SEPIC

Support to Enhance Privatization, Investment, and Competitiveness in the Water Sector of the Romanian Economy

OVERVIEW of WATER RESOURCES in ROMANIA

Submitted to:
U.S. Agency for International Development/Romania

and also to
ANAR and MEWM

August, 2004
Bucharest, Romania

The SEPIC project, Task Order 822 under USAID's GBTI IQC (PCE-I-00-98-00015-00), is implemented by Chemonics International Inc., 1133 20th Street, NW, Washington, DC 20036, with assistance from its principal subcontractor, International Resources Group (IRG). Romanian subcontractors include SC AQUAPROIECT SA, SC AUDITECO SRL, SC ECEROM GRUP SRL, Interactive Communications Systems and Business Consulting, Technical University of Civil Engineering of Bucharest

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Acronyms

AEWS – Accidental Emergency Prevention and Warning System
ANAR – National Administration "Apele Romane"
ARS – Accidental Spill Spots
DESWAT – Disaster Water project
EU/ UE – European Union
GIS – Geographical Information System
ICIM – Environmental Research and Engineering Institute
ICPDR – International Commission for Protection of Danube River
ICPE – International Commission for the Protection of the River Elbe
INHGA – National Institute of Hydrology and Water Management
ISO – International Standards Organization
PIAC – Principal International Allert Centre
RBMP – River Basin Master Plan
SAPA-Rom – Alarm System for Accidental Pollution
SEPIC – Support to Enhance Privation, Investment and Competitiveness in the Water Sector of the Romanian Economy
TAIWAT – Trade and Investment for Water
UN/ECE – United Nations/ Economic Commission for Europe
WATMAN – Water Management Project
WFD – (EU) Water Framework Directive
WRI – Water Risk Index
WRC – Water Risk Classes

Introduction

The water characteristics, phase of regimes and the environmental factors critical to implementing WATMAN in Romania are described, with special attention to the extreme precipitation events that create flash floods and associated pollution and could involve accidents to dams and other hydraulic infrastructures.
A general description of the catchments in Romania is provided, regarding both quantity (surface and groundwater, water regime, reservoirs and other hydraulic water works, floods and droughts) and quality aspects (water quality of different sectors and accidental spills).

Climatic Conditions

The importance of describing the climatic conditions is based on the following two reasons: first, the climatic conditions could have a peculiar effect on the operational conditions of DESWAT Project. Hence the main climatic characteristic estimates concerning the precipitation and the air temperature must be considered. Their distribution around the territory of Romania should be explained by the main features of the climatic circulation of the air masses that influence the spatial and temporal variation of the main climate parameters of importance to the DESWAT Project. Second, the climate regime and its characteristics have a significant influence on the river’s flow regime as well as on the formation and the evolution of floods. This influence must be defined as well.

Climatic Features of Romania

The air humidity originates especially from the region of the Atlantic Ocean (80%) and a part (20%) is formed over the territory of Romania as a result of the local circuit of the air masses. That is the reason why the mountainous slopes exposed towards the direction of the principal centres of water provenience will generally be wetter and will show a Meridional zonation of different regions of Romania.

For example the mean amount of precipitation in the western part of Romania exceeds that of the eastern part by 20-50%.

The latitudinal zonation is also sensitive in the quantity of the precipitation and the evapo-transpiration, in the western areas it results in increases of 10-20% and in the eastern ones a decrease of 10-15% is observed (Ujvary, 1972).

The climate of Romania is moderate-continental. The cyclones, which traverse Romania, contribute to increasing the air temperatures during winter and the decrease of these in the summer season. The Mediterranean cyclones contribute to the increase of the temperatures and the precipitation during wintertime when periods with snowmelt-augmented rainfalls lead to the winter floods.
The Carpathian Mountains have a strong effect on the atmospheric circulation acting as an obstacle in the paths of the moving air masses and hence producing significant modifications of the trajectories of the cyclones and their normal development. Thus a

compartmentalisation of the country from climate point of view is due to the Carpathian range.

The highest amounts of precipitation of the Romanian territory are produced along the cyclonic trajectories coming from the Atlantic Ocean as well as from the Baltic Sea. The trajectories from the Mediterranean Sea also contribute to the precipitation formation during autumn and winter in the western and southern zones of the country. At the crossing of the mountains the cyclones split out and further on they recompose and due to the adiabatic coldness, precipitation in the mountain and sub-mountain areas results.

The driest periods occur in two seasons: in the winter due to the cold and at the end of the summer and the autumn periods they are due to anticyclone activity.
The anticyclones trajectory originating from Eurasian area provokes very low temperatures; especially in the eastern and southeastern zones of the country while the Azores anticyclones circulation brings about the dry periods at the end of the summer and during the autumn season. During dry periods in the warm season the precipitation might be absent during 50-100 days, and due to this persistence of the drought the some rivers become completely dry.

This climatic compartmentalization has a direct impact on the climate and hydrological characteristics in several parts of the Romanian territory. At the east of Carpathian Mountains all the peculiarities of the so-called “climate of the east-European province” are met, with high thermal contrasts and with low air humidity eastwards. At the west of Carpathian Mountains prevails the specific climatic elements of the “climate of central European province” with continental background but with both Atlantic and Mediterranean influence. To the west, at the Carpathian Mountains the influence of the Atlantic climate is more pronounced than in the southern zone of the country. The effect of the Black Sea is manifested along a narrow strip in Dobrogea region by moderating the winter climate.

Meteorological conditions that generate the high floods in Romania can be of the following two types (Mustetea, 1996):

- Inputs of warm air masses, sometimes of tropical origin coming across the Mediterranean Sea that have as an affect a considerable increase of the humidity content of the atmosphere. Vertical ascendant movement that leads manifests these types of air masses, having pronounced termodynamic instability to condensation of the “cumulus” type followed by intense precipitation across large areas.
- Cold fronts originating from the Atlantic Ocean favored the abundance of rainfall, which transform the southern circulation into a western one. Cyclonic nucleus of a “cut-off “ type, located at the western boundary of the country.

Under these circumstances, the territory of Romania is found in the anterior part of that nucleus where there are conditions of the development of a heavy south-south-western circulation. That facilitates a continuous advection of tropical and wet air masses, which are corroborated with an orographic ascendance due to the Southern Carpathians. The combined effect of these circumstances results in a heavy cumulonimbus process, which leads to abundant rainfalls over large areas. In the anterior part of that nucleus, the air pressure gradient become steeper as the warm pulsation causes a difference of phases of the mass and thermal fields. Thus, the vertical motions become very significant and the air volumes are carried in an ascendant helical motion. These special conditions of meteorological circulation, facilitating heavy rainfalls often across large basin areas could be sometimes corroborated with rapid melting of thick and dense snow pack that substantially contributes to the occurrence of catastrophic floods. Orographic rainstorms of unusual intensities are developed in the frame of these frontal fields of precipitation, which have resulted in high flash floods occurred over small basins.

Characteristic estimates of temperature and precipitation

The distribution of the mean annual temperature estimates is a function of both the local altitude and the latitude. The difference between the temperature of the southern zones of the country and the northern ones is about 3^0C and between the eastern parts and the western ones is about 1^0C. However, this general distribution has pronounced differences within the country. While in the southern plain zone, the annual estimates of the temperature do not have important differences being comprised between 10 – 11^0C, in the mountainous areas the gradients suddenly increase. Thus there are significant differences between the bottom of the valleys and the slopes, or the crests of the mountains, where the mean annual temperatures are of –2.5^0C at 2500, 3.50-4^0C at the altitudes of about 1300m, 6^0C at about 900m and 8-9^0C at 350-400m. The annual isotherm of 0^0C is found at about 2000m in the Meridional Carpathian Mountains and at 1800-1859m in the northern part of Romania.

In January there are annual temperatures less than –3^0C in the Moldavian Province and the Southern Plain as a result of the eastern invasion of a continental cold air originating from Eastern zones of Russia. In the central zones of the country in depressions, thermal inversion phenomena are ascertained.
In July, an important increase of the temperature gradient (0.6-0.7^0C/100m elevation), as compared with that of January and the other winter months is found.

The isotherm of 0^0C is found at about 3300-3500m (according to the aerologic survey) and the isotherm of 10^0C is found at about 1700-1800m. The highest mean annual temperatures are found in the Southern Plain (about 25^0C).

The extreme temperatures have high variations. The absolute maximum has been recorded at the Station Ion Sion in 10.08.1951 having a value of 44.5^0C. The absolute minimum has been recorded at the Station Bod in 25.01.1942 being of –38.5^0C. The mean duration of the interval with frost varies between less than 80 days along the littoral of the Black Sea, 100-150 days in the continental and moderate-continental zones and more than 200 days in the mountainous zones.

The amounts of precipitation have a great variation over the territory of Romania, in terms of both space and in time. In the rainy years the quantities of precipitation exceed 1000 mm in some regions of plain and hilly areas while in the mountain areas values of more than 2400m per year might be found. In the dry years the annual quantities of precipitation may reduce up to 200 mm in the southern and eastern zones of Romania, 300-350 in the hilly zones 400-450mm in the central part of the country and 400-600mm in the southeastern areas of Romania.

Twenty-four hour-rainfall events and their effects

These are of major interest for the formation of floods. The significant differences between the amounts recorded during different periods are shown in Table 1.1- 1. One group of rain gauge points belongs to the period of record of 20-25 years, another group has a record period of 50-60 years and the last group belongs to the long period of records of 80-100 years. Nevertheless, in each group, estimates of 150-160mm/24 hours have been recorded.

Outstanding amounts of rainfall in 24 hours have been recorded at different raingauge points, among them the following might be mentioned: Letea (691mm) at 29-30.08.1924, Ciuperceni (349mm) at 25.06.1925, Negru Voda (320mm) at 17.08.1900. In order to appreciate the potential of the flash floods the rainstorms are of a special interest.

1. Romanian water resources

The Danube River is – after River Volga – the second biggest in Europe with an area of 817, 000 km2 and a length of 2,778 km.

The catchment area of River Danube covers at present territories of Albania, Austria, Bosnia & Herzegovina, Bulgaria, Croatia, the Czech Republic, the Federal Republic of Germany, Hungary, Italy, Macedonia, Moldova, Poland, Romania, the Slovak Republic, Slovenia, Switzerland, Ukraine and the Serbia and Montenegro. Out of these 18 riparian States 13 States hold territories in the Danube Basin bigger than 2,000 km²: Austria, Bosnia & Herzegovina, Bulgaria, Croatia, the Czech Republic, the Federal Republic of Germany, Hungary, Moldova, Romania, the Slovak Republic, Slovenia, Ukraine and the Serbia and Montenegro.

The Danube River Basin District covers an area of about 823,334 km^2 and includes the Danube River Basin and the River Basins adjacent to the Black Sea that are influenced by the Danube River. The areas of Romania (238 391 km²) as riparian to the Danube River Basin District is 99% and estimation of the riparian inhabitants are round 22.3 Mio.

On the 238 391 km², of the Romanian territory there are more than 4000 rivers the watershed surface of which is larger than 10 km². The total length of these rivers exceeds 60.000 km.

Water resources in Romania were evaluated as a potential of round **136** billions cm/year, of which: round **40** billions cm/year of the Romanian catchments, **87** billions cm/year of the Danubius (disponible for water use round. 30 billions cm.) and round **9** billions cm/year from groundwater (only **6** billions cm/year economical usefull).

The main divide in our country is formed by the Carphatic Mountains which due to the tectonic movements are penetrated by three important passages: Somes, Mures and Olt. In the six groups of hydrographical systems distinguished in Romania are 11 large basins (Ujvary, Hydrography of Romania).

Certain river courses are characteristic for all type of relief regions. The typical mountain rivers display almost a linear course of their steep slopes which permit a rapid flow. These are the most destructive rivers for different water works, posing the most difficult problems for flood mitigation point of view. The courses become more winding for the typical hill-rivers because of the decrease of the slope and are very meandered for the typical plain rivers, where the small slopes permit them to wind. In the mountains zones there are valleys the cross profile of which is V-shaped, characteristic for young undeveloped valleys (i.e. the upper valleys of the rivers Somesul Cald, Somesul Rece, Cerna etc.) valley cross-profile as gorges with steep slopes and hundreds of meters depth (the Jiu, Olt, caras, Nera, Dambovita gorges) and valleys having U-shaped cross-profiles, moulded by the erosion of the quarternary glaciers (Sambata, Bilea, Arges, Topolog etc.). The valleys have a typically trapezoidal cross-profile in the hill and plateau zones, sometimes asymmetrical because of the system of terraces unequally developed on both river-sides (Tarnava, Birlad, Jijia etc.). In the plain zones, the local rivers as well as the great rivers which cross them, have a large opened trapezoidal profile (Ialomita, Siret etc.). These typical forms help in modeling if some shape approximation is needed.

The important **alteration of the river network** was linked about different stages of urban development. Thus, in the XVIII-th century aiming to avoid flooding in Bucharest, Dambovita River was regulated. For increasing water supply for paper-mill, Rastocea and Sabar were connected.

The Bega River canalized a length of 115 km (110 km on Romanian territory) and the Cerna and Cris rivers were regulated and canalized. Within Cris rivers area, the works undertaken can be grouped in three great land reclamation complexex: Beretau, Crisul Repede – Crisul Negru – Crisul Alb.

Potable water supply as well as water for industries and irrigation was assured by a series of canals and penstocks among which the most important were: the canals Bilciuresti – Ghimpati, Iazul Morilor – Ialomita, Iazul Morilor- Prahova, leaotul, Iazul Morilor- Teleajen.

The hydro-technical constructions for a complex use modified sometimes irreversible the water courses (Bistrita, Arges, Lotru, Olt etc.).

2. Water regimes

Runoff regime of the Romanian rivers differs greatly from year to year and from zone to another, due to the climatic influences and to an extremely varied relief. The types of the river flow regime is defined by the variation of the flow throughout the year as the *timing* of the maximum and minimum flow seasons and range in the discharges during each flow phase dependent on its origin and the basin peculiarities.

The effects of the climate on the river flow regimes are considerably controlled by the physiographical properties of the basin. Among these, in Romania the altitude plays the most important role as it expresses on the one hand the gradual variation on the vertical of a particular macro-type of the climate and it implicitly reflects the configuration of the hydrographical network, channel and slope gradients, soil and land cover. The diversity and the features of the regimes are connected with the time and space scale at which the hydrological analysis is made.

The daily runoff regime can be characterized and typified on the basis of the hydrograph of the mean characteristic year. This is a design hydrograph based on the most frequent runoff magnitudes, occurrence and duration of the regime phases. It was identified a number of 8 typical hydrographs and 2 sub-types. As most general expression of the runoff regime, have been established on three criteria: the hydrograph slope, the seasonal runoff distribution and the supply sources. The types of regimes on the Romanian territory are: High Charpatic, West-Charpatic, South-West Charpatic, South Charpatic, East Charpatic, Hill and platform type regime, plain regime and Dobrodja regime. These water regimes are important in designing water supply systems in specific years (DSS for water supply optimization procedures).

3. Groundwater resources

The total underground exploitable water resources are evaluated as following: (SERBAN P., BRETOTEAN M., 1996, *Resursele si cerintele de ape subterane ale Romani - The underground water resources and needs -* Rev. Hidrotehnica, vol. 43, nr. 6 1998.):

- 364,6 m^3/s ($11{,}5 \cdot 10^9$ m3/year) - I.N.M.H.;
- 384,2 m^3/s - Institutul de Geologie-Geofizica (1988);
- 383 m^3/s - I.S.L.G.C. (1990).

The exploitable balance resources, satisfying the quality criteria and the technico-economic ones go up to 304,9 m^3/s ($9{,}6 \cdot 10^9$ m^3/year), out of which:

- 149,4 m^3/s ($4{,}7 \cdot 10^9$ m^3/year) from freatic;
- 155,5 m^3/s ($4{,}9 \cdot 10^9$ m^3/year) from deep waters.

The $9{,}6 \cdot 10^9$ m^3/year represents only 15% from the technically usable resources of Romania, in value of $64{,}6 \cdot 10^9$ m^3/year.

With respect to the geographical repartition, the exploitable balance resources (304,9 m^3/s) are distributed as following:

West plain, North from Mures river	-	38 m^3/s (12,5%)
Banatului plain	-	26 m^3/s (8,5%)
Transilvaniei plateau	-	25 m^3/s (8,2%)
Moldovenesc plateau	-	35 m^3/s (11,5%)
Romana plain	-	137,5 m^3/s (45,1%)
Danube wetlands and terraces (including Delta)	-	29 m^3/s (9,5%)
Dobrogea	-	14,4 m^3/s (4,7%)

The major aquifer systems, of national interest, cover for about half of the total exploitable water balance resources of Romania; the rest of 50% is represented by the resources of county or local interest.

The underground exploitable underground water resources homologated by the Inter-departmental Commission of Homologation is set close to 146,6 m^3/s (meaning about 40% from the total exploitable underground water resources) and there are distributed as following:

- 69,4 m^3/s in categories B and C_1, which may fundament investments for in-take;
- 75,2 m^3/s in category C_2.

The difference of 220 m^3/s between the totally exploitable resources (364,6 m^3/s) and the homologated exploitable resources (146,6 m^3/s) represent the prognosis resources and resources of category C_2, requiring supplementary hydro-geological investigations as to be promoted into the superior categories, which may allow for their capitalization.

By report to the 146,6 m^3/s of homologated exploitable resources, the needs for underground water, strongly influenced by the socio-economic evolution of the last decades, had values from $0{,}35 \cdot 10^9$ $m^3/year$ (1960 – 1985) and $2{,}6 \cdot 10^9$ $m^3/year$ (1989) to $1{,}3 \cdot 10^9$ $m^3/year$ in 1996, on in flow equivalent from 11,1 m^3/s (1960 – 1985), to 82,4 m^3/s 1989 and 41,2 m^3/s in 1996.

The structure of the out-takings of underground water between 1989 – 1996 has evolved as following:

1989		1996		Water users
Debit (m^3/s)	%	Debit (m^3/s)	%	
33,8	41 %	24,1	58 %	Population
31,3	38 %	13,6	33 %	Industry
17,3	21 %	3,6	9 %	Agriculture

By comparison with the exploitable resources homologated by the Inter-departmental Commission of 146,6 m^3/s, the effective out-takings for 1996 have been of about 28 %, and out of the total of the effective out-takings of 326,6 m^3/s ($10{,}3 \cdot 10^9$ $m^3/year$) from the sources of surface and underground waters for 1996, the out-takings from underground (41,2 m^3/s or $1{,}3 \cdot 10^9$ $m^3/year$) have represented 12,6 %.

COMMENTS

1. The resources of underground water of Romania are insufficiently capitalized at present by report to their potential.

2. Given the impact of the atrophic activities, industrial or agricultural, as well as the vulnerability to pollution of the aquifers, the exploitable resource of balance can be diminished in the future; it is especially the case of the freatic

aquifers, but these processes are not excluded in the case of the depth aquifers, at which there exists the vertical communication between the different levels of water.

3. It is necessary the rigorous definition of the vulnerability in view of the setting up of some perimeters of protection or of other special measures, going up to the interdiction of some industrial or agricultural activities in the areas of aqvifers supplying. It is only in this way that the current resource of balance can be maintained in the future to the present values.

4. The water management, within each of the hydro-graphic basins must be perceived from the using view point by corroborating the surface water resources to the underground ones.

4. Reservoirs and other hydraulic waterworks

The use and capitalization of water resources is conditioned by both their quantitative limitations and their uneven distribution in time and space, as well as by the need to ensure of proper quality conditions.

In order to harmonize the variable regime (annual and seasonal) of the rivers flow, with that of the needs for water of the users, much better balanced, there have been made hydro-works (accumulation lakes, derivations), as to ensure the redistribution in time and space of the water resources.

Between 1950 - 1966 there have been build the dams on the Bistrița and Argeş rivers, (as well as the Secu accumulations on Bârzava river, Teliuc on Cerna river, and Stramtori on Firiza river) in view of obtaining electricity/ electric power, in the most rapid way possible.

Between 1966 – 1982 there have been put into function the cascades of accumulations: Oieşti – Goleşti on the Argeş river, and Dăieşti – Drăgăşani on the Olt river, as well as the accumulations Porțile de Fier I on Dunăre, Vidra on Lotru, Tarnița on Someş, Paltinu on Doftana, Poiana Uzului on Uz, Pucioasa on Ialomița, Bucecea on Siret, Stânca-Costeşti (1400 millions qm) on Prut and Gura Râului on Cibin, some of these being mostly energetic ones, others having as main destination the uses of water consumption.

Finaly, between 1983 – 1990 it has been continued the Oltului arrangement in cascade to Izbiceni, the arrangements on Sebeş river, and Râul Mare - Retezat, with the ones on Siret river, at Galbeni – Bereşti and Călimăneşti, as well as with the accumulations: Porțile de Fier II on Dunăre, Siriu on Buzău, Poiana Mărului on Bistra, Pecineagu on Dâmbovița, Bolboci on Bistrița, Râuşor on Târgului, Mihoieşti on Arieş, Goleşti, Mărăcineni and Zăvoiul Orbului on Argeş and Surduc on Timiş.

At present, in conformity with the dams' cadastre from România, conducted in September 2002, the total number of the accumulation lakes, including the fish ponds and the recreation lake, it comes up to 1840. In conformity with the annuaries of water management in the recent years (2001, 2002), from this total, 1232 of accumulation lakes are permanent accumulations, 217 are non-permanent accumulations and the rest of 391 are fish ponds.

Within the documentation elaborated by Aquaproiect for SEPIC, it has been made an analyze for a number of **241 water** accumulations. The reference documents are in Romanian and are annexed to this report.

The ***table 1***, presents, by hydro-graphic basins and of total/ country, the characteristic number and the volumes of these accumulation lakes with respect to the two types: permanent (Per) and non-permanent (NP) accumulations.

Table 1

#	Hydro-graphic Basin (space)	No. accumulations			Volume (mil. sqm)				
		Total	Per.	NP.	Maxim	Gross	Net	Attenuation	
								ac. Per.	ac. NP.
0	1	2	3	4	5	6	7	8	8
1	SOMEŞ - TISA	13	12	1	522.1	414.1	320.9	102.0	6.0
2	CRIŞURI	23	9	14	476.5	292.4	231.9	52.6	131.5
3	MUREŞ	21	14	7	655.0	486.9	428.4	98.1	70.0
4	BANAT	24	10	14	455.1	204.3	186.5	48.5	202.3
5	JIU	12	11	1	200.0	85.7	68.5	20.3	94.0
6	OLT	44	40	4	1579.5	1443.5	986.1	111.7	24.3
7	ARGEŞ - VEDEA	29	28	1	1113.1	868.2	771.1	206.4	38.5
8	IALOMIȚA	17	17	0	860.4	678.4	562.3	182.0	0.0
9	SIRET	18	18	0	1857.7	1621.7	1256.5	236.0	0.0
10	PRUT - BÂRLAD	33	26	7	1921.6	839.0	591.4	1040.9	41.7
11	DOBROGEA	5	5	0	28.2	15.4	14.7	12.8	0.0
12	DUNĂRE	2	2	0	3900.0	3230.0	250.0	670.0	0.0
TOTAL		**241**	**192**	**49**	**13569.2**	**10179.6**	**5668.3**	**2781.3**	**608.3**

This classification has been made with relevance for the aspects regarding the water resources management, especially the activity of water resources allocation, as well as the floods mitigation capacity by using the flash floods attenuation in lakes particularly designated for this purpose.

Out of the total of **241** important accumulation lakes**,** a number of **192** are permanent accumulations, which have diverse designations, and **49** are non-permanent accumulations, which purpose is to attenuate the flash floods waves.

The max. total capacity of accumulation in these lakes is of **13,57** md sqm, out of which **10,18** md sqm gross volume and **3,39** md sqm attenuation volume. The net / utile volume represents **5,67** md sqm from the gross volume, and the attenuation volume is divided into **0,61** md sqm in non-permanent accumulations and **2,78** md sqm in permanent accumulations equipped with attenuation chunks.

Out of the **241** analyzed accumulations, **103** represent complex accumulations with a max. sum volume of **6.86** md sqm, **15** are accumulations designated to the potable and industrial water supply, with a max. sum volume of **0.12** md sqm, **74** are energetic accumulations with a max. sum volume of **6.10** md sqm and **49** are non-permanent accumulations designated to the attenuation of the flash floods waves, with a max. sum volume of **0.64** md sqm.

Table 2

#	Hydro-graphic (space) basin	Accumulations Total Basin out of which:		Complex Accumulations		Accumulations for water supply		Energetic accum.		Attenuation accum.	
		No.	Vmax (mil sqm)	No.	Vmax (mil sqm)	No.	V max (mil sqm)	No.	Vmax (mil sqm)	No	Vmax (mil sqm)
0	1	2	3	4	5	6	7	8	9	10	11
1	SOMEŞ - TISA	13	522.1	7	181.7	0	0.0	5	333.6	1	6.8
2	CRIŞURI	23	476.5	7	327.4	2	10.7	0	0.0	14	138.4
3	MUREŞ	21	655.0	5	132.3	1	9.5	8	433.2	7	80.0
4	BANAT	24	455.1	9	229.7	0	0.0	1	14.7	14	210.7
5	JIU	12	200.0	1	31.7	2	6.6	8	61.7	1	100.0
6	OLT	44	1579.5	0	0.0	5	48.4	35	1505.9	4	25.2
7	ARGEŞ - VEDEA	29	1113.1	18	1048.7	4	19.9	6	5.8	1	38.7
8	IALOMIŢA	17	860.4	15	855.3	0	0.0	2	5.1	0	0.0
9	SIRET	18	1857.7	8	1761.9	1	21.5	9	74.3	0	0.0
10	PRUT - BÂRLAD	33	1921.6	26	1877.4	0	0.0	0	0.0	7	44.2
11	DOBROGEA	5	28.2	5	28.2	0	0.0	0	0.0	0	0.0
12	DUNĂRE	2	3900.0	0	0.0	0	0.0	2	3900.0	0	0.0
TOTAL		**241**	**13569.2**	**103**	**6798.3**	**15**	**116.6**	**74**	**6010.3**	**49**	**644**

downstream view

upstream view

Vidraru dam and lake *– Argeş river*

At the same time with the accomplishment of the big accumulation lakes, with the main purpose of energetic or complex using, and of the hydro-power centrals, there have been also made the in-taking galleries and their afferent energetic derivations. These are meant to either capitalize on the water falls, or to supplement the water stocks of the lakes. We will mention here the big hydro-energetic complexes developed around the Fântânele and Tarniţa (r. Someşu Cald), Drăgan (r. Drăgan – b.h. Crişuri), Gura Apelor (Râul Mare), Oaşa (r. Sebeş), Valea lui Iovan (r. Cerna), Vidraru (r. Argeş), Vidra (r. Lotru) lakes, the in-takes which converge toward U.H.E. Crăinicel downstream Gozna (r. Bârzava), etc. Most of the debits which flow through these in-takes are then used also for the supply of some water consuming uses.

Another category is represented by the in-takes exclusively designated to the maintaining of the debits for the supply with potable or industrial water of the big urban areas like: Bucureşti, Iaşi, Timişoara, Craiova, Baia Mare, Bacău, Hunedoara, Reşiţa, Târgu Jiu, Zalău, Bârlad, Slobozia, Covasna, Valea Jiului localities, Moineşti-Comăneşti-Oneşti, Botoşani-Dorohoi ocalities and of some industrial complexes, or units of national interest like: C.N.E. Cernavodă, Termocentralele Turceni Rovinari, Işalniţa, etc.

Important derivations which ensure the water for irrigations Derivații are done in Câmpia de Vest, in the Crişuri and Mureş basins, the derivation Ipoteşti in the Olt basin, the derivations from the Argeş river toward the tributaries and from Dâmbovița in Ilfov, derivations from Ialomița toward its tributaries, the derivation from Siret toward Ialomița for the irrigations in Bărăgan through the Siret – Bărăgan canal, through Dunăre – Marea Neagră canal for the irrigations in Carasu system, the canals Dunavăț and Dranov for the irigations in Razelm – Sinoe system, etc.

As derivations of big waters there can also be evidentiated the ones from Câmpia de vest, Derivation Bega-Timiş for the protection of Timişoara town, the derivations for the protection of Bucureştiului: Brezoaiele, Bolovani, Ilfov-Dâmbovița, etc.
A special mentioning it deserves the Dunăre – Marea Neagră canal, which represents an international river naval way, as well as the Sulina (Sulina branch) canal, which, together with Dunărea Unică up to Galați represents the Maritime Dunărea.

Siret – Bărăgan canal

The works to the river banks arrangement done at present in Romania count for a total length of 6656 km, and those of regularization 10063 km.
In the Aquaproiect docs, there are identified for the presentation, as being more representative, a number of **309** hydro-works along rivers, summing up to **8022** km banks arrangement, and **5053** km of river beds regularization, for the whole country. A detailed description of these hydro-works is presented, per hydro-graphical basins, in the doc of reference, from AquaProiect.

5. Quality, accidental spills

Alteration of river water quality is linked by the urban development, too. From the population of Romania of 22.8 million inhabitants, 56 % are living in urban areas and 44% in rural areas. About half of the population of Romania is connected to the sewage system, discharging 57.3 m^3/s waste water. About 46% of this flow of wastewater is treated using mainly activated sludge process.

An analysis of the Romanian surface water quality within 312 sections reveals that about 68% of the total water lengths are of 1st category, about 18.7% are of 2nd category, about 6.3% are of the 3 rd category and about 7% are degraded.

At resent the main difficulties that qualitative water management is facing are:
- presence of nitrates in phreatic water;
- accumulation of heavy metals and organic compounds in sediments;
- high nutrients content (nitrogen, phosphorus) of waste water subjected to the treatment process.

In general, the most important danger of pollution potential in the case of point sources comes from the units belonging to the public utilities, chemical industries, animal-growing industries and commercial enterprises for extraction (including mining) and metallurgic industries.

At the level of Romania, the standard 4706/1998 describes the concentration levels for different chemicals / parameters for three water classes:
- Class I – mostly provided for the water used for drinking water supply, food industry and salmonides waters.
- Class II – for industrial intakes.
- Class III – for the irrigation purposes.

If for one determinant (or classes of determinants) the limits are exceeded, there is considered a “pollution”

At least for the period 1990-2001, not only at the level of Romania, but even in the framework of the Danube River Protection Convention, no provision has been created in order to assess the accidental pollution. In 2001, the AEPWS – EG / ICPDR started to implement the emissions approach based on the Rhine / Elbe Comissions experience. In principle the accidental pollution could be quantified taking into account the type of chemical (R – phrases / Water Risk Class) and discharged quantity, from these two parameters being calculated the W.R.I. (Water Risk Index). However this approach will be presented after the discussions at the level of the experts group.

An inventory (2001) made by the National Administration “Romanian Waters” (ANAR), pointed that during 1992 – 2000 period of time about 600 accidental pollution have been recorded in Romania. Despite of the approximation generated by the lake of quantitative definition (assessment) of accidental pollution up till 2001 when the emission approach has been adopted, the following remarks could be described:

Temporal trends

A general overview of the number of the accidental pollution recorded in Romania time trend is presented in the figure 2.1. it should be noted that this numbers are referring to the total number of the recorded accidents (local accidental pollution with local affects + transboundary accidental pollution generated by Romania or induced into Romania respectively)
- as a general trend two time period could be identified: (i) 1992 – 1997 with the maximum of the level of 1995 (115 accidents) and (ii) 1998 – 2000 with the maximum in 2000.
- If the first interval (i) presents a decrease trend after 1995, for the second one (ii) the general temporal trend is the increase of the number of the accidents.

Specific pollutants

Based on the data presented in the table 3 and fig. 1, the following elements are relevant in order to characterize the involved specific pollutants in the accidents statistics:

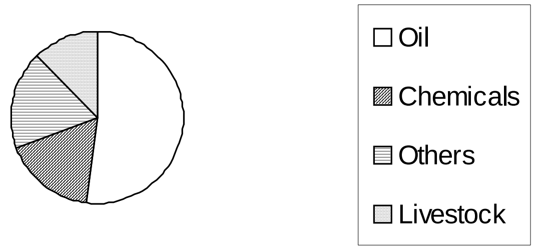
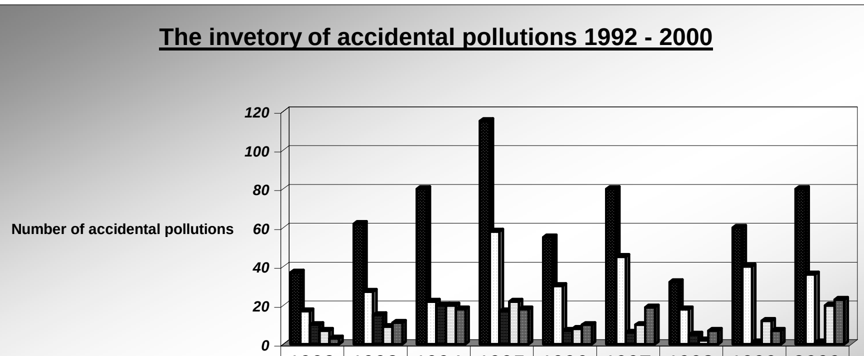


Fig. 1 The weight of different pollutants involved in accidental pollution

Table 3

Year	*Total number*	*Oil*		*Livestock*		*Chemicals*		*Others*
		Number	*%*	*Number*	*%*	*Number*	*%*	*(number)*
1992	37	17	45.9	10	27	7	18.9	3
1993	62	27	43.5	15	24.2	9	14.5	11
1994	80	22	27.5	20	25	20	25	18
1995	115	58	50.4	17	14.8	22	1.7	18
1996	55	30	54.5	7	12.7	8	14.5	10
1997	80	45	56.2	6	7.5	10	12.5	19
1998	32	18	56.2	5	15.6	2	6.2	7
1999	60	40	66.7	1	1.7	12	20	7
2000	80	36	45	1	1.2	20	25	23
TOTAL	**601**	**293**	**-**	**82**	**-**	**110**	**-**	**116**
%	**100**	**48.8**	**-**	**13.6**	**-**	**18.3**	**-**	**19.3**

Figure2



	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total	37	62	80	115	55	80	32	60	80
Oil	17	27	22	58	30	45	18	40	36
Livestock	10	15	20	17	7	6	5	1	1
Chemicals	7	9	20	22	8	10	2	12	20
Others	3	11	18	18	10	19	7	7	23

- As an overall the oil represents the most frequent pollutant recorded in the accidents, the weight being average 48.8%. The maximum weight 66.7% has been recorded in 1999 and the minimum 27.5% in 1994. However, with a few exceptions the average weight is 55% for the all period of time. One explanation in the fact that oil accidental pollution could be easy detected in comparison with other chemicals.
- On the second place are situated other chemicals (as detergents, phenols, etc.) with an average weight of 18.3%, the maximum values being recorded in 1994 (25%) and 2000 (25%).
- The accidental pollution created by livestock, with an average weight of 13.6% presents a continuous decrease from 27% (1992) to 1.2% (2000) as a consequence of decline on this field of activity in Romania in the last period of time.
- Other causes (pollutants), sometimes unidentified pollutants have a significant weight (19.3%) with a maximum recorded in 2000 (23%).

Operational information from AEWS Danube

As was already pointed since May 1997 an operative system AEWS Danube is operating. The table 2.2 presents an overview of the recorded accidental pollution.

Temporal trends

For the period 1997 – 2001 AEWS Danube has recorded 25 accidental pollution.

- There is obvious an increasing time trend from 2 accidents detected in 1997 to 8 accidents recorded in 2000;
- Practically the same time trend is related with the transboundary effects with above-mentioned accidental pollution. With an average weight of 47% the transboundary impact increased from 0% in 1997 to 25% in 1998, 80% in 1999 and 75% in 2000.

Specific pollutants

The AEWS system information flow, consider 2 main conditions for sending a message:

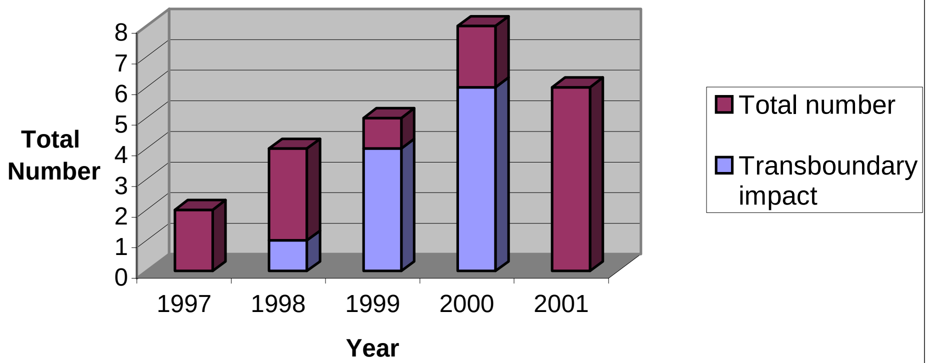
- the accidental pollution is known (source, pollutant, quantity) at the beginning;
- the accidental pollution is detected but there are not (yet) information concerning the type and quantity of pollutant

Based on the data presented in the table 4 and figure 3 the following elements could be pointed in order to characterize the weight of different pollutants involved in the recorded accidents.

Table 4

Year	*Total recorded accidental pollution*	*Transboundary impact*	*Pollutant (s)*	*Received / generated by Romania*	
1997	2	-	Oils (1) Salts (1)	Affected -	Generated -
1998	4	1	Oils (3) Pesticides (1)	-	-
1999	5	4	Oils (3) Phenols (1) Detergents (1)	1 Danube detergents	1 Crisul Repede oils
2000	8	6	Oils (2) Cyanides (1) Heavy metals (1) Ammonium (1) Others (3)	-	3 - CN^- Baia Mare Somes - Heavy metals Sasar, Tisa - Crasna (color)
2001	6	-	Oils (2) Others (2)	-	-
Total	**25**	**11**	**Oils (13) – 52%** **Salts (1)** **Pesticides (1)** **Phenols (1)** **Detergents (1)** **Cyanides (1)** **Heavy metals (1)** **Ammonium (1)** **Others (5) – 20%**	**5** **1**	**4**

Fig. 3 - Time trend of accidental pollution number recorde by AEWS Danube



- The accidental pollution with oil represents an average more than 50%, the maximum being recorded in 1999 (60%).
- Unknown causes (chemicals) have a consistent weight (an average of 20%).
- Other chemicals (phenols, pesticides, cyanides, etc.) together have a weight of about 30%.

It should be underlined that all of this % (weights) are related with a number of incidents and not with magnitude / consequence of different accidental pollution.

A comparison between international / national data concerning accidental pollution.

Table 5 presents a comparison between recorded (total) accidental pollution at the level of Romania and statistics of the AEWS during 1997 – 2000.

Table 5 – An evaluation of local / transboundary accidental pollution - Romania

Year	*Total accidental pollution recorded in Romania*	*Total at the level of AEWS*	*Transboundary*		*Romania local accidental pollution*	
			Induced in Romania	**Generated by Romania**	**number**	**%**
1997	80	3	-	-	80	100
1998	32	4	-	-	32	100
1999	60	5	1	1	58	96.7
2000	80	8	-	3	77	96.2
Total	**252**	**20**	**1**	**4**	**247**	**98**

Based on this the following remarks could be given:

Local / transboundary accidental pollution

In the manual (international) of the AEWS Danube an accidental pollution is considered a sudden an unpredictable change in the water characteristics. This narrative definition do not permit any quantification between chronic pollution and accidental pollution.

Based on the data presented in the table 2.5 it is obvious that the local (generated and with effects) accidental pollution in Romania have more than 95% weight. However this value is based on the statistical approach of the accidents number and not based on the magnitude / consequences of these.

Ecological Status of the Romanian Rivers

In Romania, the biomonitoring activity is an integrated part of the complex monitoring of water quality and is made by Water Authority (Apele Romane) and National Research and Development Institute for Environmental Protection (ICIM) – Water Quality Department, under the jurisdiction of Ministry of Water and Environmental Protection.

This specific activity is performed systematically and periodically at local and national scale in order to obtains the main elements regarding water quality and decision-making.

The territorial hydrobiology laboratories of Water Authorities and ICIM too survey approx. 200 watercourses with approx. 410 control sections, representing data from 15 basins, including Danube basin.

The biomonitoring of river water quality is based upon the analysis of qualitative and quantitative composition of the main biotic aquatic communities, benthic macro invertebrates completed with phytoplankton and zooplankton. According with European Water Framework Directive the phytobenthos has been studied experimentally since 2001. Until now, communities like macrophytes and fishes have been studied for scientific reasons.

The biological variables include: composition of different biotic communities (taxa), numerical density (no/m 2 or no/dm^3) and biomass (mg/m^2 or mg/dm^3). There are taken in consideration: the changes in the natural structure of the biocenoses, the changes in the ratios between different trophic levels, simplification of the biocenoses structures, disappearance of some links in the trophic chains, restoration of the specific biodiversity, illustrated by ecological considerations in unaffected and anthropic impact areas along the water courses. Determination of chlorophyll "a" is possible in ICIM and in few territorial laboratories only.
The biological samples on the rivers are sampled seasonally in the same time with some physical-chemical samples and almost in the same place. The sampling and analysis techniques are connected with biotope and community type. For macroinvertebrate community, considering the substrate (stone, sand, mud, vegetable banks, large and fast watercourses) we used different types of dredges (grab, a dredge with net) and handnet. The artificial substrates are experimented successfully in Romania.

There is not a biological standard for surface water quality except some ISO standards regarding macroinvertebrates sampling methods or analysis of chlorophyll "a" already adopted, but for all hydrolabs network there are the same guidelines (norms) for hydrobiological analyses elaborated in 80’s by ICIM. All territorial hydrolaboratories use these guidelines. Phytoplankton biomass is standardized and is used for classification the water quality, the lakes especially, into trophic zones.

The Romanian guidelines for the assessment of the water quality with biological analyses refers to sampling stations, the frequency of biological analyses, description of sampling field equipment for plankton, macroinvertebrates, microbenthos and macrophytes, sampling and processing of plankton samples, sampling, processing and sorting of macrobenthos, microbenthos samples, sampling and analyze of macroflora samples, lists with bioindicators and volumetrically values of phytoplankton and zooplankton species, description of different biological method for assessment of water quality, some ecological considerations, data processing and interpretation, case studies etc.

Usually, the methods used in Romania for river water quality assessment is: Knopp method, determination of the relative cleanliness condition, in correlation with Szabo relation and Pantle Buck method. Occasionally, are used other methods like: species deficit method (Kothe), saprobic valence method (Zelinka-Marvan).

The above-mentioned methods are based upon the use of “Saprobes system” which meets a complex of bioindicator species. According to this system the species included are grouped in 4 categories, corresponding to 4 degrees of saprobity or classes: oligosaprobic (o) (1 st), beta-mesosaprobic (β) (2 nd), alfa-mesosaprobic (α) (3 rd) and polisaprobic (p) (4 th).

The determinations are for the species, genus or family level. For species determinations, catalogues, taxonomic works and other scientifically works are used (e.g. Romania’s Fauna, European literature). In the same time, specialists from Universities, Museums and Biology Institutes are consulted, in order to verify the results.

The list with the bioindicators and their saprobic values is the Liebmann’s with Sladecek changes. Some species were included after own investigations. For macroinvertebrates we already used a recommended list by ICPDR (International Commission for Protection of Danube River) with more than 1600 species. A list of 33 fish species as an indicator of water quality is used to characterize the water from very clean to polluted water.

The relative cleanliness degree (C%) and saprobic index respectively (S) are calculated for routine biomonitoring based upon the macroinvertebrates and phytoplankton structure according to Knopp and Pantle Buck methods. These two determinants are calculated because comprise a basis for biological water quality evaluation.

Knopp and Pantle Buck methods give us the possibility to classify the running waters into 4 main zones, levels or classes: oligosaprobic (1 st), beta-mesosaprobic (2 nd), alfa-mesosaprobic (3 rd) and polisaprobic (4 th) respectively. The 3 intermediate zones could be described also.

For graphical representations we used colours according with the different 4 saprobic zones or classes:
oligosaprobic zone (o) - blue
beta-mesosaprobic zone (β) - green
alfa-mesosaprobic zone (α) - yellow
polisaprobic zone (p) - red

For the intermediate zones there are used the two colors both of principal zones.

Usually, the frequency of the biological analyses for rivers is seasonally (trimestrial) and in special situation (like accidental pollution, fish mortality etc). In a few situations, when the water is important for human water supplies, for example, there is a monthly frequency. In the same time with the framing in the saprobity zones or classes suggested by the bioindicators presence, another aspects may be considered: possible secondary biological process determined by pollution or leading to pollution, such as: water blooming, massive bacteria and fungi growth and biological effects generated by specific toxic pollutants which may produce: depopulation, flora and fauna extermination of a certain river sector and mortality of the fish. At the each section there are investigated first of all the left and the right bank and if it is possible the watercourse. It is noteworthy to mentioned that there are investigated different types of biotopes in order to evaluate the variety of taxa and realize a correctly assessment of water quality.

The assessed biological observations are connected with a series of characteristics of some quality chemical parameters: oxygen content, oxygen saturation, BOD, COD (organic substances), biogenic elements (nitrogen and phosphorus), some toxic components, bacterial charge degree. In the sampling moment are collected different data about water depth and width water, current speed, substrate type, riverine vegetation, aquatic macrophytes vegetation, substrate algal cover, algal blooming, bacteria and fungi presence, the bottom of stones, riverine activities, anthropic impact, weather etc.

For Danube river, the biological water quality monitoring includes the survey of the benthonic and the planktonic community's evolution dynamics. ICIM and the territorial

Water Authorities perform the determinations regarding Danube water quality. Researches are based on biological material monthly and seasonally sampled according to the methodology established for Danube water quality study, i.e. average samples for left bank, right bank, middle water course in the same time with the physical-chemical analyses for national and international interest control sections. The analytical data are considered in respect to trophic and saprobic characterization of water. Thus, the qualitative (composition of flora and fauna) and quantitative (abundance) are surveyed. The saprobic structure of macrozoobenthos and planktonic communities (especially phytoplankton) is also analyzed, determining the pollution degree of the river with bioindicators for water quality, using the Pantle Buck method, in the same time with Knopp method. The saprobic index determined frames the water in saprobity zones or classes.

The whole Danube river, the Danube Delta, the Iron Gate Lake are also studied and monitored in different scientifically programs by the next institutes: Biology Institute from Bucharest, National Research and Development Institute for Danube Delta from Tulcea, Bucharest University - Faculty of Biology, including Research Center for Biology from Braila.

The water quality monitoring through biological analyses is based on data and information collected, stored and processed by informational flow. The registration and record of the information is the annual synthesis on water quality protection, made on hydrographic basins and on national scale, which includes biological data.

All the data produced within the water quality monitoring in the field or/and in laboratories are collected at the zonal level of Water Authority and ICIM and than in accordance with the planned deadlines or at special request are reported, according with an operational procedure, to the central level where the National Report is produced annually.

Short description of rivers' ecological status

Depending of abiotic conditions the Romanian rivers are populated with different biotic communities, flora and fauna, producers and consumers. Lists with characteristic and representative forms are given below for different kind of watercourses. The data are from monitoring observations and from literature.
a.Rivers (watercourses) with:
- boulders and stones substrate
- high velocity of the water (2,3 – 4 m/s)
- relatively low flow
- clear water
- oxygen saturation (9,4 – 10 mgO2/l)
- relatively constant and cold temperature; small fluctuations (7 – 10^0C);
maximum temperature: 17 – 18^0C

b.Rivers (watercourses) with:
- boulders and stones substrate
- high velocity of the water (2,3 – 4 m/s)
- relatively low flow
- clear water
- oxygen saturation (9,4 – 10 mgO2/l)
- relatively constant and cold temperature; small fluctuations (7 – 10^0C);
maximum temperature: 17 – 18^0C

• ***Phytoplankton/ Phytobenthos***
Diatoma hiemale
Achnantes sp.
Synedra sp.
Cymbella sp.
Gomphonema sp.
Cladophora sp.
Oedogonium sp.
Batracospermum sp.

Nostoc sp.
Lyngbya sp.
Rivularia sp.
• *Macrophytes*
Fontinalis sp.
Callitriche sp.
Veronica sp.
• *Macroinvertebrates*
-Perlidae, Perlodidae, Leuctridae, Chloroperlidae, Capniidae, Taniopterygidae
-Heptageniidae, Ephemeridae, Potamanthidae, Palingeniidae, Leptophlebiidae, Siphlonuridae
-Sericostomadidae, Goeridae, Phryganeidae, Beraidae, Leptoceridae, Lepidostomatidae, Brachicentridae
-Blephariciidae, Athericidae
-Ancylidae, Acroloxidae
-Planariidae •
Ihtiofauna
Salmo trutta fario
Salmo gairdneri irideus
Hucho hucho
Romanichthys valsanicola
Salvenilus fontinalis
Phoxinus phoxinus
Cottus gobio
Coregonus lavaretus marenoides

c.Rivers with:
- stones, gravel and sand substrate
- high velocity of water (2,3 m/s)
- different flows
- maximum temperature: 22^0C; high fluctuations (18 – 19^0C)
- oxygen saturation (9,28 mg O2/l)

• *Phytoplankton/ Phytobenthos*
Ceratoneis arcus
Diatoma hiemale
Diatoma vulgare
Cocconeis pediculus
Synedra ulna
Lemanea fluviatilis
Hildebrandia rivularis
Ulothrix zonata
Cladophora glomerata
Vaucheria sessilis
Macrophytes
Fontinalis antipyretica
Chilosciphus rivularis
Rhyncostegium rusciforme
Callitriche sp.
Myriophyllum sp.
Potamogeton sp.

Spharganium sp.
Butomus umbelatus
• *Macroinvertebrates*
-Nemouridae
-Ephemerellidae, Oligoneuriidae, Potamanthidae
-Rhyacophilidae, Glossosomatidae, Hydroptilidae, Polycentropidae, Psychomyidae, Brachycentridae, Limnephilidae
-Blephariciidae, Athericidae
-Ancylidae, Acroloxidae
-Planariidae, Dendrocoelidae, Dugesiidae
-Hydropsychidae
• *Ihtiofauna*
Thymallus thymallus
Phoxinus phoxinus
Leuciscus cephalus
Leuciscus souffia agassizi
Alburnoides bipunctatus
Gobio uranoscopus
Barbus meridionalis
Cobitis romanica
Cottus gobio gobio
Cottus peocilopus
Noemacheilus barbatulus

d.Rivers with:
- sandy, muddy substrate
- maximum 2,3 m/s water velocity
- different flows
- maximum temperature (25^0C); huge thermic oscillations
- oxygen saturation max. 9,2 mg O2/l

• *Phytoplankton/ Phytobenthos*
Cyclotella comta
Melosira varians
Fragilaria crotonensis
Navicula sp.
Cymbella ventricosa
Nitzschia linearis
Phacus caudatus
Diatoma vulgare
Cymatopleura solea
• *Macrophytes*
Elodea canadensis
Callitriche stagnalis
Sparganium simplex
Scirpus lacustris
Potamogeton densus
Sium angustifolium
• *Macroinvertebrates*
-Hydropsychidae
-Baetidae, Caenidae

-Collembola
-Calopterygidae, Lestidae, Platycnemididae, Coenagrionidae, Cordulegasteridae, Aeschnidae, Gomphidae, Corduliidae, Libellulidae
-Piscicolidae, Hirudinidae, Erpobdellidae, Glossiphoniidae
-Hydrometridae, Gerridae, Hebridae, Veliidae, Mesovelidae, Nepidae, Pleidae, Notonectidae
-Asselidae, Gammaridae, Corophiidae, Mysidacee
-Tipulidae, Ceratopogonidae, Chironomidae
-Physidae, Limnaeidae, Planorbidae, Viviparidae, Valvatidae, Bithyniidae, Melonopsidae, Bythinellidae, Lithoglyphidae
-Dreissenidae, Sphaeriidae
-Gordiidae
-Helodidae, Gyrinidae, Dytiscidae, Haliplidae, Hydrophilidae
-Aeolosomatidae, Lumbriculidae, Tubificidae
• *Ihtiofauna*
Chondrostoma nassus
Gobio uranoscopus
Cobitis elongata
Cobitis aurata
Cobitis romanica
Barbus barbus
Cobitis taenia
Gobio kessleri
Esox lucius
Rutilus rutilus
Leuciscus leuciscus
Leuciscus cephalus
Alburnus alburnus
Rhodeus sericeus
Gobio gobio
Lepomis gibbosus
Aspius aspius aspius
Alburnoides bipunctatus
Silurus glanis
Cottus gobio gobio

e. Rivers with:
- sandy and muddy substrate
- low water velocity (0,3 - 1,5 m/s)
- high fluctuant flow
- high turbidity
- 20^0C minimum temperature
    - aprox. 9 mg O2/l oxygen saturation

• *Phytoplankton/ Phytobenthos*
Cladophora sp.
Melosira sp.
Cyclotella sp.
Pediastrum sp.
Scenedesmus sp.
Closterium sp.

Eudorina sp.
Microcystis sp.
Anabaena sp.
Aphanizomenon sp.
Ceratium sp.
Peridinium sp.

• ***Macrophytes***
Callitriche hamulata
Myriophyllum alternifolorum
Sium erectum submersum
Veronica anagalis aquatica
Ranunculus fluitans
Ranunculus circinatus
Ranunculus trichophyllus
Zannichellia palustris
Potamogeton sp.
Glyceria maxima
Phragmites australis
Nymphea alba
Caltha palustris
Elodea canadensis
• *Macroinvertebrates*
-Asselidae, Gammaridae, Corophiidae, Mysidacee
-Baetidae (g. Cloeon)
-Tipulidae, Ceratopogonidae
-Calopterygidae, Lestidae, Platycnemididae, Coenagrionidae, Cordulegasteridae, Aeschnidae, Gomphidae, Corduliidae, Libellulidae
-Piscicolidae, Hirudinidae, Erpobdellidae, Glossiphoniidae
-Hydrometridae, Gerridae, Hebridae, Veliidae, Mesovelidae, Nepidae, Pleidae, Notonectidae
-Physidae, Limnaeidae, Planorbidae, Viviparidae, Valvatidae, Bithyniidae, Melonopsidae, Bythinellidae, Lithoglyphidae
-Dreissenidae, Sphaeriidae
-Gordiidae
-Helodidae, Gyrinidae, Dytiscidae, Haliplidae, Hydrophilidae
-Aeolosomatidae
- *-Psychomidae, Stratiomydae, Rhagionidae, Chaoboridae, Culicidae, Tabanidae,*

-Lumbricidae -Naididae -Mermithidae
-Ephydridae, Thaumaleidae, Chironomidae
-Syrphidae -Tubificidae
• *Ihtiofauna*
Cyprinus carpio
Perca fluviatilis
Leuciscus cephalus
Rutilus rutilus carphathorossicus
Rhodeus sericeus
Cobitis taenia
Gobio gobio

Gobio albipinatus
Esox lucius
Carassius carassius
Carassius auratus
Alosa pontica
Acipenser ruthenus
Acipenser nudiventris
Acipenser stellatus
Acipenser guldenstaedti colchicus
Huso huso
Clupeonella cultrivestris
Leuciscus idus idus
Tinca tinca
Scardinius sp.
Aspius aspius aspius
Alburnus alburnus
Abramis brama
Abramis balerus
Vimba vimba
Pelecus cultratus
Misgurnus fossilis
Silurus glanis
Pungitius platigaster
Lepomis gibbosus
Acerina cernua
Stezostedion lucioperca
Aspro zingel etc

Because of anthropic impacts the natural abiotic and biotic conditions are disturbed along many rivers in Romania. The routine monitoring shows that only upper and very upper sections of almost all rivers are unaffected and in natural conditions, characterizing the oligosaprobic zone such as: Somes Mare river in the upper section, Bistrita river until Colibita reservoir, Cerna river until Cincis (Teliuc) reservoir, Arges river until Vidraru reservoir, Jiu river and its tributaries until human activities etc. Tisa River seems to be in oligosaprobic conditions in Romania even its tributaries are affected by different impacts. Due to the self-purification process and to the border with Ukraine the biotic communities are not affected.

A lot of rivers or sections of the rivers are in oligo-beta-mesosaprobic conditions such as: Bistrita river until Izvorul Muntelui reservoir, Suhariver, tributary of Moldovita river, Suceava river until confluence with Sucevita, Putna river until upstream Focsani, Ialomita river until Targoviste, Dambovita river until Vacaresti reservoir, Mures river and almost all its tributaries in the upper sections and so on.

The Danube river, Prut river until Jijia confluence, Moldovita river until confluence with Ozana, Siret river till confluence with Cracau, the upper section of Trotus river, the upper section of Buzau river and its tributaries until Buzau town, Calmatui river, Arges river and some of its tributaries (Argesel, Valsan, Doamnei) until Bucharest, Olt river until Miercurea Ciuc town and in some sections, including downstream Slatina and some of its tributaries (upper section of Raul Negru, Hartibaciu, Cibin downstream Gura Raului reservoir, Lotru river downstream Vioneasa tourist area, Topolog river, Oltet river), Cerna river, Nera river, Timis river until confluence with Vena Mare, Bega river until Timisoara, Mures river until Targu Mures town and downstream confluence with Niraj till border and some of its tributaries (Tarnava Mica, Tarnava Mare, sections of Aries, Strei etc.), Cris rivers, except Crisul Repede downstream Oradea town, Somes river until Cluj town and then in some downstream sections, tributaries of Tisa river (Viseu, Iza) are beta-mesosabrobic according to biota analyses.

The following sections of the rivers are in beta-alfa-mesosaprobic conditions: Baseu river, Prut river downstream confluence with Jijia, sections of Bahlui river, Oituz and Casin rivers, Buzau river downstream Buzau town, Ialomita river and it tributary Prahova river almost along whole their stretch, some tributaries of Arges river (Sabar, Neajlov, Dambovnic), Arges river after confluence with Najlov, Vedea river almost along whole it reach, Olt river between Sfantu Gheorghe and Slatina, Ampoi river, Abrud river, Mures river downstream Targu Mures town, Bistrita river downstream Bistrita town, Bega river downstream Timisoara city, Crisul Repede downstream Oradea, Fizer river, sections of Somes, Barcau and Crasna rivers.

Alfa-mesosaprobic conditions are along Jijia river and it tributary Miletin, some sections of Bahlui river, Barlad river in Barlad town area, Siret river downstream Bacau until confluence with the Danube, Putna river downstream Focsani town, Somes river downstream Cluj until confluence with Somesul Mare.

Some sections of the rivers Sitna, Miletin, Bistrita upstream Siret confluence, Trotus upstream confluence with Siret have alfa-meso-polisaprobic waters, while Jijia river downstream Iasi till confluence with Prut, Barlad river downstream Vaslui town until upstream Barlad town and then upstream confluence with Siret river, Arges river downstream confluence with Dambovita river, Olt river in a section upstream Sfantu Gheorghe, Cibin river for a short section downstream Sibiu town, Jiu river upstream and downstream Craiova town, Sasar river have poli-saprobic waters.

Case studies

• Along the Romanian stretch of the **Danub**e, different ***phytoplanktonic*** systematic groups (i.e. *Cyanobacteria, Bacillariophyta, Euglenophyta* and *Chlorophyt*a) and taxa are identified. Algae from *Bacillariophyta* and *Chlorophyta* groups and *Asterionella formos*a, *Melosira granulata, Synedra sp., Cyclotella sp., Scenedesmus quadricauda Oscillatoria sp.,* are very common. The number of taxa differs from sampling section to sampling section. Using phytoplanktonic biomass, the trophic potential of the Danube river water can be evaluated.

Using bioindicator forms and the Pantle Buck method, the Danube river water quality may be framed in the beta-mesosaprobic limits. For very short sections the Danube water quality could be alfa-mesosaprobic.

The phytoplankton communities are controlled by ***zooplankto***n. The zooplankton communities were composed usually from the following groups: *Rhizopoda, Ciliata, Rotifera, Copepoda* and *Cladocer*a. *Dreissena* larvae (Bivalvia) are identified in some sections.

The *Ciliata, Rotifera* and *Copepoda* species are observed along whole river. Rotifera, filtrators forms, dominates the zooplankton especially. The crustaceans, elements with high trophic degree, are found almost in all sections, some of them like juveniles. Few common species are to be mentioned: *Brachionus calyciflorus, Brachionus angularis, Brachionus diversicornis, Keratella cochlearis, Keratella ticinensis, Keratella quadrata, Eucyclops serrulatus, Macrocyclops sp., Bosmina coregoni, Ceriodaphnia reticulata, Vorticellidae, Difflugia sp., Dreissena polymorpha* (larvae) etc.

The presence of ***macroinvertebrates*** fauna illustrates the variation of the abiotic factors in watercourses and reservoirs. The macroinvertebrates communities structure depends on water velocity, flow direction, type of substrate, depth of the water, human impact. The structure, function and dynamics of animal communities have always been strictly dependent on the Danube's hydrology and hydrochemistry, as well as on its interaction with human activities.

Along Romanian stretch of the Danube could be identified taxa belonging to different invertebrates groups: *Porifera, Nematoda, Gasteropoda, Bivalvia, Polychaeta, Oligochaeta, Hirudinea, Acari, Isopoda, Amphipoda, Decapoda, Mysidacea, Ostracoda, Ephemeroptera, Odonata, Heteroptera, Coleoptera, Diptera, Trichoptera, Bryozoa.*

Animal groups such as *Gasteropoda, Bivalvia, Oligochaeta, Chironomidae* and *Amphipoda (Gammaridae* and *Corophiida*e) are identified in all sampling sites. Forms such as: *Lithoglyphus naticoides, Dreissena polymorpha, Corbicula sp., Oligochaeta sp., Corophium curvispinum, Dikerogammarus villosus, Dikerogammarus haemobaphes, Chironomidae* are identified in most of the sampling sections. Other taxa could appeared only in one or two sections, e.g. *Heptagenia coerulans, Sigara sp., Plumatella repens, Valvata piscinalis, Bithynia tentaculata, Chironomus plumosus, Setodes punctatus, Asellus aquaticus, Erpobdella octoculata, Nais communis, Synurella ambulans etc.*

The mollusc, both gasteropods and bivalves, are very good represented along all Romanian stretch.

The macro invertebrates benthic fauna is dominated by tolerant organisms to organic loading and to pollutant accumulations.

According to the existing data, it has been established that the Danube river water quality may be framed in the beta-mesosaprobic limits.

• The **Olt** River and some of its tributaries (Cibin, Lotru, Latorita) were monitored in order to assess the influence of the abiotic factors dynamics and human impacts on the structure of ***macroinvertebrates*** communities. Olt River is one of the main rivers in Romania, with a length of 670 km. It collects waters from a 24.010 km 2 catchments area. Of its numerous tributaries, Cibin and Lotru rivers were studied (Cibin - 80,3 km, Lotru - 76,6 km). The Olt River is studied along the stretch between Cibin confluence and Lotru confluence.

Olt and its tributaries are affected by anthropic impact under different forms:

hydrotechnic works, supplement of water flows, excavations of water beds, diffuse and point pollution sources due to industry, agriculture, transports, tourism, urbanization, deforestation etc. Human impact influences the structure of biotic communities as well, including the benthic macroinvertebrates.

The richness of taxa varies spatially in rivers, depending to anthropic impact (hydrotechnic works, agricultural activities, municipal wastewater discharges etc.), abiotic conditions (substrate, water speed, oxygenation, process of sedimentation etc.).

On Cibin River, the number of taxa has decreases rapidly in section Gura Raului-Sibiu due to anthropic impact. Before the Olt confluence, Cibin River receives the clean waters of its tributary, Sadu River, despite its location downstream Sibiu city, which is considered a major pollution source. Also, due to abiotic conditions the increase of taxa number is observed in the section upstream Olt confluence.

The taxa richness of macro invertebrate's communities registers, also, a spatial variation from upstream to downstream on the studied rivers, under the influence of abiotic conditions and of anthropic impact.

Stoneflies and mayflies are the prevailing forms in the reference sampling station on Cibin River. The mayflies and flies prevailed in the section upstream the Olt confluence.

On Lotru river, the composition of macro invertebrate's communities from the benthic compartment includes: prevailing mayflies, cadet-flies, and stoneflies. Taxa richness is changing downstream, before Olt confluence, by disappearance of stoneflies and cadet-flies.

Mayflies prevailed on Latorita River. On Olt River, in the studied reach, cadet-flies, leeches and flies prevailed. Generally, taxa richness was lower than in other studied rivers. Due to the influence of Lotru waters, the quality of Olt river water was slightly improved downstream the confluence of the two rivers.
Some identified taxa: *Perla marginata, Isoperla rivulorum, Isogenus nubecula, Protonemura praecox, Rhabdiopteryx alpina, Ephemerella ignita, Ecdyonurus venosus,*
Baetis sinaicus, Baetis rhodani, Ephemerella ignita, Leptophlebia sp., Paraleptophlebia
*sp., Oligoneuriella sp., Caenis macrur*a.

In order to illustrate the saprobity degree using bioindicators, the saprobic index (S) was calculated with the method Pantle-Buck. Thus, on Cibin river the values of saprobic index vary in the oligo-beta-mesosaprobic limits. On Lotru River, the values of the saprobic index decreases slowly from upstream to downstream (S = 1,3 – 1,9; oligo-beta-mesosaprobity). On Olt River, the water quality improved after the confluence with Lotru River (beta-mesosaprobity). In Latorita River the macroinvertebrate communities indicate beta-mesosaprobic conditions.

The variation of abiotic factors and human impact influenced the content of the benthic macro invertebrate's communities in the studied watercourses of the Olt river basin. The analyses of the obtained data showed the depreciation of the water quality of Cibin River upstream to downstream and the partial recovery of the biotope conditions upstream the confluence with Olt River, influencing the number and richness of taxa. On Lotru River, the life conditions for macro invertebrates are slowly disturbed upstream to downstream direction. Lotru river water influenced positively the quality of Olt river water, which is reflected over the associations of benthic communities.

• Development of social-economical system produced important impairments over the environment. The complex engineering of **Arges** River, chain dams building and reservoirs respectively, have permitted to produce power, to control the flows, to ensure domestic and industrial water consumption, to develop different leisure activities etc.

All aquatic ecosystems along Arges River are affected by direct or indirect pollution, due to the human activities in the area (agriculture, industry, tourism, localities etc.). During the development of the riparian localities, the anthropic factors became more important and the water resources were used more intensely for different uses. During '60-'80 period, many reservoirs were built along the Arges river: Vidraru, Olesti, Curtea de Arges, Zigoneni, Valcele, Budeasa, Golesti etc. The engineering of the Arges was made to capitalize the hydropower potential of the water river, to mitigate the high floods, to ensure water quantities for drinking and industrial supplies of cities like Bucharest and Pitesti.

Comparing to natural status, the dams building modified the hydrological balance. The chain-placed reservoirs determined many undesirable phenomena such as silting, algal blooms, nutrients and heavy metals sediment accumulation, all of these with results about water quality and aquatic biota.
Dams building, regularization of river sections, addition of water flows from other resources were some alterations of natural conditions. The biotope and biocenoses were drastic modified due to the anthropic impact. The running water biotopes *(loti*c) were replaced by stagnant water biotopes *(lenti*c); the benthic biocenosis, the most important in river, declined; the planktonic biocenosis increased.

Along the Arges river there are few sections with natural conditions (upper course), where the biocenoses structure is unspoiled or just a bit modified by perturbation factors (oligo-sapobic zone); on mountain and hill areas, few sections are moderately deteriorated (beta-mesosaprobic zone); few sections are very polluted on lower area, mainly after confluence with the Dambovita river (polisaprobic zone).
Into unpolluted or little altered zones, the biocenoses have a complex structure with a relative great number of plant and animal populations, making up the reserve of the river biodiversity. In these sections, over 80 ***phytoplanktonic*** algae ***species*** *(Cyanophyta, Bacillariophyta, Euglenophyta, Chlorophyt*a; diatoms prevailing) and over 50 ***zooplanktonic*** and zoobentonic species were identified.
Depending on the substrate type, the ***macroinvertebrates fauna*** comprises many groups; the most representative are: *Turbellaria, Hirudinea, Oligochaeta, Gasteropoda, Insecta (Ephemeroptera, Plecoptera, Trichoptera, Odonata, Diptera), Bryozo*a.

Upstream Dambovita confluence, the Arges river fauna is typical for running waters, where the insect's larvae are prevalent (90%), while *Tubificidae* are 8% and *Gasteropoda* are 2% from all present forms.

Biocenoses are total or partial impaired in the polluted sections such as downstream confluence with Dambovita River, where plant and animal organisms were not identified. Dambovita River intercepts domestic and industrial wastewaters from Bucharest. The wastewaters disturb the ecological balance, with biological devastation phenomenon. The flow of the Arges in the Danube determines alteration of the water river quality in the confluence area and negative changes of planktonic and benthic biocenoses downstream.

Due to the presence of reservoirs, the river's natural ecosystem was replaced and broke up during a short period. Setting up of reservoirs modified hydrological, chemical, biological characteristics of the water in the new ecosystems.

•**Tisa** River is border between Romania and Ukraine. Some tributaries from Romania are affected by different human impacts. Tisa itself is not directly polluted except some domestic and agricultural activities from riparians.
The river is monitored in 2 sections usually. The stony substrate, very oxygenated water, fast flow, little organic load are the main characteristic of the abiotic conditions.

Both sections have the similar biotic conditions regarding the representatives. The ***macroinvertebrates*** communities include organisms from different groups: Hirudinea, Crustacea, Ephemeroptera, Plecoptera, Trichoptera, and Diptera. The most common taxa are: *Glossiphonia complanata, Gammarus fossarum, Ecdyonurus fluminum, Heptagenia sulphurea, Rhitrogena semicolorata, Oligoneuriella rhenana, Baetis rhodani, Ephemerella ignita, Perlodes microcephala, Perla bipunctata, Perla marginata, Isoperla grammatica, Taeniopterix seticornis, Hydropsyche lepida, Rhyacophila nubila, Stenophylax stellatu*s. Using the mentioned bioindicators the cleanliness degree calculated with Knopp method is in the oligosaprobic or oligo-beta-mesosaprobic limits (95 – 98%).

A tributary of Tisa – Viseu and itself tributary – Vaser according to composition of macroinvertebrates communities are in beta-mesosaprobic conditions. Species such as: *Ecdyonurus venosus, Ephemerella ignita, Baetis rhodani, Isoperla grammatica, Perlodes microcephala, Isogenus sp., Rhyacophila dorsalis, Silo nigricornis, Hydropsyche pellucidula, Stenophylax sp., Helmis mengei, Blepharocerca fasciata, Gammarus fossarum* are very common. The cleanliness degree varies near 90% value characterizing the beta-mesosaprobic zone.

The ***phytoplanktonic communities*** are comprise in diatoms and green algae with common taxa such as: *Meridion circulare, Cymbella cistula, Ceratoneis arcus var. amphioxys, Synedra acus var. angustissima, Neidium productum, Frustulia vulgaris, Tabellaria flocculosa, Oedogonium capillare, Ulothrix zonata, Staurastrum punctulatum, Closterium lunul*a. The values of quantitative parameters are low. The phytoplanktonic biomass shows the oligotrophic status of the water. Using the phytoplankton bioindicators and Knopp method the cleanliness degree is almost 95 – 96 %, characterizing the oligo-beta-mesosaprobic zones.

The ***zooplankton*** is poor regarding richness of the taxa. Only few species of ciliates and rotifers are identified usually such as: *Colurella uncinata, Euchlanis parva, Notomata pachyura, Lepadella s*p.

• **Cerna** River is situated in Banat catchment area and is a tributary of the Danube. Along it reach are only point pollution sources such as Herculane spa. The ***macroinvertebrates*** communities have characteristic of oligo-beta-mesosaprobic waters and comprise species from different groups: *Ancylus fluviatilis, Erpobdella octoculata, Eiseniella tetredra, Gammarus roeseli, Baetis carpaticus, Ecdyonurus sp., Ephemerella ignita, Oligoneuriella rhenana, Perla sp., Hydropsyche sp., Rhyacophila dorsalis, Stenophylax sp., Sericostoma personatum, Helodidae, Chironomidae* etc.

The composition and the values of abundance vary along the river because of abiotic factors variation and human impacts. Generally, the bioindicators of macroinvertebrates show the beta-mesosaprobity.

The ***phytoplankton*** is composed from species belonging to: Cyanobacteria *(Oscillatoria limosa, Oscillatoria formosa, Lyngbya limnetica, actylococcopsis irregulari*s), Bacillariophyta *(Asterionella formosa, Achnanates minutissima, Amphora ovalis, Ceratoneis arcus, Cymbella lanceolata, Cymbella ventricosa, Diatoma vulgare, Diatoma elongatum, Fragilaria crotonensis, Gomphonema acuminatum, Navicula gastrum, Nitzschia sigmoidea, Pinnularia gibba, Synedra acus, Synedra ulna,Cymatopleura solea, Surilella biseriata* etc.), Euglenophyta *(Euglena acus,Trachelomonas volvocin*a), Dinophyta *(Ceratium hirundinell*a), Chlorophyta *(Scenedesmus bijuga, Closterium venus, Cosmarium turpini, Ulothrix zonata* etc.). The cleanliness degree calculated with Knopp method and based on phytoplanktonic species varied in beta-mesosaprobic range (75 – 92 %).
Species such as: *Coleps hirtus, Vorticella communis, Stynonychia mytilus, Brachionus angularis, Keratella quadrata, Rotaria sp., Notholca labis* etc. composed the ***zooplankton*** in Cerna river.

• **Putna** river, tributary of Siret, at reference station, has characteristics of water with very good status. The abiotic conditions with hard substrate (stones and rocks), very good oxygenation and fast flow permit the development of diverse benthic communities.

The ***macroinvertebrates*** are dominated by sensitive forms of the groups: Plecoptera, Trichoptera, Ephemeroptera (g. *Perlodes, Leuctra, Stenophylax, Ecdyonurus, Oligoneuriella, Baeti*s). The cleanliness degree has characteristic values for beta-mesosaprobic zone (90 – 94%).

Downstream, because of the changes in abiotic conditions (sandy substrate) and increasing of pollution sources, the benthonic biocenoses are restructured usually, with dominance of chironomids and worms (Tubificidae). The cleanliness degree has values in beta-meso-alfa-mesosaprobic limits (50 –55%).

• The **Rosia** brook, tributary of Abrud river (Mures river catchments area), is a typically case of a watercourse affected by human impacts.
In the spring area, no matter what the season is, the conditions (gravel and rocks substrate, clear, oxygenated water, with low concentrations of organic matter and

nutrients, fast flow and no color and odors) offer a rich biodiversity, both for benthic community and for the plankton. Insect larvae (Ephemeroptera, Trichoptera, Plecoptera, Coleoptera, and Diptera) dominate the macroinvertebrates communities, together with Turbellaria, Hydracarina and Crustacea. The following species may be mentioned: *Baetis vernus, Gammarus sp., Sericostoma sp., Planaria lugubris, Heptagenia sulfurea,Taeniopterix sp., Polycentropus sp., Helmis sp., Lebertia sp.* The identified organisms are framed in the oligo-beta-mesosaprobic zone and the cleanliness degree is specific for beta-mesosaprobic zone (85 – 91%), with a low to moderate load of biodegradable organic matter.

The ***phytoplamkton*** is represented by several groups of algae: Cyanobacteria, Bacillariophyta, Chrysophyta, Euglenophyta, and Chlorophyta. The most numerous group is Bacillariophyta (90%) with representative forms: *Navicula radiosa, Diatomahiemale, Navicula rhynchocephala, Nitzschia linearis, Cyclotella sp., Synedra acus,Gomphonema olivaceum,* together with *Dinobryon sertularia, Trachelomonas sp.* Most of identified taxa are beta-mesosaprob, indicating a low to moderate pollution with biodegradable organic matter. The cleanliness water degree (C%) is characteristic for beta-mesosaprobic zone (85 – 90%), Rhizopoda, Rotatoria, Cladocera and Copepoda represent the zooplankton. The rotifers and copepods prevailed. Best represented species: *Keratella quadrata, Eucyclops serrulatu*s. Most of the forms were grouped in the beta-mesosaprobic area.

In the section upstream Abrud river confluence the banks are low, regularized, the riverbed is rocky, the water flow is fast. Due to the natural and human impact, the water is yellow-reddish and presents large quantities of suspended minerals. Substrate deposits have been observed also. Biotope conditions do allow the presence of biotic communities, neither in benthos, nor in water mass.

Only ***planktonic*** organisms are found *(Synedra acu*s). Planktonic biocenosis has an allochthonous origin. Sometimes worms (Oligochaeta) are present. Physical chemically, the water is acid, with organic load, suspended solids, sulfates, ammonia, phosphorus, total iron, manganese, lead, chromium, copper, zinc, cadmium, nickel.

All these nuisances did not permit biotic community's development in the area. Thus, Rosia brook, a tributary to Abrud river in hydrographic subsystem Aries, is influenced by the natural and human (anthropic) impact from the catchment area. The less influence was in the spring section, where the communities of organisms were very well represented during the samplings. The bioindicator organisms identified were belonging to oligosaprobic and beta-mesosaprobic zones of quality. Clean water degree registered the highest values, specific for beta-mesosaprobic zone, with low polluted water.

As the biological determinations show, in the section upstream the Abrud river confluence, Rosia brook is affected by the influence of the human impact. This led to a drastic reduction of the biological communities, even to disappearance, and to major perturbances of the aquatic ecosystem balance (e.g. development of *Synedra acu*s). Sometimes, due to the weak presence of the benthal and planktonic organisms, the clean water degree (C%) could not have been calculated.

Depreciation of the water quality from upstream (springs) to downstream (Abrud river confluence) is illustrated by the reduction of the number of taxa in macroinvertebrates (benthal) and in the phytoplankton and zooplankton. The species deficit is due to the human impact.

As a follow-up to the cyanide spills in the Tisza River basin government representatives from Romania, Hungary, Ukraine and Slovakia agreed at a Tetralateral Commission meeting held in Cluj (Ro) on 23÷24 May 2000 to prepare national inventories of potential accidental risk.

In June 2000, the Permanent Secretariat of the International Commission for the Protection of the Danube River (ICPDR) in Vienna received the national contributions and made an evaluation producing the 1 st Regional Inventory of Potential Accidental Risk Spots (ARS) in the Tisza catchment area of Romania, Hungary, Ukraine and Slovakia, which was issued in the July 2000. The objectives were to identity those ollution sources, which may pose the most important transboundary accidental risks.

In the 1 st Regional Inventory it was indicated that there were still some information gaps existing concerning a complete picture of the risk spots in the Tisza catchment area.

Accidental spills and risk spots identification

Upon the request from Permanent Secretariat additional information was received from Romania concerning risk spots in the Crisuri and Mures sub – basins. No additional data were obtained from the other countries. Based on this available information, the Regional Inventory of Potential Accidental Risk Spots in the Tisza catchment area in Romania, Hungary, Ukraine and Slovakia was completed by the Permanent Secretariat of the ICPDR. In September 2000 the ICPDR Steering Group encouraged all ICPDR member states/Danubian Countries to elaborate national ARS in order to come at a common inventory for the whole Danube River Basin, based on the methodology applied for the Tisza.
The realisation of this task was entrusted to the AEWPS (Accidental Emergency Prevention and Warning System) Expert Group, who in their turn delegated a panel of experts (ad-hoc ARS Expert Group) to carry out the analysis. The basis-valide Inventory of Potential Accidental Risk Spots has been made on the basis of information supplied by each of the ICPDR contracting parties and has been approved by the 4 th Plenary Session of the ICPDR (29÷30 November 2001, Vienna, Austria).

Reference Data and Applied Methodology The inventory was prepared using natural criteria for activities with hazardous and polluting substances and by arranging them into a prescribed format table. Priority should be given to the mining activities. It was further stated that the AEWPS EG dealing with a "Methodology for Accidental Risk Inventory" and the Baia Mare Task Force shall prioritise the most hazardous activities and shall work out recommendations to improve the safety of installations. Based on the national information provided, three categories were chosen for the first Tisza Regional Inventory:
- **High Risk Spots**. The country information indicates directly or indirectly a high accident risk (existing leakage etc.).

- **Lower Risk Spots**. The information provided to ICPDR states a certain risk or it is incomplete (i.e. it does not exclude a potential "risk").
- **Other Spots**. The country information provided does not indicate a major accident risk of environmental pollution. These spots are only listed in the national reports but not in the registered inventory.

Limitations of the First Inventory As was already pointed to the second meeting of the Baia Mare Task force, and latter on the first ARS ad-hoc EG meeting some inconsistencies between the content and presentation of the national ARS inventories have been identified. More than this, not all ICPDR contracting parties presented the above-mentioned inventories, despite of certain delays in this respect. As a consequence it was considered that in the process of the ARS – inventory preparation some difficulties could exist, particularly for the countries with the economy in transition.

As an overall the approaches in the Inventory preparation are still different:
(i) Starting from the point and diffuse accidental discharges inventories of wastewaters into the surface waters, based on the best expert judgment and taking also in the view the landfill relevant sites; this represents usual way of the ARS – Inventories draw-up system for the most countries with the economy in the transition process.
(ii) Using the Rhine/Elbe methodology (EU member)

The Baia Mare Task Force represented from this point of view, the post step in the overcoming these general difficulties, being realized the first ARS inventory at the level of Tisza River Basin. The ICPDR – ARS **second Inventory** could be considered the second step in the process of the harmonisation of the approaches first of all, despite of some inconsistence, which may still exist.

For Romania, no basic major difficulties have been recorded during the ARS Romanian Inventory preparation. However some particular difficulties have been identified during the ARS Inventory carrying-out process, the most relevant being as follows:
- Database availability for the chemicals toxic properties assessment
- Lack of a basic methodology or system for the ARS ranking (at the level of the Baia Mare Task Force)
- Data / Information from the territory to the Central Authority
- The implementation / access to the GIS – especially the specific software
- Lack of the proper information in some circumstances related with deactivation of old installations.
- Flood events consequences and landfills sites control (in the view of risk assessment and management).
- Proper training of the Local Authority responsible persons in the data / information content issues for the inventory drawing up process.

The first regional inventory and raking of accidental risks is based on four national risk evaluations, which in fact give extremely brief information on the kind of risk on each site, which are difficult to judge, especially at an international scale of comparison.

However, the list provides the first-ever regional overview of the most risky industrial sites for the Tisza River basin.

Basin-Wide Approach for the Ranking of Potential Accidental Risk Spots The basin-wide Inventory of Potential Accidental Risk Spots has been made on the basis of information supplied by each of the ICPDR countries. Additional data have been supplied by the ad-hoc ARS Expert Group. The analysis reflects the state of potential hazards as of December 2001.

General Framework Since 1997 on Accidental Emergency Warning System (AEWS) in the Danube River basin is in operation (Environmental Programme for the Danube River Basin – PHARE). Its major task is propagation of the alarm message on the accidental spill to mitigate the consequence of an accident. Preparation of an Inventory of Potential Accidental Risk Spots is a part of a complex of measures designed to support the AEWS and represents a contribution to fulfillment of the goals set out in the ICPDR Joint Action Programme" for 2001 to 2005.
The selection of the installations was made on the basis of the potential danger they represent, based on the nature and quantity of the raw materials handled in these installations that could cause water pollution.
In this context it must be made clear that a definitive statement of the actual danger level was not possible on the basis of those findings only, since no investigation has been made of those locations. An evaluation of the quality of prevention, or of the safety rating of the factories concerned, is not the object of this analysis, even though suggestions are proposed as to what steps could be taken to make progressive improvements in the safety level (checklist – methodology).

The philosophy of water protection, as seen in relation to industrial installations in the development industrial countries is based on presumption that the potential hazard to water bodies can be compensated by comprehensive technological and organizational safety precautions.
The analysis executed here gives an overview of the potential dimensions of the hazard, showing at what points actions needs to be taken, that is, which aspects of the safety of an installation need to be referred to as a matter of top priority.

Reference Parameters A quantitative evaluation of hazardous locations in the Danube catchment area, including Tisza River Basin was carried out for the first time with reference to possible water pollution resulting from accidents. The analysis is reflecting the potential danger; the actual danger level can only be determined on the basis of an analysis of the safety measures that have been put in place.
The method used is based on the transposition of substances present that could lead to water pollution into WRC (Water Risk Classes) 3 – equivalents. From the sum of the WRC 3 equivalents a so-called WRI (Water Risk Index) can be calculated logarithmically, analogously to the Richter scale in the case of earthquake On this basis it was possible to analyse the potential ARS in the Danube catchment area and assess their relative significance. The reporting in the WRC 3 equivalent is of relevance for the basin wide approach when there are ARS of different WRI.

Selection and Prioritisation of Hazardous Locations Because systems for classifying accident – susceptible industrial activities in the various countries of the

Danube catchment area are quite different from one another, if they even exist at all, the first task was to find a common procedure to be used for the classification.

As a basis for this:
- the EU "Seveso II" directive
- The UN/ECE agreement on the transboundary effects of industrial accidents (Industrial Accidents Convention) as well as
- The findings of the International Commission for the Protection of the River Elbe (ICPE)

The first criterion for selection in all cases was the quantity of dangerous substances present at each of the various locations.
As early as 1995 a method was developed within the ICPE for categorising those industrial activities in the Elbe river basin that represent a hazard of water pollution. The basis of this was the framework for determining the assessment of water pollution caused by accident that had been worked out by the Elbe warning and Alarm Plan.

The critical factors here were the potential for causing water pollution combined with the quantity of hazardous substances present in each case. These considerations gave the so-called Water Risk Index (WRI). In the year 2001 this methodology has been also established by the ICPDR (Alarm criteria).

Water Risk Classes (WRC) Water risk classes have already been used in Germany for more than 20 years as a means of assessing "substance-specific water hazards" particularly in determining the potential for water pollution represented by hazardous installations. By now about 6000 substances and mixtures of substances have been classified in those terms.

The following properties of substances are the essential factors that are taken into account when classifying in terms of Water Risk Classes (WRC):
- Toxicity (acute, chronic)
- Toxicity to humans and mammals
- Aquatic toxicity
- Persistence
- Biological degradability
- Physical and chemical degradation
- Properties of distribution in water and soil
- Accumulation in organisms.

In detail the water risk classes is determined by assessing the effects of substances that are categorised in terms of the 25R - ratings. The difference is made between substances poising no danger (WRCO) and those ranked into three classes of danger:
WRC 1: low danger to water
WRC 2: dangerous to water
WRC 3: high danger to water

Contrary to both the EU "Seveso II directive" and the UN/ECE "Industrial Convention "the water hazard classes are an integrated method of evaluating water hazards.

Water Risk Index (WRI) Substance – specified determination of water hazard makes distinctions between the separate water hazard classes based on the factors 10-100. For a simplified assessment of potential water hazard in industrial activities, The International Warning and Alarm Plan Elbe was the context for the development of the so-called Index of water pollution. Here in the assessment of water pollution caused by an accident a water risk index (WRI) was introduced which, like the Richter scale in the case of earthquakes, makes it possible to classify water-related accidents according to their potential danger. The WRI corresponds to the base 10 logarithms of the WRC substance equivalents.

For categorising dangerous activities in the Elbe catchment area the above-mentioned principles were referred to. In addition the following secondary criteria were introduced:
(i) For the sake of determining which activities carried the highest risk potential, a cut-off threshold of WRI 5 was introduced;
(ii) Only those activities were investigated that are located directly on the Elbe, or up to 50 km upstream on its tributaries.

Procedures followed in the Danube Catchment Are On the basis of an analysis of the various prescriptions described above, the ICPE's way of proceeding was found to be the most suitable for the analysis of industrial activities with high potential for causing water pollution. An analysis just in terms of the EU "Seveso II" directive would have selected installations susceptible to accident without discriminating on the basis of their potential for causing water pollution. The UN/ECE "Industrial Convention" would have taken the water hazard more into account, but a weighting of the various activities in terms of hazard potential would not have been possible.

The ICPE's way of proceeding embodied a pragmatic approach, making possible a rapid determination of the most hazardous activities and, on that basis, a recommendation of safety measures that should be given the highest priority.
Seeing that the substance classifications of the water hazard classes incorporate the substance criteria of the EU "Seveso II" directive as well as those of the UN/ECE-" Industrial Convention", while at the same time going beyond them, we can be assured that all industrial activities that are singled out on the basis of these prescriptions will also be selected by following the ICPE method. Activities presenting a water hazard in terms of the EU "Seveso II" directive or in terms of the UN/ECE "Industrial Convention" would therefore be a subclass of the activities determined by the ICPE approach.

Only reservation no. 2 of the ICPE methodology, having in view the UN/ECE "IndustrialConvention", has not been taken into account.

Analysis and Evaluation

General Elements. In October 2000 the various member's states of the ICPDR were requested to compile a listing of their industrial activities that could represent a water hazard, in the light of a table supplied to them. Nodal points of the survey were the place and name of the activity, along with the presence of substances capable of causing water pollution and their quantity. In addition, in the interests of cartographical precision the co-ordinates of the place were to be supplied.
The data resulting from the enquiry at the end of June 2001 was of variable quality.

Although the listing consisted of very few heads to be filled, it was obvious that some countries had found it very difficult to respond to the questions. In order to analyze these difficulties and to draw the appropriate conclusions, all member states of the ICPDR were asked to make a statement.

On the basis of a technical analysis of the results of the questionnaire, the following could be established as principal difficulties:
- Geographical co-ordinates are evidently familiar only in a few countries.
- For complex mixtures of substances there have often been no reliable R-ratings or water hazard indices established. So in the analysis a number of water hazard indices were estimated (for example with water-polluting solvents in tailing ponds Æ WGK=1).
- The total quantity of the hazardous substances can often only be estimated.

A major difficulty consists in the question of how an ‘industrial activity’ is to be defined. Are pipelines or refuse depots to be taken as belonging to this category? Seeing that immediately following on the Seveso II directive the question has been raised whether the cyanide accident in the Tisza catchment area falls within the scope of the directive, in carrying out this survey an open mind was maintained on this issue, and the various ICPDR countries were offered the latitude of forming a definition of activities representing a water hazard in the light of their own experience. This way of proceeding resulted in some spectacular results, e.g. with reference to the potential risk of tailing ponds by comparison with "conventional" industrial activities.
Sixty-seven ARS’s were reported by Romania. The available data were sufficient for the evaluation of 59 installations. After Germany, Romania has the second highest overall WRI. However should be mentioned that the “industrial hazard potential” of Romania represents not even 0.1 percent of the high hazard potential of tailing ponds and wastewater sumps arising from a wide range of mining activities.

Based on the summary given in the Table 6, the following remarks could be given:

ARS’s Distribution – Sensitive Areas
- The most sensitive areas to accidental pollution in terms of ARS number and WRI range belong to the N-W part of Romania where almost 70 percent of ARS have been recorded.
- The highest WRI (8.6) has been computed for Somes Tisza hydrographic basin.
- From the WRC point of view the range is 1 – 3 with a lower relevance for Bega Timis hydrographic basin.
- The Arges River basin (WRI 3-4) and Jiu River basin (WRI 5.7) are of less relevance for the potentially accidental pollution in comparison with the above-mentioned area.

Target Groups – Specific Pollutants in the Case of Accidents As was already mentioned the mining activities are the most important “target group” in the ranking list of potential risk to accidental pollution. The industry target group, chemical field of activity particularly, is situated on the second place. For example maximum WRIs are related with SM Baia Mare UP Sasar (WRI = 8.61) and SC Moldomine SA (WRI

= 8.57); in the case of S.C. Terapia Cluj SA the WRI is 3.9 despite that one of the used chemical is cyanide.

Table 6. Overview of the ARS's Inventory in Romania (2001)

No. of ARSs	River Basin	Type of Dangerous Substances (most relevant)	WRC Range	WRI Range
13	CRISURI	Cyanides, heavy metals, phenols, oil, ammonium	1 – 3	4.77 – 8.04
11	MURES	Cyanides, heavy metals, organic substances	**1**	6.40 – 8.44
4	BEGA TIMIS	Heavy metals	0 – 1	2.23 – 8.57
19	SOMES TISZA	Cyanides, heavy metals, ammonium, phenols	1 – 2	3.04 – 8.61
9	IALOMITA BUZAU	Chromium, oil	1	2.04 – 3.53
1	JIU	Ammonium	1	5.66
1	ARGES	Ammonium, cyanides, phenols, oil, heavy metals	1 – 3	3 – 4
8	SIRET	Phenols, benzene, ammonium, oil	1	3.02 –6.68
1	PRUT	Organic substances	3	3.12
67				**9.3(total)**

For the agriculture target group – pig farms particularly, the potential risk of accidental pollution is lower: SC Cantara SA Bega Timis hydrographic basin (WRI = 2.23), SC Somes SA Dej (WRI = 3.04).

Based on this approach it could be concluded that the most relevant pollutants in the case of emergency are cyanide and heavy metals. However, the following basic elements should be considered:
(i) Cyanide it self (CN) is not stable in water; a distinction has to be made between CN - and different cyanide complexes (particularly with cooper, cadmium and lead);

in fact the Baia Mare accident was characterised by such cyanide/ heavy metals complexes;
(ii) Heavy metals are almost associated with suspended matter/ sediment pollution (in average 70 to 85 percent); more than that, from ecotoxicological point of view the pH and water hardness have to be considered.

Accidental Pollution Consequences Taking into consideration the most relevant target groups and related pollutants two main consequences have to be considered in the case of accidents occurrence:
(i) acute (eco) toxicity for the aquatic ecosystems and adverse effects for the human health; if in the last case there are preventive measures (drinking water supply slop) no practical alternatives exists for the “in situ” decontamination of the river;
(ii) chronic toxicity based on the bioaccumulation of persistent pollutants in biota (heavy metals especially).

Conclusions and Recommendations The problems of the water accidental pollution control (in terms risk assessment and management) in Romania started to be initiated at the regional level in the framework of Bucharest Declaration (1985) where is stated that the Danubian countries have to exchange information in case of emergency. A more systematic approach however has been carried out during Environmental Programme for the Danube River (Phare 1992-2000) when an operational tool (Accident Emergency Working System –Danube) was created 1997. After then the Danube River Protection Convention came into force (ICPDR 1998) the prevention issues have been considered in parallel with the development of the AEWS System. Based an a national inventory of the accidental pollution (water related) made by National Company “Romanian Water” (CNAR) for the period 1992-2000 the total number of incidents are about 600.
It should be mentioned that either at the national level or to the international on (ICPDR) there is not a quantitative definition of the accidental pollution. The AEWS still use a narrative definition “ a sudden and an unpredictable change in the water characteristics”. As a consequence the national records and even international areas are questionable. Only in the present an emission approach based on the type of chemical and quantity released (using the Seveso 2 Directive, Elbe/Rhine Commission provisions) is starting a “quantification” of the accidents (magnitude ranking) but this is not yet mandatory.

With all approximations it should be noted that the “600 incidents” are referring to the total number of records beside local accidental pollution being included also transboundary areas.

As a general time trend characterization two main period are distinguish: (i) 1992 to 1997 with a maximum in 1995 (115 incidents), and (ii) 1998 to 2000 with a maximum in 2000 (two major incidents).
The most frequent pollutant is oil range of 27.5 percent (1994) to 66.7 percent (1999). On the second place are situated chemicals (detergents, phenols) in overage the weight being 18.3 percent. It should be noticed that "non identified” pollutant, have a relevant weight (19 to 23 percent).

After the AEWS-Danube was operational (1997), 25 accidental pollutions have been notified and recorded.

There is an increasing time trend of incidents from 2 detected in 1997 to eight accidents recorded in 2000. The transboundary effects of accidents have on overage of 44 percent, the transboundary impact increasing from 0 percent in 1997 to 25 percent in 1998 0 percent in 1999 and 75 percent in 2000.

The accidental pollution caused by oil is in the range of 50 percent (60 percent in 1999) being followed by chemical (phenols, pesticides, cyanides etc.) with a weight of about 30 percent. However "unknown pollutants" have a consistent weight (20 percent). It should be underline that all of these weights have been assessed based on the number of incidents and not taking in account the magnitude/consequence of the incidents. Based on the both information sources (CNAR and ICPDR-AEWS), despite of the approximations, more than 95 percent of the national (Romanian) incident records are related with local accidental pollution (as origin /effects).

It should be noted the very closed weight of "oil incidents" recorded by AEWS Danube (52 percent) and CNAR (48.8 percent).
From the institutional point of view a harmonized system for alerting and notification of accidental pollution has been promoted by Ministry of Water and Environment Protection (SAPA-ROM 1993). The legal frame is represented by M.W.E.P. Orders 84/15.02.1995 and 464/1996.

The SAPA-ROM consists on two subsystems: (i) national subsystem related with the local incidents where the decision unit is represented by CNAR and (ii) international subsystem connected to the AEWS, the coordination Unit being PIAC (MWEP). I.C.I.M. plays the role of Expertise Unit (data base/Danube basin Alarm Model) and National Reference Laboratory Despite of a series of performances (satellite communication, information processing system, standard forms for messages, international/national manuals etc.) the both subsystems present limitations, the most of these being related with the detection in due time of accidental pollution. Because there are not (yet) provisions with Automatic Warning Stations, usually the alert is made by the water users, the damages being almost very difficult to be mitigated.

After the Baia Mare accidental pollution (cyanides) a special Task Force has been created one of the most important aim being to create a regional (Romania, Hungary, Ukraine and letter on F.R. Yugoslavia) inventory of Accidental Risk Spots (A.R.S). A first list was developed but a very approximation scale only. In 2001, as a consequence of the December 2000 Plenary Session of ICPDR resolution, an Ad Hoc group of experts at the level of AEPWS-EG has been promoted in order to generate a basin wide ARS inventory.

For the basic approach EV Seveso 2 Directive, Industrial Accidents Convention (Helsinki 1992) and ICPE (Elbe) provision have been, considered. Finally two parameters have been aggregated: (i) W.R.C.-water risk class based on the R-phrases (dangerous chemical characterization) and (ii) WRI-water risk index related with the quantities.

The total quantity of highly water-hazardous chemicals (WRC=3 equivalent) in the Danube River Basin lies in the region of 6 million tones (approx 7.5 T/km2. The total quality of dangerous chemical identified for Romania is 2.1 mill T. (about 8.9 T/km2).

There are ARS relevant for Romania, the WRI being 9.3 (second place after Germany).

The high hazard potential (more than 98 percent) is related with tailing ponds and wastewater arising from mining activities.

The most sensitive areas belong to the N-W part of Romania where almost 70 percent of ARS's number has been identified, the highest W.R.I. (8.6) being computed for Somes-Tisza River basin.

Based on the above mentioned conclusions is recommended to approach the possibility of the automatic working station implementation focusing particularly on two issues: (i) type of sensors related with the most relevant ARS and (ii) prioritization of the station.

6. Floods

(i) Floods in Romania

Characterisation of the flood regime in Romania The most severe regional floods have been recorded in eighties and in the last decade when practically the entire territory of Romania was affected by inundation, having often frequencies of 1/50 – 1/100 years and more. The attribute "regional" is meant for the floods, which encompass very large areas of formation, and they have a "lent" character as far as the increasing water level gradient is concerned.

During the 1950-2003 period with systematic flood records and discharge measurements, very heavy floods occurred across large basin areas from Romania. The most severe floods have been recorded in eighties and in the last decade when practically the entire territory of Romania has been struck by inundation, having often frequencies of 1/50 – 1/100 years and more. The floods that occurred during the years 1970, 1975, 1981, 1998, 2000, 2001 and 2002 are among the greatest ones. In the map presented underneath the basin areas affected by the heaviest floods are shown.

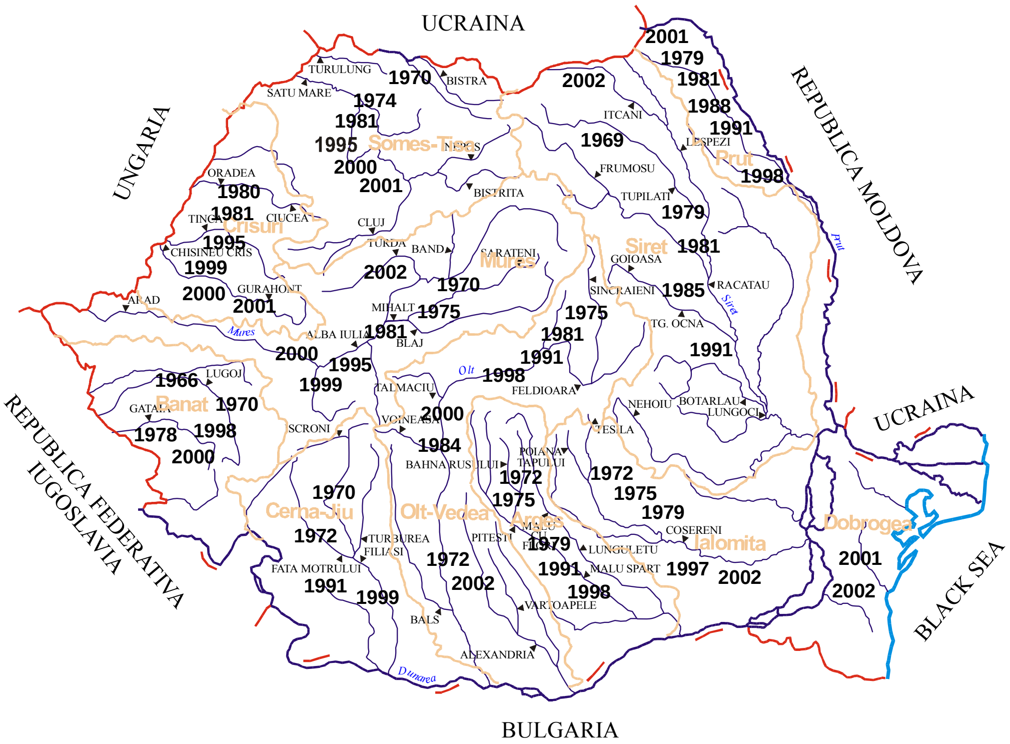


Figure 4. Years with major floods in Romania

The last decade has been characterised by very frequent floods that ccurred over all the territory of Romania. Among them the **1998 floods** are the most severe ones. During almost the entire half of the year 1998, significant floods have produced across Romania, the most affected areas being the central, western and northeastern zones of the country. Important increases of river discharges with significant surpassing of the water level inundation thresholds have recorded over basin areas of about 80000 km 2 which represent almost a third part of the territory of Romania. The peak discharges reached exceptional values both on the large rivers and the small ones (flash floods). In May 1998, as a result of high amounts of rainfalls of 50-110 mm, recorded during three days (17-20 of May), the north- eastern part of the country was affected by floods. Among the highest peak discharges observed in the half - northern part of Romania during 17-21 of May, the flood of the Prut River is to be mentioned.

The maximum discharge of 2000m 3 /s at Radauti Station had a frequency of about 1/70 years. During 17-20 June abundant rainstorms having amounts of 60-125 mm. of rainfall in the central parts of the country and more than 60-80 mm. in the eastern zones were recorded. The peak discharges produced along large rivers (Mures and Upper Olt) represent 60-70 % of the historical ones recorded in 1970 and 1975 that had a 1/50 - 1/100 year -frequency. Orographic rainstorms of unusual intensities were developed in the frame of these frontal fields of precipitation, which resulted in high flash floods occurred over small basins. Over 15 flash floods having exceptional peak discharges of 1/50-1/150 year - frequency have been recorded at the hydrological stations and many have been noticed on the un-gauged small rivers. The last decade's floods are remarkable by their special attributes:

The Exceptional frequencies lied between 1/50 to 1/200 years over quite limited river basins areas (10000-20000 km^2) in 1997, 1998, 1999 and 2000;
High frequencies between 1/10 to 1/50 years over large areas (40000-50000 km^2).

Very numerous severe flash floods developed in small basins encompassed either in large areas affected by regional floods or produced by local heavy rainstorms that brought about immense damages and lost of human lives.

The flash floods produced over relatively small basins originate either in a general meteorological context of wet air advection where the vertical motion and the cumulus are very intensive or in a context of an atmospheric instability at a local scale. The regions the most affected by flash floods are found in the sub-mountainous zones of the Meridional Curvature of the Carpathian Mountains where there is an orographic ascendance of the air masses and during the summer season there is a thermal convection superposed on the dynamic convection. Nevertheless, the flash floods could occur across all the regions of Romania from the mountainous zones to the plateau and even in the plain areas.

An example is the plain region of Dobrodgea, which are contiguous to the Black Sea. There, the cyclo-genesis of the sea associated with the high degree of relief fragmentation (the last resulting in many small sized catchments) is favourable factors responsible for heavy flash floods. Consequently, flash floods produced by rainstorms of high intensity frequently occur, bringing about important damages and even lost of human lives.

Another remarkable flash flood event has been produced in 28/29 July 1991 in the Tazlau River Basin (F=1000 km^2). The rainstorm having a maximum intensity of more than 150 mm in about two hours produced a peak discharge of 2000 m^3/s, which brought about the rupture and total destruction of the Belci Dam (located at the outlet of the basin) having a volume of 20 million m^3. As a result catastrophic damages and lost of 40 human lives has produced.
Concerning the flash flood potential the Romanian floods are lower with 50-70% than those recorded over areas less than 100 km^2 in France and Italy but rather equal to those of Spain and slightly higher than those of Bulgaria, Croatia, Portugal and Yugoslavia.

Although it is difficult to define and objectively quantify the frequency of the flood occurrence, the general perception has been that, as compared with the past, in the last decade the floods have occur more frequently, especially in the central, western and southern zones of Romania.

Apart of the “regional” floods developed over large areas of the country, very numerous severe flash floods produced in small basins encompassed either within large areas affected by regional floods or produced by local heavy rainstorms, brought about immense damages and lost of human lives. Their high degree of severity and perilousness resides in the rapidness of their occurrence and dynamic effect. Considering the growing importance of the flooding risk problem in Romania, this project is focussed to the implementation of these new concepts in the domain of flood management.

(ii) Flood prevention

In line with WFD the development of a river basin management plan for the targeted area takes into consideration the following key points:

- the need for a holistic approach to flood management (pre-flood planning, operational flood management and post-flood response
- the use of an integrated approach on the catchment level of flood defence activities integrated and considering the ecological effects
- knowledge of previous flooding or anticipated flooding for the effective planning of flood defences and for the safety of those living close to rivers, the performance of risk assessment to support decisions in flood mitigation and management actions
- the recognition that undertaken flood mitigation measures requires cross-disciplinary working of several professional affected groups
- the need to consider the associated social dimensions when engineering solutions are proposed
- the uncertainty which climate and other environmental change is bringing into flood management strategy.

As the overall objective of flood management is to minimise losses within a river basin over time subject to constraints, such as society's attitude to risk, level of expenditure, etc, an integrated approach should be considered of flood management with distinct activities of:

- Pre-flood preparedness
- Operational flood management
- Post-flood response.

It is essential to consider the impact of interventions on the flood risk in the river basin as a whole and not just at the location of a particular project. This should be facilitated by the implementation of integrated catchment modelling and management information systems as these become available. In addition, the interaction between different types of direct and associated risks of the Timis-Bega area (flood risk, erosion, risk, hydraulic risk, hydrogeological risk, geomorphologic risk, landslide risk etc) needs consideration. According to the project proposal the associated pollution risk (ground water pollution, linked to morphological change and changes of river bed) should also be investigated.

Methodology for development of the flood prevention and mitigation measures plan as part of the RBMP

The RBMP will express the sensitivity of catchments to flood risk as a result of different scenarios, including development, land use change and as much as possible, climate changes.

The RBMP will be the main tool in the overall water management strategy, measuring the sensitivity of catchments to flood risks as a result of various development scenarios.

The process for producing a RBMP is summarised as a flowchart in Figure 5. The approach is intended to provide a consistent procedure for determining the current and future flood risks associated with a particular catchment (Arges application will be developed in the pilot area) and for defining the selected long-term and sustainable policies for flood risk management.

The water and environmental data gathering, identification of environmental opportunities/constraints, environmental appraisal of catchment policies/measures and consultation with environmental stakeholders/public) have been incorporated as an integral part of the RBMP development process.

First of all, data will be collected and analysed. An improved understanding of the river basin topography, surface and soil storage capacity, flood plain geomorphology and ecology together with the regional analysis of statistical frequency and magnitude of flood occurrence and the means to maintain biodiversity in the face of flood plain development can provide the capabilities and tools needed for improving the mitigation of the flood hazard.

Additionally, knowledge of the economic, legal, social and political constraints and opportunities in flood plain management shall be reviewed in correlation with the existing hydraulic structures in the studied area.

Secondly, task refers to the effectiveness of structural alternatives (localized or territorial interventions) that will be analysed and options to shift from the traditional hydraulic structures towards considering non-structural alternatives as effective floodplain management strategies be considered. The analysis will consider the characteristics of a non-structural approach that it modifies susceptibility to flooding, as opposed to the flood routing role through structural methods such as dams, levees and channels.

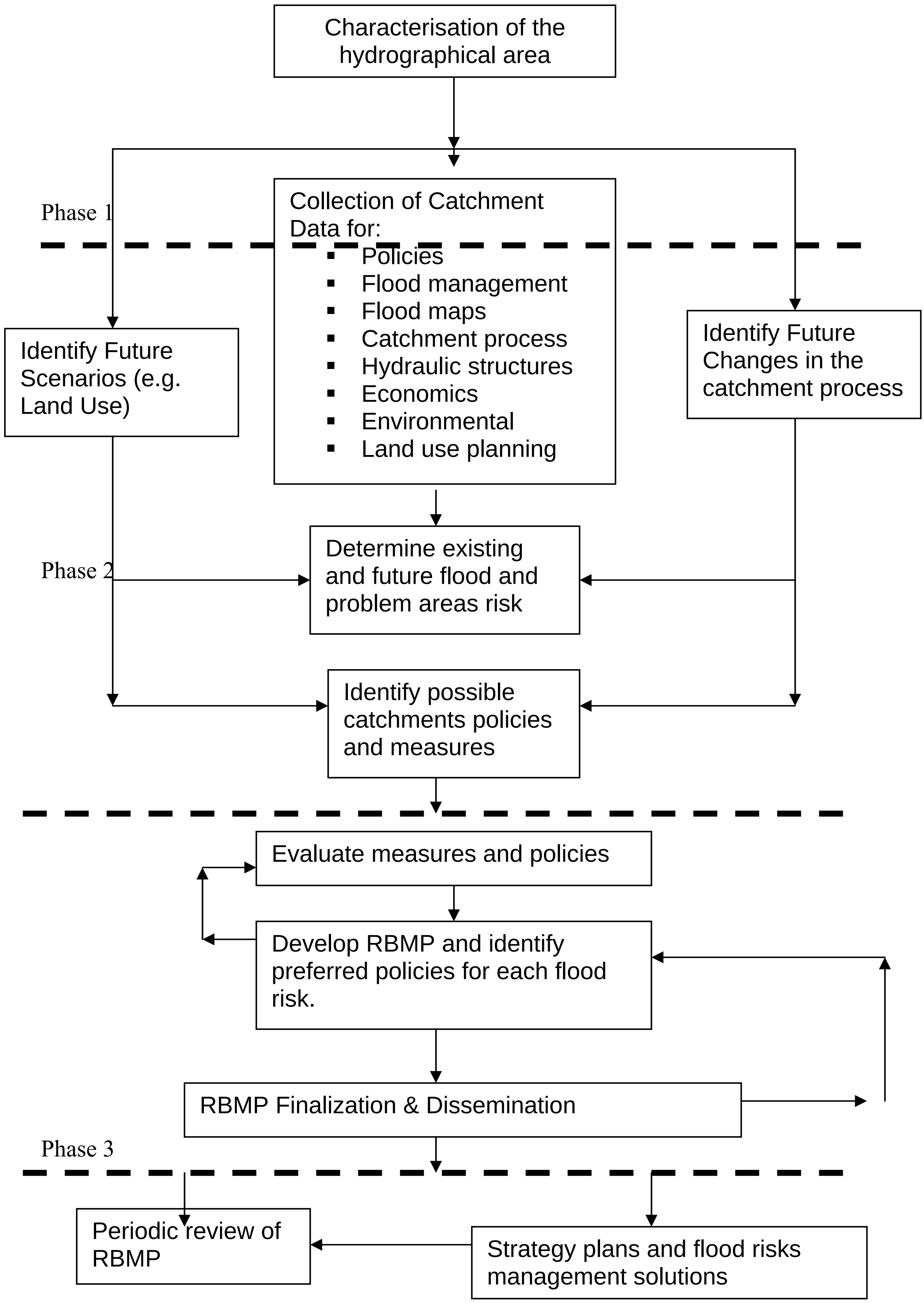


Figure 5. Outline Approach for Catchment Flood Management Planning

Structural and non-structural measures for flood management

a. Structural measures

In flood management, there are two types of measures that can be used: structural and non-structural. The structural measures include catchment wide interventions, (reservoirs, dikes, levees, floodwalls, channel changes, high flow diversions, spillways, shoreline protection works, and storm water management river), training interventions and other flood control interventions. Historically, the common strategy to manage with floods follows the implementation of the civil works such as dams, floodwalls, embankments, conduits and reservoirs. Structural measures tend to mainly consider the hydrological and hydraulic implications of flooding, which generally are solved by choosing the alternative that maximizes the expected net benefit. In addition, such measures can have a substantial impact on the riverine environment and ecology. Additionally, while structural solutions contribute to flood reduction and protection, they also have other hidden disadvantages, such as the issue of their false awareness of security, and high costs related with their operation and maintenance.

An additional disadvantage for non-structural works in the bazin area is how to deal with the aging inventory of existing flood control structures. Most of the hydraulic structures are nearing or even past their design lives and the actual financial resources are not available to undertake all required remedial actions.

Flood control structural measures - dams - permit deliberate changes in the volume of runoff, reducing peaks, peak stage of the flood in the reservoirs, time of rise and duration of flood waters, location of flooding, extent of area flooded, and velocity and depth of flood waters. The effectiveness of these measures to save lives and properties from damage, injury, and death has been well demonstrated in most of the interventions in the country. However, the number and size of structural flood control projects have been decreasing due to some adverse effects. These effects are for creating a false sense of security, for their long-term value, high construction costs, which have made some structures unaffordable, but mainly to the critics on their possible environmental impact for destroying riparian habitat, scenic values, and water quality.

However currently, with the introduction of bioengineering techniques (use of vegetation for civil engineering purposes), some structural measures have become environmentally friendly.

Non-structural measures offer a variety of options considered to be sustainable and less expensive, ranging from legal and institutional rules on land use planning and soil management, till perception and awareness, public information actions, emergency systems and post-catastrophe recovery. Non-structural measures deal with risk acceptance and risk reduction strategies.

Table 7. Structural and Non-Structural Measures

TYPE OF MEASURES			
STRUCTURAL MEASURES		Catchment-wide interventions (agriculture and forestry actions and water control works) River training interventions Other flood control interventions (passive control, water retention basins and river corridor enhancement, rehabilitation and restoration)	
NON-STRUCTURAL MEASURES	RISK ACCEPTANCE Tolerance strategies	Toleration Emergency response systems Insurance	
	RISK REDUCTION	Prevention strategies	Delimitation of flood areas and securing of flood plains Implementation of flood areas regulation Application of financial measures
		Mitigation strategies	Reduction of discharge through natural retention Emergency actions based on Monitoring, Warning and Response Systems (MWRS) Public information and education

In the guidelines of RIBAMOD Concerted Action (Samuels, 1999) it is suggested that for flood management, a holistic approach should be carried out in order to cover all sequence of activities, including post flood activities as well.

Table 8. Holistic approach to flood management: pre-, "during-" and post-flood activities

HOLISTIC APPROACH		
Pre-flood activities	During-flood activities	Post-flood activities
Flood risk management for all causes of flooding and disaster contingency planning.	Detection of the likelihood of a flood forming (hydro-meteorology).	Relief for the immediate needs of those affected by the disaster.
Construction of physical flood defense infrastructure and implementation of forecasting and warning systems.	Forecasting of future river flow conditions from the hydro-meteorological observations.	Reconstruction of damaged buildings, infrastructure and flood defenses.
Land-use planning and management within the whole catchment.	Warning issued to the appropriate authorities and the public on the extent, severity and timing of the flood.	Recovery and regeneration of the environment and the economic activities in the flooded area.

Discouragement of inappropriate development within the flood plains.	Response by the public and the authorities.	Review of the flood management activities to improve the process and planning for future events in the area affected and more generally, elsewhere.
Public communication and education of flood risk and actions to take in a flood emergency.		

Relevant for the floods prevention and mitigation for the catchment area are the river training interventions. This is particularly important to limit the dynamic of the rivers, therefore managing and controlling the morphological evolution of watercourses through meandering. These interventions also have the function of reducing solid transport and the natural processes of bed and bank erosion along the water bodies.

Among the possible interventions, the maintenance of the hydraulic cross section is essential to keep the functionality of structural works providing protection and regulation actions with respect to floods. Maintenance works, like cutting of vegetation and reshaping of the hydraulic cross section is the most common. There are many places in the basin, where simply cleaning up or cutting of natural vegetation is also important to permit easy access to the torrent bed and banks in order to allow other maintenance works of the existing hydraulic structures but with possible risk of destruction of ecological and environmental properties of natural river habitats. Selective cutting of vegetation (e.g. thinning out of elements interfering with the water flow) should therefore be undertaken not only to reduce the flood velocity and bank erosion but also to respect the continuity of these habitats along the watercourse. In any scenario, careful cutting must be considered to not facilitate erosion by flowing waters or vary the water velocity.

The reshaping of the hydraulic cross section permits to regulate the transversal and longitudinal course of the torrent bed subjected to morphological changes due to the presence of sediments and/or bank instability processes and to carry out planned hydraulic cross sections in order to guarantee flood discharges of a fixed return time period. Reshaping interventions are particularly necessary in torrent stretches subjected to aggravation because of high sedimentation rate.

These maintenance interventions should be directed towards the creation of hydraulic sections with a “natural” transversal shape, in order to recreate different riverine habitats. However, in some cases, reshaping interventions to allow meandering courses may be also undertaken.

Finally, the application, where possible, of techniques with a low impact on both the ecological aspects of river habitats and on the landscape need also to be considered in the measures of the RBMP for each basin area.

b. Non-Structural Measures

Methods used in flood management have been changed considerable in response to public demand for more visually acceptable measures, with greater understanding and implementation of legislation of the environmental issues and a willingness to consider the environmental impact and additional biodiversity benefits.

The non-structural measures include: (i) legal and institutional measures (adequate institutional and legal framework), (ii) flood preparedness and civil defense actions and measures, and (iii) early flood warning system.

Legal and institutional measures

These measures relate to the:

(i) Elaboration of land use regulation and tools for effective enforcement through appropriate training, personnel, and financial resources. The regulations vary depending upon the risk studies and mapping that have been done in the river basin, but shall include: (1) permitting for all proposed new developments and (2) reviewing existing regulations to assure that they will minimize flood damage. Considering the role of floodplain management, there is a need to review the regulation on the creation and regime of use of protected zones, and incorporate floodplain management provisions into zoning regulations.

(ii) Development policies to avoid inappropriate development of the floodplain, including a careful review of the impacts on the floodplain of proposed activities. Plans to rationalize land usage in flood-prone areas including possible incentives to private owners must be developed.

Changes in land use in floodplains to allow more frequent flooding and reduced drainage would benefit biodiversity and could provide flood defence protection advantages for urban areas. A good management of floodplain will provide more room for floods to move within their natural boundaries. The final output of the project, the RBMP should consider ways in which the synergies between wetlands and land use improvements might work for reducing food risks in the considered area.

(iii) Creation of a unit in each community that would coordinate civil defence, flood warning, consultation on hydraulic works, maintenance of flood defence facilities, and provision of environmental protection related to flooding issues. For this purpose, revision of the current rule for the functioning of local commission on flood prevention and control activities is required as to adopt the need to include environmental protection related to flooding issues.

Regulations have a potentially greater impact on flood loss reduction, as development that conforms to regulations is less prone to flood damage than pre-existing development. These aspects will be presented in detail in Task 1.2 Report – Review of Legal and Policy Framework for Water Management.

Effective enforcement often requires more training, personnel, and financial resources. Regulations cannot provide full protection; they have a limited impact on existing buildings and infrastructure already subject to flooding, and they do not prevent development in floodplains. In addition, most floodplain regulations do little to protect the natural resources of floodplains. In fact, to the extent that floodplain regulations allow development in floodplains-even though it may not be subject to damage-they can contribute to the loss of natural and cultural resources.

It is suggested that for the studied area, several regulations shall be drafted or amend. The requested regulations shall depend upon the risk assessment results and mapping that have been done in the area. They will address:

- Permitting for all proposed new developments
- Protection of new water and sewage systems and utility lines from flooding;
- Enforcing risk zones and floodway requirements after the flood insurance map for the area becomes effective.

River corridor enhancement, rehabilitation and restoration

The river's riparian system, consisting mainly of trees and vegetation, represents the main ecological corridor. In the interventions on the water bodies to control floods, the ecological role of the riparian vegetation must be taken into account. In addition to its ecological function for aquatic habitats and terrestrial wildlife, this vegetation provides important socio-economic benefits (e.g. flood defence, aesthetic quality and leisure) as well as regulation of ecosystems (e.g. riverbed stability, erosion control, filtering/retention of sediments, flood defence, waste water treatment and pesticide control).

Therefore, ecologically oriented interventions in the riparian vegetation should in turn consider the influence of periodical flooding processes, sedimentation and erosion. Current methods for integrated management of river basins aim at the integration of conservation strategies and valorization of fluvial systems, as alternatives to planning and management.

Alternatives to fluvial systems management are considered in Figure 6.

NATURAL

Preservation or conservation
Restriction of land or resources use

Mitigation – regulating activities such as regularization
Recovery and restoring – establishing a reconversion process: recovery of water quality, of the hydrological regime, of habitat structures and riparian zones

Abandonment

DEGRADED

Figure 6. Conservation perspective (PREMO, 1999)

The overall interventions on river corridors should focus on maintenance, rehabilitation and restoration of well-structured corridors consisting of wide lateral strips containing varied topographical elements such as mounts, depressions and marshes, and populated by grass, bushes and tree species.
To this end, the interventions must consider a collection of principles and technical methods that enable to conjugate the use of the resources with the conservation, valorization of the river corridor as a natural space, recovery and restoring objectives.

There are a number of situations where wetland creation can be considered in relation to flood management schemes. The impact of the wetland creation on the effectiveness of flood management scheme should be assessing for each selected scenario.

Therefore, creation of wetlands can be considered in three hypotheses:

- on land previously protected from flooding to a high probability (it arrives to a change in the standard of protection).
- in existing or new reservoirs, wash-land, to maintain the high water level which reduces the ground storage available.
- along side river channels, that increases the capacity of the channel for passing the flood flows as needed.

The channel vegetation option might be a very good proposal for the considered area, for its benefits for banks protection and improving biodiversity.

Non-structural measures allow the control of the vulnerability component of flood risk. Therefore, non-structural measures can be grouped into two categories: risk acceptance and risk reduction measures (Table 1).

There is a positive attitude in our country towards the non-structural measures for reducing raising expenditures for structural protective works and because of concerns over their environmental costs.

The risk acceptance of the selected non-structural measure is considered according to the type of strategy proposed: toleration, emergency response systems and insurance. Risk acceptance implies that a the local community accepts the degree of human and material loss perceived due to a flood that could hit their area of jurisdiction in the short, medium and long term.

Still, the risk reduction is important and that's why the success in the management of flood areas depends on the selection of appropriate measures, based on flood characteristics, physical and morphological characteristics of flood areas, economical and social conditions, political and environmental conditioning or flood control works planning. Structural measures cannot reach these objectives if they are used alone, thus non-structural measures such as land use control and planning may be tools to reduce flood risk but also to develop a "sustainable" approach to flood management. Risk reduction can be dealt with in two ways: prevention strategies and mitigation strategies.

The delimitation of flood areas and securing of flood plains are the main prevention strategies (basin area management). This is to preserve and improve flood discharge and bed load transport. Flood zoning is also promoted within Arges pilot area and the hazard and risk maps can be drawn up.

Finally, the development and implementation of flood areas regulation are essential tasks. This legislation refers to flood-prone areas.

<u>Flood Preparedness and Civil Defense</u>

Disaster preparedness incorporates plans for mitigation, warning, and emergency operations; training; public information activities; exercises to test disaster preparedness plans; readiness evaluations; research; review and coordination of disaster preparedness plans and programs; and post-disaster evaluations. For vulnerable areas not considered to guarantee further investment in hydraulic structural defenses, the proposed measure would provide shelters (multi-purpose installations) and improved housing for lower income families in flood-prone zones.

Early Flood Warning System

Warning systems and acAdministrationing emergency response have long been recognized as effective ways to save lives and reduce flood damages in both riparian and coastal flood prone areas. This measure would aim to ensure the development of a more adequate and extensive flood warning system linked to the National Administration -National Institute of Hydrology and Water Management (INHGA) and river basins systems belonging to National Administration Apele Romane. It would include a new hydro metering system, new computational equipment, new software, new communication system, and the creation of local flood warning system and emergency plans in each vulnerable areas.

Early flood warnings, flood information and forecasts are extremely important to be able to timely recognize dangerous situations in the flood-prone areas. Through examining recent natural floods disasters and having consultations with central and local water and environmental authorities who are involved in natural disaster management, the urgency and significance of the use of GIS made clear that need to properly assess both the benefits and costs of implemented such system in Romania.

In many areas, the heavy rainfall associated with snow melting cause floods, which cover large areas of agricultural land, destroy bridges and roads, and bury hundreds of houses and displaced hundred of people. Both central and local governments have already implemented various prevention measures. Yet much work remains undone to prevent and reduce damages in order to distinguish a flood risk and the period between the beginning of a flood event and its reaching critical levels.

The creation of a harmonious meteorological and hydrological information system and database with fully automated data communication system is the main objective of flood prevention and control strategy.

*

*   *

Testing different scenarios for the management plan, and identifying the ecological influences will aim of identifying the best alternative which needs to be (i) comprehensive as a result of the joint approach of the technical, economic, environmental and institutional aspects of hydrologic disasters, (ii) rational, aiming at an optimal use of several beneficiaries for the satisfaction of all needs of protection against flooding and associated pollution, (iii) integrated, coordinating the interfaces with the planning activities of the various sectors, and (iv) participatory, involving the economic agents and the affected populations and aiming at a large consensus.

The abilities and methods for integrating hydrologic hazards knowledge into the water resources development, management and economic uses of watersheds will be assessed during the selection of the most appropriate measures.

The investigation should lead to a better understanding of the complexity of the hydrographical area, including issues as the role of the sediment transport in the river, the cohesive sediment transport, long term influence of the river morphology, processes triggering debris flows, interaction of pollutant with sediments, etc.

Adoption of a final variant of the "master plan" of the water management in the basin will be developed in line with WFD requirements. The complex aspects related to the institutional framework for flood management will be also considered. The plan should also identify a suitable set of range of decision-making levels for various activities that need coordination at the level of the river basin.

7. Droughts

(i) Endemic droughty areas in Romania

The drought phenomenon on Romania's territory is a specific characteristic for the conditions of the location of our country in an excessive temperate climatic area with very large deviations from the normal values of the climatic, agroclimatic and hydrological parameters.
This phenomenon, although without a strict ciclicity shows a repeatability at 15-25 year intervals.

The duration of the droughts varies between 12-15 years with short term interruptions of about 1-3 years with rainfalls above the normal values. These interruptions do not modify the general features of the droughty periods from the point of view of the severe climatic characteristics as well as of the water resources in the soil and in the surface and ground hydrographic network.

From the analysis carried out over the entire territory of the country on the climatic characteristics during the last century (1894-1994), a progressive warming of the atmosphere was revealed associated with the increase of the heat phenomenon and the diminution of the precipitation conditions.
This phenomenon is emphasised by a continuous increase of the atmospheric pressure (Fig.1) favouring the increase of the sunshine duration meaning at the same time a gradual decrease of the conditions for the occurrence of the anticyclones and therefore of the rainfalls generated by these (Figure 7).

From the standpoint of the frequency of the droughty and excessively droughty periods three long intervals can be mentioned when this occurred in a very severe way, that is: 1894-1905, 1942-1953, 1982-1996 intervals
The periods with very low water discharges on the rivers and the groudwaters are characterised by deficits with various degrees of severeness on Romania's territory.

The periods of hydrological drought following more rapidly the meteorological drought, have occurred more often than the agro-meteorological drought over shorter time intervals but preserving the general water deficit character especially during the intervals 1894-1900; 1961-1965 in Transylvania and 1943-1952; 1958-1964; 1982-1996 in Oltenia, Muntenia, Moldavia.

The occurrence frequency is revealed by grouping the droughty, rainy and normal intervals over various time periods (Fig.8 and Fig. 9).

It can be noticed that from the point of view of the evolution with time, the frequency of the droughty years has increased almost continuously, fact which shows an obvious trend aridization of the entire territory of the country. Thus, from a 33.4 % frequency of droughty and extremely droughty years an 80 % frequency was reached during the recent period 1982-1996.

(ii). Actual tendency

The drought between the last period 1982-1996 is comparable as intensity and duration only with that during the interval 1942-1953 but with a much larger territorial extent and with extremely severe socio-economical consequences.
The analysis of the areas affected by drought during the considered period shows that, if at the beginning of this period the mostly affected areas were in the western part of Baragan and Dobrudja. Presently, the area affected by the water deficit extended to the entire Romanian Plain most severely in Oltenia (Mehedinti, Dolj, Gorj, Olt and Teleorman), Dobrudja and Baragan.

The annual precipitation amounts were by more than 50-70 % below the monthly annual normal values. A general gradual extent can be noticed of the areas with an acute deficit of precipitation over larger and larger areas, the phenomenon getting propagated from the East to the West.

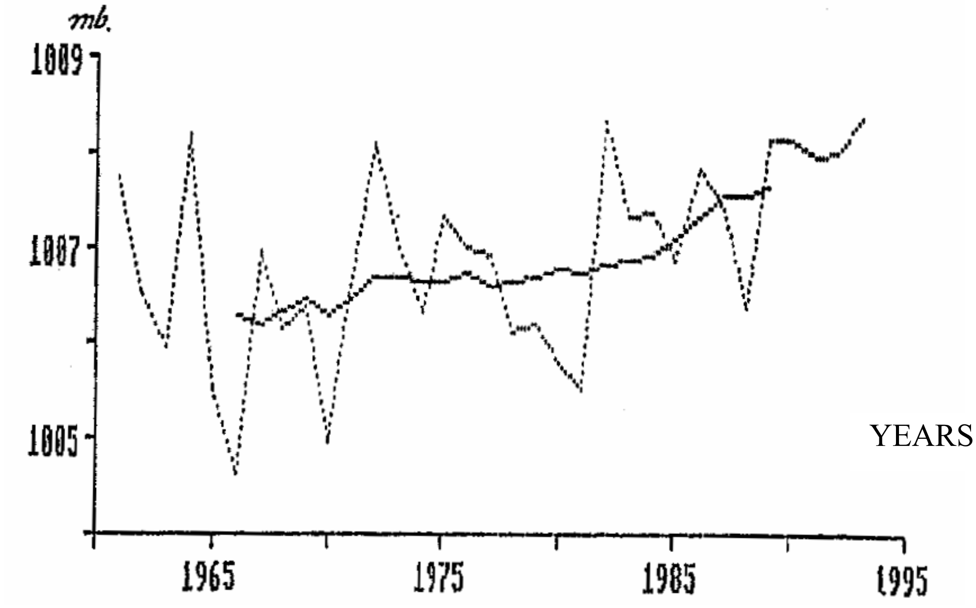


Figure 7. The evolution of the annual atmospheric pressure and of the moving averages at BUCHAREST- FILARET

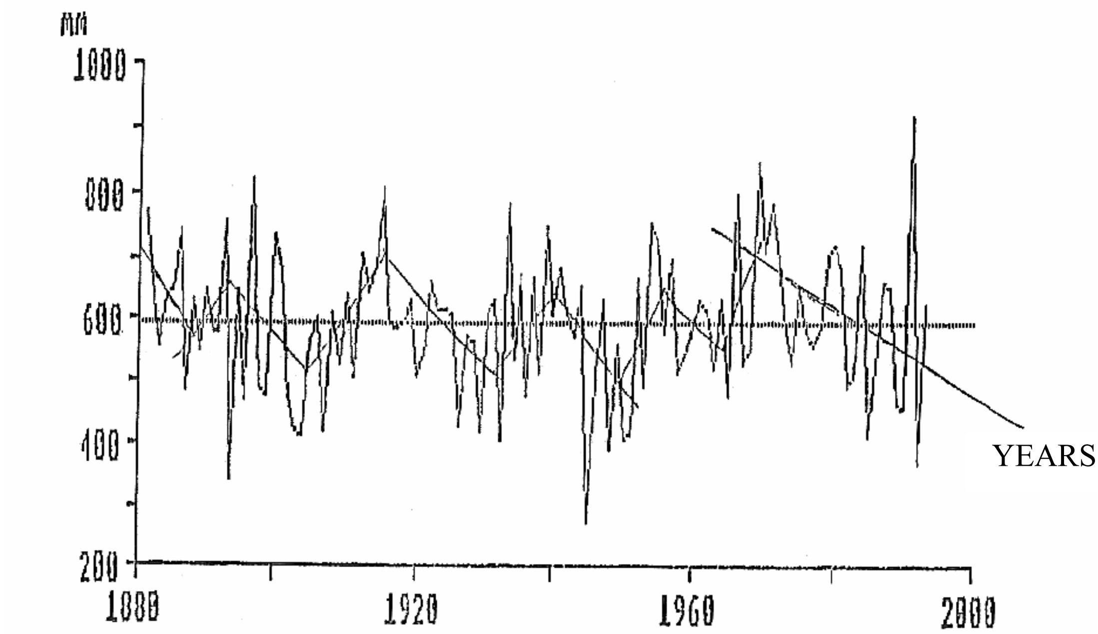


Figure 8. The evolution of the annual amounts of precipitation at BUCHAREST- FILARET, between 1881 -2000

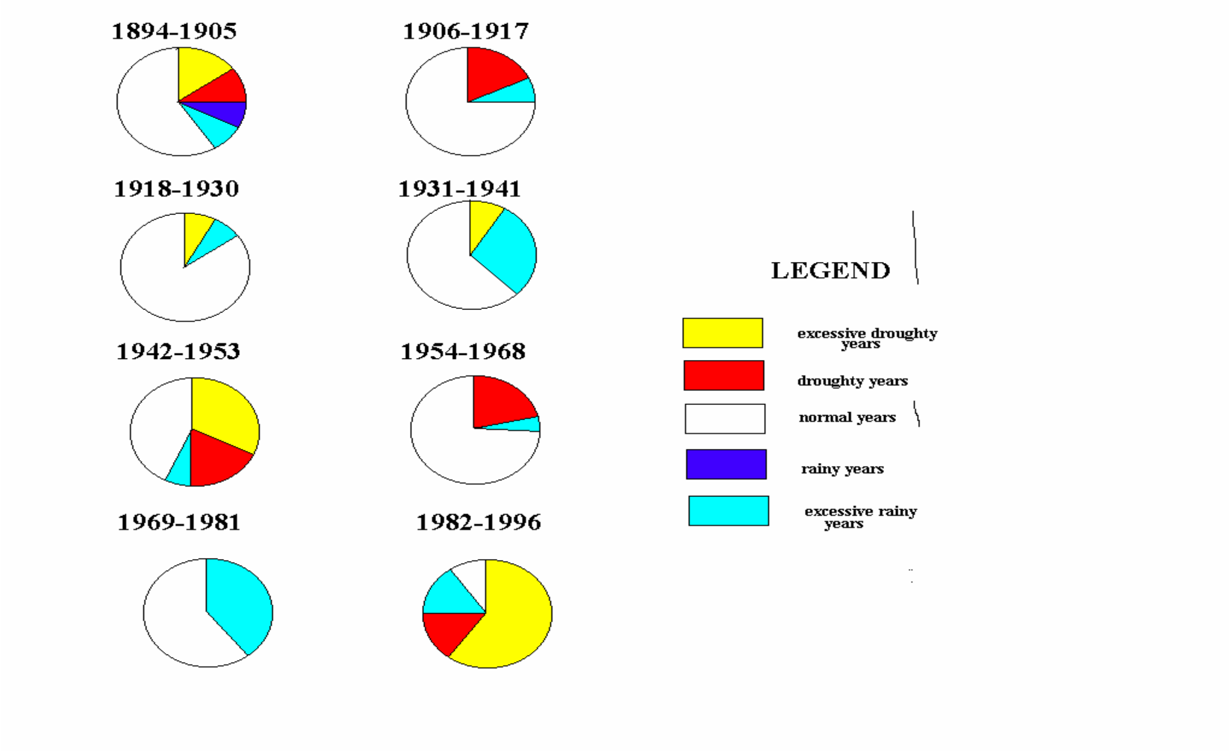


Fig. 9. Frequency of the draughty normal and rainy periods

As concerning the evolution of the moisture accessible to plants in the soil layer 0-100 cm during the last decade, it can be noticed that its value decreased down to values of 50-100 m3 he-1 simultaneously with an areal development having covered the entire area of the Romanian Plain.

The minimum values of 50-100 m3/ he represent about 5 % from the normal water capacity used for the soils. At the same time, the aridisation phenomenon increased during the last years due to the large number of days with temperatures above 30-32°C during the period July - August and the tropical nights (night temperature above 17°C).

From the point of view of the water resources, during the period 1982-1996, 7 years with hydrological drought were recorded: 1983, 1985, 1987, 1989, 1990, 1992, 1993 characterised by the extreme severeness of the phenomenon especially in the river basins in the southern part of the country. In these areas the annual runoff of the rivers was 50 % of the monthly annual value and in the plain areas even below 30 %.

The discharges flown on the rivers on the southern part of the country have maintained almost the same values even over the seasons without intervals modifying this continuous decreasing character.

The relatively low snow cover during the last winters and the low precipitation amounts in the spring season did not allow the reconstruction of the water resources in the ground and in the reservoirs.

The analysis of the piezometric level dynamics for the last 5 years indicates an obvious and continuous decrease, being by 25-300 cm below the multiannual monthly means.

The chronicle feature of the drought in the southern part of the country leads to the settlement on the aridization state in the area of the Oltenian Plain. The aridization phenomenon is more significant from the hydrological aspect, an exaggerated decrease of the discharges in most rivers of the country and especially in Oltenia being the result of the cumulated and simultaneous action of several causes:
- the decrease of the annual precipitation amounts, especially during the last 12-13 years;
- the increase of the annual mean temperature of the year with intensification influences of the evaporation and evapotranspiration;

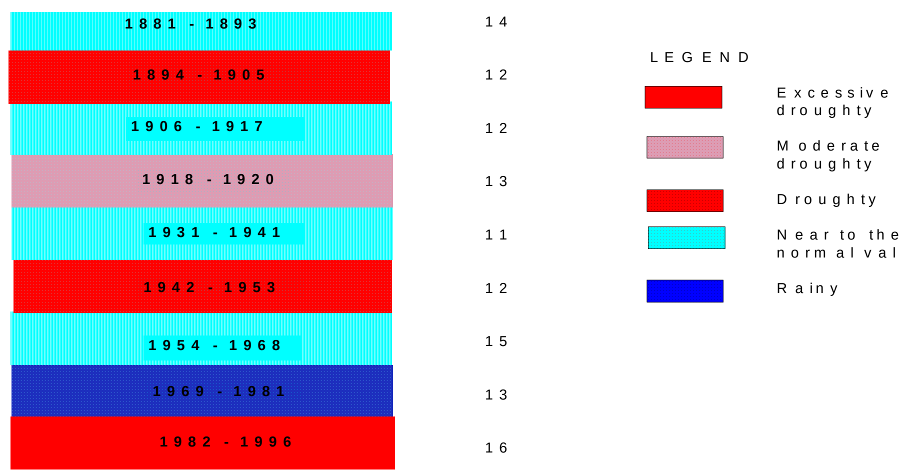


Figure 10. The successive droughty, normal and rainy periods (1881-1996)

- the decrease of the shallow water levels and the river terraces with negative implications in the air supply during the seasons without rainfalls;
- the ever higher frequency and longer duration of the drying phenomena of the rivers with catchment basins smaller than 500 km2.

From the point of view of the water resources in Oltenia area during the period 1982-1996 seven years with hydrological drought were recorded; 1983, 1985, 1989, 1990, 1992, 1993, the years 1992-1993 were characterised by an extreme severeness of the phenomenon finally leading to the calamitation of the area. During this period, the annual runoff of the rivers in Oltenia represented constantly less than 50 % of the multiannual mean runoff and in the low plain areas even below 28 %, drying phenomena occurring frequently. Even over the season, during the period 1992-1993, this deficit got a permanent aspect.

(iii). Endemic drought areas

From the analysis of the climatological data (precipitation and temperature) during the last century as well as of the hydrological and agrometeorological ones over a long time period, the areas mostly frequently affected by drought were identified on Romania's territory.

From the climatological and agrometeorological standpoint, the endemic drought areas are grouped over a relatively significant territory as a surface as well as an agricultural yield potential. These area include: the Oltenian Plain, B††r††gan, Dobrudja and Birlad Plateau.
The drought phenomena have a general trend to extend and migrate towards the western and central regions of
the country (Fig.11).

From the hydrological point of view, the water deficits have as results areas with intermittent runoff of the rivers in the plain, represented in Fig.12. These areas are located in the river basins in the southern part of the country, Dobrudja and partially central Moldavia.

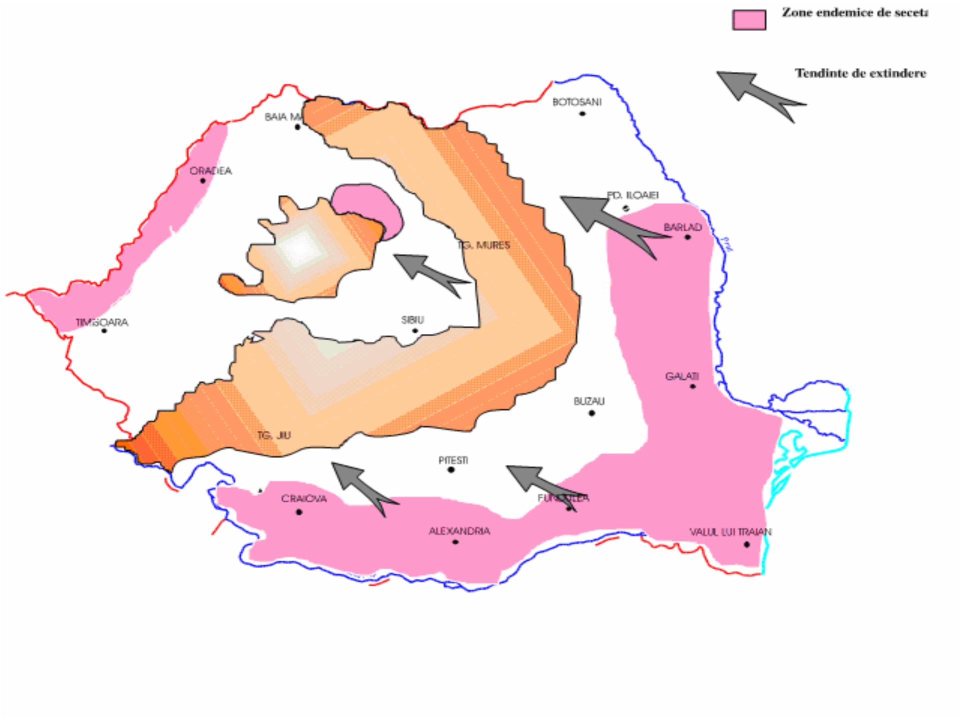


Fig.11. The expansion of the draught phenomenon in centraland western zones

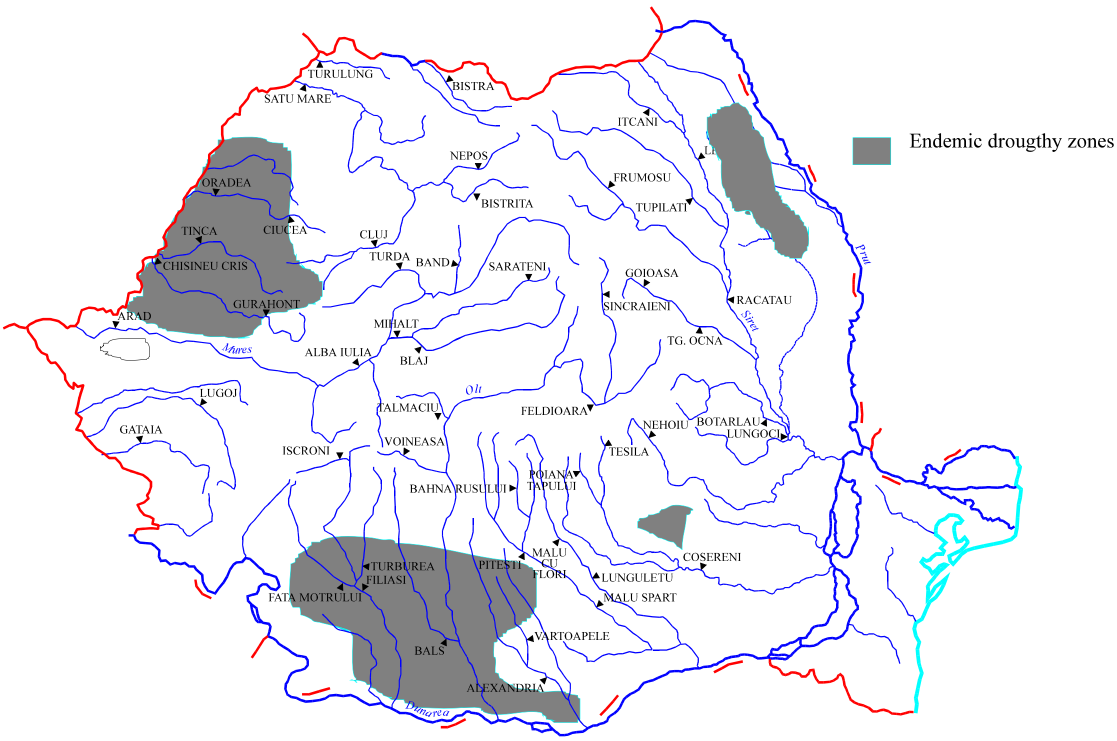


Fig. 12. The endemic draughted zones

As a conclusion, from the first analysis carried out upon the drought phenomenon, the following can be noticed;
- the drought phenomenon is specific for the excessive climate area of our country and especially in the large extra-Carpathian agricultural areas;
- the presence of the meteorological, agrometeorological and hydrological droughts over long periods imposes a continuous stress upon the socio-economical development of the country;
- phenomenon with an extreme severeness and a record extent have occurred over an unusual long period during the last decade.

8. National strategy of the domain in water resources

The strategic objectives of the development of the agriculture in Romania are meant to ensure the alimentary safety of the population at proper standards and at a quality level corresponding to the international standards, to eradicate poverty in the rural areas, where half of the present population of Romania lives, and at the same time, to ensure the long term use of the climatic, water and soil resources.

The major objective of the strategy for the development of the policy in the water domain refers to the provision of the water resources with a proper quantitative and qualitative level for agriculture and industry as well as for the population in the urban and rural areas.

The amplification of the drought phenomenon during the last decade has significant implications upon the social and economical potential of the country generally, but especially upon the agricultural and water management strategy. This fact has determined the development of research and technological development projects and programmes for the study of the causes and for knowing the trends of the phenomenon in order to carry out the actions meant to reduce the negative effects upon several significant domains of the Romanian economy.

CONCLUSIONS

In Charter 1 we analyzed the water resources characteristics in Romania, taking into account the two major phases: floods and droughts.
Regarding **floods**, we made an inventory of hydrotechnical water works (reservoirs, deviates and dykes). Looking to the area afecetd by flash floods and to the existing water works, flood risk areas in each basin were identified:

1. **Somes Basin:** zonele oraşelor: Cluj-Napoca, Dej, Beclean, Sângeorz Băi, Sighetu Marmației, Jibou, Zalău, Carei, Seini etc., bazinul râului Someşul Mare unde există numai lucrări punctiforme de apărare împotriva inundațiilor, fie subdimensionate, fie deteriorate de ultimele viituri, râul Someşul Rece, râul Lăpuş şi afluenți, râul Crasna şi afluenți, râul Tisa şi afluenți (Vişeu, Iza), râul Tur şi afluenți.

2. **Crisuri:** râul Barcău pe sectorul Nuşfalău - Marca; râul Barcău pe sectorul Balc - Şumal - Almaşu Mic; râul Inot la Marghita; Valea Călata pe sectorul Călățele - confluență Crişul Repede; Valea Secueu pe sectorul Mărgău - confluență Crişul Repede; pârâul Peța; Crişul Negru pe sectorul Vaşcău - Beiuş; râul Crişul Negru pe sectorul Tăut - Beiuş; râul Crişul Băița pe sectorul Nucet - Ştei; Valea Sighiştel; Valea Nimăieşti pe sectorul Curățele - Budureasa; Valea Roşia pe sectorul Roşia - Pocola; Valea Crăiasa; Valea Finiş; râul Crişul alb pe sectorul Blăjeni - Buceş; râul râul Crişul Alb pe sectorul Criscior - Brad - Vața de Jos; râul Crişul Alb pe sectorul Gurahonț - Bocsig etc.
3. **Mures:** Zonele cu risc de inundatie sunt numeroase, cele principale fiind situate în lungul unor cursuri de apă, rămase sub efectul inundațiilor sau la care lucrările de indiguire, datorita vechimii de cca. 25 ani, subdimensionării şi a intenselor solicitări la care au fost supuse în ultimii ani, trebuie reconditionate. Printre acestea se pot aminti : localitățile de pe râul Mureş pe sectoarele Remetea - Toplița, Chirileu - Iernut şi Alba Iulia -Vântu de Jos - Ilia – Lipova; localitățile de pe râul Târnava Mare pe sectoarele Sighişoara - Mediaş, Copşa Mică - Mihalț şi Crăieşti – Blaj; r. Târnava Mică în zona localitătilor: Sângergiu de Padure, Coroi - Sânmartin, Sona, Săcel, Blaj, Cetatea de Baltă, Jidvei; râul Niraj (localitățile Acatari, Ilieni, Ghe. Doja, Leordeni); p. Zau de Câmpie, p. Comlod, p. Poclos, p. Voiniceni, r. Strei la Bot, r. Arieş (în zona localităților Câmpeni, Baia de Arieş, Lunca Arieşului - Jud. Alba) şi râul Cerna aval de lacul de acumulare Cinciş-Teliuc.
4. **Timis-Bega**: Only some area downstream of old dams are under flooding risk, in case of concentrated rains.
5. **Jiu Basin**: the flooding risk basin are as follows - râul Amaradia pe sectorul Târgu – Logreşti - confluența cu râul Jiu, râul Gilort amonte oraşul Târgu – Cărbuneşti - confluența cu râul Jiu, râul Motru pe sectorul Motru – Văgiuleşti, râul Jiu pe sectorul localităților Brădeşti, Filiaşi, Coțofenii din Dos, râul Orlea pe sectorul Coştei – Arjoci, râul Jaleş pe sectorul Runcu – Stolojani.
6. **Olt:** The major flooding risk area are situated on the efluents and upstream of the following rivers: Frumoasa, Mădăraş, Cosmeni, Fişag, Brețcu, Lemnia, Lunca Mărcuşului, Geamăna, Muiereasca, Sălătrucel, Sărat at Ocnele Mari, Olteț, Bistrița at Băbeni, Urşani, Luncavăț, Râmeşti, Sâmnic at Goleşti and Blidari, Plapcea and Teleorman sectors Tătărăşti - Trivalea Moşneni - Orbeasca.
7. **Argeş - Vedea**, hydrological space, the most dangerous area for flooding are: Neajlov on Vadu Lat – Călugăreni sector, Sabar on Puțu cu Salcie - Găiseni sector and Brezoaiele – Ogrezeni deviates secotrs, Ciorogârla - on Joița confluence area and Videle sector, Ilfov, Mircea Vodă - Cuza Vodă sector, Dâmbovița -. Săveşti vilage and Tătărani - Săveşti sector, Argeş Găiseni - Popa Nae area.
8. **Ialomita –Buzău** : Buzau on Vama Buzăului-Sita Buzăului sector, downstream Buzău City-confluence with Siret, Bâsca Chiojdului Chiojd confluence-Cătina sector, Ialomița on Dridu-Urziceni-Slobozia

sector, Prahova on Breaza-Câmpina-till confluence with Ialomița, Ialomița on Gura Ocniței-Finta-upstream confluence with Prahova

9. **Siret**: flooded areas are all along the rivers with old dykes, more then 30 years which needs to be fixed and consolidated, as Suceava, Izvorul Sucevei - Frătăuții Vechi sector, Moldova, Sulița - Vama and Cornu Luncii sectora, Baia, Gura Humorului - Păltinoasa, Răcătău river on Parincea – Horgeşt sector, Bistrița sectoars Țibău - Iacobeni and Borca - Poiana Teiului, Buhuşi – Hemeiuşi; Bicaz River on sector Telec - Bicazu Ardelean; Cracău River, Bodeşti – Roznov sector; Tazlău River, Frumoasa - Belci sector. Some special flooded areas are those ones affected by erosion processes of the banks as example during 1997 a sector of round 700 km was flooded.
10. **Prut-Barlad**: The main areas afected by high risk to be flooded are <u>in Prut Basin</u> : Prut River on sectors Orofteana - Dărăbani, Păltiniş - Rădăuți, Sculeni - Ungheni - Țuțora - Costuleni - Grozeşti, Drânceni - Lunca Banului - Berezeni - Fălciu, Jijia River on sector Hilişeni - Horia, Buhai River, sector downstream Şendriceni , Sitna River, sector Lunca - Râuşeni, Başeu River, sector Havârna - Tătărăşeni, Bahlui River, sector Scobinți - Cotnari, Albeşti River, sector Băieşti - Lungani, Elan River, sector Găgeşti - Blăgeşti. <u>In case of Bârlad Basin</u> are some risk sectors as Garboveta River, sector Dagâța - Băceşti, Buda River, sector Oseşti - Bălteni, Rebricea River, upstream confluence Bârlad, sector Scânteia - Rebricea, Lohan River, sector Crețі - Budeşti, Vaslui River, sector Schitu Duca - Codăeşti, Tutova River, sector Plopana - Iveşti, Berheci River, sector Berheci Spring-Feldioara, Zeletin River, sector Coloneşti - Podu Turcului.
11. In **Dobrogea** hydrographical space has a flash flood character, all of them have a high flooding risk. Some localities are more affected as Rahmanu, Haidar şi Saraiu de pârâul Topolog, areas of Runcu locality on Cartal River, Călugăreni and Nistoreşti localities on Casimcea River, urban areas of Tulcea and Babadag.

Some water works are old and need to be consolidated.

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