World Meteorological Organization

STUDY OF HISTORICAL FLOODS IN CENTRAL AND EASTERN EUROPE FROM AN INTEGRATED FLOOD MANAGEMENT VIEWPOINT

SLOVENIA

Submitted by: Environmental Agency of the Rep. of Slovenia, Ljubljana

For the WMO/GWP Associated Programme on Flood Management

1. The floods of the savinja river, causes and consequences

The Savinja river is second largest of the Sava tributaries and has especially with its own tributaries (Lučnica, Ljubnica, Dreta, Paka, Bolska, Ložnica and Voglajna) a typical torrential character. The Savinja drainage basin covers 17% of the Sava river basin (or, 1847.7 km^2, or, 9.13% of the Slovenia landscape).

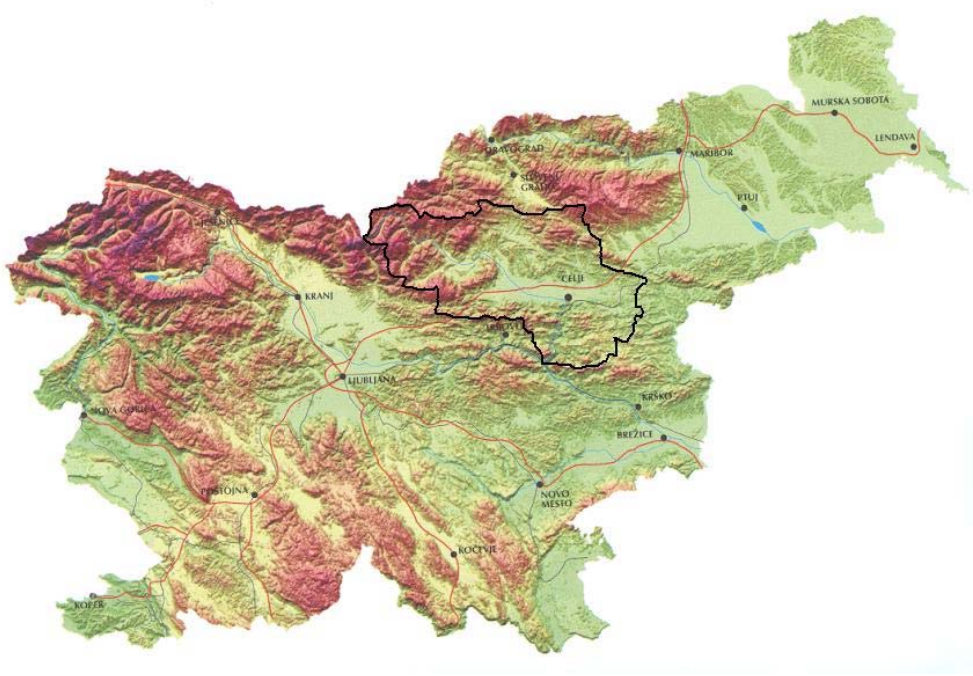


Figure 1. The map of Slovenia with the Savinja drainage basin

2. GEOGRAFICAL CHARACTERISTIC OF THE SAVINJA RIVER BASIN

The Savinja drainage basin consist of six geographical units: the western Kamniško-Savinjske Alps with the high mountains (max. 2340 m above the sea level), the distinctly karstic and forested plateaus of Dleskovška planota, Golte, Menina, Velika Planina and narrow U-shaped glacially valleys. All these valleys has flat bottoms and steep sides and above rise sharp and long crests (Logarska dolina, Matkov kot, Robanov kot valleys). The surface built of carbonate rocks, more or less karstified limestone and dolomite. There are very frequent landslides, wich are dangerous for environment and are causing bad damages. In the northern part of the Savinja river basin are the Ložniško and Hudinjsko hills, which pass in to Velenjsko and Konjiško mountains. The ground composite less permeable schists and tuffs, as well as sandstones and clays. More or less of similar rock composite is the southern extensive region Posavsko hribovje between Celje and Zidani most too. Among them, permeable limestones and dolomites occur sporadically only. In the eastern part of the Savinja drainage basin is Voglajnsko hills, that are composed of impermeable Tertiary, Mesozoic and Paleozoic rocks. That area is a major part of the Voglajna drainage system, which drains waters from the most eastern part of the Savinja drainage basin.

The impermeable Tertiary sediments compose also bottom of the Celje basin which lies between mentioned regions and extend from Letuš to the Celje town and is covered with a gravel layer. The gravel accumulation varies in depth, increasing from the Savinja notrhwards and represents an important source of the groundwater.

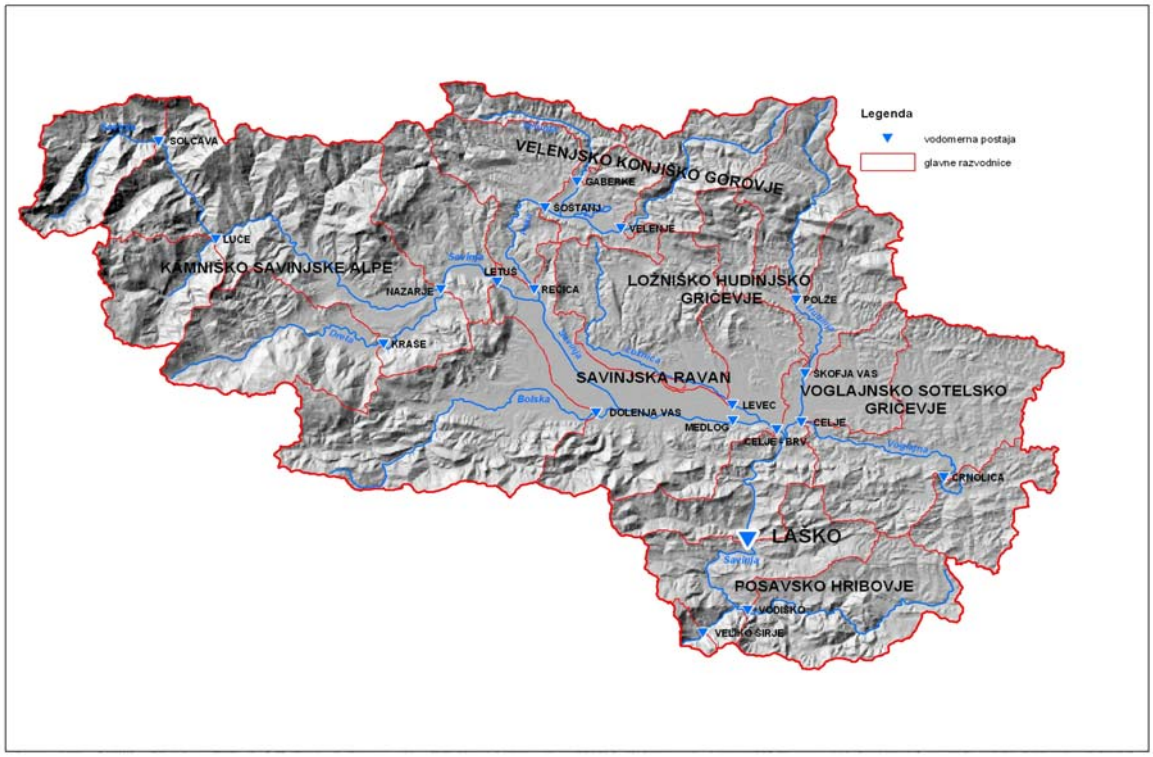


Figure 2. The Savinja drainage basin with geographic areas

In the Celje basin with average 2.2° terrain inclination, forests occupy one fifth of the surface. The Celje basin is important for farming, industry and settlements. Farming areas cover 62% of the Celje basin, while the population density is 526 inhabitants per km^2. The large confluence of rivers and brooks in the Celje basin causes most frequent floods in the most densely inhabited area of the drainage basin including the town Celje (40.000 inhabitants). Before large regulations of the Savinja River (1876-1893), and its tributaries (Ložnica, 1953-1964, Trnavca 1959-1966, Bolska 1964-1968 etc.) the plane areas was almost flat, wich was almost no inhabitate, except major towns like Celje, Žalec etc. (about 40 km^2 of flood area was natural retension, were 40 milions m^3 of flood water were stored).

After 2nd World War and river regulations they have been areas were rapidly building of houses took place: the Medlog, Lisce, Polule at Celje and upstream of the Savinja, there are Petrovče, Dobriša vas, Vrbje, Roje, Dobrteša vas etc. In the region Kamniško-Savinjske Alps almost two thirds of the surface (75%) are covered by forests, and 16% by agriculturical land with prevailing grasslands. On the other hand in the Celje basin is only 18% of area covered by forest and 62% by agriculturical land.

Forests extends to 1650 meters, while some trees grow at altitudes up to 1900 meters. With increasing altitude and distance from centres of settlement places become less and less densely build up with small villages and solitary homesteads, which are typical for settlement pattern of this and other remaining mountainous areas. The terrain inclinations are mostly between 20-30°. The plain areas with inclinations is less then 6° are only 7 %, all on the gravel deposit of the Savinja river and its tributary the Dreta river.

The Ložniško and Hudinjsko hills have inclination in the average 11°, and in the Velenjsko and Konjiško mountains 18.1°. A few less, 16.6° has Posavsko Mountains, while in eastern Voglajnsko low hills has average 10° surface inclinations.

Table 1. Geographical characteristic of the Savinja river basin.

Region	1.	2.	3.	4.	5.
Kamniško – Savinjske Alps	24	23.3	75.0	16.0	9.0
Velenjsko and Konjiško maunt.	175	18.1	73.7	19.0	7.3
Ložniško and Hudinjsko hills	78	11.0	59.3	32.7	8.0
Voglajnsko low hills	121	10.0	32.5	59.5	8.0
Posavsko mountains	72	16.6	63.3	32.7	4.0
Celje basin – plain	526	2.2	18.0	62.0	20.0

1. population density (people/km2), 2. inclination (^{0}), 3. forest (%), 4. agricultural areas (%), 5. rest (%).

For the regions, which reach out of the Savinja drainage system, the data are approximate values. This is however not true for the central area of the Celje basin, where the values are true.

3. HYDROGRAFICAL CHARACTERISTIC

The average drainage basin density of the Savinja amounts to 1.58 km/km^2. Individual tributaries of the Savinja River vary intensely in the drainage density, from 1.00 km/km^2 at the Lučnica, to 2.50 km/km^2 at the Velunja, which is a tributary of the Paka with the drainage density of 1.89 km/km^2. The tributaries of the Savinja, the Bolska and the Voglajna have the drainage density of 1.43 km/km^2 and 1.66 km/km^2, respectively.

Orography of the Savinja river catchment area has strong influence on the precipitations regime and their quantity. On the western side of drainage basin average precipitations are up to 2000 mm, towards east and in the lower part of the drainage basin the precipitation decreases (Table 2).

Table 2. Average annual precipitation of the 1961-1990 period

Precipitation station	height above sea level /m	meassured /mm
Logarska dolina	755	1902
Gornji Grad	428	1561
Ljubno	422	1362
Celje	244	1146
Vitanje	478	1110
Laško	223	1230

The river regime of the Savinja and their tributaries is most dependent of the time distribution of precipitations. The Alpine high mountain snow-regime is characteristic for the Upper Savinja to the Nazarje . The water discharge distribution curve is typical of two high and two low extremes. The primary high extreme occurs in late spring, in April, and secondary high water occurs in November and cannot reach the primary high extreme. The primary low water extreme occurs in January or February and secondary low summer waters (August).

The group of streams with the Alpine rain-snow regime includes in the middle and lower part of Savinja and its tributaries the Dreta, the Paka, the Bolska, the Voglajna. The basic features are manifested as the primary high extreme, which occurs in April, although it can also occur in March, or even May. The secondary high extreme always occurs in November or December. The primary low extreme occurs in the summer, usually in August. The secondary low extreme occurs in the winter, it is not long lasting and is higher than summer low extreme.

For autumnal-winter of weather situations are typical orographical precipitations with some days continuous intense precipitations, usually followed by floods in the Savinja wide sizes. For the summer precipitations events are typical convective precipitations, they are intensive with the short duration times. The floods are mainly entirely local, with smaller damage (The Kozarica and Voglajna 1987, The Lahomnica 1989, Bolska, Motniščica, Konjščica in years 1990,1992, 1993, 1998, The Velunja, Toplica 1990, etc.

A list of operating level-recorders with the location, distance from the mouth of the stream, size of the catchment area, and characteristic discharges of the 1961-90 period is presented in table 3. There are 20 operating gauging stations of which 14 is equipment with level-recorder, 6 with gauge-staff. On the Savinja river are 3 automatic gauging stations (The Nazarje, Laško, Veliko Širje) and 1 on its tributary Paka in the Šoštanj for operative work of hydrological forecast service In the table are given only several important gauging stations.

Table 3. Gauging stations with characteristic data and discharges of the 1961-90 period

Gauging station	stream	distance km	F km^2	nQnk m^3/s	sQs m^3/s	vQvk m^3/s
Solčava	Savinja	89.45	63.7	0.12	2.26	86.3
Nazarje	Savinja	56.64	457.3	2.20	17.0	635
Celje	Savinja	25.30	1189.2	3.54	32.1	1208
Laško	Savinja	14.34	1663.6	4.20	41.5	1406
Veliko Širje	Savinja	2.00	1841.9	4.72	45.1	1490
Kraše	Dreta	7.66	100.8	0.25	4.26	236
Šoštanj	Paka	12.45	31.2	0.02	2.53	137
Dolenja vas	Bolska	2.23	169.5	0.15	3.89	182
Levec	Ložnica	2.50	102.9	0.07	1.74	82.3
Celje	Voglajna	2.18	202.2	0.11	3.31	102

nQnk – the minimum low discharge in the period
sQs – mean discharge in the period
vQvk – the maximum high discharge in the period

One of indications of the torrential character of the Savinja river and its tributaries are rates between characteristic discharges, and specific runoff as well.
The rates between the lowest, middle and the higher extremes are high, dependent mainly on the quantity and the intensity of precipitation, geological structure, antecedent soil moisture and snow cover. The rate of characteristic discharges between nQnk, sQs, and vQvk shows table 4.

Table 4. The rate of characteristic discharge (period 1961 – 1990)

Solčava	Savinja	1 :18.8 : 719
Nazarje	Savinja	1 : 7.7 : 289
Laško	Savinja	1 : 9.9 : 334
Kraše	Dreta	1 : 17 : 944
Dolenja Vas	Bolska	1 : 25.9 :1213
Levec	Ložnica	1 : 24.8 :1176

In November 1990, during the extreme high waters, the specific runoff of the Savinja amounted to 1389 $l/s/km^2$ at Nazarje, and 845 $l/s/km^2$ at Laško. At the same time, the extremes were also registered at tributaries of the Savinja, however smaler than that of November 1998 when the maximums of the Dreta at the Kraše were 2495 $l/s/km^2$ (maximum discharge is surplus value of period 1961 – 90, 2346 $l//km^2$), the Bolska at Dolenja vas 1073 $l/s/km^2$ etc.
Some examples specific runoffs by floods 1990 and 1998 shows figure 3.

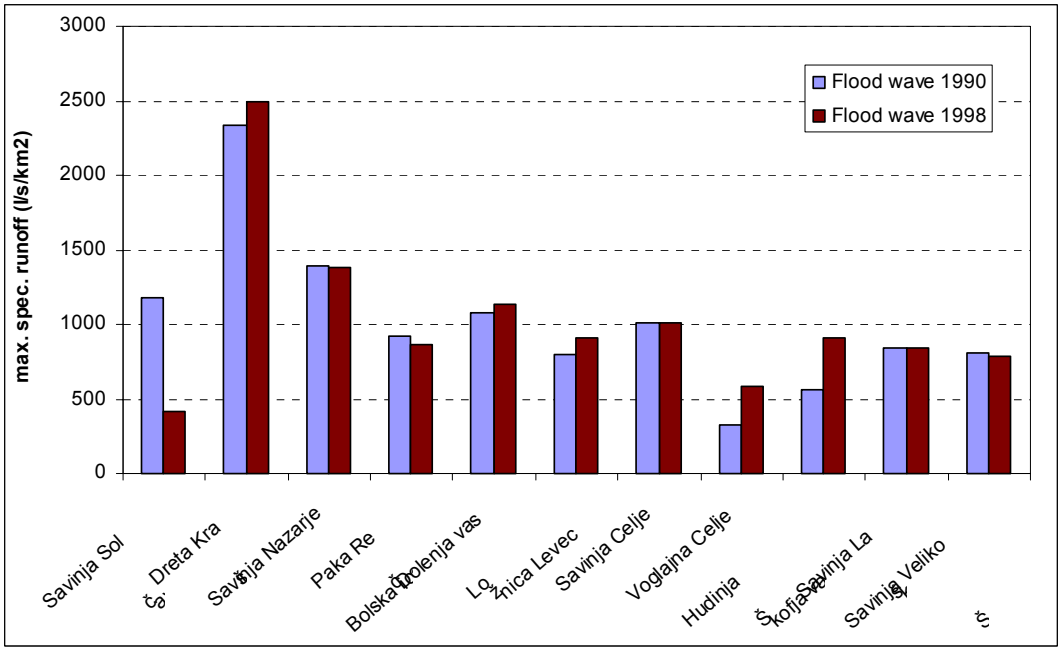


Figure 3. Specific runoff during floods 1990 and 1998 in the Savinja river basin.

The high waters flow of the torrential tributaries fast off down to Savinja river. The torrential waters activated bed, bank and dams erosion, and transported high quantities of gravels, woods, and rubbish downstream. Only from the valley of the torrential the Bela brook (Robanov kot) go off about 910 m^3/km^2/year of the gravel materials. On the torrential tributaries to Savinja river from Olševa mountain above 590 m^3/ km^2/year. The gravel material transported by the extreme high waters is one of the main causes of flood devastation and damages.

4. THE FLOODS ON 1 OF NOVEMBER 1990 AND 5 OF NOVEMBER 1998

The floods on 1 November 1990 and 5 November 1998 were of typical for autumnal – winter times. In the both example it was above north Atlantic extensively and deep sphere low air pressure with frequent precipitations over of Slovenia. The secondarily cyclone above north Italia with high and wet winds from south – west to carried abundant precipitations.
Antecedent precipitations (show table 5), and extreme rainfall 1 November 1990, as 4- well as 1998 were caused rapid raise water level and destructive floods on the Savinja and on its tributaries.

Table 5. Monthly precipitations (in mm)

Precipitation station	October 1990	October 1998
Logarska dolina	297	320
Gornji Grad	230	284
Ljubno	217	-
Celje	176	230
Vitanje	134	221
Laško	164	266

From table one can see difference between Upper and middle part of the Savinja basin in different years. Figures 4, 5 show spatial of integral precipitation distribution at the flood wave 31 October - 1 November 1990 and 4-5 November 1998 on the Savinja river basin.

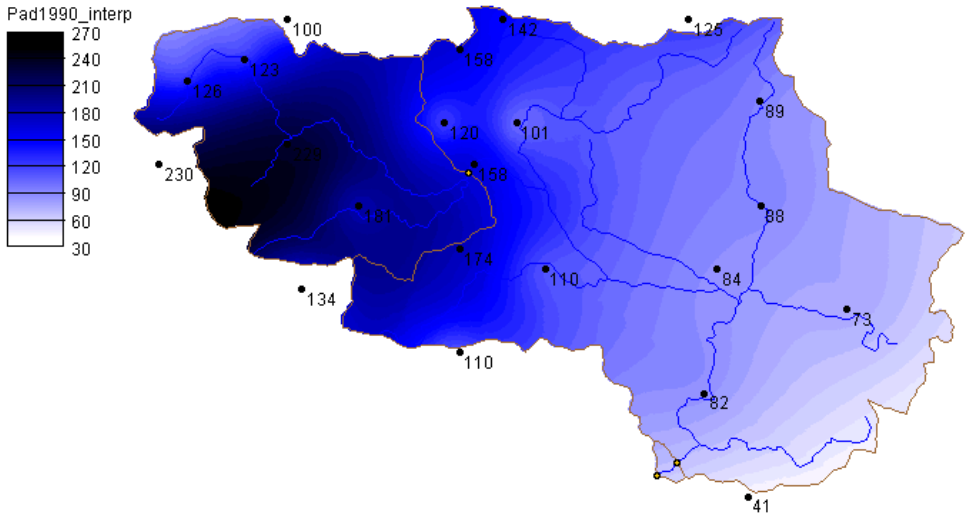


Figure 4: Integral precipitation distribution - flood wave 31th of October – 1st of November 1990.

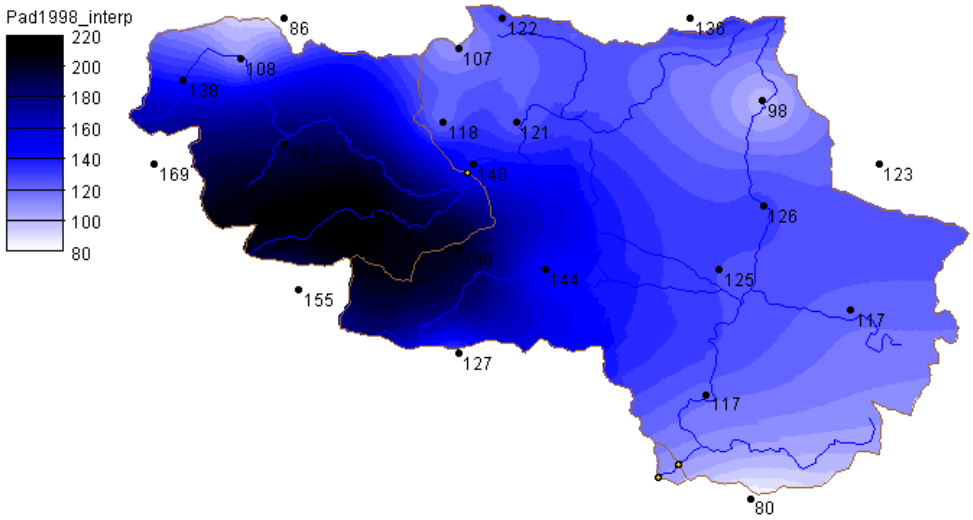


Figure 5: Integral precipitation distribution - flood wave 4th – 5th of November 1998.

In two days 31 October and 1 November 1990 average precipitation quantity in the Savinja river basin to Nazarje reach 169 mm, from Nazarje to Veliko Širje 98 mm. In year 1998, 4-5 November to Nazarje 160 mm, and Nazarje – Veliko Širje 124 mm. In both cases was similar situation, however with some larger precipitation in the middle and south part of Savinja river basin in November 1998.
Antecedent soil moisture, heavy rainfall and thunderstorms caused presently catastrophically floods and damages after 1933 year, with exception of the 1954 flood in Celje and high waters mainly in upper flow of Savinja river in the year1964. This period was relative favourably.

Hydrographic characteristic and precipitations as mentioned above were causing arise catastrophic flood wave 1 November 1990 and 5 November (figure 6, 7).
On November 1, 1990 Savinja river reached maximum water level 467 cm at Nazarje, 722 cm at the Celje, and 694 cm at the Laško. Savinja river water level at Nazarje raised 382 cm in comparison with the middle water level, at Celje 578 cm, and 579 cm at Laško.

In the November 1998 water level was lower in upper stretch of the Savinja (Nazarje 425 cm), while at the Celje, and Laško it was almost the same (721 cm, 692 cm). Somewhat the water level increases also on the Savinja tributaries in the middle and lower part of the river basin. The water level on the Paka at Šoštanj increases from 243 cm to 353 cm, on Ložnica at Levec from 318 cm to 334 cm, on Bolska at Dolenja vas from 400 cm to 420 cm and on Voglajna at Celje from 312 to 380 cm.

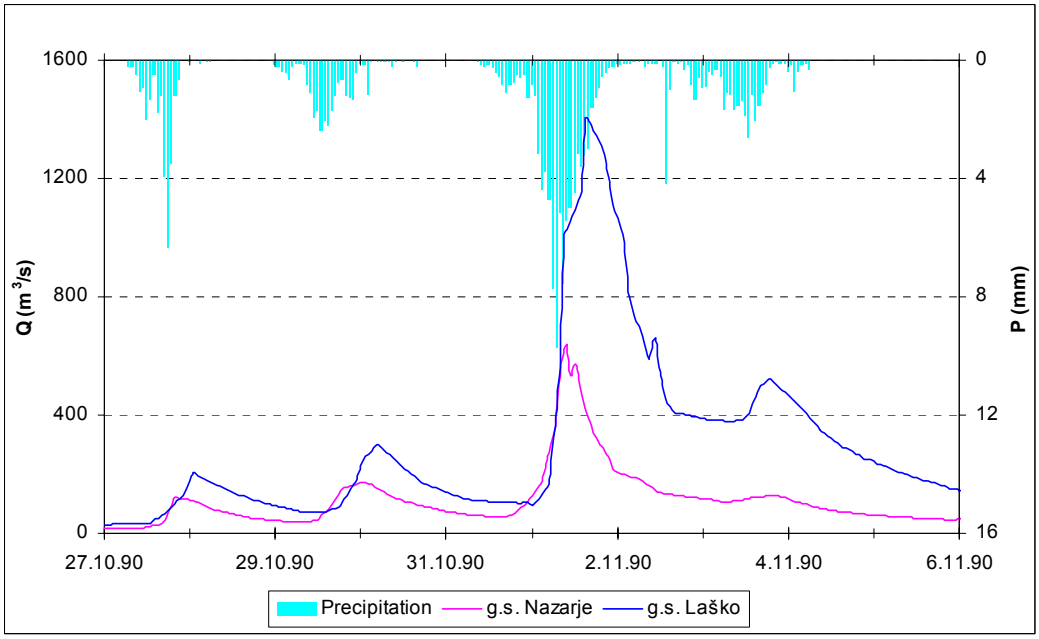


Figure 6. Hydrograph of the flood wave and average precipitations in 1990

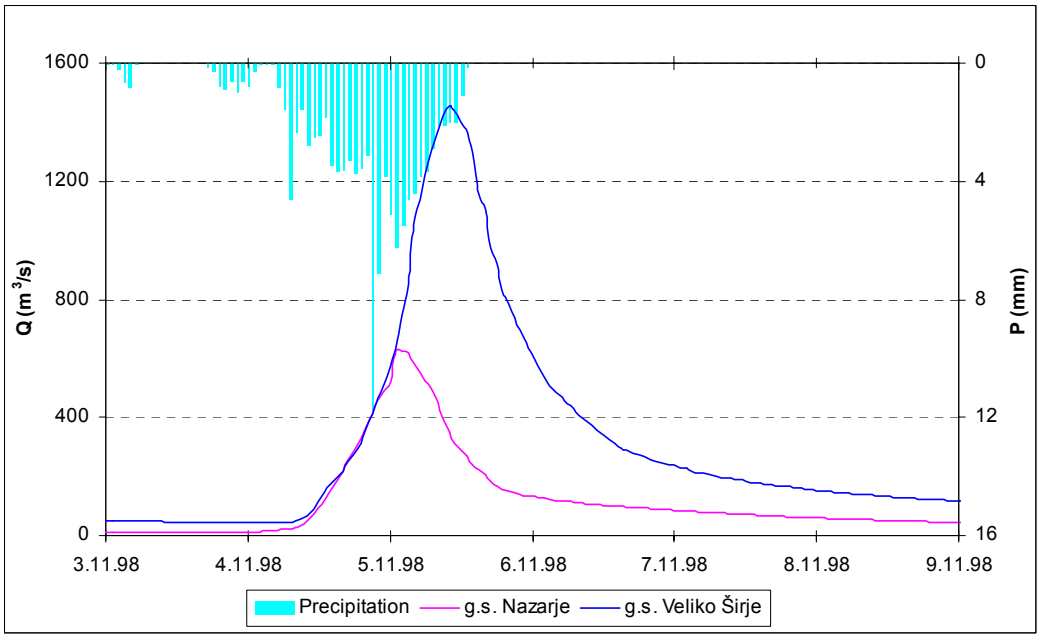


Figure 7. Hydrograph of the flood wave and average precipitations in 1998

In following table are shown volumes of flood wave with total and direct runoff and corresponding precipitations.

Table 6. Volumes of flood wave in November 1990 and 1998

1990

Gauge station	V total m3	Precipitation mm	V direct m3	Precipitation mm
Nazarje – Savinja	58399760	154.5	34835391	76.2
Celje – Savinja	160424870	134.9	111494209	93.8
Laško – Savinja	197443464	118.7	140813304	84.6
Kraše – Dreta	15543642	154.5	11475433	114.1

1998

Nazarje – Savinja	56117592	122.7	43487813	95.1
Celje – Savinja	132177765	111.1	95760180	80.5
Laško – Savinja	159179317	95.7	125140734	75.2
Kraše – Dreta	16463072	163.6	13221797	131.4

Flood wave of the Savinja in November 1998 reached recurrence interval between 50 – 100 years: Celje 1205 m^3/s, Laško 1395m^3/s, Veliko Širje 1458 m^3/s. Recurrence interval 100 years were reached on its tributaries: the Dreta 251 m^3/s, Bolska 193m^3/s, Ložnica 94 m3/s,and Hudinja 142 m^3/s tributary of Voglajna.

Recurrence interval 100 years was reached on the Savinja river in November 1990; Nazarje 635 m^3/s, Celje 1208 m^3/s, Laško 1406 m^3/s, Veliko Širje 1490 m^3/s, and tributaries Lučnica 172 m^3/s (water broke the dam build by landslides causes extreme discharge appraised on 300 m^3/s), and Bolska 182 m^3/s.

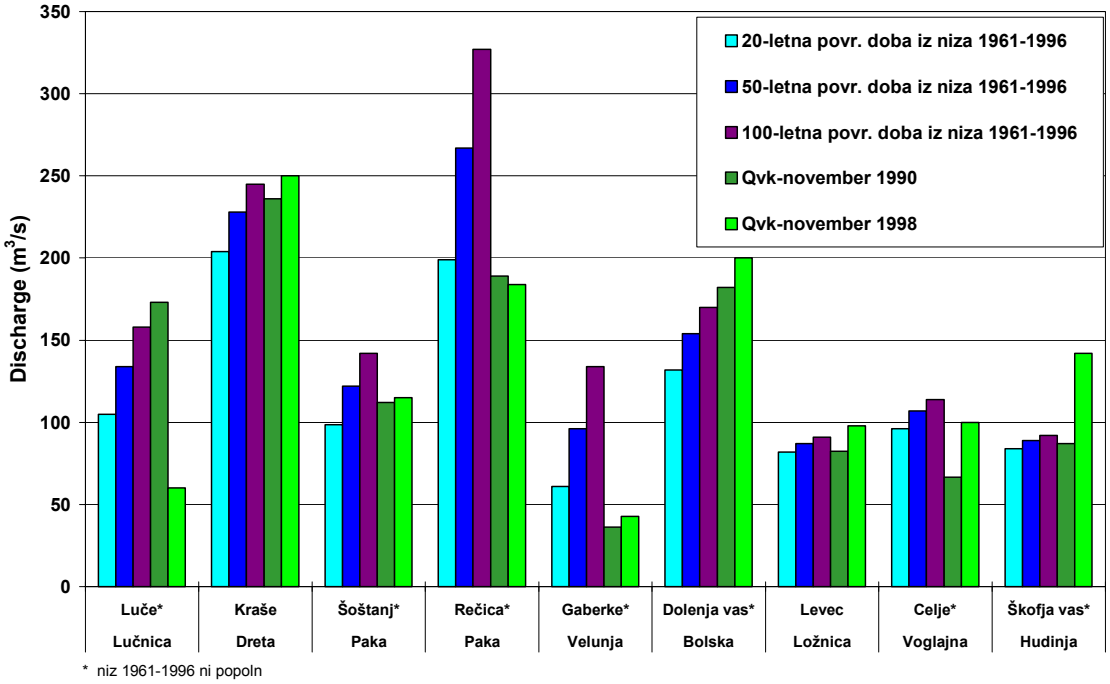


Figure 8. Comparison of maximal discharges of Savinja tributaries in November 1998 with maximum discharges in 1990 and calculated discharges recurrence intervals.

Table 7. shows flooded areas caused by catastrophic floods on Savinja river catchment with recurrence interval 20 years:

Rivers	Savinja	Voglajna and Hudinja	Paka	Dreta	SUM
Urban area	560 ha	40 ha	21 ha	11 ha	632 ha
Other area	1940 ha	530 ha	239 ha	269 ha	2973 ha
SUM	2500 ha	570 ha	260 ha	280 ha	3610 ha

5. EFFECTS AND CONSEQUENCES OF FLOODS

The flood in 1990 occurred in upper part of the Savinja valley, while in 1998 in the lower part of the Savinja valley as well as on the majority its tributaries.

The flood on November 1, 1990 the most demolished lower part of the Lučnica valley and the Savinja valley between Luče and Nazarje. In the upper Savinja valley numerous smaller lansdlides were triggered and two major, one at Raduha mountain and the other at Podveža in an alpine valley formed by the Lučnica. Landslides demolished a small farm house and blocked the Lučnica river valley at as a consequence of that in few hours almost 1km long and 10 – 15 m deep lake with about 10 million m^3 water arised in s few hours. Five residential buildings were completely flooded and an older person drowned. The water broke the dam of landslides next day at 5.40 a.m. when a two – meter high wave flooded the lower section of Luče village. The water wave reached an approximate discharge of 300 m^3/sec. This landslide and other landslides in the upper Savinja valley are the consequence ofgeological structure. In the last ice age because of peri-glacial processes large slopes of gravel were formed, which slide slowly downhill of the impermeable base of andesite tuff with intervening clay layers. This process goes on independently of human activity. In the valley were affected 44 households, i.e. 43 % of the population. Gravel drifts covered 32.7 ha of cultivated area, and landslides affected around 10.0 ha, more woods then meadows. Traffic routes were damaged to a large extent.

On the 126 km^2 of the Zadrečka valley of the Dreta river, flood damaged 111 houses and 67 industrial buildings mainly in the vicinity of the Nazarje industrial zone. Large damage was caused to agriculture as the flood waters covered 150 ha of cultivated land with gravel, river sand and other deposits. The same happened to road network, especially on bridges and footbridges. Most landslides (96) occured along the left tributaries of the Savinja river.

Flood along the Paka river in 1990 were the strongest in the Velenjsko – Šaleški valley, where above 80 % of the land drains into the Paka river. Along the Paka was flooded above 114 ha of farmland, 163 houses were under water, and about 50 landslides were triggered.
Strongly affected by the flood were areas along the Savinja river between Letuš and Celje where high water flooded over 700 ha of urbanised areas.

The regulations of the Savinja river, and its tributaries (Ložnica, Voglajna with Hudinja, Koprivnica) in the last hundred years did not eliminate all the danger of floods. There are influences betwen ground water, unsuitable canalisation and stream water. Outflow of the waste water from canalisations raises flood water in inundation. The flood water in the Celje was 1.5 m high. Inundated were cellars, ground-floors of habitation houses, blocks of flats, and historical archives, public buildings, security and educational establishments etc., and hospital in Celje with about 20.000 m^2 areas, where the equipment for sterilization, laboratory, dialysis, magazine for remedies were destroyed. Two persons lost their lives by floods.

The flood devastated also in the narrow valley of the Savinja downstream from Celje to Zidani most, the most settlement Debro in Laško. Farming co-operative, Merx, Police station, Petrol filling station, Brewery Laško, public buildings and Health – resort Laško were flooded. The water reached to 2 m altitude.

Intensive precipitation on 1 November 1998 caused rivers to rise and flood again. Flood areas and damage were exceeded of catastrophic flood in 1990, the most in the middle and down stretch of the Savinja river and its tributaries.

The most effect was again in the Laško with already mentioned buildings and infrastructure construction. Electric conduits, and telephonic connections were destroyed.

The floods were on the Savinja tributaries too. Huge damage on the Dreta, Paka, Bolska, Ložnica,

Voglajna occured in river beds and their sorroundigs, infrastructure, residential and other buildings and to farmland. In torrent hinterland were activated numerous erosion zones.

6. ESTIMATION OF FLOOD DAMAGE

Table 8. shows estimated damage on the flood areas, including damage in the economy and infrastructure for some local communities. The estimations prepared the Community commissions. The value is calculated in USD using exchange rate in November 1998.

Table 8. Estimated flood damage in November 1990, 1998 (in mio. USD).

Community	1990	1998
Mozirje	205,90	102,55
Žalec	44,91	175,97
Celje	147,45	227,40
Laško	34,10	126,50
Velenje	16,00	12,46
Šentjur pri Celju	0,91	33,72
Total	**449,27**	**678,60**

Total damage caused by floods in November 1998 for all Community (13) was estimated around 750,60 mio. USD.

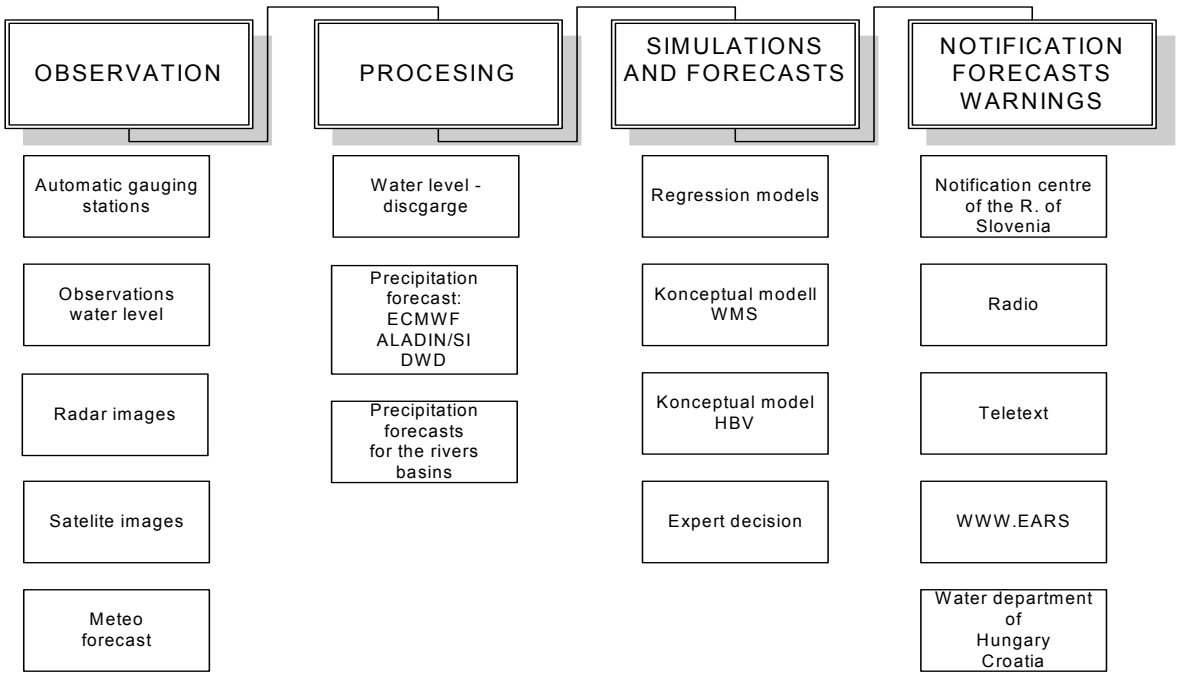
From 20 – 25 % of total value were caused because of destroyed road bridges, footbridges, dams and several undercuts of the roads along the river (too small dimensions of openings, unregulated riverbed ahead of culvert, inadequate foundations of supporting walls and bridge pillars, inadequate protection of road dikes near riverbed, primarily on concave parts of banks). Extremely high water of the Savinja and torrential tributaries scoured and carried materials from the bed and banks, and destroyed hydrotechnic infrastructure. The damage on the water management sphere reached about 15 % from total value. Damages on the agriculture and forestry have been estimated about 20 %. The rest of the damage aroused on the residential and communal infrastructure, and other economic activities.

7. HYDROLOGICAL FORECASTES

The Environmental Agency of the Republic of Slovenia includes the Service for Monitoring Hydrological Conditions, Forecasts and reporting, whose task is to make forecasts and warnings, and to produce situation reports. Hydrological data are collected from national network stations (4 automatic stations with on-line sending data, and 14 water-level recorder stations and reports of the hydrological observes). Meteorological data in particular precipitation forecasts, weather maps, and radar (Lisca station) pictures are easily available in house. Hydrological forecasts and flood warnings are regulary dispatch to the Ministry of Defence, Notification centre of the Republic of Slovenija, at Administration for Civil Protection and Disaster Relief (CORS) which send a notification to the Regional Notification centres which co-operate and coordinate the rescue squads on the field (services for maintenance waters, fire brigades, civil protection units etc.). During the floods the individual services and organizations work according to warnings in accordance with their determined tasks.
Hydrological forecasts and warnings are distributed also to hydrological services of Hungary and Croatia (Figure 9).

Hydrological forecast service uses as an input to the hydrological models the data from automatic hydrological and meteorological stations, precipitation forecast of meteorological model ALADIN / SI / 25, ECMWF and data from the Lisca radar station. All data are used as a base for simple regression models. Use of conceptual rainfall-runoff models, WMS, HBV are in test use.

Figure 9. Working process of the Hydrological forecast department at Environmental Agency of the Republic of Slovenia (EARS).



The forecasting period is usually 24 hours, but continuously during flood situations.
At the flood case in November 1998, Hydrological Forecasts Service issued 13 warnings messages from 2nd of November to 5th of November to the Notification Centre of Republic of Slovenia (CORS) and other services as well as the public media. The reports contains current hydrological conditions (water levels, discharges) and foreseen increase of water level with flood warnings.

Yearly analyses showed that lead-time is 36 hours. The accuracy of hydrological forecasts for Slovenia is about 85 per cent.

8. RESPONSE OF THE PEOPLE ON THE FORECASTS AND WARNINGS

On the June 19th 2003 was organized a round table on hydrological forecasts and warnings at the Environmental Agency of the Republic Slovenija. The users to hydrological reports, forecasts service from Governmental service, local authorities and media were invited. The aim was to identify the differences between flood warnings designed for the governmental services and local authorities, as well as the requirements for media. It was the opportunity to hear the suggestions from the local Civil protection services and from the Notification Centre of the Republic of Slovenia.

The discussion with end-users and questionnaire responses gave several useful hints to improve flood forecasts and warnings. The questionnaire was developed for the inhabitants of the town of Celje that was seriously flooded in 1990 and 1998. Four areas of the town were included to this research (Center, Glazija, Lisca, Skalna klet areas).

The end-users were gave some recommendations for improvement to their operative work and triggering necessary actions at floods:

- Predicted flood magnitude should be recognized with warning levels.
- Information and on-line now-casting should be issued more frequently, especially in the time of flooding.
- Prediction of flood areas of a small rivers and also (tributaries) should be given.
- More on-line hydrological data are needed to enable the actions that can be taken before flood.
- Flood warnings should be different for media and governmental services. The media and the public do not well understand some of the professional terms used for the forecasts.

Furthermore, people mostly trust at reports weather forecasts and flood forecasts of Local radio, less Newspaper, because print data with 24-hour time lag are obsulate. National TV and national radio are more regionally oriented without special attention to local conditions. Many people are still not connected to the Internet. The people like to be informed and to receive the accurate information timely. The answers of the inhabitants from Mozirje and Celje, affected by November natural disaster 1990, indicated that people in the affected areas were badly acquainted with the actual danger of floods and landslides.

Similar lack of warnings was stated before flood disaster occured in 1998 on the territory to the Laško. The cause of lack of information was not explained till today while the responsible services operated certainly and timely.

Despite of frequently floods the majority of the people hoped that such disasters were not possible in their regions. They also believe that such disasters will not happen again. The people are accustom on the floods and used to live with them. They responded actively to the danger during the disaster. After floods majority affected expect that the districts and the Government of Republic Slovenia will take steps to prevent damages caused by floods and offer more support to Insurance companies.

9. WATER QUALITY

The main water quality problems caused by the floods in the Celje region were hygiene-epidemic and chemical water contamination. The most acute problem in the Celje was the danger than an epidemic of infections diseases could break out. The greatest danger was caused by polluted drinking water, and later there was a danger of diseases spreading by contagion and food. The degree of danger depended on the pollution of the floodwaters. The town of Celje was most threatened by of spieled fuel oil.

The Institute for Social Medicine and Hygiene in Celje immediately took the actions to reduce all the danger to the health of stricken people regarding floods on this area.
In order to evaluate the degree of contamination of the flooded area they took the samples of drift and earth in the centre of Celje and Laško. Organic and inorganic substances were analysed and microbiological analyses performed. The analyses of the samples taken Celje showed the presence of organic substances and heavy metals Cd, Zn, Cu, but all in the allowed extent. Warning has been given to the local authorities that drinking water should be boiled because of bacteriological pollution.

10. FLOOD PROTECTION POST FLOOD

The intensive use of land (urban development, agriculture e.t.c.) need flood protection measures and regulated river regimes. As measures for flood protection we use structural and non-structural solutions. After flood November 1998 was planned the construction of the hydrotehnic structures as flood control reservoir, and levees, flat-retentions, reconstruction of damaged river-beds and stabilization of torrential headwaters, first of all on the andezit-tuf (depth to several meters) covered with forests, the landslides have been triggered.

Non-structural measures consist of reduction of potential flood damages. Management of the torrential drainage basin and rivers needs comprehensive and not partial solutions with elaboration of complete documentation and its approval. The services and organizations as well as civil defence associations should be well organized with clear goals and tasks. All this call for the appropriate legislation and permanent financial sources.

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