Non-Structural Measures – Also Significant Factors of Flood Disaster Reduction

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Abstract
Beginning of paper is devoted to physical and geographical condition of the Slovak Republic according to the creation floods. Determination of regions, where an occurrence of floods as well as flash floods with extreme effects is much more frequent as on the rest territory was been done. Results contain a "flood index" evaluation from 300 water stations for 12 years series of vegetation season (April – September) and for 12-year series of the hydrological year. Innovation of forecasting and warning system of the Slovak Republic has contribute to considerably improving of the quality of information necessary for early and effective protection against floods by – enlargement and updating of monitoring and telecommunication system of the Slovak Hydrometeorological Institute (SHMI), expanding the network of real-time operating water gauge stations and precipitation stations as well. Two Local Warning Systems had been created. Furthermore, the Act no. 444/2004 Coll. of Laws on Flood Protection which deals with conditions for protecting life, health and property against flooding; responsibility of the Civil Service, the government and cooperate bodies and subjects concerning the scope of flood protection in all river basins; delivering personal assistance and devices for flood protection was introduced in the Slovak Republic. The list of specific flood protection measures is included. Because majority of rivers flow from country or cross its area, there are very important to have the effective tools for cooperation in flood protection. The Slovak Republic has the bilateral agreements with neighbouring countries called: "Co-operations on the transboundary water with fifth states".

Introduction

Floods are natural phenomena that cannot be protected sufficiently. In addition to economic and social damage, floods may bring severe environmental consequences. Flood can destroy wetland areas and reduce biodiversity. Large floods in recent year caused large damages of infrastructure and properties.
The natural conditions of Slovakia are rather complex with narrow valleys, which caused relatively short lead-time and created conditions for flash floods. There are approximately 2 300 small basin areas in range 5 – 50 km^2 with a large potential risk for flooding, especially with respect to this type floods.

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Area 49 036 km^2		Agricultural land	50%	Area mean temperature	7,5 º C
Over 300 m a.s.l.	60%	Forest land	41%	Area mean precipitation total	745 mm
Over 1000 m a.s.l.	5,4%	Water area	2%		
The lowest point	94 m a.s.l.	Build-up areas	3%		
The highest poit	2655 m a.s.l.				

Fig.1 The Slovak Republic – basic information

Only between 1996 and 2002 Slovakia had been suffered over 80 major damaging floods including the catastrophic flash floods in the middle and north part of the country. Majority of them have caused losses of lives, the displacement the hundreds people and several millions EURO of economic losses. The example:

1998 - Upper part of the Hornád river - 50 victims, extensive damages on municipal private properties
1999 – Šahy - Ipeľ river -flood damages only on municipal and private properties
2001 - Štrbský potok, flood damages were large on municipal and private properties.

Danube – Bratislava, 2002, August 10 - 13

Ipeľ – Šahy, 1999, June 21 - 22

Štrba – Štrbský potok , 2001, July 24

Svinka – Jarovnice, 1997, July 20

Fig.2 Flood events in different part of Slovakia

Occurrence of flash floods in the years 1977 – 2002 were recorded in 77 of small river basins. The flood damages and flood cost for removals are reflected in Fig. 3.

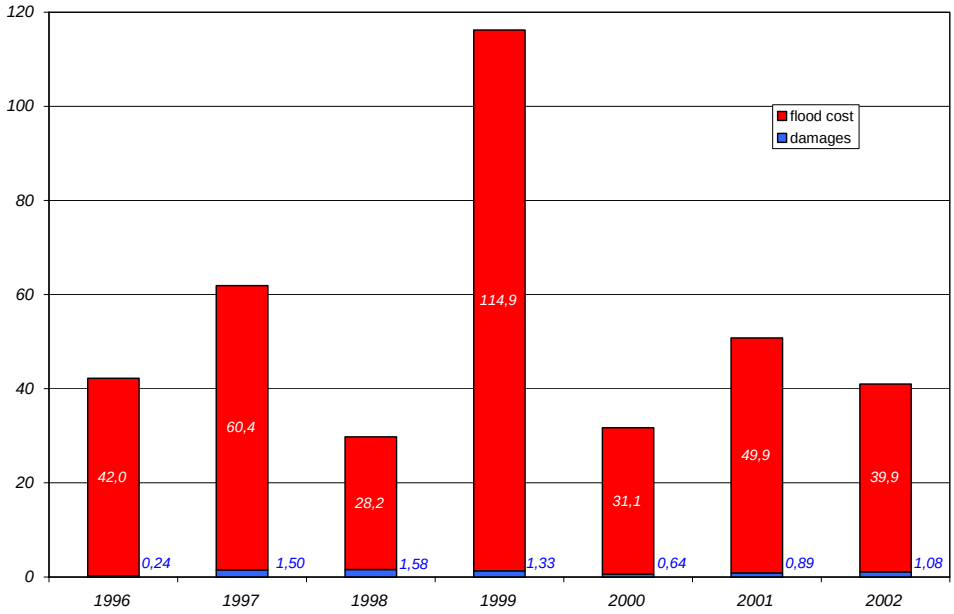


Fig.3. Flood damages and flood cost for years 1996 - 2002

Sensitivity analysis to creation the floods

The first what we have to know is determination of regions where an occurrence of classical regional floods as well as flash floods with extreme effect is much more frequent as on the rest areas. The idea of "Flood index" (K) had been applied to look on sensitivity of the Slovak territory to creation the floods extremes. Following formula was used:

$$K = \frac{1}{n} \sum \frac{Q_{max}}{Q_{annual}}$$

Q_{max} - maximum discharge observed in the water gauge station for considered period
Q_{annual} - annual discharge Q in the water gauge station
n - number of years of hydrological series

Results, which we obtained from data processing, contain an evaluated K index from 300 water gauge stations:

- For 12 year series of vegetation season (April – September)
- For 12 year series of the hydrological year

As follows from definition – the higher K indicates the more significant flood situation. In other words –the region of basin, or basins are more sensitive to floods. For vegetation period, particularly summertime, which is connected with increasing storm activities and frequent heavy precipitation occurrence, K values reach higher values.

Based with "flood index" K , the selected regions (included basins or linked small basins) were indicated as

Very sensitive	K = 30 and more
Sensitive	K = interval (20 - 30)
Less sensitive	K = interval (10 - 20)
Negligible sensitive	K = les than 10

Spatial matrix of Flood index K for vegetation period (April – September) and for given time period (processing data from 1989 to 2000) documented Fig. 4, 5.

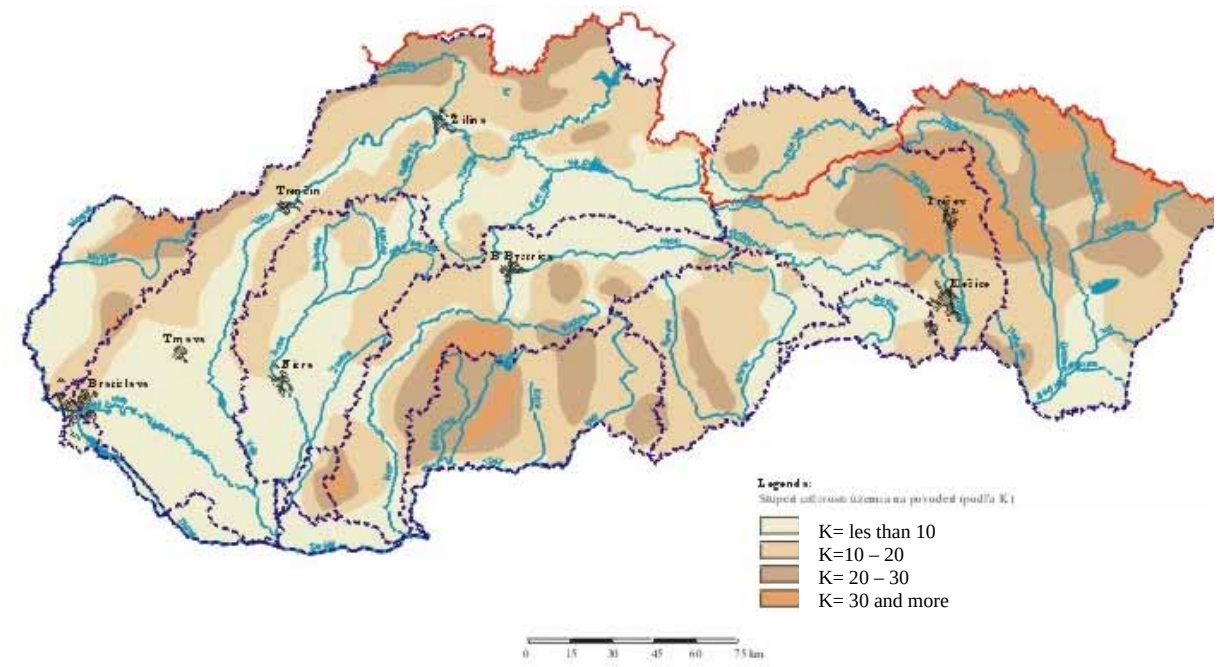


Fig.4 Flood index K for time period (1989 – 2000)

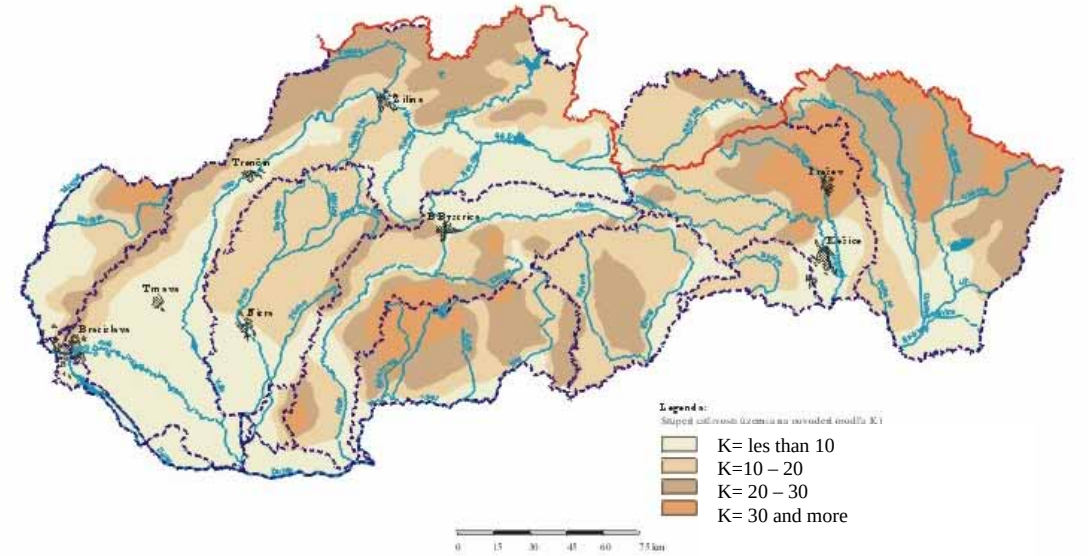


Fig. 5 Flood index K for vegetation period April – September (1989

Forecasting and warning system, innovation, local warning systems

The Hydrological Forecasts and Warning Department of the Division of Hydrological Service of the Slovak Hydrometeorological Institute (DFW – DHS SHMI) is responsible for providing operational information on the hydrological situation on the territory of Slovakia. The network for the main river basins (Dunaj, Morava, Váh, Nitra, Hron, Ipeľ, Slaná, Bodva, Hornád, Bodrog, Poprad) is illustrated on Fig.6

Fig. 6 Eleven main river basins in Slovakia

This network consists of 80 hydrological forecasting stations, was created and arranged according to the best representation of the hydrological situation and its progress on all Danube river sub – basins in Slovakia. The hydrological information contains the following parameters: water stages, discharges, water temperatures, the appearance of ice effects and the relation of current water stages/discharges to their long-term means. Apart from these current values, the Department provides set of various types of forecasts as follows.

Numerical forecasts are providing for:

- 5 hydrological forecasting stations on the Danube River
- 1 hydrological forecasting station on Morava River and 1 on Bodrog River

Forecasting trends in water stages – increases, decreases, stability

- are provided for other rivers. The time arrival and expected culmination are issued during flood situations.

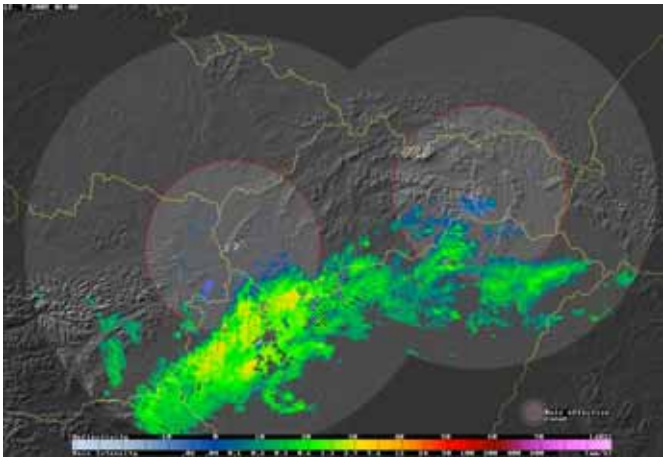
Distribution of the hydrological forecasting stations in 11 main river basins is described in Table1 and their distribution is illustrated in Fig 7.

Table 1 Distribution of water gauge stations in 11 main river basins in Slovakia

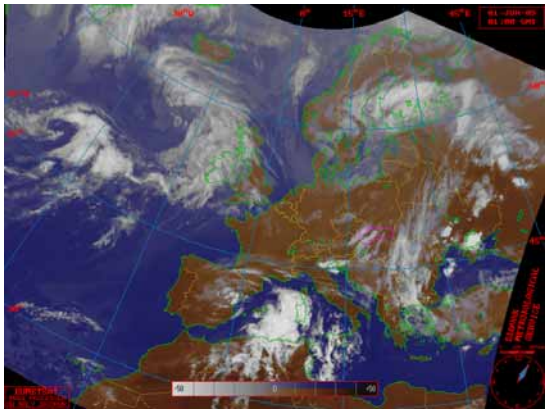
Basin	Number of stations	among them - number of telemetric stations)
Morava	25	13
Dunaj	17	14
Váh	114	70
Nitra	27	20
Hron	50	30
Ipeľ	26	20
Slaná	28	20
Bodva	8	6
Hornád	34	34
Bodrog	42	42
Poprad	15	15
Total	386	205

The following input data for hydrological forecasting are used:

- Hydrological information (*water stages, forecasts*) from neighbouring countries – Germany, Austria, The Czech Republic, Hungary, Poland, Ukraine
- Total precipitation in a basin or set of basins
- Meteorological information – air temperature, vertical gradient of air temperature for next 24 hours and next 2 or 3 days
- Information used from other meteorological services: rainfall amount for predefined areas – Germany, Austria, Slovakia and the Carpathian-Ukraine graded at intervals (0 – 5 mm, 5 – 10 mm)
- Output from NWP (Numerical Weather Programme) model ALADIN
- Radar measurements of rainfall intensity, accumulated rainfall for 1, 3, 6 and 24 hours, rainfall amounts for some predefined basins within the range of a radar
- Satellite images for visual usage (state and development of the meteorological situation)



Radar



Satellite

Network of meteorological station consists from synoptic stations and climatologically network of the precipitation stations, as well.

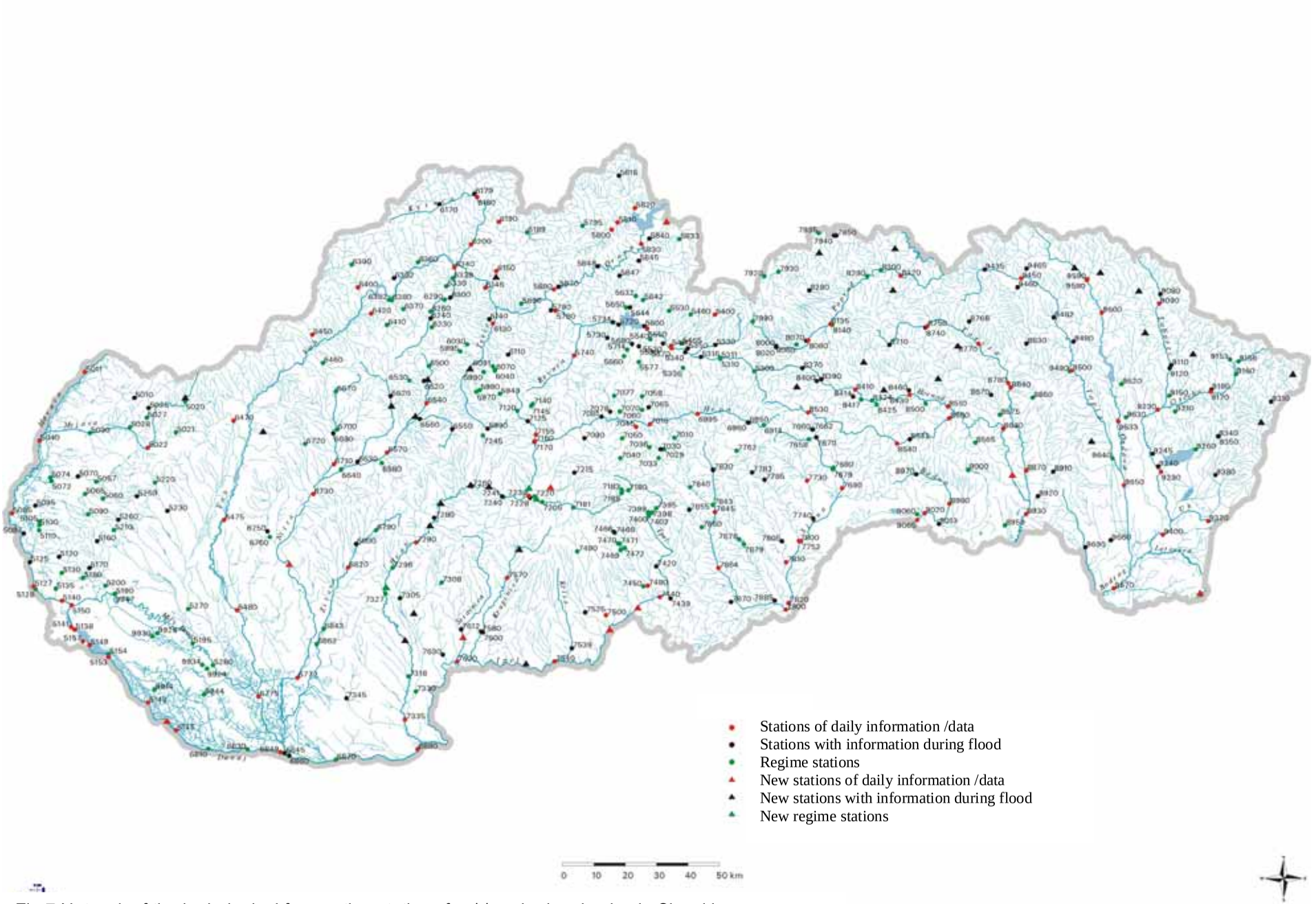


Fig.7 Network of the hydrological forecasting stations for 11 main river basins in Slovakia

Fig 8 Network of meteorological and climatologically stations

The quality and correctness of the available data for the hydro-meteorological service is highly time-dependent and decreases significantly over time on scale of a few hours up to 10 days. Also, in the event of flash floods connected to convective thunderstorms in the mountains terrain of central, and especially the eastern parts of Slovakia, our hydro-meteorological service lacks relevant information of essential time and space resolution.
The improvement of the situation in the field of hydro-meteorological forecasting is realised by project "Flood Waning and Forecasting System of the Slovak Republic" realisation of which was lunched in year 2002. The aim of Project is to provide considerable innovation in flood warning and forecasting practice as well. The main goal of project is to develop the tools, which will make it possible to reduce the risk to life and property of those who may be affecting by future floods. The Project has contributed to improve the quality of information necessary for early and effective protection against floods by – enlargement and updating of monitoring and telecommunication system of SHMI, expanding the network of real-time operating water gauge stations and precipitation station as well. Important part of Project is completion of meteorological radar network over the whole territory of Slovakia and making it compatible with existing or planned radar networks in neighbouring countries. Along with, there is running upgrading and processing of short and mid-term real-time hydrological and meteorological forecasting methodology. In near future results project EFAS (European Flood Alert System) in co-operation with JRS (Join Research Centrum for Europe) in Ispra will be used in the flood forecasting process.

Up to now there are in operation: 2 radars; 34 meteorological stations – on line; 202 telemetric precipitation stations; 205 water gauge telemetric stations. In the selected regions very sensitive to floods and flash floods as well, has been constructed 2 "Local Warning System" .

Local warning system (LWS) – brief information
Goals: To provide the local authorities with sufficiently lead-time warning on originating of floods in small basins to eliminate their destructive consequences
For selection of basins, the several criteria have been considered:

- Sensitivity regions according to K
- Climatologically indicators as - the precipitation intensity, mapping of storms, etc.

Localisation of basins: upper part of the Myjava basin – west part of Slovakia K = 30
tributary of upper part of the Hron river basin – brook Čierny Hron K = 20
In selection of LWS we followed experience of NOAA National Weather Service and there was selected an approach – Automated Local Evaluation in Real Time (ALERT). System is basing on the so-called one-way road – alarm is receiving by coordinator/operator responsible for organising salvage operation. System has been purchased and operating by villages, firms, small settlements, and so on. LWS contains the parts as follows:

- Equipment for monitoring of hydrometeorological network – remote
- Indicator equipments, monitoring network
- Communication system
- Local coordinator
- Model/scenarios of hydrological response
- Municipal Flood Plan – rescue band secure work

Additional information as – saturation of basin, radar estimation of total precipitation, meteorological warning – can enter the system from SHMI.
Information from monitoring network – there are automated stations with remote data transmission and warning system for defined rain intensity and of the water stage increasing: Precipitation stations, water gauge stations. Both equipments have to be installing to provide adequate information in space and time.

Communication system – data transmission via radio network, GMS etc. from stations to central PC, indication of warning by SMS message /other ways as possible/ to mobile phones of the selected users. There are possibilities of the SHMI products distribution to local centre.
Control computer – data collection and archiving, projection adjustment of parameters.
Hydrological model/scenario – from inputs by rainfall-runoff model:

- processing of scenarios response of basin
- outputs of system – basis for beginning of flood salvage operations according to the Municipal Flood Plan

Local administrator – coordinator of system – receives warnings and manages salvage operations including humanitarian, safety, sanitation and hygienic measures.
Administrator supervised and controls operability of the system.

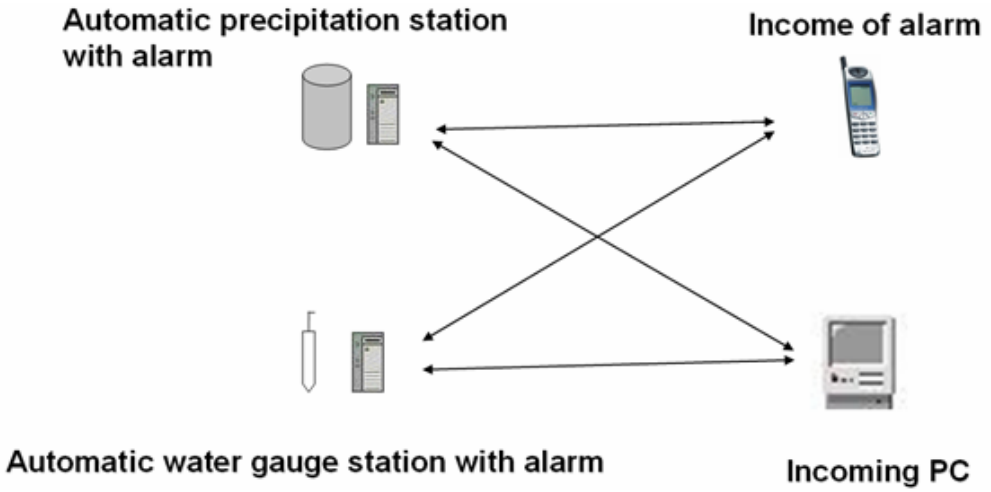


Fig.9 LWS – scheme

The SHMI products for LWS (not a necessary part) consist of:

- Monitoring of saturation of basin (API) by precipitation
- Meteorological forecast
- Quantitative forecast of precipitation

Legal approach:

- LWS is loan out to municipal for 5 years – reproduction left for owner (village, etc.)
- Maintenance and operation – financed by SHMI
- After 5 years system become property of municipality, further operations are financed by municipality in charge

In addition: for alerts are defined fixed limits for both, precipitation and water gauge stations, as well and estimated maximum discharge Q (experimentally by T year Q) in different scenarios for API and precipitation.

Čierny Balog – Krížne

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Fig. 10 LWS – telemetric stations (for temperature, precipitations)

Review of the institutional and legal framework in the Slovak Republic

The **Act no. 444/2004 Coll. of Laws** on Flood protection chiefly deals with:

1. Conditions for protecting life, health and property against flooding;
2. Responsibilities of the Civil Service, the government and corporate bodies and subjects concerning the scope of flood protection in all the river basins;
3. The flood-protection commissions, their duties and responsibilities in the field of flood protection;
4. Delivering personal assistance and devices for flood protection;
5. Sanctions for legal violations.

The specific flood protection measures include:

- Flood plans
- Flood inspections
- Forecasting and warning service
- Patrol service
- Flood prevention work
- Salvage operations.

The measures to be performed include preventative actions as well as measures during the obvious risk of flooding, during flooding, and after flood events. Among the precautionary measures belong mainly technical measures (*for instance, the construction of protective dikes, retaining reservoirs, and river training, maintenance and repair*).

Organization of flood prevention works

The competent authorities for flood protection in the Slovak Republic are:

1. The Ministry of the Environment
2. Regional and district environmental offices
3. Municipalities.

The Government of the Slovak Republic authorizes the Central Flood Commission and regional, district and municipal flood commissions by operation of law. The chairman of the Central Flood

Commission is the Minister of the Environment, and the vice-chairman is the Minister of the Interior. The government appoints other members of the Commission at the behest of the chairman of the Central Flood Commission. The activities of the Central Flood Commission are derived from its own bylaws, which have been approved by the Slovak Government.

The Flood Commission manages and inspects the activities of all the bodies and organizations functioning in the flood protection system before, during and immediately after floods. One of the most important tasks of the Central Flood Commission is co-operation on flood prevention measures with Slovakia's neighbouring states (*in the Danube River basin with Austria, the Czech Republic, Hungary and Ukraine*).

Each flood commission has a technical staff composed of expert, consultative, and executive teams. The head of the technical staff of the Central Flood Commission is the Director General of the Waters section of the Ministry of the Environment. The subhead of the technical staff of the Central Flood Commission is the President of the fire and rescue brigades. The members of the technical staffs in the regional, district and municipal commissions are representatives of the public authorities, the relevant river basin authorities, fire and rescue brigades, army, police, civil defence, health service and other experts, who are appointed by the head of the environmental office in the relevant territory.

Contingency planning, emergency measures planned

Flood Plans

The preparations for flood prevention are including in the flood plans. The flood plans are organizational and technical documents, which include the roles and responsibilities of the flood bodies, the river basin authorities and the owners and managers of the water structures, water equipment and other subjects involved in flood prevention activities.

A flood plan must be developed for every building or technological structure at or close to rivers and creeks. The river basin authorities organize the development of the floodplains according to the natural hydrological basins. The municipal governments as well as the district and regional authorities devise the plans for flood prevention work and salvage operations. The fire and rescue brigades develop their own plans of preventive work within a specified range.

The extent of the flood risk determines the order of the flood prevention activities:

I. State of alert
II. State of danger
III. State of emergency.

The individual states depend on the water levels or discharges, which are defined for every section of the river according to the flood plans. The state of alert generally occurs when the water level rises above the river channel. The state of danger and the state of emergency are proclaimed at the behest of the competent river basin authority with reference to the hydrological forecast:

- The mayor for the region of one municipality;
- The head of the district environmental office for several municipal regions;
- The head of the regional environmental office for the territories of several districts.

The state of alert is cancelled after the water level recedes into the river channel and when the water level stage has a decreasing trend. The competent authority cancels the state of danger or emergency when the reasons for its proclamation have ceased.

Flood inspections

The goal of flood inspections is to detect defects in river channels and on floodplains, which might create a flood risk. The river basin authorities execute flood inspections in cooperation with other flood prevention bodies after every relevant flood episode or at least once a year. The owners, administrators or users of structures near the river must eliminate any defects by a stated time.

Patrol service

The patrol service follows up the evolution of a flood course directly on-site. The river basin authorities appoint a patrol service during a state of danger, and the municipalities appoint a patrol service during a state of emergency.

Flood prevention work

Flood prevention work represents a large complex of organizational and technical measures. Their purpose is the observation of a flood's route and the prevention of the occurrence of dangerous situations. The river basin authorities, which collaborate with the owners of structures near rivers in the execution and pursuance of this work, carry out flood prevention work initially.

Flood salvage operations

Flood salvage operations concentrate on rescuing the civilian population and the safekeeping and salvage of property on endangered floodplains, one component of which is the potential evacuation of the population. Part of the salvage operations includes humanitarian, safety, sanitation and hygienic measures.

Co-operation on the transboundary water

Because majority of rivers flow from Slovakia or cross its territory there are very important for flood protection effective tools for cooperation. The Slovak Republic has the bilateral agreements: cooperation on transboundary water with 5 neighbouring riparian countries: Austria, the Czech Republic, Hungary, Ukraine and Poland.

To the end it is important mentioned that there are many structural measures in the Slovak Republic to help mitigate flood damages, but without the development about mentioned measures all they loss their effect.

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