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FACULTY OF GEOGRAPHY

PHD THESIS

URBAN HIDROLOGY STUDY IN TURDA- CÂMPIA TURZII DEPRESSIONAR CORRIDOR

- SUMMARY -

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Key words: urban hydrology, urbanization, water supply, drainage, sewerage, cleaning, management, flooding, risks, vulnerability, prevention.

PART I.

PHYSICAL-GEOGRAPHYCAL CHARACTERISTICS AND URBANISATION DINAMIC IN TURDA-CÂMPIA TURZII DEPRESSIONAR CORRIDOR

1. ELEMENTS OF TERRITORIAL UNITY

Turda-Câmpia Turzii depressionar corridor, known in the geographical literature as Lower Arieş Corridor, has the function of a typical corridor, being an important axis of mass, energy and information fluxes, with a remarkable individuality between the neighboring geographical spaces. The depressionar corridor settles at the contact between the Apuseni mountain area and the Transylvania Plain, having a general north-west – south-east orientation, with a distinct geographical complexity (Figure 1).

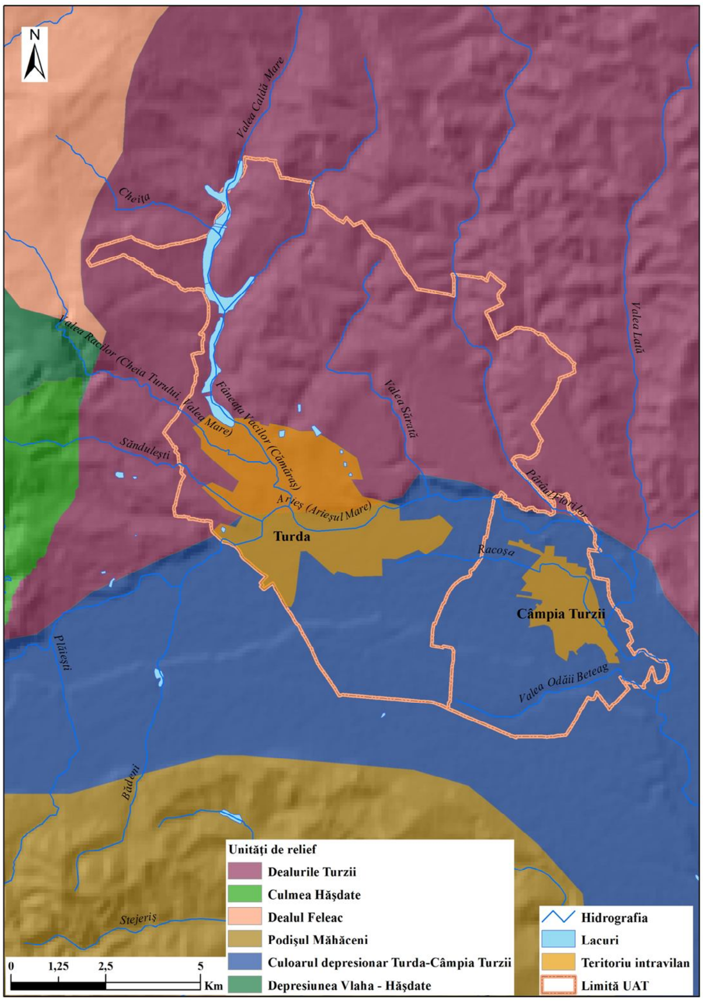

Fig.1. Geographical position and limits of Turda - Câmpia Turzii depressionar corridor (after Posea G., 1980)

The calcareous ridge of Trascău Mountains that reaches Tureni represents the region’s *northern* limit through its abrupt on the line Podeni-Moldoveneşti; in *southern* limit is represented by Turda Hills that continue the Feleac Massiv, with over 150 m above it; in *east*, the contact with the Transylvanian low hilly plain is made by the Arieş left bank till its confluence with Mureş River; the *southern* limit with the Târnavelor Plateau is represented by the high Măhăceni Plateau (Morariu, T. and Savu, Al., 1970).

The corridor’s individuality is underlined by its geographical continuity function and defined by the flooding plain width, terrace system and its regional economical importance.

2. PHYSICAL-GEOGRAPHICAL CHARACTERISTICS OF TURDA-CÂMPIA TURZII DEPRESSIONAR CORRIDOR

2.1. Substratum particularities and geomorphological characteristics

As a main component of the geosystem, the relief is a leading factor geographical landscape elements’ interaction. The current sector’s configuration is the result of a long evolution under the complex action of tectonic phenomena and exogenous geomorphologic processes.

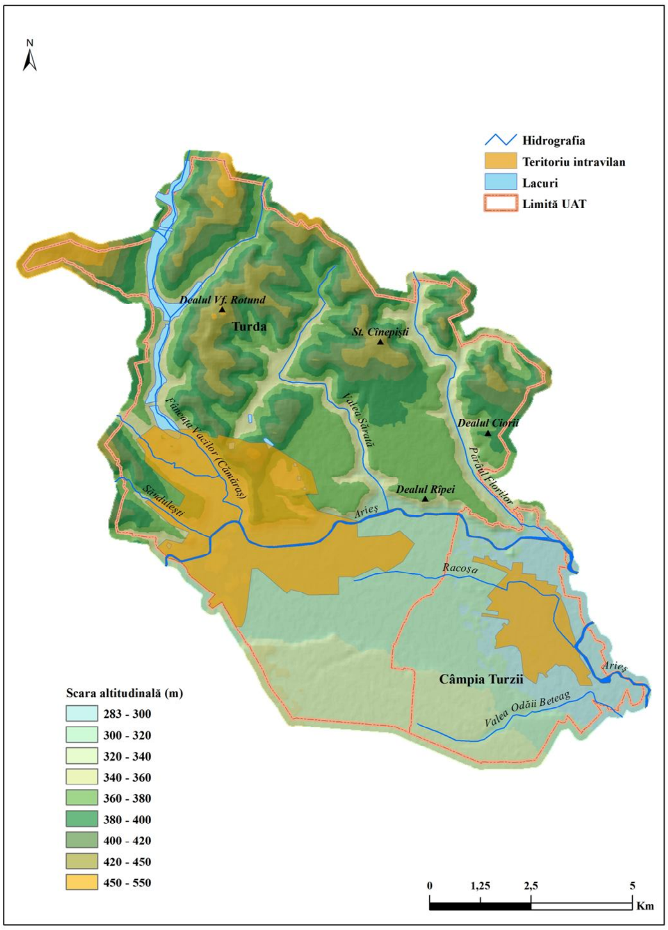

Fig.2. Hypsometric map of Turda – Câmpia Turzii depressionar corridor

The corridor's geological analysis presents the following geo-chronologically periods: Late Jurassic (limestones), Badenian (salt formations), Sarmatian (clay and sands with tufa intercalations), Panonian (carbonate and sandy clays) and Quaternary, with various sedimentary deposits (sand, gravel, silt), but also, in some places, with Tortonian deposits (shale clay, sand and tufa) and cineritic levels.

The Turda-Câmpia Turzii depressionar corridor as a result of differential erosion at the contact between Mesozoic limestones resistant barriers and Neogene sedimentary formations, was sculpted by Aries, whose valley widens gradually cutting into the left bank and leaving on the right large terraces, starting with the one of 3-6 m and ends with 65-70 m terrace. The main relief's particularity is represented by its continuous asymmetry: a gradual development in south, from flooding plain to terrace complex; in north and north-east an abrupt with *elevations* of 60-100 m as a result of Arieş River tendency to drift towards north and north-east, undermining the left bank and creating fan terraces on the right one (Figure 2). This asymmetry is represented by a slow local subsidence that probably counterbalanced the uplifting movements in the neighboring diapir area (Morariu, T., Iacob, D., 1958).

The flat aspect of the depressionar corridor is shown by relief's low energy and by the high frequency of lower category slopes (below 5 degrees). Slopes with more of 5-15 degrees appear on high terrace fronts and on the slopes of Arieş left tributaries. Slopes with more than 15 degrees appear only at the corridors margins, at contact with neighboring regions. The actual hearth of the corridors two towns is settled in the Arieş River wide plain. The exceptions are the exterior districs from north Turda, situated on high terrace fronts and on the wide Racilor stream valley.

2.2. Climatic conditions

After analyzing the observations made on the main climatic elements variation into the depressionar corridor, some conclusions have been taken. The air's temperature has strong connections with atmosphere's general circulation and with corridor's orographic particularities, and has a annual average of 8.8°C. The analysis of annual average temperatures' non-periodic variations over 50 years shows a maximum oscillation of 3.4°C, with a maximum in 1951 (10.4°C), and a minimum in 1976 (7°C). Average monthly temperatures range from -3.6 ° C (January average) and 19.6 ° C (July average) resulting in a 23.2 ° C temperature variation (Figure 3).

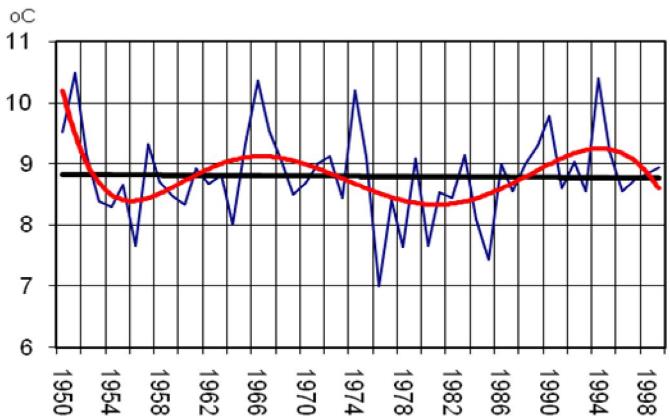

Fig.3. The variation of annual average temperatures (1950-1999)

The region's characteristics are lower air humidity values that appear especially in sheltered areas of Apuseni Mountains south-east limit. They are determined by foehn circulation in this region. The multiannual average of relative humidity values registrated at Turda station during 1967-1997 is 76%.

Sheltered conditions determined by Apuseni Mountains natural obstacle determine rainfall quantity reduction inside the depressionar corridor (Figure 4), delimitated by 600 mm izoline. Inside town's hearth, annual rainfalls decrease much below 600 mm, and below 550 mm in Câmpia Turzii because of foehn processes influence (Fărcaş, I., 1977). Through all the year, most rainfalls appear in the warm semester (April-September), with almost 2/3 from the annual quantity (350 mm); the other 1/3 (170 mm) fall in the cold semester (October-March). In summer are registrated the heaviest rainfalls because of frontal processes and also because of thermal convection processes. So the rainfalls quantity varies between 200-350 mm, almost 40% of the entire annual quantity.

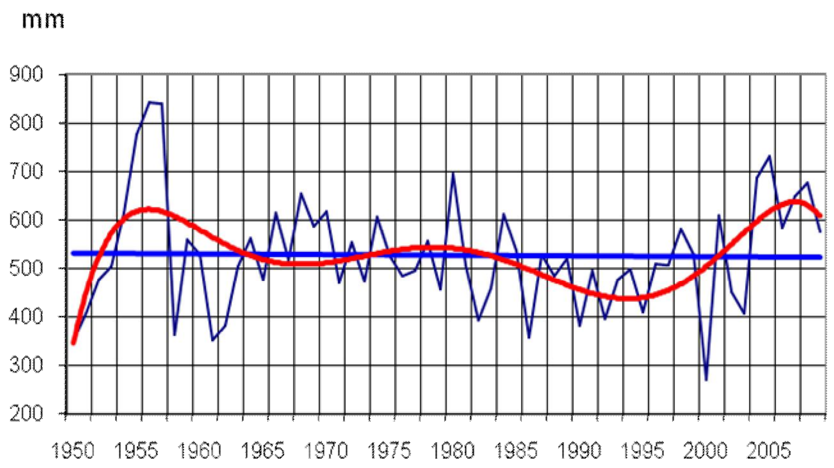

Fig.4. Chronological variation and annual rainfall quantities trend (1950-2009)

Wind's direction has a dominant north-west frequency, followed by the directions south-east and south-west. Wind's velocity has higher values on north-west direction (5-6 m/s), with lower annual average on south-east and south-west sectors (2-3 m/s). Low velocity values appear on eastern sector (1-2 m/s), because it is less exposed to air currents circulation. Annual variation presents a spring maximum (April-May) and an autumn minimum (October-November).

2.3. Hydrographical characteristics

Water flow in Lower Arieş Corridor presents a temporal variation determined by the climatic factors evolution (especially rainfalls) and a spatial variation**,** determined by relief, rock, soil, vegetation and human activity conditions. Annual flow variations hover around the multiannual average discharge value 25.5 m^3/s (Figure 5). Following the annual average discharge deviation to the multiannual average period of 60 years (1950-2009) presents a maximum value recorded in 1970 – 41.9 m^3/s, and a minimum of 12.6 m^3/s in 1961.

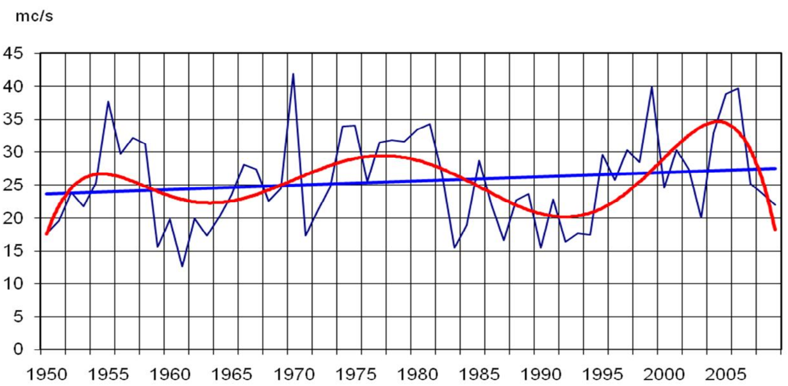

Fig.5. Annual average discharge deviation multiannual average at Turda station (1950-2009)

Monthly flow regime underlines April's maximum discharges (52.5 m^3/s). The April's high values are determined by the intensification of cyclone activity that generates heavy rainfalls, overlapping snow melting. The lowest discharges appear in September (13.5 m^3/s), determined by anticyclone regime materialized in summer droughts.

According to the researches of Morariu, T., Iacob, D. (1958) and subsequent Mac, I. (1965), some conclusions have been made according to corridor's hydrogeological characteristics. The hydrostatic level in Arieş plain terrace is represented by single 1.20 – 2 m groundwater, supplied through direct infiltrations from Arieş River upstream Mihai Viteazu, where the river intersects impermeable basal formations. This explains the reachness and constance of discharge, supplied also by springs from other terraces where alluvia accumulate high water quantities. High and constant discharge of the phreatiq level of Arieş plain may provide high industrial and drinking water quantities. The high underground water supplies from the 30-45 m terrace provide all the water necessary for the corridor's industry.

2.4. Biopedogeographical characteristics

The biopedogeographical cover of Lower Arieş Corridor appears in the landscape through the interrelations between vegetation, fauna and soils, and reflects, through its general characteristics, the transition position between mountains and Transylvanian Plain, the temperate climate, the corridor morphology, determining specific genetic, evolutionary and physiognomic parameters.

The dominant steppe vegetation (especially xerophile herbaceous formations), including secondary grassland associations with fescue or plants characteristic to a drier climate. Forests occupy only a small percentage due to frequent cuts that took place. However, two plant associations dominate the region studied, namely deciduous forests, essences "strong", and riverside coppice meadow, essences "white" or "soft." First cover heights, ancient terraces and secluded faces of the hills and the second, meadows and riverbanks. Fauna of the depressionar corridor Turda - Câmpia Turzii is specific to the forest and steppe marginal area of the Transylvanian Depression, including specific biotypes. The main classes of soil, with adjacent genetic types, identified in the corridor are: cernisoils (chernozems and faeozems), Luvisols (preluvisols and luvisols) hidrisoils (Gley soils and stagnosoils) protisoils (regosoils and alluvisoils) and antrisoils (erodisols).

3. URBANIZATION DINAMIC

The towns from the corridor appeared in different stages, with different purpose and evolution, brought forward by the advantages generated by the supporting geographic space that conditions the nowadays development. So, its position as a corridor places the unity between the geographic spaces with high geographic potential. This thing justifies the social-economical development from early times.

The urban life in the corridor began in the XIIIth-XIVth centuries, but they were not urban structures similar with the modern ones. The urbanization process in the corridor developed in the last centuries strongly connected with the industrialization processes that marked the apparition of manufacturing enterprises in the XVIIIth century. The industrial phenomenon appeared more powerfully at the end of the XIXth century and became more “excessive” in the last half of XXth century. This thing quickened very much the time-space dynamic of urban phenomenon and had its consequences.

In this depressionar corridor exit two twons: Turda – a medium size town with over 50000 inhabitants, and Câmpia Turzii – medium-small town (25000-50000 inhabitants). The villages are from medium and small category. The settlements size and density indicates a high population density in the corridor – 80-150 inhabitants/km^2; exceptions are the town towns: Câmpia Turzii (1129,7 inhabitants/ km^2) and Turda (609,1 inhabitants/ km^2) – measured in 2002 (Pop., Gr., 2007).The urban system incise a permanent dynamic of the geographic space, an evolution that adapts or modifies the initial structure, according with the mutations appeared inside the components and in the relations between the components.

<u>PART II</u>

WATER SUPPLY AND SEWAGE SYSTEMS IN THE TOWNS FRON THE TURDA-CÂMPIA TURZII DEPRESSIONAR CORRIDOR

1. WATER SUPPLY SYSTEM

In the first part of this chapter we present a brief history of water supply and sewerage systems in the towns from this corridor, following a gradual development in the broader context of the entire system of water management. Thus, the phenomenon’s chronological analysis brings to the fore the existence of three evolution stages: the stage of early water supply systems (late XIXth century – mid XXth century), the stage of extensive development (second half of XXth century), and the contemporary stage (late XXth century – early XXIth century).

1.1. Zonal drinking water production systems

The water supply sources of the urban systems inside the Lower Arieş Corridor are connected with Arieş drainage basin, their repartition being conditioned by town’s position inside the river ax’s general system.

The main drinking water sources is represented by the underground water - Turda, and 40% for Câmpia Turzii. The main Câmpia Turzii surface water source is Hăşdate Brook, captured by a spillway dam (Table 1). The captured water reaches through gravitation or through pumping the treatment plant. Underground supply sources of the towns from Lower Arieş Corridor are represented by the underground water from flooding plain and superior terraces (6-8 m, 10-12 m and 30-45 m), with high discharge and small depths, facilitating operating conditions.

Town	Supply sources	Discharge brought by this sources
Turda	Underground *Corneşti* *Mihai Viteazu* *Mihai Viteazu-Varianta* (in conservation) *Turda Veche* (in conservation)	Q med = 11 278,5 mc/day (130,5 l/s)
Câmpia Turzii	Underground *Poiana* *Călaraşi*	Q med=1 925 mc/day (22,6 l/s)
	Surface *Hăşdate Brook*	Q med = 4 445 mc/day (51,5 l/s)

Table1. Water supply sources for Turda and Câmpia Turzii

Regarding water quality from underground sources, they require only chlorination at storage tanks. The water from Hăşdate source corresponds with the intended purpose, with corrections needed to remove impurities and organic components, suspensions and clays. To correct raw water quality in the treatment process from Turda water plant, use the following substances: aluminum sulphate as coagulant, lime paste to adjust pH, and liquid chlorine as a disinfectant. Of laboratory analysis reports performed in Aries Water Company we find the following characteristics of physical-chemical and microbiological evidence demonstrating that water comes under Law 458/2002 and Law 311/2004 on drinking water quality: pH: 7.5; turbidity: 0.5 to 0.7 FNU, conductivity (25 ° C): 4.2 to 6.5 mS/cm; nitrate: 5.8 to 15 mg/l oxidation: 0.5 to 1.5 mgO2/l , free chlorine: 0.1 to 0.2 mg/l microbiological indicators absent.

1.2. Water distribution systems

Distribution network belongs to the general supply system structure with water in final position – the most dynamic component, in a continuous development, in accordance with the needs of service units. It also includes many other subcomponents as “all pipes, valves, gauges and control apparatus and outbuildings, where water is taken from storage buildings and distributed to all consumers in required quantity and pressure” (Mănescu, Al., Sandu, M., Ianculescu, I., 1994, p. 424). The distribution networks have been separated by the specialist, according to some complex criteria (localities structure, execution time and material, diameter) into three types: ramified, ring-like and mixed.

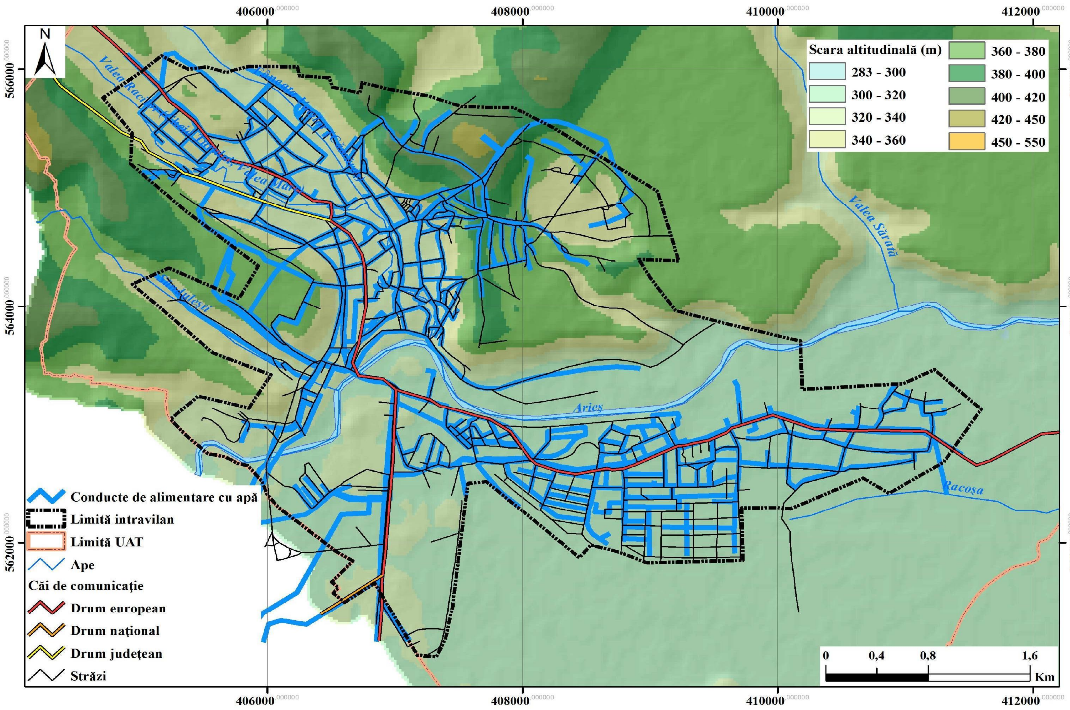

Fig.6. Turda's water supply network

Drinking water distribution networks from Turda belong to the ring-like and ramified (in the peripheral areas) type and are 119.8 km long; 87% of the town's inhabitants are connected to this network (Figure 6).

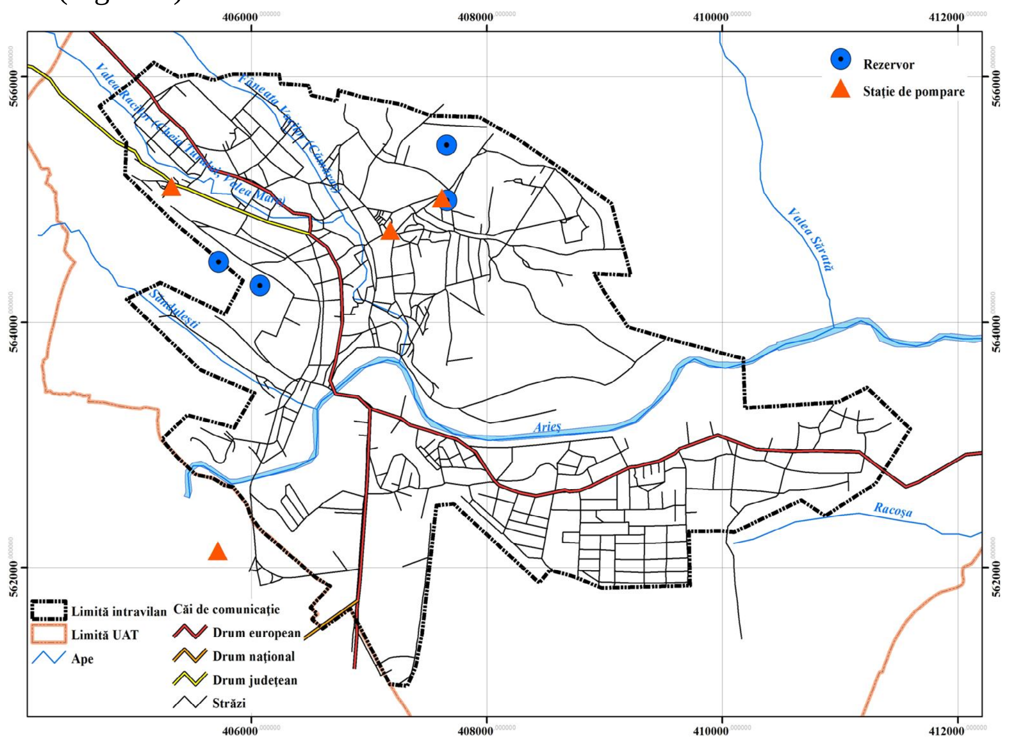

Fig.7. The location of main reservoirs and pumping stations in Turda

The existent distribution network contains pipes with diameters of 100-300 m. If we think that the network was developed in 1912, pipes wear is very advanced. They are mostly old, from steel and in some parts cement, and in the last years PVC extensions. The losses inside the network are estimated at 51% from the entire consume because of pipes age and because of frequent network accidents. The town is settled on the left and right banks of Arieş, between the contour line of 310 – 323 m on the right bank, and between the 316 – 450 m contour line. Because the town's level difference is 100 m, the distribution network contains three pressure zones: Zone I- between 316-350 m, Zone II - between 350-400 m, Zone III – above 400 m.

The same network from Turda contains some work areas, each area being "distributed" to a storing reservoir (Figure 7). We can mention the pressure zones connected with the reservoir from pumping station Mihai Viteazu that supplies the whole system, the one distributed to Cetate reservoir (Zone II) and the one distributed to Frăgărişte reservoir (Zone III).

The water distribution inside Câmpia Turzii uses a network of 48.72 km long, with 96% inhabitants being connected to it. The network belongs to the ring-like and ramified type.

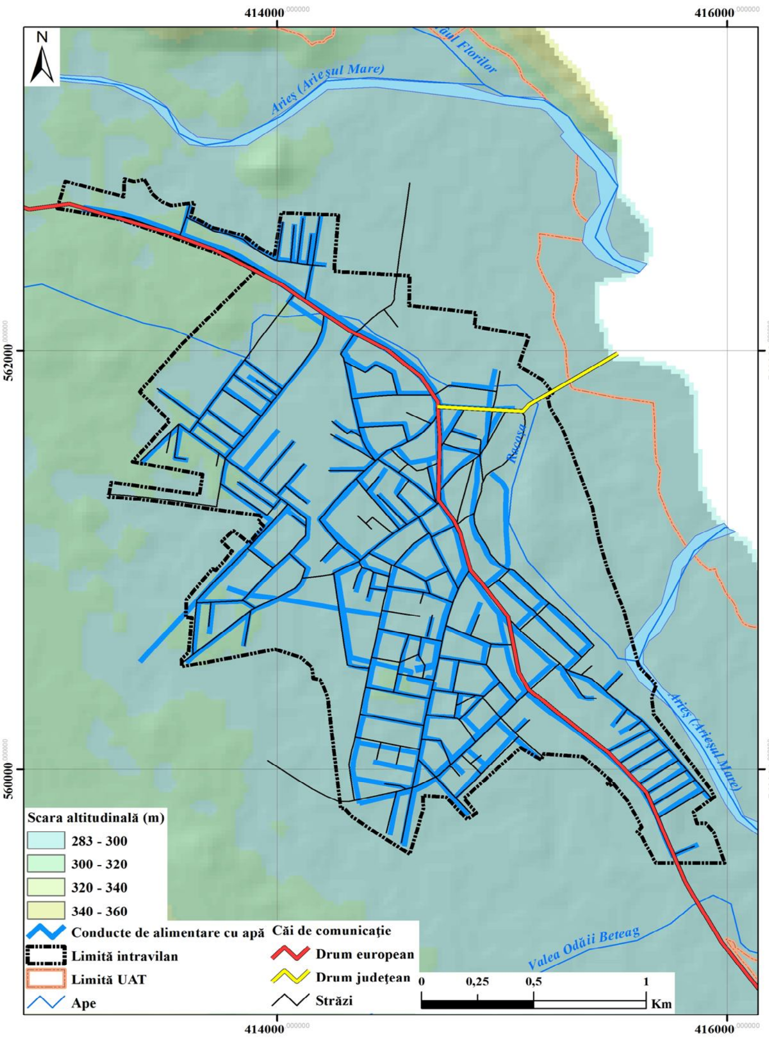

Fig.8. The water supply network from Câmpia Turzii

Most pipes (32.7 km) are steel, cement, iron and prestressed concrete (except for small sections of polyethylene and Premo, which are rather extensions made in 2002 and 2006), with exceeded operating time. Because of their age appear frequent accidents on the network pipes, leading to disruptions in the supply of drinking water to consumers and a very high percentage of losses (estimated at 42%). Another danger is the infestation of delivered water with various chemicals or pathogens due to infiltration from the surrounding environment.

From the Turda Veche treatment station, the water goes through two adduction pipes of 400 and 600 m diameter to the Câmpia Turzii pumping station. Câmpia Turzii has a pumping station for drinking water that assures water slump through a pipe of 600 m diameter and 1850 km long to a storing reservoir of 5000 mc that will assure the compensation of hourly flow variation.

2. WATER DRAINAGE IN A DEVELOPED URBAN SYSTEM AND SEWERAGE SYSTEM

The interaction between human activities and water's natural cycle that happens especially inside urban areas is the one that sustains developed urban systems. This interaction has two main forms: one - water taking from its natural cycle needed to assure water necessary inside the town; two - soil sealing that modifies natural drainage parameters. These conditions represent a distortion of water's natural cycle by creating an urban cycle that marks a strong connection between humans and water inside urban areas.

Analyzing the typology of drainage systems in terms evolution and current situation, two forms come in front: one organized, allowing appropriate management and control, and an unorganized one, which is more difficult to control, representing an unknown variable in the equation corresponding to the management of "urban" water.

Historical evolution of drainage systems and its components highlights the gradual transition from open sewer simple systems (shallow), which joined the natural ones, represented by natural channels and streams in underground sewers, then the separation mixed until the later stages with maximum control possible.

Organized drainage network components that appear in our area are:

- Proper sewerage networks that drain wastewaters (sewage and industrial ones), and also rain water;
- Town's protection line, that includes earth dikes (and/or) covered with concrete or even sectors with banks covered in concrete;
- Elements of water gravitational evacuation into an emissary (spill-ways and pipes);
- Water courses as natural organized forms of drainage concentration.

There exists a new concept in modern drainage systems that combines old rain direct drainage evacuation measures with the control of a part of drainage that goes through drains into underground or into permanent accumulations (Stănescu, V. Al., 1995).

A second drainage systems category (unorganized) includes those areals with favorable morphology – concentrated or diffused, but also those with high infiltration rates: untended or in work roads, gardens, permeable surface courts, urban areas with no sewerage.

Sewerage systems from Lower Arieş Corridor towns take the function of adjuvant in perfecting urban water management, converting into an important component of organized drainage. A common characteristic of all analyzed urban systems is the pronounced trend of sewerage network extension; authorities desire to ensure the most effective control of drainage areas

Sewerage system from Turda includes service channels and collector channels with a total length of 60.22 km; the sewerage system is not well developed, covering only 53% from whole water distribution network length (Figure 9). The sewerage networks follow th*e* streets plan, with a gravitational collection through service channels, wastewaters and sewerage waters, industrial and pluvial waters, reaching through secondary collector channels the main collector that is connected with Câmpia Turzii cleaning station.

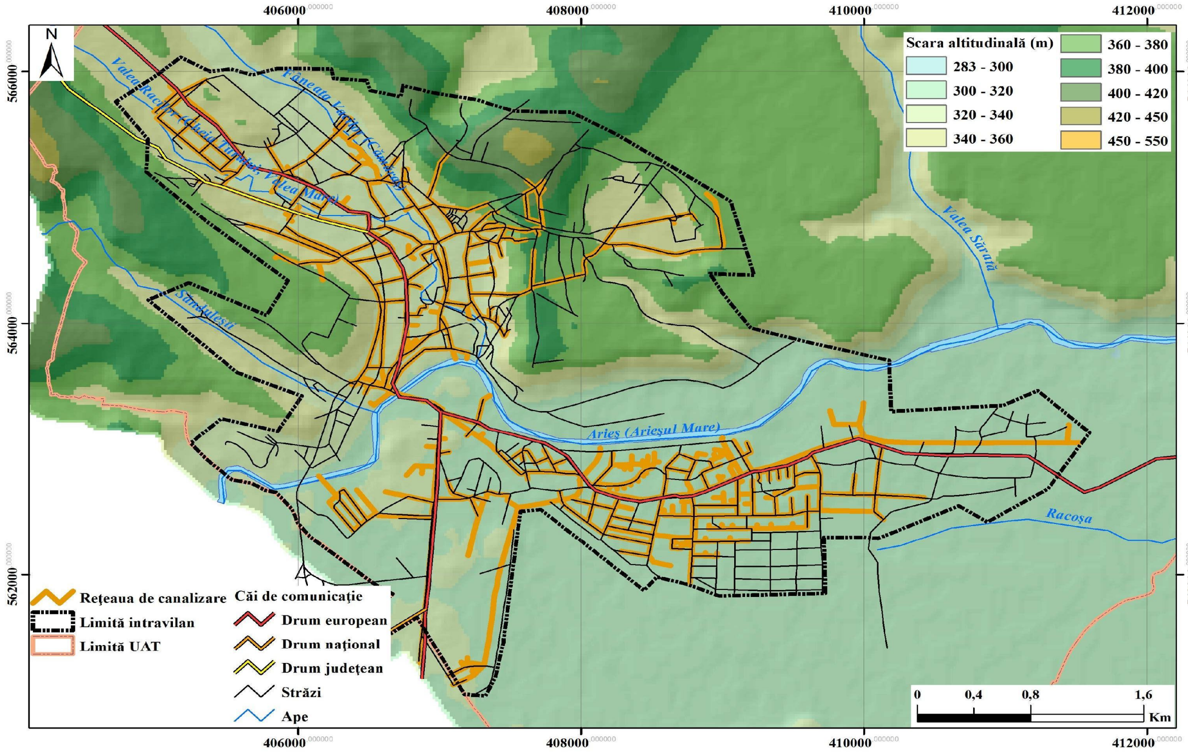

Fig.9. Sewerage network from Turda

Domestic sewerage network has a length of 57 km, and the pluvial sewerage network 13 km. The sewerage network represents a divider system (35%) on the left side of Arieş River (sewerage and pluvial), and a unitary system (65%) on the right side of Arieş River. The sewerage pipes are composed of concrete and PVC-KG and have circular sections (45.54 km; 77%), oval (9.08 km; 15%) and bell-shaped (4.84 km; 8%); their dimensions are: circular – 20-60 cm; oval – 40-60 cm and 140-210 cm; bell-shaped – 160-101 cm and 280-177 cm. The sewerage pipes under crosses some water courses: Arieş River (one under cross) and Copăceni Valley (three).

Domestic consummators that are not connected to sewerage network evacuate wastewaters or in emptying basins, or directly into the emissaries: Valea Racilor Brook - Ion Corvin, Andrei Mureşan, Mihai Eminescu and Republicii streets; Arieş River – Contructorilor Street. Almost 50% of all sewage networks are older than 20 years. The materials from collector *pipes* are PVC and concrete (95% from the total length). According to the 2006 statistics provided by the Operator, about 66% of the population receives sewer service.

The sewerage network from Câmpia Turzii is a unitary type for a rate of 100%. It works gravitationally. The total length of sewerage networks is of 49 km and represents 85% from the whole distribution network (Figure 10). Today, only 5% from whole streetscape's length from Câmpia Turzii has no sewerage network to take-over meteoric and residual waters. Meteoric waters are collected through a system of gullies and channels.

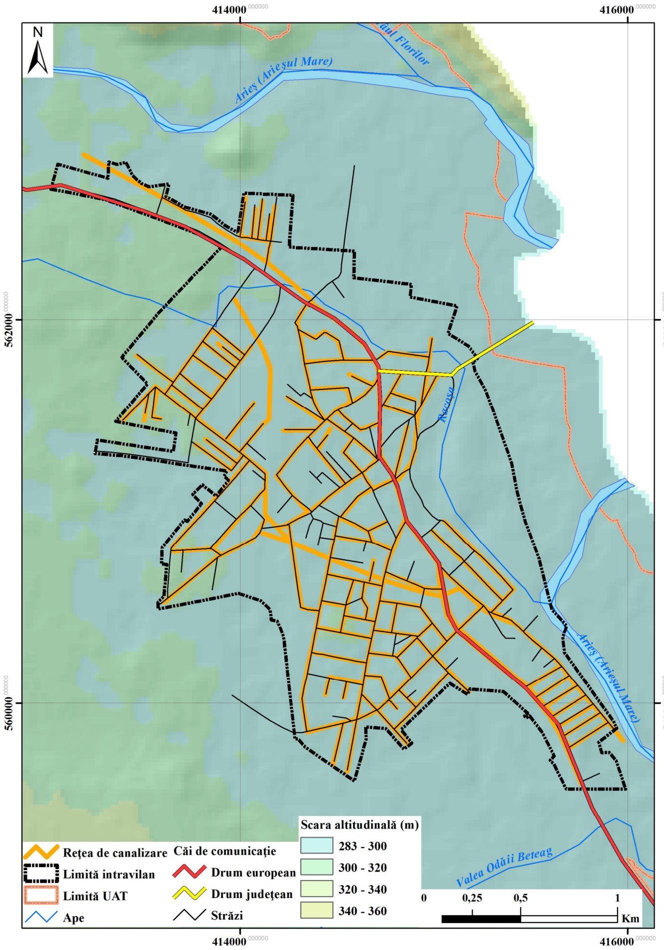

Fig.10. Sewerage network from Câmpia Turzii

Sewerage network is made of prestressed concrete, plain concrete and PVC pipes. Channels section's form is circular and oval and reaches dimensions between 300 – 900/1350mm. Main sewers are: the sewer from Şărât District (plain concrete sewer with a diameter of 600mm and a length of 7.5 km) and the Poiana – Treatment Plant sewer (takes residual waters that come from Turda; oval channel, plain concrete, 90x135mm). The last one has two emergency channels for Arieş direct discharge in case of overflowing its transport competency (in case of pouring rain). Residual waters collected into the sewerage network are treated into the treatment plant from the south part of Câmpia Turzii on the right bank of Arieş, in a protected flood area.

3. EVACUATION – TREATMENT SYSTEM

The Câmpia Turzii treatment station is placed on Arieş right bank, downstream Câmpia Turzii. The mechanical – biological treatment plant was created to take the residual waters from Turda and Câmpia Turzii.

Câmpia Turzii treatment station was made up in two stages:

- Stage I – in 1974, with a mechanical foot board made for 850 l/s. The station reached in 1976 after some improvements 1000 l/s.
- Stage II – the treatment plant extension with a biological foot board of 1000 l/s (made 65% until 1997).

Nowadays, on the location of the old treatment plant builds-up a new treatment plant. In the time of construction some elements of the mechanical foot board are maintained in operation. The other remaining elements have been demolished. Treatment waste (primary mud collected into a decanter, and sand removed through desandings) are transported from the treatment plant. Final storage is made in authorized storehouses that accept such wastes. Mechanical separated waste waters are evacuated into Arieş through a pipe of 1200 mm diameter.

The new station will have an influent discharge of 1194,4 l/s (4300 mc/h) and will be constructed in the next stages:

- Rehabilitation/extension of primary treatment stage;
- Construction of secondary and tertiary treatment stages;
- Implementation of mud thickening installations;
- Construction of mud treatment and biogas use installations;
- Implementation of mud desiccating installations.

PART III

WATER RESOURCES MANAGEMENT IN THE TOWNS FROM THE TURDA - CÂMPIA TURZII DEPRESSIONAR CORRIDOR

1. WATER MANAGEMENT IN URBAN AREAS

Today, having enough quality water is a natural right. In the economy, water has become a genuine public right and a market product or a service-product after the development of prices, that needs a public in interest. Water management appeals to public’s well training. This “public policy” (Bailly, A. S., 1997) that appears in the institutions from various territorial levels, uses various regulation and control instruments and associates various members. This system reconciles public service principles with market and competition rules.

For a sustainable water resources management we need a good communication and collaboration between politics and science. Any decision, work or investment that concern water must be interdisciplinary discussed, organized and implemented so it will have multiple valences and benefits. We must evolve from the prevailing hydro-technical and economical approach to a new long term ecological and multidisciplinary approach, with the main objective – sustainable development and resources protection and not just only the satisfaction of water needs.

2. WATER MANAGEMENT IN TURDA AND CÂMPIA TURZII URBAN AREAS

The water and sewerage services administration and management from the "Arieş Valley Water" Intercommunity Development Association is made by S.C. Arieş Water Company S.A. under the Decisions of Local Councils together with an Organization and Activity Regulation using *Contractul de delegare a gestiunii serviciilor publice de alimentare cu apă şi de canalizare.* Local councils, as concessioner, have the right to inspect the concessioned public goods, activities and services, to check the stage of investments implementation, and also to check the conformation to contract agreements.

The sole water service and sewerage operator in "Arieş Valley Water" Intercommunity Development Association is **S.C. Arieş Water Company S.A,** as legal entity with full state heritage that manages and operates with public water supply and sewerage systems, and ensure the delivery/maintenance of water and sewerage systems to consumers. Company's objectives are: the growth of life's quality by providing public services according to European standards; assurance of sustainable development; priority for rehabilitation and modernization in order to operate a reliable water and wastewater infrastructure; continuous optimization of costs to achieve desired performance so that consumers services involve minimal costs; concern for increasing costumers confidence and ensure maximum transparency in actions; continuous concern for the protection of public health and the elimination of issues with significant environmental impact.

Knowledge of water balance components and mechanisms in an urban area has special importance in terms of assembly works and adopted measures for rational use of water in order to meet the needs, prevent, combat pollution and water conservation. The life of urban inhabitants needs high hygiene and comfort standards provided by an appropriate economic development in a strong connection with the good function of water supply and industrial water supply systems, and also with a good quality of waste and meteoric water evacuation; all these things involve a good knowledge of water quantities that enter, transit and get out of the urban systems.

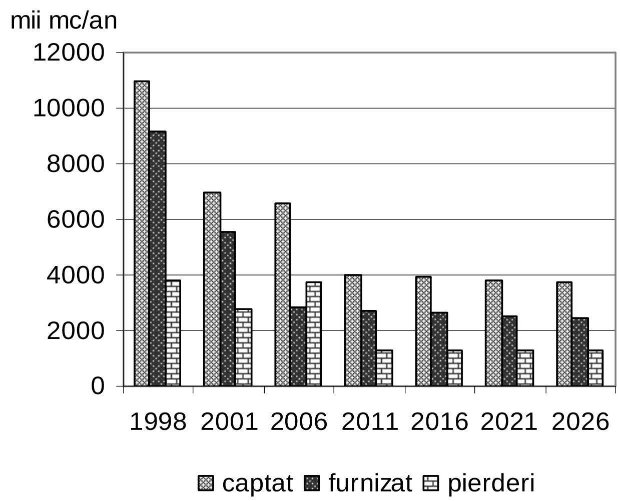

Fig.11. Evolution and estimation of distributed water quantity in Turda

The evolution analysis of ratio between the volumes of water abstracted, lost and discharged during the last decade present the general recessive trend of all water volumes in the calculation. Main causes for consume decrease are the reduction of industrial unities in Turda and Câmpia Turzii and particular metering that reaches higher and higher amounts. Also, insufficient maintenance of the water supply network (and also of sewerage network) justifies the high values of network losses; together, these causes determined a pronounced decrease of water production and the conservation of some sources. The decrease grew after 1999 when the metering was performed in more than 90% of both towns, the water production decreasing to 40% till 2001 (Figure 11 and 12).

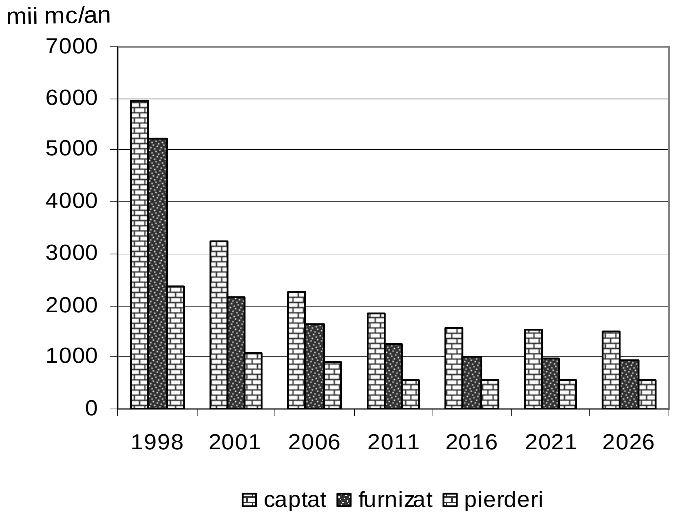

Fig. 12. Evolution and estimation of distributed water quantity in Câmpia Turzii

In the future it is expected to maintain a relatively constant non residential consumption and a decrease in residential consumption, due to negative evolution of inhabitants number. The optimal specific consumption values will reach values of 95-110 l/person/day. We hope these values will maintain in the next years according to the feasibility studies made for the European Project for the rehabilitation of water supply networks from Turda and Câmpia Turzii. Even though till 2001 the population of the two towns has been decreasing in the last years, we can see a slight increase of inhabitants connected with the town's water supply network, especially in new built areas. It is estimated that the rehabilitation of the water network will reduce network losses from a previous high percentage (40-50%) into a small percentage (25-30%), which is intended to be kept in perspective.

After analyzing the water input and output quantities in the system, we observe a slight variation of caught water quantities. It presents a decrease between 2001 and 2003 together with the decreasing consume trend, followed by a increase till 2006 due especially to high distribution network losses. From 2007, water service appointed to Arieş Water Company, which tries to maintain a relatively constant water quantity according to the water needs of urban systems. Throughout the period there is a greater amount of discharged water volumes (Figure 13) compared with caught and lost volumes, determined by the use of water into sewerage network and also by the high quantity of underground water infiltrations into the sewerage network.

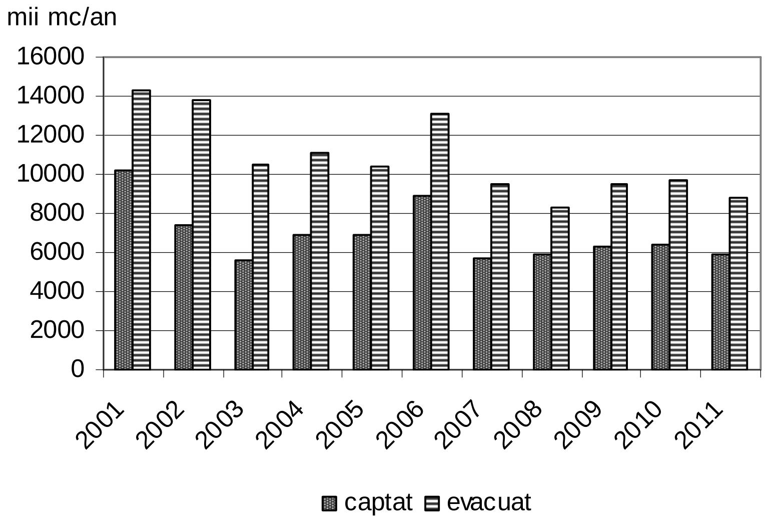

Fig.13. Evolutionary analysis of the water quantities caught and evacuated in the urban systems of Turda and Câmpia Turzii

Because today water supply systems and also sewerage systems from Turda and Câmpia Turzii present some operational deficiencies, some with significant negative impact, appears a stringently need for their rehabilitation, upgrading and monitoring. Arieş Water Company is the beneficiary of a rehabilitation project for water supply and sewerage networks from Turda and Câmpia Turzii that will end in 2013. The project is funded from a grant provided by the European Union through the SOP Environment Programm, by the State Budget and from a bank loan took by Arieş Water Company and by the contribution Mayor's Local Budget.

For the achievement of the modernization and expansion of water supply systems will be used current technology with superior performance compared to traditional technology. Water and sewerage network rehabilitation includes the use of new materials, but also of new equipments and technologies that have a lower environmental impact.

Rehabilitation and investments imply:

- Rehabilitation and equipment of caught fronts;
- Treatment plant rehabilitation;
- Water distribution network extension (10,4 km - Turda and 2,2 km - Câmpia Turzii);
- Sewerage pipes replacement (11,52 km - Turda and 13,19 km - Câmpia Turzii);
- Sewerage network extension (26,19 km - Turda and 4 km - Câmpia Turzii);
- Demolition of 80% of the existent buildings and installations inside the wastewater treatment plant, construction of new components and buildings according to the new infrastructure.

In conclusion we must mention as a positive aspect the modernization of water supply and sewerage networks, and also the effort for the replacement of time worn pipes and equipment; the final challenge is the complete reduction of losses and the optimal and efficient consumer service.

PART IV

HYDRIC RISK PHENOMENONA AND PROCESSES IN THE URBAN AREA FROM TURDA-CÂMPIA TURZII DEPRESSIONAR CORRIDOR AND THEIR PREVENTION

1. HYDRIC RISK PHENOMENONA AND PROCESSES IN URBAN AREA

Risk is defined as the perception of a danger, of a possible catastrophe. They do not exist unless they are related with a human, social or professional group, a community, a society that fears it and treats it through specific practices. It can be evaluated, estimated, calculated. Risk can be the translation of a treat, of a danger for those who feel it and see it as a risk (Veyret Yvette, 2005),

Risk concept includes three terms: danger, vulnerability and exposure. Danger represents the phenomenon or process with a certain intensity and causes damages to population, activities or environment (Sorocovschi, 2007). Vulnerability characterizes more or less the sensitivity to danger of an existing element and expresses the damages level caused by it. For Dauphiné, vulnerability expresses "the level of foreseeable consequences of a natural phenomenon over the elements at risk (people, property and environment)". There exists human, social-economical and environmental vulnerability. It may represent first the physical exposure, even though potential, to a hazard, second a certain fragility to this event and at last a poor knowledge of the behavior that is to be adopted in case of disaster (Veyret Yvette, 2003, p. 31). Exposure refers to the elements disposure in an area where they may suffer from a hazard (Sorocovschi, 2007).

In outlining areas with different degrees of vulnerability to hydric risks inside the urban territories of the Turda - Câmpia Turzii depressionar corridor, we took into account the presence and the manifestation of several categories of factors: flooded areas, areas with high waterproofing degree and steep slopes, beds sectors with active dynamic, areas with moisture excess and shallow groundwater, water markets assembly, areas with slow slope drainage into sewage or into an undersized sewage.

The floods from Arieş flow regime represent an important phase through the induced effects on the environment by the floodings they have caused. The historical maximum discharge was 950 mc/s at Turda in 03/07/1975, a year with major floods which affected two thirds of the city's population. Studies made by Sorocovschi, V., Şerban, Gh. and Bătinaş, R. (2002) bring forward the problems connected with floods characteristics inside Arieş Lower Basin and the risks the flooding plains are exposed to.

Thus, for the flood of March 1981, Corneşti water source that supplied Turda drinking water was put temporarily out of use and the riverbed presented many changes resulting in the erosion, deposition, destruction of banks consolidation. During the flood of 1995, discharges maintained over defense level; in Turda attention level was exceeded for more than 120 hours, at Aries entrance into an engineering equipped area (dammed). At the flood from December 1995 was affected water catchment of Turda cement factory and the dam was damaged over a length of 500 m, in different parts. Floods from the spring of 2000 determined the damage of a bottom sill near the Turda drinking water source (Moldoveneşti - Corneşti), being needed in this area also a bank consolidation. An important aspect is changing the look of the river bed after floods.

Thus, with floods in the spring of 2000, at Turda Hydrometric Station, thalweg dropped with a meter and the river bed slightly slid to the left side, confirming the asymmetric character of the flooding plain. At the flood from December 2009 river's left bank was strongly eroded, temporarily deflecting his course and leaving without water the flooding flap of Mechel Factory (Figure 14).

Fig.14. Arieș river deflected after the flood from December 2009 and the flooding flap of Mechel Factory

Major floods happen after the overflow of Aries in 1970, 1975 and at smaller scale in 1981, 1984 and 1995. Overflowing of tributaries like Racilor Valley, Fâneața Vacilor, Săndulești, Pordei, with smaller scale, took place in 1984, 1995, 2005, 2007 and 2009. In June 2010, Racilor Valley overflew and the streets were flooded after torrential rains, affecting tens of households from Turda Nouă District (Figure 15).

Fig.15. Racilor Valley overflowing, together with pluvial flooding in June 2010

In Câmpia Turzii, in addition to floodings that occurred after the overflow of Arieş, there were affected some objective in areas without drainage, with moisture excess or pooling of water (Șarât District), areas with undersized sewerage networks due to heavy rains. In June 2006, after two days with heavy rains, that determined slope followings in Călăraşi area and flooded the villages Călăraşi and Bogata, the phreatic level grew and so flooded Şarât District. In July 2011, a torrential rain of 20 minutes was enough for flooding the downtown area because of high repellent surfaces and because of sewerage network failure to evacuate rain water (Figure 16).

Fig.16. Flooding at Câmpia Turzii after torrential rains and the rising of phreatic level

2. FLOODING RISK PREVENTION AND REDUCTION IN THE URBAN AREAS FROM TURDA – CÂMPIA TURZII DEPRESSIONAR CORRIDOR

Vulnerability's reduction in flooding exposed areas may take place by applying some structural measures (banking, riverbed regulations) in interaction with non-structural measures, such as prevention and protection ones (warnings, land development, laws, insurance).

Prevention represents a set of measures taken before the appearance of a hazardous event, to reduce its damaging effects. Prevention can be represented as a star with three arms, each corresponding to action fields of sustainable development: prevention ways and works; land development and constructions; security. In the middle lies the awareness and responsibility developed by finding and organizing information and public debate (Bourrelier, P.H., 1997).

Prevention includes the following actions:

- *Land occupation control:* the measures stipulate installation conditions (technical frame, authorizations). They include directives about land development, urbanism plans and construction standards.
- *Attenuation*: measures for the reduction of construction's vulnerability.
- *Protection*: operations or ways of intervention to reduce risk extension.
- *Monitoring*: a device made for risk knowledge and prediction, but also for triggering the alerts.
- *Preparation*: measures made to reduce society's reaction capacity (information, formation, reaction and alert).

The first recommended prevention measure is risk's scientific evaluation and location, and the information of population. The focus is on vulnerability mitigation by preparing the events, which involves individual and collective training. There is a tendency to substitute protection measures (works as dikes, dams) designated by the term *structural measures* through land use oriented planning.

Territorial planning scheme plays an important role in risk prevention. As the city grows, appears the problem of urbanization in sectors adjacent with risk exposure areas. Territorial planning scheme may define principles of risk management by providing development alternatives; can promote risk industries movement from urban areas to other ones. Also, the services brought by risk prevention plans can offer some spaces less exposed to risk, that are good for sustainable development.

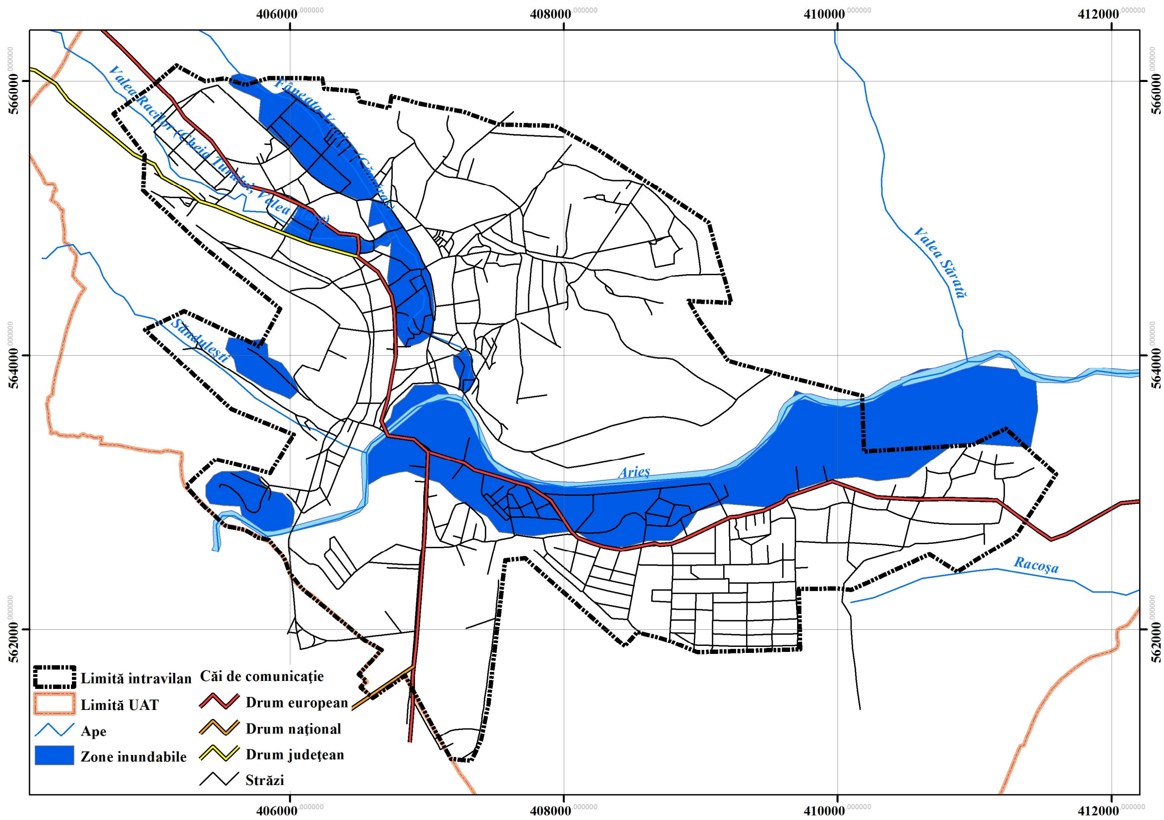

Fig.17. Map of flooding risk areas in Turda

In the urban areas of Câmpia Turzii and Turda, Local Committees for Emergency Situations within municipalities are made, organized and takes function for the prevention and operation of emergency situations, for the coordination of human, material and financial resources needed for bringing back normality. The municipalities supervise the execution of locality's flooding risk map (Figure 17 and 18) monitoring rivers' overflows, slope flows and pluvial waters, and the map's insertion in Urbanism Plans, but also the conformation to building regime in floodplains, according to Law No. 575/2001 about approving the National Land Development Plan.

The role of committees is to organize public information services and civil protection training exercises. They advise people, provide alarm and prepare them in case of flooding. According to the local plans for flood protection, actions are organized to limit and eliminate the effects of floods, to evacuate the population, to house the victims and their food supply, to provide health care services. Also, it provides the necessary funds for operational actions against flooding, the maintenance and repair of hydraulic structures and the maintenance of river beds in the towns.

Various tools can contribute to the development of risk culture. Primarily, the reinforcement preventive information regulatory provisions, supplemented as needed with information actions: publications, exhibitions, TV clips, radio ads or public meetings.

The concept of sustainable development emphasizes the need to involve the local population in risk management. But it is a theoretical necessity; basically it varies depending on the mentality and culture specific to populations according to the organization and functioning of a society. Important is not only the dissemination of information about risks, but also the encouragement to public participation in risk management. This implies a strengthening of the links between population and inhabited territory, the recognition of territorial identities and of local cultural events (Bourrelier, PH, 1997).

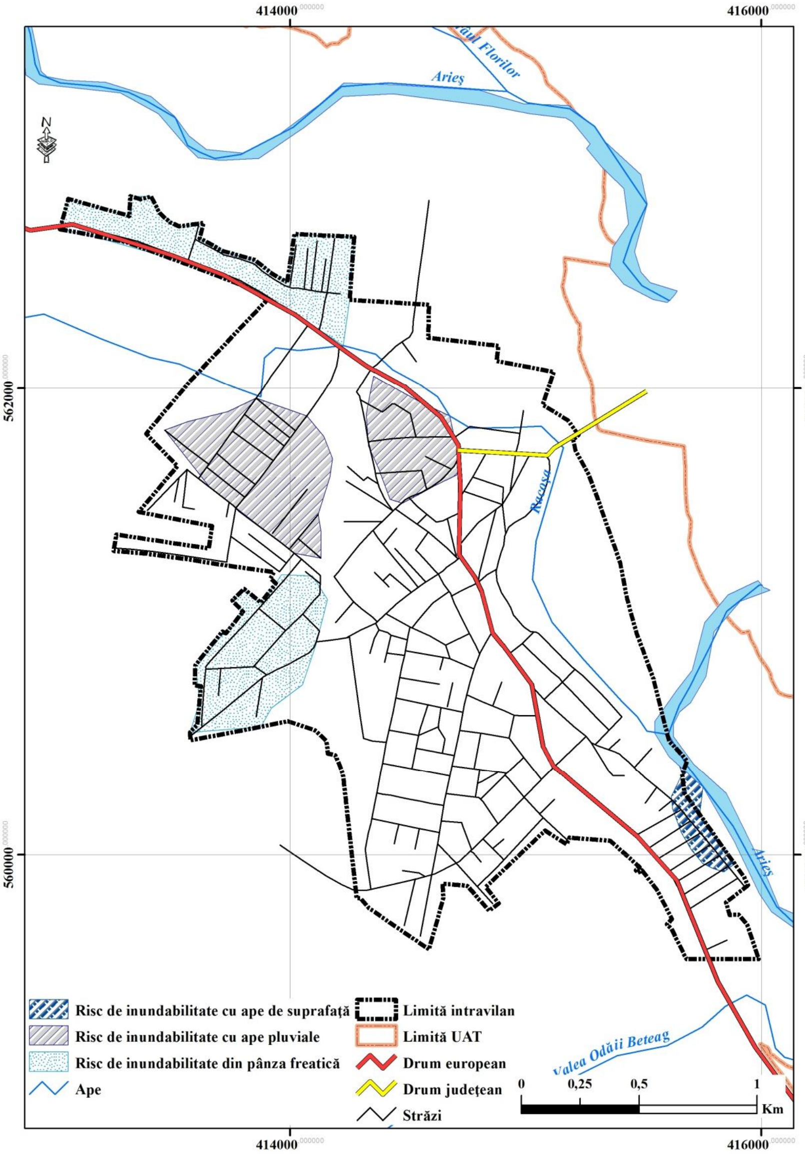

Fig.18. Map of flooding risk areas in Câmpia Turzii

To know the levels of flood risk perception was conducted a survey based on a questionnaire designed for this purpose (Sorocovschi, 2004), among the inhabitants of Turda and Câmpia Turzii. Questions were addressed to a sample of 560 persons with permanent residence in cities from the studied region, from February to April 2012.

An important factor in the perception of the analyzed phenomenon is the households' location in areas with different exposure degrees to this extreme event. Thus from the respondents, the majority live in the floodplain (62%), corresponding to high risk area. The other ones are located on terraces (29%) or slopes (9%), considered as medium and minimum risk areas. Living on a riverbank implies also the existence of imminent dangers taken differently, depending on the people's attitude (passive, active, preventive or complex) and actions taken to protect from the effects of dangerous hydrological phenomena, especially floods (Pandi, 2002). Still, there are situations when urban floodings appeared on terraces, taken the people under surprise.

The level of experience and awareness, together with direct personal knowledge shape the complexity of a perceptual act regarding extreme events, creating an open attitude towards a better organization to prevent phenomena or, on the contrary, a harmful ignorance (Conțiu, 2007).

Of those surveyed, 28% said they were not flooded, and from the flooded people 32% said that they had damages. No one said that in addition to property damage would have been casualties or injures (Figure 19).

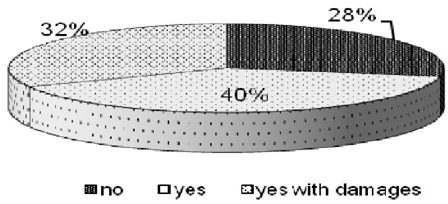

Fig.19. The perception of flooding effects in the studied area

A nonstructural measure for the prevention of damage caused by extreme natural phenomena is providing material goods and a better life to people. Of all subjects, 30% said they have benefited from the damage caused by floods in 1975. Recent experiences of urban flooding, mass- media information and security legislation led to increased insurance in the last decade. 75% of the respondents said they had an insurance against natural disasters such as floods (Figure 20).

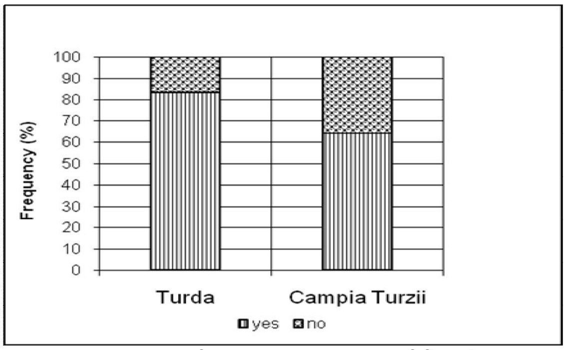

Fig.20. Degree of insurance in case of flooding

To see how it is perceived the authorities involvement in the prevention, control and reduction of flood damage, subjects were asked several questions. Many of those interviewed (86%) said they are willing to take the necessary measures to reduce damage before the intervention of the authorities. People who rely on the intervention of authorities have a low weight, mostly elderly. A percentage of 68% of the interviewees consider that the authorities don't make everything to prevent flooding, 18% are satisfied with what authorities undertake, and 14% have no opinion in this regard.

Regarding the measures taken by the authorities to reduce damage, 29% of respondents said they had been informed by the authorities about impending floods (Figure 21). After the floods started, the authorities helped to evacuate the population (26%) and facilitated water drainage (45%).

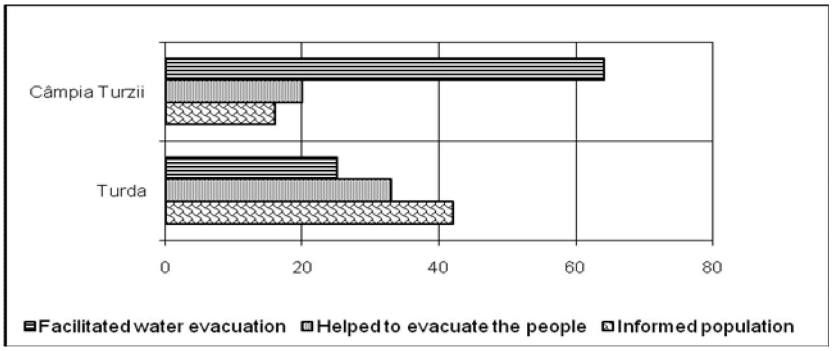

Fig.21. Measures taken by the authorities to reduce damage

Actions taken by the authorities to prevent flooding are varied, the most common being the embankments, cleaning and maintenance of watercourses, reservoirs development (Fig.22).

Most people that were questioned said there have been made embankments (40%) and cleaning and maintenance of watercourses (cleaning and maintenance of watercourses), but only knew about the development of some reservoirs.

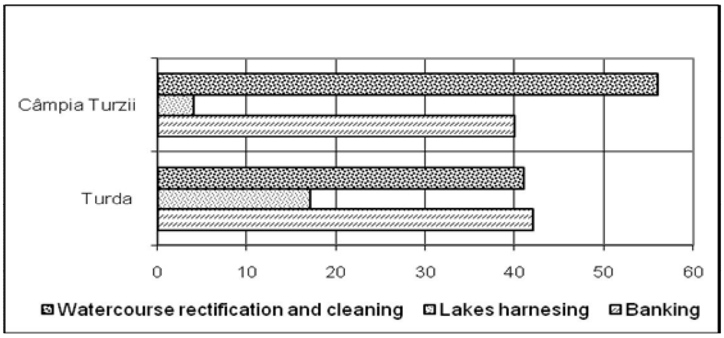

Fig.22. Actions taken by the authorities for floodings prevention

There have been executed a series of fitting watercourses to reduce the risk of flash floods induced in Aries Lower Basin (Table 2). To reduce flood risk in urban areas the Lower Aries are located several small scale reservoirs with impermanent nature located within the catchment (Sorocovschi, V., 2002). Tureni accumulation, located on Racilor Valley, a left tributary of Aries, helps flood defense for Tureni, Copăceni and Turda. Fâneața Vacilor and Tăul Ceanului accumulations, located in Fâneața Vacilor river basin provide also flood protection for Turda. Embankments are another means of flood protection. Aries River has dikes in section Turda - Câmpia Turzii on a length of 21 km, from the village bridge unto Cheia village (upstream) and till Aries confluence with Racoş at Camp Turzii (downstream).

Table 2. Defense characteristics data of flooding targets in the urban area of Turda-Câmpia Turzii

No.	Water course / Flooding risk sources	Targets within range of risk	Existing hydrometric defence systems	Account insurance of existing hydrometric constructions
1.	R. Arieş – Poştarât District	102 households, 2 economical ag., 2 km roads, 50 ha agricultural lands		Q asig.5% = 640 mc/s
2.	Valea Racilor Brook (till confluence)	540 households, 20 economical ag., 9,2 km roads, 6 bridges	Tureni Accumulation Vol.Tot=10,5 mil. mc; Brook regulation L=2 km	V coresp. asig. level 1% = 3.9 mil. mc;
3.	Fâneața Vacilor Brook	1100 households, 10 economical ag., 3,3 km roads, 3 bridges	Fâneața Vacilor Accumulation Vol.tot.=8,3 mil.mc; Brook regulation L=3km	V coresp. asig. level 1% = 3.9 mil. mc;
4.	Valea Racilor Brook (after confluence, till reaching Arieş River)	170 households, 5 ag. Economici, 5 km străzi, 6 poduri	Brook regulation L=3 km	
5.	Săndulești Brook - Săndulești Street	20 households, 2km roads, 10 ha agricultural lands, 2 bridges	Brook regulation L=2 km	
6.	Pordei Brook - Cheii Street	30 households, SC Holcim, 1 km roads, 4 ha agricultural land, 1 bridge		
7.	Arieş River – the left bank near the Park	15 households, 0,5 km roads	Banking Mihai Viteazu-Turda-Câmpia Turzii; Arieş Dam left bank L=600m, l ridge = 3m embankment slope L=1,5 and L=1,2	Third importance class, Q asig.5%=640 mc/s An PIF 1987
8.	Arieş River – right bank - Oprișani District, Poiana	7800 aparts., 30 economical ag., 41,6 km roads, 20 km sewerage, 2 bridges	Banking Râul Arieş right bank L=3798 m l ridge =4m embankment slope L=2,0 and L=2,5	Second importance class, Qasig.1%=1100mc/s An PIF 1988
9.	Arieş River at Câmpia Turzii	Wastewater treatment plant	Arieş earth dam, L=3 Km	Qasig.1%=1100mc/s An PIF 1982

For effective measures to prevent and combat the effects of the extreme natural phenomena, a particular attention should be paid to public awareness on a correct perception of floods and to their responsibilities as individuals and of local authorities. The correct information of the population on the degree of risk to which it exposes, the awareness of a contract of insurance, encouraging participation in preventing and combating the effects induced by the floods, the collaboration with local authorities, will allow the harmonious integration of the community to the environment and mitigation of effects induced by the extreme events.

SELECTIV BIBLIOGRAPHY

1. Armaş, Iuliana, (2006), *Risc şi vulnerabilitate. Metode de evaluare în geomorfologie*, Ed. Universităţii, Bucureşti.
2. Armaş, Iuliana, (2008), *Percepţia riscului natural: cutremure, inundaţii, alunecări de teren*, Ed. Universităţii, Bucharest.
3. Arghiuţ, V. I., (2007), *Studiul viiturilor de pe cursurile de apă din estul Munţilor Apuseni şi riscurile asociate,* Babeş-Bolyai University, Geography Faculty, Cluj-Napoca, PHD Thesis.
4. Ambroise, B., (1998), *La dinamique du cycle de l'eau dans un basin versant*, Edition HGA, Bucharest.
5. Bailly, A.S., (1997), *La pérception de l'espace urbain*, Ed. CRU, Paris.
6. Bătinaş, R., Sorocovschi, V., Şerban, Gh. (2002), *Fenomene hidrologice de risc induse de viituri în Bazinul inferior al Arieşului*, "Dimitrie Cantemir" Geographic Seminary, no. 21-22, Iaşi.
7. Beaujeu, G., (1997*), Géographie urbaine*, Armand Colin, Paris.
8. Belozerov, V., (1963), *Contribuţii la cunoaşterea climatului Câmpiei Turzii*, Studia UBB, Geology-Geography series, Fasc. 2, Cluj-Napoca.
9. Bojoi, I., (2000), *România. Geografia fizică*, Ed.Universităţii « Al.I. Cuza », Iaşi.
10. Cocean, P. (2002), *Tipologia riscurilor din Bazinul Inferior al Arieşului,* in vol. "Riscuri şi catastrofe", year I, Ed. Casa Cărţii de Ştiinţă, Cluj-Napoca.
11. Conţiu, H.V., (2007), *Culoarul Mureşului dintre Reghin şi confluenţa cu Arieşul. Studiu de hidrologie urbană*, Ed. Casa Cărţii de Ştiinţă, Cluj-Napoca.
12. Conţiu, H.V., Conţiu, Andreea (2005), *Percepţia inundaţiilor în culoarul Mureşului dintre Reghin şi confluenţa cu Arieşul*, in vol. "Riscuri şi catastrofe", year IV, no. 2/2005, Ed. Casa Cărţii de Ştiinţă, Cluj-Napoca.
13. Cheval, S., (2003), *Percepţia hazardelor naturale.Rezultatele unui sondaj de opinie desfăşurat în România*., vol. II, *Riscuri şi catastrofe,* Ed. Casa Cărţii de Ştiinţă, Cluj-Napoca, pp. 49-59.
14. Dauphiné, A., (2001), *Risques et catastrophes*, Armand Colin, Paris.
15. Desbordes, M. (1991), *Eaux pluviales et urbanisation*, Agence Regionale pour l'Environnement, Provence-Côte d'Azur.
16. Fărcaş, I., (1977), *Zona industrială Turda-Câmpia Turzii. Studiu bioclimatic*.,UBB, Geography Faculty, PHD Thesis.
17. Florea, N., (1968), *Geografia solurilor României*, Ed. Ştiinţifică, Bucharest.
18. Gâştescu, P. (2002), *Resursele de apă ale bazinelor hidrografice din România,* Terra, year XXXI (LI), vol. 1-2/2001, Bucharest.

19. Gâştescu, P., Rusu, C. (1980), *Evaluarea resurselor de apă din râuri şi amenajarea bazinelor hidrografice în România*, Terra, XII (XXXII), 2, Bucharest.
20. Giurma I., Drobot R. (1990), *Hidrologie,* vol. II, I.P. Iaşi.
21. Guézo, B., Verrhiest, G.(2006), *Réduire la vulnerabilité urbaine aux risques majeurs,* Revue Techni.Cités, Dossier CERTU, no. 10.
22. Guiton, M.(1998), *Ruissellement et risque majeur*, LCPC, Paris.
23. Mac, I. (1965), *Observaţii hidrogeologice în Valea Arieşului între Câmpia Turzii şi confluenţa cu Mureşul*, in "Comunicări de Geografie", vol. III.
24. Mănescu, Al., Sandu, M., Ianculescu, O., (1994), *Alimentări cu apă,* Ed. Didactică şi Pedagogică, Bucharest.
25. Mihăilescu, V. (1969), *Geografia fizică a României*, Ed. Ştiinţifică, Bucharest.
26. Morariu, T., Gârbacea, V. (1960), *Terasele râurilor din Transilvania,* in Comunicările Academiei RPR, nr.6. tom X. Ed. Academiei, Bucharest.
27. Morariu, T., Posea G., Mac I. (1980), *Regionarea Depresiunii Transilvaniei*, Studii şi Cercetări de Geologie, Geofizică şi Geografie, Geography Series, tome XXVII, no. 2, p. 211-223, Bucharest.
28. Nemeş, M., Bujor, E., (1998), *Câmpia Turzii. Istorie, cultură, civilizaţie.*, Ed. Casa Cărţii de Ştiinţă, Cluj-Napoca.
29. Pandi, G., (2002), *Riscul în activitatea de apărare împotriva inundaţiilor,* in vol. *Riscuri şi catastrofe*, Ed. Casa Cărţii de Ştiinţă, Cluj-Napoca.
30. Pandi, G., Moldovan, Fl. (2003), *Importanţa prognozelor în diminuarea riscurilor meteorologice şi hidrologice,* in vol. *Riscuri şi catastrofe,* II, Cluj-Napoca.
31. Pâslăraşu, I., Teodorescu, M., Rotaru, C., (1981), *Alimentări cu apă*, Ed. Tehnică, Bucharest.
32. Pop, Gr. P., (2001), *Depresiunea Transilvaniei,* Ed. Presa Universitară Clujeană, p. 274.
33. Pop, Gr. P., (2007), *Judeţul Cluj,* Ed. Academiei Române, Bucharest.
34. Sorocovschi,V.,(2002), *Riscurile hidrice,* în vol. *Riscuri şi catastrofe,* pp. 55-65, Ed. Casa Cărţii de Ştiinţă, Cluj-Napoca.
35. Sorocovschi, V., Şerban, Gh., Bătinaş, R. (2002), *Riscuri hidrice în Bazinul inferior al râului Arieş,* in vol. "Riscuri şi catastrofe", year I, Ed. Casa Cărţii de Ştiinţă, Cluj-Napoca.
36. Sorocovschi, V., (2007), *Vulnerabilitatea componentă a riscului. Concept, variabile de control, tipuri și modele de evaluare*, în "Riscuri și Catastrofe", year VI, no. 4, Ed. Casa Cărţii de Ştiinţă, Cluj-Napoca.
37. Stănescu, V. Al, Drobot, A. (2002) *Măsuri nestructurale de gestiune a inundaţiilor,* Ed. HGA, Bucharest.
38. Şelărescu, M., Podani, M., (1993), *Apărarea împotriva inundaţiilor*, Ed. Ştiinţifică, Bucharest.
39. Veyret, Y. (2001), *Géographie des risques naturels,* La Documentation française, Paris.
40. Zaharia, Liliana, (2006), *Tehnici alternative la sistemele clasice de canalizare şi rolul lor în diminuarea riscurilor,* in vol. *Riscuri şi catastrofe*, no. 3, p. 43-54.
41. Zaharia, Liliana, Catană, Simona, Crăciun, E., Toroimac, Gabriela - Ioana, (2008), *Flood vulnerability of Tecuci city*, in vol. *Riscuri şi catastrofe,* year VII, no. 5.
42. *** (1996), *Risques naturels. Risques des Sociétés.*, sous la direction d'Antoine S. Bailly, Economica, Paris.

43. ***, (1997), *La prévention des risques naturels,* Rapport de l'instance d'évaluation presidée par Paul Henri Bourrelier, La Documentation française, Paris.
44. *** (1995), *Géstions Urbains de l'Eau*, sous la direction de Dominique Lorrain, a Economica, Paris.
45. *** (1982), *Geografia României, I, Geografia fizică* (under the redaction of L. Badea, P. Gâştescu, Valeria Velcea), Ed. Academiei, Bucharest.
46. *** (2003), *Les risques*, Ed. Sèdes, Paris