Basin in Romania) and the Lower Tisza (downstream from the Hungarian/Yugoslavian border).

As for the vegetation cover, from the hydrological point of view, first of all the extent and distribution of forests is important. In the Tisza River Basin, the average share of forest cover is 26%. It is concentrated in the northern and eastern part of the basin, while there is only sporadic forest cover both in the Great Plain and the Transylvanian Basin..

The multi-annual mean values of annual precipitation vary within the Tisza River Basin between 500 and 1600 mm/a, their areal distribution also mainly following the orographic pattern of altitudes). The lowest values (500 mm/a and below) occur in the SW part of the Basin, close to the Tisza River itself. The highest values (around 1600 mm/a) were measured in the NE-Carpathians and in the Apuseni Mountains. As for the seasonal distribution of precipitation, all over the Tisza Basin: the monthly maxima fall regularly to June (from 11 to 15% of the annual value) and the minima mostly to January and February (5-6%). Dry spells (with less then 10 mm/month) are frequent in most sites of the Tisza Basin in February and March. The months with much precipitation surpassing 100 mm/month are most frequently June and July.

2. Meteorological and hydrological observations in countries sharing the Tisza Basin

2.1 Ukraine

At present there are two institutions engaged in regular hydro-meteorological observations, namely Regional Center of State Hydro-Meteorological Service (SHMS) and Regional Department of State Committee for Water Management (SCWM). They have different measuring equipment, methods of data collection, processing and transmission though they use databases of each other.

The regular meteorological network of SHMS for the basin includes 46 meteorological station and 38 stream gauging stations. So, one from 46 rain gage stations in average covers territory of 277 km^2, and one from 38 stream gage station - 336 km^2. 12 stream gauging stations of the basin, that have a period of measurements 30-50 years, were closed mainly at the end of 80s.

The list of hydrological stations of SHMS is given in Table 2 and the list of meteorological ones – in Table 3 correspondingly.

#	Name	River	Original code	Inter-national code	Coordinates		Altitude	Basin	Station history
					Longitude	Latitude			
1	Pidpolozzya	Latorytsya	44085	L002	23.03	48.74	356.54	Latorytsya	1958,1947-p.t.
2	Verhnya Grabivnytsya	Zhdenyavka	44094	L003	22.99	48.73	371.88	Latorytsya	1952-1987
			Out of operation						
3	Svalyava	Latorytsya	44087	L006	22.99	48.56	190.00	Latoritsya	1927,1961-p.t.
4	Mukacheve	Latorytsya	44090	L011	22.71	48.44	119.60	Latorytsya	1880,1948-p.t.
5	Chop	Latorytsya	44093	L016	22.21	48.46	96.58	Latoritsya	1878,1956-p.t.
6	Nelipeno	V'acha	44096	L024	23.05	48.57	225.58	Latorytsya	1957-p.t.
7	Polyana	Pinie	44098	L026	22.97	48.61	240.32	Latorytsya	1928,1946-88, 2000- p.t.
8	Znyats`ovo	Stara	44100	L027	22.53	48.49	104.92	Latorytsya	1928,1946-p.t.
9	Zhornava	Uzh	44108	L032	22.63	48.98	328.40	Uzh	1927,1946-p.t.
10	Velykyi Bereznyi	Uzh	44110	L033	22.47	48.90	198.26	Uzh	
11	Chorno-golova	Lyuta	44120	L037	22.61	48.86	255.09	Uzh	1926-88, 1999-p.t.
12	Zarichovo	Uzh	44113	L038	22.50	48.77	154.56	Uzh	1946-p.t.
13	Uzhgorod	Uzh	44116	L044	22.31	48.62	112.38	Uzh	1889-p.t.
14	Simer	Tur'ya	44124	L056	22.52	48.73	151.23	Uzh	1957-p. t.
15	Tur'ya Polyana	Tur'ya	44121	L057	22.80	48.70	278.46	Uzh	1964-88, 1999-p.t.
16	Rakhiv	Tisza	44006		24,13	48,04	429,73	Tisza	1929,1949-p.t.
17	Dilove	Tisza	Out of operation					Tisza	1933-41;46-87
18	Vylok	Tisza	44019		22,50	48,06	115,15	Tisza	1888-p.t.
19	Yasin'a	Chorna Tisza	44025		24,22	48,16	645,50	Tisza	1921,1947-p.t.
20	Bilyn	Chorna Tisza	Out of operation					Tisza	1946-1987
21	Luhy	Bila Tisza	44028		24,25	48,04	602,05	Tisza	1946-p.t.
22	Roztoky	Bila Tisza	Out of operation					Tisza	1955-1987
23	Kosivs'ka Polyana	Kosivs'ka	44031		24,07	48,01	406,77	Tisza	1962-p.t.
24	Kobylets'ka Polyana	Shopurka	Out of operation					Tisza	1954-1987
25	Ust'-Chorna	Teresva	44034		23,56	48,20	523,86	Tisza	1945-p.t.
26	Dubove	Teresva	Out of operation					Tisza	1946-1987
27	Neresnyts'a	Teresva	44036		23,46	48,07	298,36	Tisza	1948-p.t.
28	Rus'ka Mokra	Mokranka	44038		23,53	48,22	549,04	Tisza	1927,1945-p.t.
29	Lopukhiv	Brusturanka	Out of operation					Tisza	1946-1987
30	Chervone	Krasna	Out of operation					Tisza	1957-1987
31	Neresnyts'a	Luzhanka	Out of operation					Tisza	1956-1987
32	Ostryka	Tereblya	Out of operation					Tisza	1947-1963
33	Kolochava	Tereblya	44036		23,42	48,25	531,17	Tisza	1951-p.t.
34	Bovtsary	Tereblya	Out of operation					Tisza	1930-42;47-55
35	Verkhniy Bystry	Rika	44050		23,31	48,37	524,23	Tisza	1946,1965-p.t.

#	Name	River	Original code	Inter-national code	Coordinates		Altitude	Basin	Station history
					Longitude	Latitude			
36	Mezhhir'ya				23,30	48,32			1946-p.t.
37	Nyzhniy Bystry	Rika	44053				283,28	Tisza	1924,1946-88, 2000-p.t.
38	Khust	Rika	44054		23,16	48,11	156,41	Tisza	1898-p.t.
39	Holyatyn	Holyatynka	Out of operation					Tisza	1955-1980
40	Maidan	Holyatynka	44062		23,27	48,37	497,53	Tisza	1956-p.t.
41	Repyne	Repynka	44064		23,27	48,36	467,76	Tisza	1956-p.t.
42	Pylypets'	Pylypets'	44067		23,20	48,40	568,79	Tisza	1956-p. t.
43	Nyzhniy Studeny	Studeny	44073		23,22	48,43	605,89	Tisza	1946-p.t.
44	Dovhe	Borzhava	44079		23,17	48,22	168,35	Tisza	1925,1946-p.t.
45	Shalanky	Borzhava	44080		22,54	48,15	114,32	Tisza	1960-p.t.
46	Irshava	Irshava	44083				134,20	Tisza	46-88,2000-p.t.
47	Vel.Bychkiv	Tisza	44010		24,01	47,58	294,78	Tisza	1926,1945-p.t.
48	Tyachiv	Tisza	44013		23,35	48,00	208,97	Tisza	1921,1942-p.t.
49	Khust	Tisza	44015		23,19	48,09	154,73	Tisza	1946,1966-p.t.
50	Chop	Tisza	44023		22,11	48,25	92,35	Tisza	1860,1950-p.t.

Table 2

All water gauges are equipped with automatic recorders, besides, the most of them were used to meter water discharge regularly beginning 1946.

Information for the period of 1946-1999 regarding daily flow of rivers in the river Tisza basin being processed by Kiev hydrometeorological laboratory was published in Hydrological yearbooks.

There are 41 gauging stations (eg 90% of the total number of stations) where data related to daily flow for more than 30 years are available.

In 20% of cases flow observation period exceeds 50 years.

Table 3

#	Name	Original code	International code	Coordinates		Altitude	Basin	Station history
				Longitude	Latitude			
1	Khust	33638		23,18	48,11	164	Tisza	1946-p.t.
2	Rakhiv	33647		24,12	48,02	430	Tisza	1945- p.t.
3	Mizhhir'ya	33633		23,30	48,31	456	Tisza	1951- p.t.
4	Nyzhniy Studeny	33518		22,38	48,13	615	Tisza	1946- p.t.
5	Pozhezhevs'ka	33646		24,30	48,09	1451	Tisza	1946- p.t.
6	Nyzhni Vorota	33517	L019	23.10	48.77	496	Latorytsya	1949- p.t.
7	Beregovo	33634	L029	22.63	48.20	113	Latorytsya	1945- p.t.
8	Velyky Berezny	33514	L034	22.45	48.90	205	Uzh	1946- p.t.
9	Plai	33515		23,10	48,41	1330	Tisza	1968- p.t.
10	Uzhgorod	33631	L046	22.16	48.38	115	Uzh	1945- p.t.

The basic instrumentation used in the hydrological and meteorological network of SHMS was produced in 60's - 80's. There is only one automatic station of the precipitation measurements in Uzhgorod, in all other stations the measurements are doing manually. The existing network is heavily under invested, instruments are older types, and limited number has data logger. Older instrumentation has a recording mechanism, which determines the accuracy and data quality. Most of the current off-line instrumentation needs upgrading.

State Committee of Ukraine for Water Management (SCWM) has been developing an automatic information measuring system "TISZA" (AIMS "TISZA") by technical and financial assistance of Hungary. The system is intended for automatic measuring of hydrological and hydro-meteorological parameters of the environment in on-line mode.

The system was put into operation in October 2000. It comprises communication network, analyses centre and two automatic stations: a stream gauging and a meteorological one. The microwave transmission system was established along the Tisza network also by support from Hungarian aid programme.

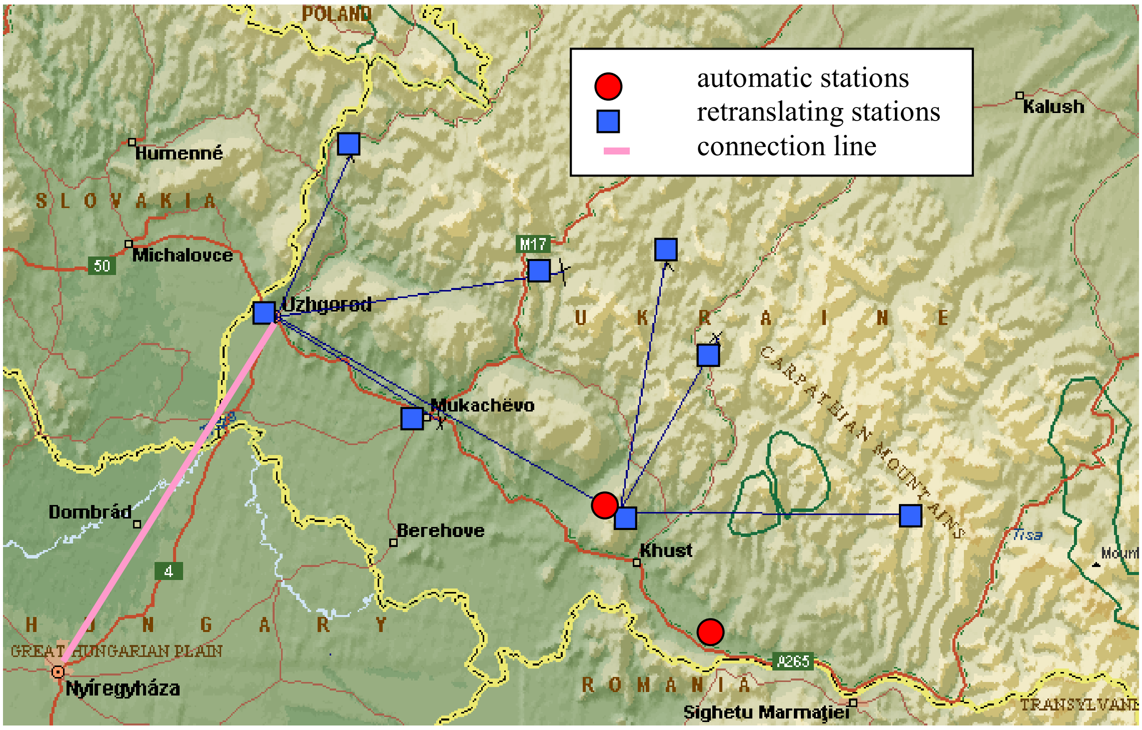


Fig.3 Map of the SCWM automatic stations (red dots - stations, blue squares – transmitters)

The automatic hydro-meteorological gauging station is situated inside the hydrological post on the Tisza River in Tyachiv. It measures precipitation, air temperature and water level in the Tisza (2 water level sensors).

The automatic meteorological measuring station is situated near Khust on the Rokosovo retransmitter. It measures precipitation and air temperature.

Every 5 minutes the automatically measured parameters transfer in a digital format through UHF-radio communication channels from the stations to the data collection and processing centre in Uzhgorod where they are put into databases. The process runs continuously and uninterruptedly. The inner database of the iFix Dynamics software records all the received data (including power supply, accumulator voltage problems, attempts to break in, antenna condition, etc.). The following information is exported in the real time to the outer database (MS Access), allocated on the file server of the computer network: water levels according to two sensors, air temperature, station precipitation amount on the Rokosovo retransmitter. Data post-processing (formation of graphs, tables, excerpts, etc.) is carried out by MS Access 97 and MS Excel 97 software. An archiving of the available data and all primary-processing procedures are carried out in the iFix Dynamics environment. The meteorological situation is also forthcoming from a US made meteorological radar in Nyiregyhaza as colour figures for the PC screen.

The Regional Hydrometeorological Centre has a real-time access to these data for forecasting purposes.. On the base of agreement between The Ministry of Environment and Waters of Hungary and The State Committee of Ukraine for Water Management (October 2002) 12 more observation stations are to be added to the network (see Fig.4).

The location of the station proposed can be seen on the Fig. 4.

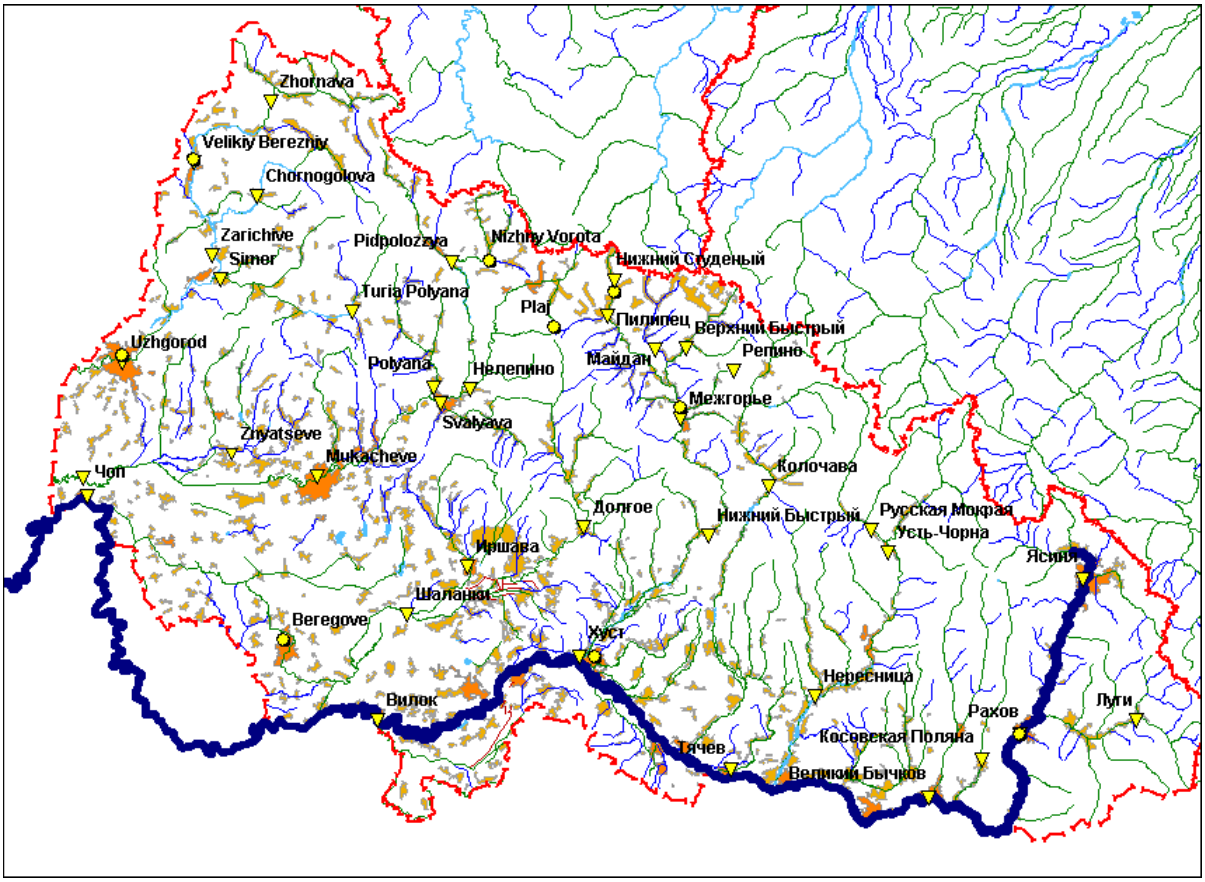


Fig. 4. Map of proposed observation stations (dots – rain gauging stations, triangles – stream gauging station)

2.2 Romania

2.2.1 Meteorological network

In Somes-Tisza Basin the meteorological information is delivered by Regional Meteorological Center Cluj using 14 meteorological stations:

2 stations are working 10 hours/day (Huedin and Sighetul Marmatiei)

12 stations are working permanently

In Crisuri Basin the meteorological informations are delivered by Regional Meteorological Center Arad using 21 meteorological and pluviometrical stations.

In Mures Basin the meteorological informations are delivered by Regional Meteorological Center Cluj and Sibiu using 63 meteorological and pluviometrical stations.

To Banat Basin the meteorological informations are delivered by Regional Meteorological Center Arad using 9 meteorological and pluviometrical stations.

Satellite data for hydrological forecasting are supplied by meteorological forecast from two satellites:

METEOSAT 7,geostationary, operated by the Eumetsat,
with a resolution from 3 to 5 km. It scans the earth at every 30 minutes.

NOOA 12, 14, 15, 16,polar orbiting, operated by the USA, with a 1,1 km
resolution. Each one of them supllies satellite imagery at six hours.

Monitoring satellite station (The Satellite Meteorology Laboratory – SML) from NIMH (National Institute of Meteorology and Hydrology) consists in:
a reception station METEOSAT / SDUS (Tecnavia);
a reception station NOAA / HRPT (SMARTech);
a reception station MSG (Meteosat Second Generation) supplied by satellite
imagery from METEOSAT 7, at present.

METEOSAT satellite supplies:
- digital data for MSG reception station;
- analog data (WEFAX) for METEOSAT / SDUS (Tecnavia).

NOAA satellite supplies digital data for NOAA / HRPT station.

Satellite imagery provides snow distribution and snow-line, land-use and land-cover which are data that are taken into account in hydrological forecasting. For quantitative analysis of snow depth, satellite observations are used in conjuction with ground observation.

Other meteorological and hydrological elements observed or inferred by satellite are liquid water content of clouds, cloud patterns, areas and intensity of rainfall, the presence of moisture either in clouds or as falling rain.
The usefulness of satellites for forecasting is limited by the frequency of their passing over the area of interest (Tisza river basin), the resolution and nature of sensing equipment, and its sensitivity to any obscuring clouds.

Automatic communication system transmits satellite imagery or data from monitoring satellite station – SML to the meteorological forecast centre, via INTRANET.
The main derived products are: cloud top temperature; sea surface temperature; cloud cover; cloud analysis; NDVI; snow cover; meteosat movie loops; land surface temperature.

The network of meteorological radar in our zone of interest consists in 4 radars located thus:

Type	Band	Wavelength [m]	Operational range	Locality	Obs.
Plessey 42	X	0.032	300 km	Cluj-Napoca	british
MRL - 2	X	0.032	300 km	Oradea	Russian
GEMATRONIC	C	0.053	240 km	Oradea	german, dp
MRL – 5	X, S	0.032, 0.103	300 km	Timisoara	russian

The network of meteorological and hydrological radars is now being modernized
The radar allows the observation of the location and movement of areas of rainfall and can yield estimates of rainfall rates over areas within the range of the radar.

For hydrological purposes the effective radar range is usually up to 100 km, maximum range under which the relationship between the radar echo intensity and rainfall intensity remains reasonably valid.

2.2.2 The hydrological network

Somes-Tisa Water Directorate disposes of a basic network of observation consisting of:

95 hydrometrical stations on the rivers

7 hydrometrical stations on the lakes

3 hydrometrical stations for leaks pursuit in urban zones

Crisuri Water Directorate disposes of a basic network of observations consisting of:

15 hydrometrical stations on the rivers (8 in process of automatization)

- 6 on Crisul Alb
- 6 on Crisul Negru
- 3 on Crisul Repede

Mures Water Directorate disposes of a basic network of observations consisting of 15 hydrometrical stations on the rivers (2 in process of automation).

Banat Water Directorate disposes of a basic network of observations consisting of 15 hydrometrical stations on the rivers.

2.3 Slovakia

2.3.1 The meteorological network

Totals, duration and type of precipitation is currently monitored by 212 points, out of which 44 – with voluntary or professional staff is providing for precipitation total once a day. 61 points are equipped with a registration automatic apparatus for a continuous record of intensity of precipitation (recording rain gauges). In selected climatic points depth of snow cover is being measured and based on that water rate of snow is being scored.

Data from Meteosat Second Generation (MSG-1) is received by EUMETCAST DVB system
with the possibility of using all 12 channels and their combinations. Frequency of data is 15 min.

Nowadays in Slovekia two meteorological radars are in operation (Malý Javorník – near Bratislava – west Slovakia and Kojšovská hoľa – near Košice – east Slovakia).

Radar on Malý Javorník scans clouds every 15 min, Kojsovská hoľa every 7.5 min, with automatic production of typical radar data (base reflectiv, rain intensity, VIL, CAPPI, PPI, etc.)

Lightning system SAFIR is in operation since 2001. Nowadays there are 3 sensors in Slovakia, none of them is situated in the Tisza basin.

2.3.2 The hydrological network

113 water-gauge stations form currently the monitoring network of surface waters. In all the water-gauge stations water level and in winter ice phenomena are being observed on the water course on a daily basis. Hydrological network for forecasting purposes consists of 32 water gauge reporting stations, mostly are equipped with an automatic station for a long-distance data transmission.

2.4 Hungary

2.4.1 The meteorological network

17 synoptic stations are operated in the Hungarian part of the Tisza drainage basin, beside standard 3-hourly observations, 1-hourly observations are also reported. There are 31 reporting „climate" stations sending 12-hourly or daily reports, 56 hydrometeorological stations operated by district water authorities may add the above set of information in the period of floods.

The Hungarian Meteorological Service has been receiving digital images of the geostationary Meteosat since 1991 and images of the polar orbiting NOAA satellites since 1992 (analogue images since 1967).

Calibrated and processed data are used mainly in nowcasting and short term forecasting. From Meteosat images (half hourly) processed data like cloud detection, cloudiness, cloud top temperature, cloud top height (hourly) and cloud types are available for the forecasters operatively, while from NOAA images (4-6/day) cloud and fog detection, snow detection and surface parameters (albedo, NDVI, land surface temperature) are calculated (1-2 times/day).

Two meteorological radars cover the Tisza Basin Budapest and Nyíregyháza-Napkor supplementing land based precipitation measurements. Around 30 telemetry rain gauges are in operation at the end of 2001 enabling calibration of radar measurements.

The SAPHIR lightening detection system has been in operation since 1999 in Budapest, Sárvár, Vémend, Zsadány and Varbóc. The system separately registers cloud-to-cloud and downward strikes. In case all of the sensors are in operation the system maintains 2 km resolution throughout the Hungarian part of the Tisza catchment and partly beyond.

2.4.2 The hydrological network

There are 87 reporting water level gauges on the Hungarian section of Tisza and tributaries. The usual pattern of observation follows daily twice observations but only daily reporting. Over ~40 gauges report more frequently to regional centres as equipped with recording and telemetry equipment. All the station report more frequently during flood alert: 2-hourly or 1-hourly. During flood periods special gauge readings are also reported, the number of special flood gauges totals 240.

2.5 Serbia

2.5.1 The meteorological network

On the Serbian part of the Tisza river basin there are 5 synoptic stations with one-hour observation and three-hour reporting. On 4 "climate" stations observations are performed three times per day with monthly reporting, while 24-hour measuring is carried out on 51 rainfall station, also with monthly reporting.

The network of meteorological radars consists of 3 Doppler-type radars METEOR 400 SLP 13. Two radars are located in Bajsa and Samos (in THE Banat region), and used in hail suppression system since 2000. The third radar is located on the Fruska Gora in K. Stolica, and started the operation in 2002.

Setting up of connections between radars is in progress, and thus the 3D wind field will be obtained. One of them, with double polarization, will be able to measure the rainfall quantities more precisely and to give better information on the cloud structure.

Operation range of radars is 250 km. For hydrological purposes the effective radar range is usually up to 100 km, maximum range under which the relationship between the radar echo intensity and rainfall intensity remains reasonably valid.

For determination of rainfall quantities over the certain part of the basin, new options should be added to the existing software. In addition, for the purpose of radar calibration (establishing of connection between the intensity of radar reflection and rainfall quantity), automatic meteorogical stations (Sinmet/Log-D – Lambrecht) were installed in Bajsa and Samos in 2002.

2.5.2 The hydrological network

The Republic Hydrometeorological Service of Serbia maintains the basic network for surface water monitoring, including 16 hydrological stations in the Tisza river basin (7 on rivers, 7 on weirs, 2 on Dam on the Tisza river).

Water levels are measured twice per day on 15 stations, water temperatures on 11 stations and ice phenomena on 14 hydrological stations. River flow measurements are performed on 3 stations, while sediment concentration is measured on one station. Five stations are equipped with devices for continual water level record. Real-time information is sent from nine stations (once a day). In the course of flood defense, additional observations and reporting are preformed every six and three hours.

3. Data exchage, methology and dissemination of forecast and warning

3.1 Ukraine

The existing observation network over hydro-meteorological parameters provides measurements according to a unified method in standard terms (recommend by WMO), guaranteeing compatibility and uniformity of data. Standards: instructions guiding observation, processing and storage of the data, i.e. Instruction on Forecasting Service, Guideline on Forecast Development. Informational and forecasting service consists of several levels: interregional, regional, and state (national).

Regular hydrological data exchange within Hydrometeoinformational network is being done once a 24-hour, in the period of natural hazard development – every 4-6 hours, in the period of meteorological hazard development - when parameters of critical points is being reached. Storm warning and forecasting exchange is being done immediately after their obtaining. Information transmission to the users is carried out once per 24-hour, forecasting and warning transmission – after their compilation. The same frequency is in the hydrological international data exchange practice.

The regional SCWM branch users have an access to the data through the database (MS Access), allocated on the file server of a local computing network and up-dated in the real-time. The RHMC users have the access to the data through FTP-service. Overview of the data available in the tabular form is given in Table 4

#	Type of hydro-meteorological data	Frequency of measurements	Real-time volume (number of points/stations)	Data format	Notes
1	Water levels during the between-flood periods	8 a.m., 8 p.m.	38 of hydro-stations	Paper in the form of standard table forms (STF)	There exist file xls. data of the November 1998 and March 2001 floods. On all the other floods- there are available non-systematized, mostly in paper format data, a part of them is stored in Transcarpathia CHM, the other part – at State Branch Archive in Kyiv.
2	Water levels during flood events	every 4 hours before the beginning of a stable level decreasing	38 of hydro-stations	-“-	
3	Maximum flood level	if recorded	38 of hydro-stations	-“-	
4	Water discharge	It is calculated by the measured water levels	38 of hydro-stations	-“-	
5	Measured water discharges		38 of hydro-stations	-“-	
6	Precipitations	24-hrs and 12-hrs sums, every 4 hours during a flood event	10 meteo-stations and 38 of hydro-stations	-“- precipitation map during the flood	
7	Air temperature.	Every three hours	10 meteo-stations	Paper in STF	
8	Flood flow volume.	Every flood event	38 of hydro-stations	In the form of tables of МДС State water cadastre	Paper

The data processing in Regional Hydrometeorological Centre is not developed in automatic mode. The existing models could not provide forecasting of the water level dynamics along the river and inundation zones. The dissemination of the information to public is provided via regional government, regional branch of Ministry of Emergency and via mass media. The system of dissemination of output results is not computerised.

Users of information and forecasting production are governmental bodies and administrations, Ministries, Departments Institutes, all dealing with weather conditions, hydrological regimes of water special areas. Main users are Government of Ukraine, Ministry of Emergency, State Water Management, Ministry of Agriculture, Ministry of Energy, regional departments of central executive bodies, etc.

Information is given as analysis and forecasting of hydrometeorological conditions, table/chart and map materials. The information is transmitted via: telephone, fax, e-mail, and direct means of information transmission.

3.2 Romania

The institutions involved in the flood monitoring and forecasting activities (The National Institute of Meteorology and Hydrology and The National Water Authority) act in compliance with the Water Law (No. 107/1996) and the Handbook for the elaboration and transmission of warnings in case of dangerous meteorological and hydrological phenomena (1995).

Data transmission is based mainly on the radiotelephone facilities and the GSM-telephone system. During flooding periods the stations transmit the information (level, discharge, rain) hourly, starting with the exceeding of critical thresholds (warning water level determined for each gauging station and/or rainfall warning threshold: 15mm/3 hours or 25 mm/6 hours).

3.2.1 Organisational structure

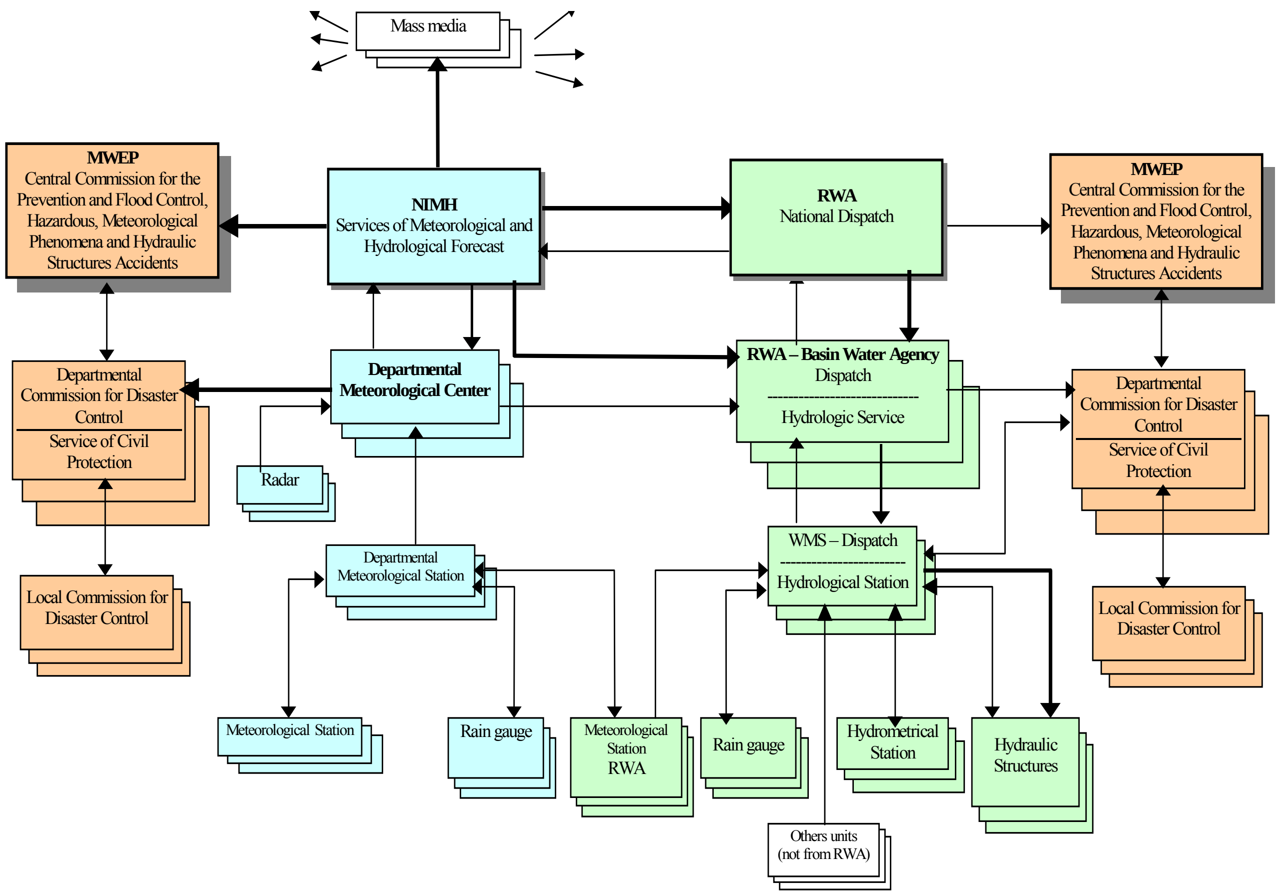
On the regional scale (TISZA-SOMES, CRISURI, MURES, BANAT for Bega river basin), the Hydrological Services are responsible for the operational tasks of data collection and analysis and for monitoring all on-site problems in relation with water. The basin level is the first level for co-ordinating the services and analysing the data coming before national level where information is produced to serve as a basis for formulating and evaluating Romanian water policy.

This prompted the creation of *HYDRO* – the national water data bank, the system for water information on a national scale. The aim of the *HYDRO* bank is to improve data collection and to enable the information to be better exploited.The final goal of the functions envisaged for a national water information system is the global management of resources (by analysing the short and medium term trends); the local management of resources; the elaboration of alert procedures (for flood warnings and accidental pollution).

River discharge data, rainfall and the other elements are stored in national banks, respectively the *HYDRO* bank and *METEO-PLUVIO* bank and they are the responsability of the National Institute of Meteorology and Hydrology – NIMH. The aim of the specific banks is to offer the user a coherent picture of one particular domain. National *HYDRO* and *PLUVIO* banks centralize the data and make available common tools for assessing, validating and handling hydrological data.

The data from hydrometric stations are analysed and sent to the NIMH by the data production services.

The hydrological forecasting services (from NIMH and CNAR) and the dispatcher services existing in the National Water Authority and at its River Basin branches, perform a permanent watch on the evolution of the hydrometeorological phenomena, ensuring the information circulation (informational flux), processing and the elaboration and dissemination of the forecasts (Fig.1).



Meteorological and hydrological warning and forecasts transmission

Meteorological and hydrological data transmission

MWEP Ministry of Waters and Environment Protection

RWA River Water Agency

The Hydrological Forecasting Service acting in the frame of the National Institute of Meteorology and Hydrology (NIMH), as the national authority, is charged with the operative hydrological short-range, medium and long-range forecasts and flood warnings at national-scale, as well as with the development of mathematical models aiming to be applied in hydrological forecasting. At the basin-wide (TISZA-SOMES, CRISURI, MURES, BANAT – from wich Bega river basin interests us) the short-range forecasts are downscaled by the River Basin Hydrological Services of the branches of the National Water Authority – Compania Natională "Apele Romane" (CNAR).

The hydrological forecasting and warning activity is based on:

- the information (rainfall, levels, discharges, ice formations, snow cover) obtained from the national hydrological network (under the administration of the National Water Authority) and meteorological network (under the administration of the National Institute of Meteorology and Hydrology);

- the meteorological forecasts supplied by the Meteorological Forecasting Service from the National Institute of Meteorology and Hydrology ;

- the hydrometeorological information data on the levels, discharges, ice, snow cover, water temperature, as well as the discharge and level forecasts from the hydrological services in the neighboring countries (Ukraine, Hungary, Yugoslavia in our zone of interest) on basis of bilateral agreements.

The hydrological diagnosis, warnings and forecasts are operatively sent to the users as informational reports and bulletins, by phone or by fax (on the paper format) or by INTERNET (FTP service – only for CNAR and Ministry of Waters and Protection of the Environment).

3.2.2 Hydrological forecasting methodoloies

The methods and procedures used in the elaboration of the hydrological forecasting are proper to each forecasting category and vary from empirical relations to complex models:

- *rainfall-runoff relations* (the maximum discharge in a given section in terms of the mean rainfall on the basin, the soil humidity status - expressed by a moisture index - and the core rainfall duration)

  volumetric method is used to forecast the maximum discharge of the flood hydrograph using the recorded rainfalls.

- *The available flood forecasting mathematical models* are: the VIDRA model and the DANUBIUS model, developed in NIMH.

3.3 Slovakia

The Hydrological Service of the Slovak Hydrometeorological Institute provides data on current situations inriver basins and forecasts for the following:

o Information on stages and hydrological forecasts is provided during prevailing outflow situations for a 24-hour period everyday in the morning; this data is confirmed or specified twice a day in the afternoon and evening.

o The time step of a hydrological forecast is shorter during the run of a flood; at that time the time step is three or six hours (depending on the type of flood wave). The information on the hydrological situationin a river basin is provided at the same time as the forecast.

Numerical forecasts are provided for:

• 5 hydrological forecasting stations on the Danube river (water stages, discharges)
• 1 hydrological forecasting station on the Morava river and 1 on the Bodrog river (water stages, discharges)
• 4 hydrological stations for Laborec, Topľa and Hornád rivers (discharges)
• daily forecasts for 13 reservoirs

Forecasting trends in water stages:
are provided for other rivers. The time of arrivals and value of culminations are issued during flood situations.

During the winter season processed and issued once a week:
- information about snow conditions for the whole territory (depth of snow) and
- water equivalent of the snow – developments from 219 climatic stations
- accumulation of water in the snow cover for 13 water reservoirs and 14 measurement gauge profiles

The Department also produces bulletins and statements concerning flood situations and droughts as well,as expert opinions and references.

For the Danube – the basis of the forecasting methods is a simple method of corresponding water stages/discharges, which can be seen as more traditional but also very reliable. Also, the rainfall – runoff relation to the API (antecedent precipitation index) with numerical and graphic expressions is used. The following methods are also used: MIKE 11 on the Bodrog river, non–linear basin system, Muskingum method and method of regression relations.

At the present time several approaches for rainfall – runoff models ("HRON" model, adaptations of the HBVmodel etc.), are being developed within the framework of the project "Flood Warning and Forecasting System in the Slovak Republic".

3.4 Hungary

The National Meteorological Service generates meteorological warnings. These warnings reach District Water Directorates by means of an information system called Operational Hydrological Module the National Water Authority (NWA) Preparedness Unit or the National Hydrological Forecasting Service (NHFS-VITUKI) directly. Generation of hydrological warnings is the primary responsibility of district water authorities however any agency (NHFS etc.) receiving information indicating the necessity of flood warning or flood alert should act with no time delay.

Regular (daily) hydrological forecast for River Tisza and main tributaries (46 gauging stations) are issued by NHFS-VITUKI. The conceptual modularly structured GAPI/TAPI modelling system is in use containing rainfall- runoff (with snow accumulation and ablation, soil frost sub-modules); channel routing; statistical updating; and simplified hydraulic - backwater modules. The use of Quantitive Precipitation Forecasting products obtained from ECMWF and ALADIN models output and values provided by Hungarian Meteorological Service enables hydrologists to extend the lead time of their forecasts in Tisza basin up to six day ahead

Forecasting of flood crests is the responsibility of the agency named by Rules of Hydrometeorological Activity During Floods - NWA Directive. As a principle the territorially competent water authority is named as responsible. Different versions of multiple (linear) regression models are in use. The practice of forecasting allows some overlaps between district water authorities of neighbouring river reaches and NHFS-VITUKI issued forecasts.

The *Flood Management Information System* (FMIS) which was put into operation in 1994 presently include:

an important part of the reports, notes, data and instructions associated with flood- and undrained runoff emergency measures, further with controlling water pollution accidents;

dissemination daily by the NHFS to 16 institutions of the hydro-meteorological information received from the neighbouring states in the Carpathian Basin and in the Danube catchment.

The data exchange between Hungary and neighbouring countries on daily basis are performed by NHFS-Vituki using the meteorological Global Telecommunication Network, and the e-mail and the FTP services on the INTERNET. During floods regional water directorates directly exchange information on flood situation and the completed or planned measures with the neighbouring domestic and foreign partners. Recommendations for Hydro-meteorological Service on Danube river of the Danube Commission and bilateral agreements between Hungary and all neighbouring countries sharing the Tisza basin serve as the legal basis for international exchange of hydro-meteorological data and other information for flood mitigation.

3.5 Serbia

Hydrometeorological Service of Serbia – Forecast office is amenable for collection and distribution of hydrological and meteorological data.

Hydrological data are collected from 9 stations with real-time reporting, via radio and telephone. In the course of 2003, the automatic transfer (GSM) will be established on hydrological station Novi Knezevac. Meteorological data are collected from 5 stations via radio.

Available data from S&M part of the Tisza River basin are not sufficient for warning and forecasts delivery. Namely, since floods on the Tisza River originate outside of S&M borders, the information from the upstream countries is indispensable.

Data from neighboring countries (11 stations in Hungary and 10 in Romania) are collected via GTS (Global Telecommunications System) and e-mail.

Hydrological service, using forecast function (regression and correlation equations), produces one and two-day water level forecasts for hydrometric stations Novi Kneževac i Senta on the Tisza river, using data from international exchange as well. Warnings about quick water level increase are made for confluents of the Tisza river. During winter, seven-day and approximate long-term forecasts of ice phenomena are prepared (method of physical-statistical or empirical relations between the total loss of heat necessary for ice appearance and certain elements), using short-term and long-term numerical forecasts.

Republic Hydrometeorological Service of Serbia transmits hydrological warnings to: Ministry of Agriculture and Water Management - Water Management Division, Public Water Authority “Srbijavode“ (which distributes them to responsible persons), and to the State center for observation and information, which distributes these information to endangered communities.

4. Virtual Flood Management Centre(s) for the Tisza Basin

As a platform for information as well as data-exchange regional virtual flood management centres will have to be created by the integration of national or local/regional computer aided flood management DSS-s especially in especially vulnerable regions, first of all in the upstream sections of the sub-basins. These centres will have to use the existing geospatial, hydrometeorological, resource, etc. data and computer/internet platform of a regional, state or international organization. Example: proposal on a virtual flood management centre in the Upstream Tisza river basin

- dissemination of information

An effective and reliable system of flood forecasting and warning dissemination should be set up to inform, at respective level, authorities responsible for flood defence and citizens in threatened areas. Classical and new media such as syrens, formal warnings, state and private broadcasting services, satellite-based communication system, alarm calls on the radio (switching on radios by remote control), mobile telephones, the Internet and teletext etc should be used, tested and performed according to technological progress. Alarm and action plan must be adapted to local conditions.
Such secondary services and channels of information fed regularly by the responsible authorities may also separate them from direct inquiries of the public enabling them to concentrate on the mitigation activities.

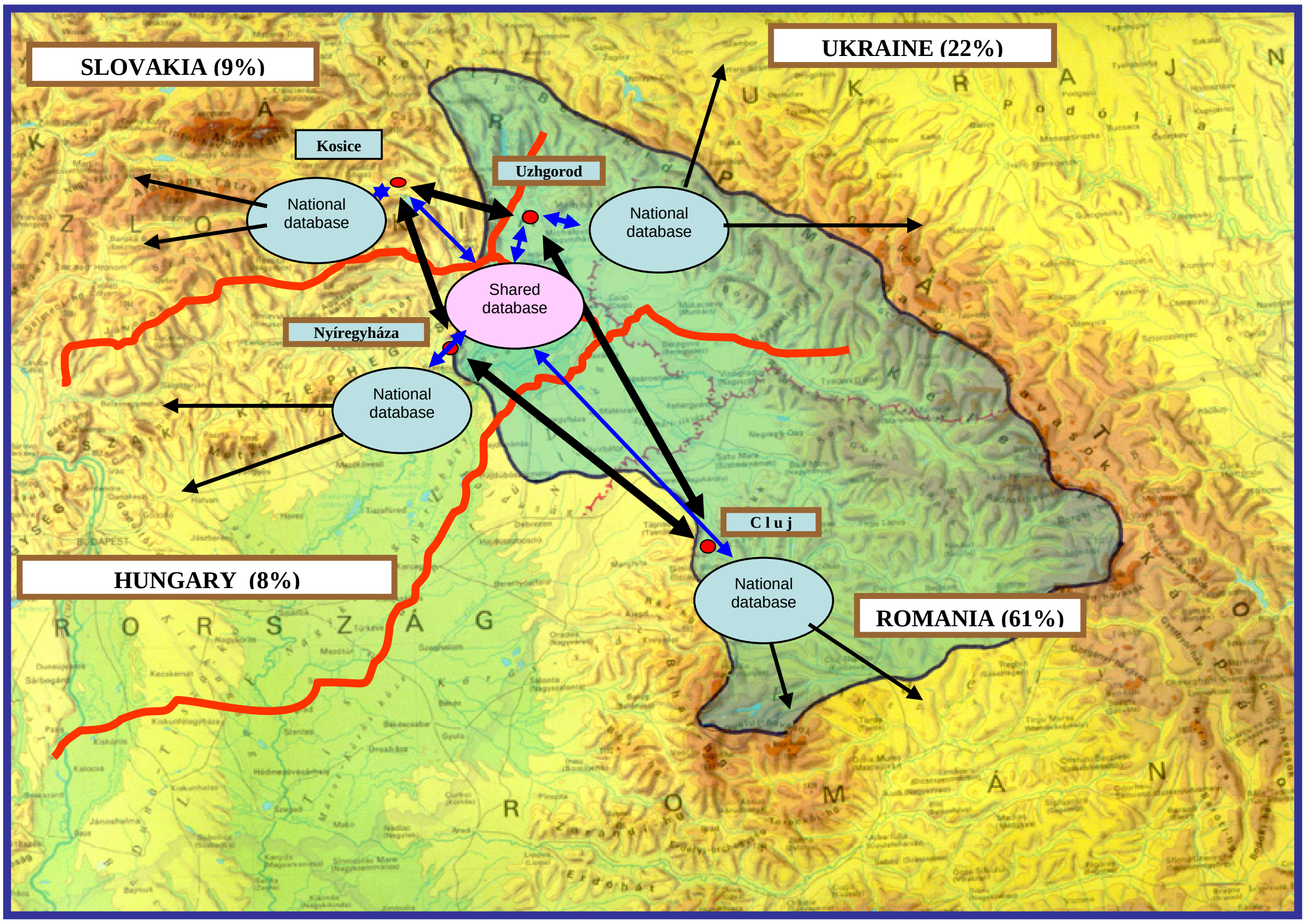
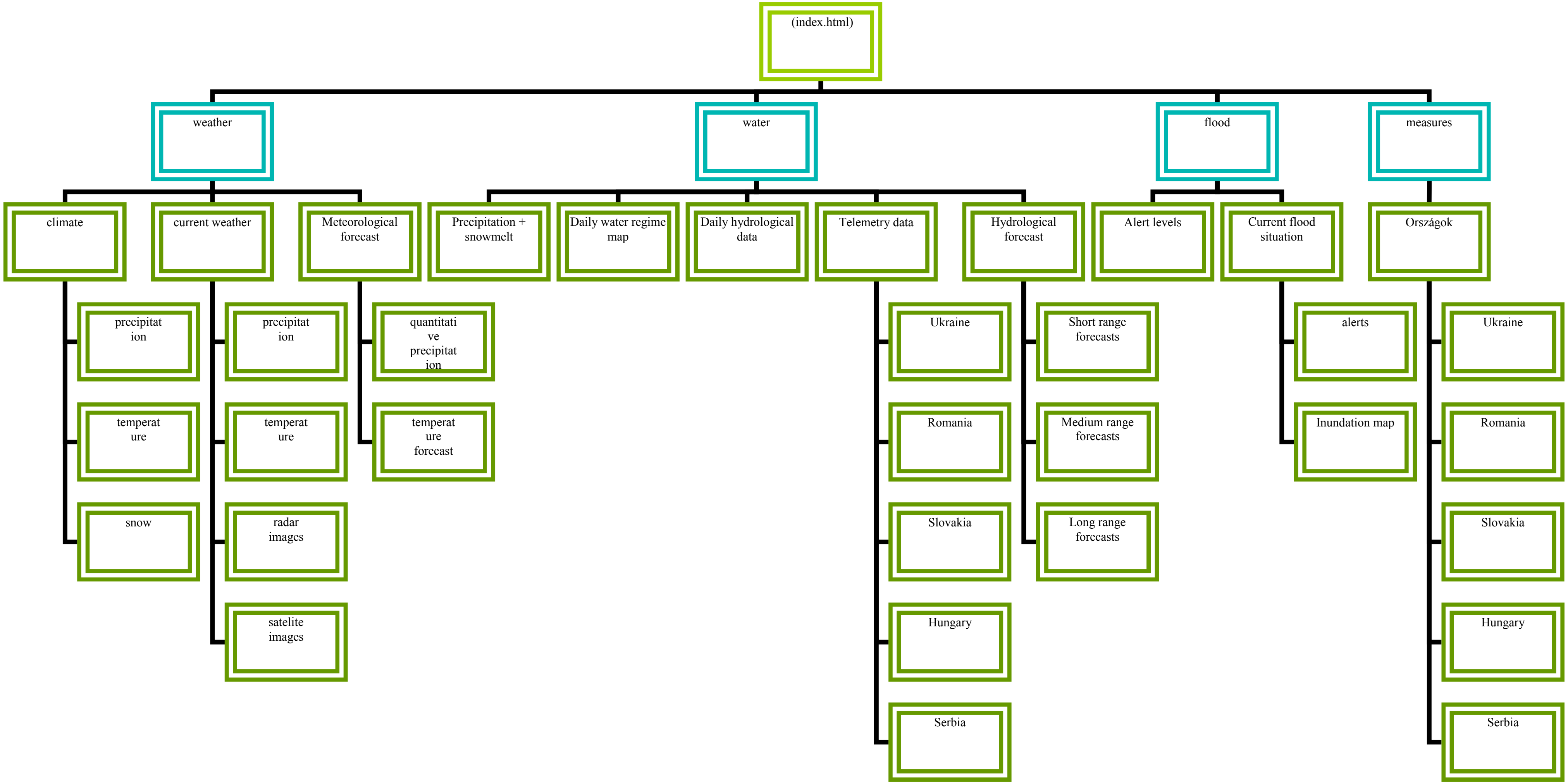


Fig.5. Proposal on a virtual flood management centre in the Upstream Tisza river basin

FIST sitemap



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