EUROPEAN COMMISSION
Directorate Environment
Direction LIFE
LIFE99/ROM/ 006607

THE MODERNIZATION
OF THE SYSTEM OF MEASUREMENT, STORAGE,
TRANSMISSION
AND
DISSEMINATION
OF
HYDROLOGICAL DATA
TO VARIOUS
DECISION LEVELS

MOSYM Project

THE MODERNIZATION OF THE SYSTEM OF MEASUREMENT, STORAGE, TRANSMISSION, AND DISEMINATION OF HYDROLOGICAL DATA TO VARIOUS DECISION LEVELS *(MOSYM)*

Partners : Ministry of Water and Environmental Protection, National Institute of Meteorology and Hydrology (NIMH), Romanian Water Authority Ape Tg. Mures, Pitesti si Bacau, Informatical System for Automation (SIAT), Master Produtel, CEMAGREF-Lyon- France, SCOT Conseil – France, SAAS GmbH – Germany

Area of application: The demonstrative project MOSYM selected three great basins of Romania (Mures, Arges and Siret), in different climatologic areas, looking for solutions to improve the hydro – meteorological informational system and to define a methodology defining area of risks (flooding risk mainly).

The project provides a demonstration, promotion and technical assistance actions for local water authorities and MWEP considering a sustainable development in water management and land use. Taking into account this consideration this actions the design of an automatic hydrological informational system and its implementation during floods, droughts and accidental pollution is important for local administration as well as for the Local Waters Authorities. The designed system is furnishing data and forecasts in real time to different decision levels, beginning with Romanian water Authority, MWEP, local administration (Disaster Commissions) to stakeholders and population. A site on Internet is dedicated to inform all users during disaster periods.

In the same time, the project makes the liance between the research institutions specialized in automatic process and hydrological sensor producers. A partnership between NIMH, SIAT, Master Produtel – Romania, Logotronic – Austria and SAAS – Germany was an opportunity in producing a prototype station – HYDRAROM.

The main objective of the project were:

1.Design and realization of a local automatic station prototype, aiming to hydrometeorological data storage, discharge measurement, and the real time transmission of the parameters (level, temperature, precipitation, data quality) and the measurement of discharges ;

2.Working out a project for the rehabilitation of the automatic informational system for three large pilot basins, located in the main specific climatic areas of Romania (Mures, Arges and Siret basins) partnership with the Romanian Waters Authority contribution as end user of the hydrological informational system;

3.Hydrologic GIS database construction and coupling with cartography of flooded areas, for social, economical and environmental damage estimation;

4.Interfaces-construction classic numerical database – GIS and with satellite images transmission;

5.Constituting of the primary and advanced processing computer programs of the classic data transmission/reception and storage in data base, data processing;

6.Define and specify an Earth observation based flood management system – application on Arges Basin, risk of inundation estimation

7.Real time dissemination of data to: model users for hydrological diagnosis and forecast, water management systems, local and governmental staff etc.

Projekt Titel: MODERNISIERUNG DES MESS, SPEICHERRUNG, ŰBERTRAGUNGSSYSTEM UND DIE VERBREITUNG DER HYDROMETRISCHEN DATEN IN DEN VERSCHIEDENEN ENTSCHEIDUNGSTUFEN – LIFE-MOSYM

Partner: Wasser, Wälder und Umweltschutz Ministerium, Nationales Institut für Meteorologie und Hydrologie NINMH, die Wasserfilianen von Tg. Mureş, Piteşti und Bacău, Informatisierung, Automatisierung und Telekommunicationsysteme (SIAT), Master Produtel SC-SRL, Mikroproduction Werkstätte für Umweltgeräte Sibiu, CEMAGRAF-Lyon-Frankreich, SCOT Conseil Frankreich, SAAS GmbH-Deutschland

Anwendungszonen: Pilot Becken in drei klimatisch characteristischen Gebieten Rumäniens, die jenseits der Grenze liegenden Becken Mureş und Siret und das Argeş – Dâmboviţa Gebiet für die Wasserversorgung und den Schutz der Hauptstadt.
Das Projekt unterstüzt die őrtlichen Behörden für die Beförderung einer dauerhaften Entwicklung im Wasserbereich und der Benützung und Planifizierung des Gebietes. Im Rahmen dieser Aktionstypen, die Projektierung eines automatischen hydrologischen Informationssystem und seine Implementierung für die Warnung der Desaster die von Überflutung, Dürre und Umweltverschmutzung verursacht werden ist von gröβter Bedäutung für die Wasserwirtschaftsysteme.

Die Kartographierung der Risikozonen (in erster Reihe für den Bestand der Überschwämmungs Zonen), wird der Organisierung des Teritoriums, der örtlichen Entwicklung helfen und wird die Implementierung der Projekte für den Bevölkerungsschutz und der Entwicklung der okonomischen Objektive erleichtern.

Das Projekt wird echtzeitige Auskünfte nationaler Bedeutung, für die Verteidigungskommision gegen Desaster liefern, wird die Möglichkeit geben tatsächlich die Bevölkerung in den Überschwemmungsgebieten verständigen zu konnen, wird die Zufriedigungstellung der Wasserbedürfnisse, der Landwirtschaft und der Ökonomie, die Warnung der Bevölkerung und der Wasserbenützer aus der Landwirtschaft und Industrie in zufälligen Umweltverschmutzungen, angeben.

Gleichzeitig wird das Projekt die Gelegenheit der spezialisierten Forschungsinstituten für die Zusammenarbeit in der Automatisierung und Herstellung von hydrometrischen Sensoren und deren Implementierung im nationalem Masstab geben. In diesem Bereich wird eine Zusammenarbeit zwischen INMH, SIAT, Master Produtel und der Sibiu Werkstätte sehr Vorteilhaft für die Implementierung von hydrometrischen Geräten die in Rumänien unter der Überprüfung und der Übertragung der "Know how" Kentnisse die von SAAS GmbH-Deutschland angeboten werden, sein.

Einmal das Projekt beendet, sollen die Ergebnisse in den Becken gleichartiger klimatischer Bedingungen unter eigenen Kräften angewändet werden.

Ziele des Projektes:

1. **Projektierung und Herstellung von Prototypen der automatischen Stationen** mit Speicher und Güte Funktionen der hidro-meteorologischen Parameter und der Übertragung dieser Parameter. (als auch der Messung der Wassermengen)
2. **Verwirklichung des Projektes für die Rehabilitierung der automatischen Informationssysteme in den jenseitz der Grenze liegenden Gebieten Mureş, Siret und Argeş**, sehr bedeutend für den Schutz und der Wasserversorgung der Stadt Bukarest.
3. **Gründung der hidrologischen Datenbasis (GIS)** durch die Digitisierung von spezifischen Ubersichtkarten und deren Verbindung mit den Plänen der Überschwemmungs Gebieten, für die Bewertung der sozialen, ökonomischen Umweltverluste.
4. **Gründung der Schnittstellen der klasischen numerischen Datenbasis – GIS – und die von Satelliten gesendeten Bildern.**
5. **Gründung von primären und fortgeschrittenen Prozessierungsprogrammen der klasischen Datenbasis.**
6. **Bestellung und Spezifizierung eines Satelliten Verfolgungssystem der Zonen die von Überschwemungen ergriffen werden - Anwendung in dem hydrographischen Becken Argeş.**
7. **Echtzeigtige Verbreitung der Daten für die Anwendung der Diagnose und Prognose hydrologischer Modelle,** bei INMH und der örtlichen Beckenprognose, bei den Wasserbehören, bei der örtlichen Führung und Regierung.

1. Flood prevention and control- a task of national interest

Floods are natural hazards as part of our life and nature. However, floods are natural phenomena that can be intensified by human alterations of the environmental status such as changes in the drainage patterns from urbanization, agricultural practices and deforestation.

Considering the evolution and recent established trends, the approach in natural hazards requires a change of paradigm. One must shift from structural and defensive actions to preventive measures and management of risks. Therefore, a holistic approach is necessary to take into account the whole river basin, with interdisciplinary planning for whole catchment area and multilateral cooperation.

One of the most significant prerequisites for proper action is the need for reliable information to be able to take necessary precautions. The answer to this request of given by a proper risk assessment and an effective and efficient information system available.

In Romania, developing and implementing sustainable measures and good management practices for flood prevention and protection that takes into consideration economic, social and environmental consideration represent major tasks performed according to the provisions of the Water Law 107/1996 and in line with the Government Decision 638/5.08.1999 on the approval of the "Rule for the protection against floods, dangerous meteorological phenomena and accidents at hydraulic structures"

In recent years, the social and economic costs associated with floods occurrence continued to rise to large values. Only during the first six months in 1999, the damages caused by floods in over 25 counties sum 984991,4 mil. Lei (cca 50 mill. USD, 2000).

2. Early Flood Warning System

Warning systems and accompanying emergency response have long been recognized as effective ways to save lives and reduce flood damages in both riverine 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 Company -National Institute of Meteorology, Hydrology and Water Management (INMHGA) and river basins systems belonging to National Company 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, 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.

The individual conception of monitoring that is separated from the establishment of the hydrological database and data collection programs led to the necessity of reconsideration of the concept of the data integrated monitoring. Modelling and data collection are not independent processes. Ideally, each drives and directs the other. Better models impose more complex type and more quantity of data. Better data, in turn, allow the development of better and more complete models and new hypotheses. This project is then mainly focused on the implementation of the new concept in flood management, taking into account the results already obtained in this domain of some previous projects (Floodaware Project of EC or MEDHYCOS, HYCOS for the Danube River of WMO, MOSYM and Phare-Tisa projects, for example).

Good results of any *risk management* largely depend on the availability, dissemination and effective use of information. The *ability to manage flood disasters* is mostly dependent of an integrated risk management approach in the sense of forecasting as well as long time flood analysis establishing the land management strategy. Considering the growing importance of the flooding risk problem in Romania, MOSYM project is mainly focussed to the implementation of these new concepts in the domain of flood management.

3. The main objectives of MOSYM Project

The Romanian network was projecting in the first half of the 20th century. During this time, data managers (MWEP, NIMH and Romanian Waters Authority) were able to operate without network analysis for a number of reasons:

1. There was little information about the temporal and spatial variation of hydrologic data so any accumulation of data was worthwhile;
2. The water resources of Romania were not overly stressed by development so the choices for data-collection sites were not as difficult to make;
3. Hydrological data collection did not have high degree of competition for funding by the social programs on the governmental and local authorities level.

Because of the ever-present budgetary constraints and the time required to collect hydrologic information, intelligent decisions about gauging station locations and duration of data collection are now a necessity. Network-analysis techniques were used more effectively in all first order Romanian Basins, to plan and operate the network to best utilize the available resources (manpower and money). Surface-water network analysis was oriented toward providing the needed stream flow information in the most cost-effective manner.

The primary objective of a network analysis was to examine the adequacy of an existing network and determine if data-collection activities need to be automated. The network analysis was conducted to answer to one of the following question:

(1) Are data collected at the proper location?
(2) What types of data should be collected?
(3) What is a sufficient duration old each data-collection activity?
(4) What is the proper frequency of data collection for each type of data?

(5) What is the most appropriate equipment to get data taking into account the balance precision-cost?

Observation networks combining different types of measurement technique (classic and automatic) are considered.

First, the hydrometeorological data acquisition stations in Romania have been considered resulting in the need to develop the automatic stations which practically are absent in the gauging network. The automatic station HYDRAROM produced by NIMH, SIAT-Romania with the help of SAAS GmbH-Germany and Logotronic-Austria, in transferring the know how allows for measuring the quantitative parameters (precipitation and water levels) and qualitative ones (conductivity, oxigen content, pH, redox potetial, water temperature) Figure 1.

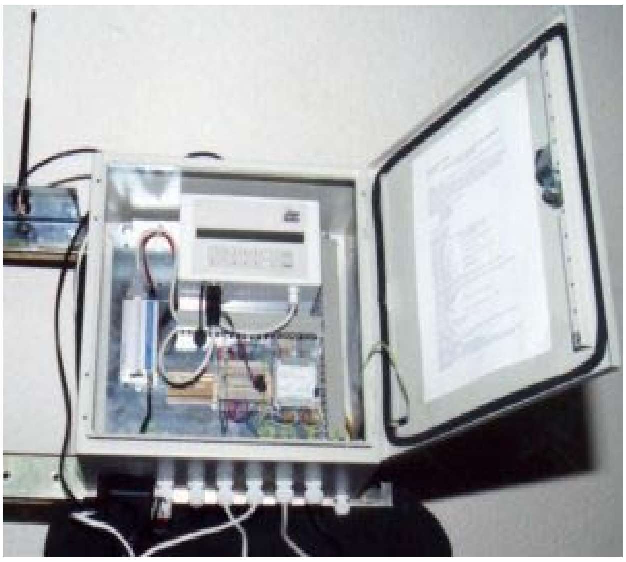

Figure 1. HYDRAROM station

On the other hand, there is a need to perform the data transfer from sensors to the location of automatic stations and further on to the concentration station. Here, the primary automatic data processing should be carried out. Thus, the next objective of the Mosym project consists in specialised software for data transmission, decoding and direct processing of information and measurements for hydrological database. In turn, real time collected data by automatic device result in a growing quantity of data of a superior quality, that further on substantially contribute to the improvement of the rainfall-runoff models.

As a result of the growing up the quantity and the complexity of the types of hydrometeorological data and in order to allow for more performable mathematical models of water resources simulation and real time forecasting, a reconsideration of the network of the hydrometeorological stations had to be carried out. For several pilot basins (Mures, Arges and Siret rivers, figure), an optimisation of the spatial distribution and a reconsideration of the locations of the hydrometeorological stations based upon the analysis of the existing ones and in complementarity with these constitute one aspect of the third objective.

The “most appropriate” measurement network is selected that is based on two often-conflicting objectives: (1) minimizing the uncertainty in characterizing the spatial distribution of parameters, and (2) minimizing the observation casts. The approach combines two common techniques, geostatistics and multi-criteria decision making to determine the best measurement network.

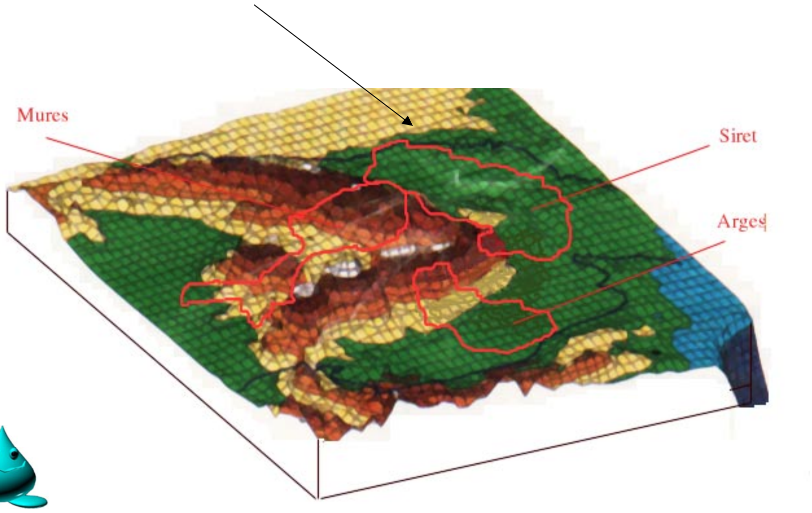

Figure 2. The demonstrative besins in the MOSYM Project

Adapted to the newly designed hydrometeorological network (the automatic stations included) the development of the flood forecasting model and the derivation of these parameters for the selected pilot basins (Mures, Arges and Siret) have been considered in the third objective of the MOSYM Project. The complete sketch of the VIDRA flood-forecasting model if presented in Figure 3.

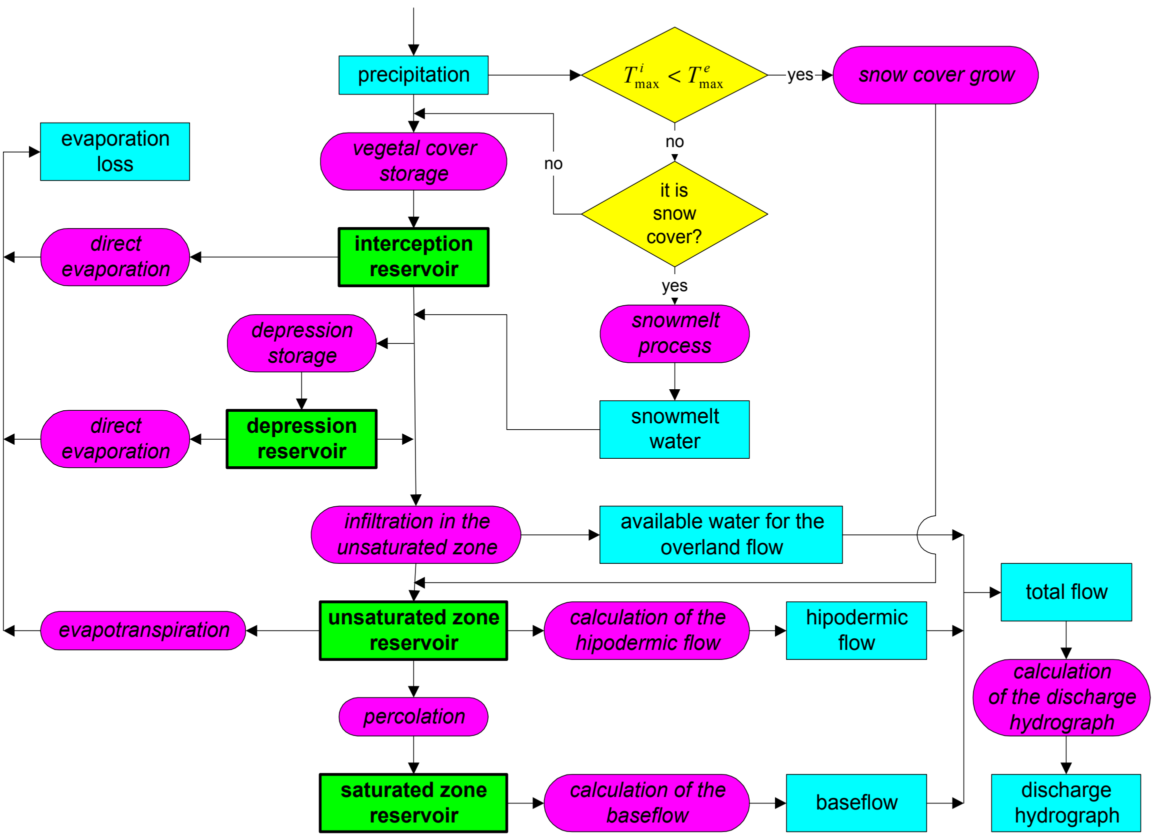

Figure 3. Sketch of the flood forecasting VIDRA Model

An example of application of the flood forecasting model is given bellow.

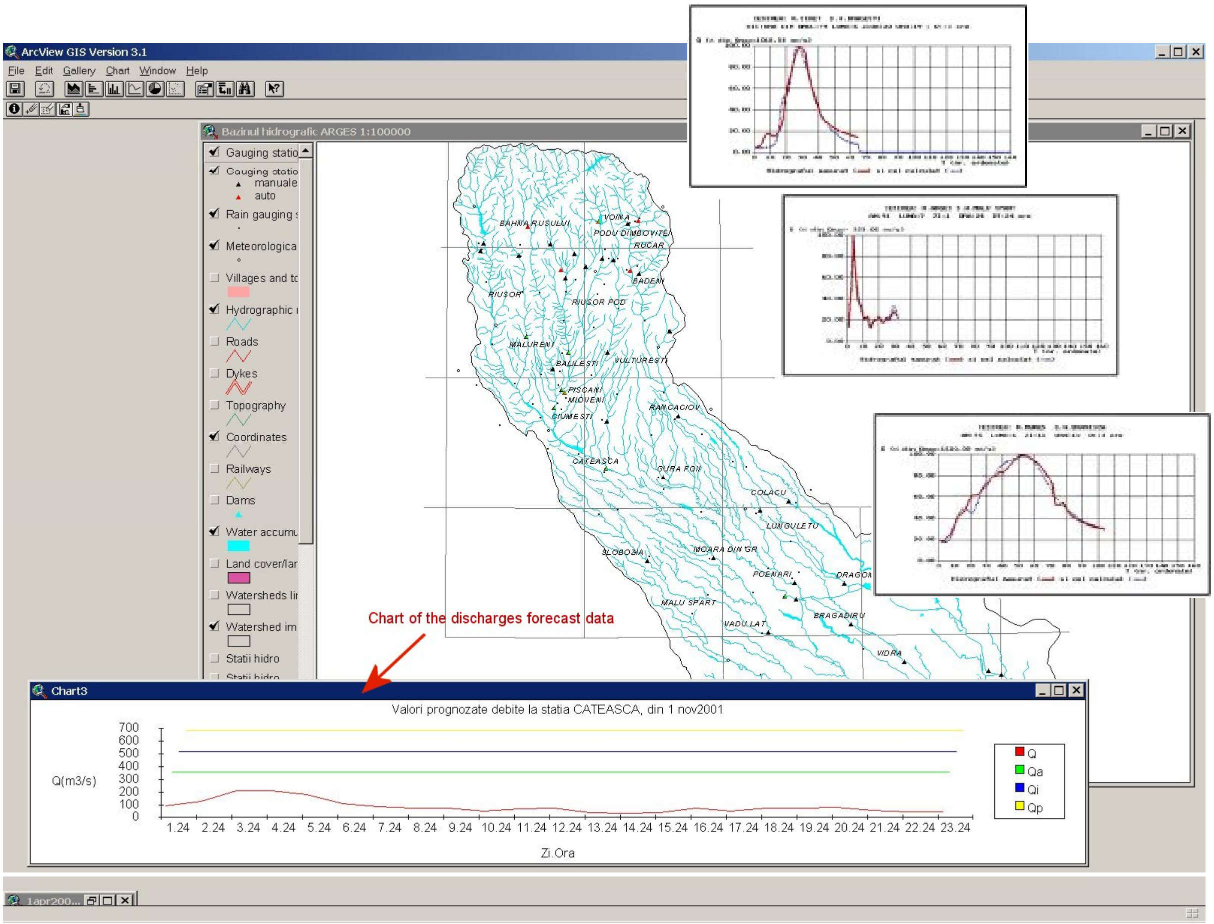

Figure 4. Example of application of VIDRA model using the registered data from HYDRAROM stations

The model is using some informational plans of a dedicated GIS database for water management in the demonstrative basins.

The plans of the highest interest that have been digitized and included in the GIS data base are: hydrographic network, subbasin and basin limits (Watershed lines), gauging station network, rainfall stations network, terrain topograpy (Contour lines), localities(urban areas), communication way network, land cover/land use, topographic profiles.

Conforming to this plan the following objectives are achieved:

- Carrying out a methodology for performing the land cover/land use from satellite images;
- Achieving the land cover/land use maps from paper maps and on the IRS satellite images over the area of Arges River Basin;
- Land cover/land use digital maps in GIS reference for flooding maps preparation.

To establish the needed methodology the Middle basin of Arges River has selected as test area of the flooding risk evaluation.

The IGFCOT 1:50000 maps, the CORINE land cover data base and the land cover map through processing the IRS satellite images have been used. In order to obtain the land cover updated maps the panchromatic (PAN) and multispectral (LISS) images from the satellite IRS have been used. In the figure 5, the GIS data base and the panchromatic and multispectral image from 8 April 1999 of the IRS satellite are presented in figure 5.

In order to obtain finer resolution the Pan and LISS maps are merged.

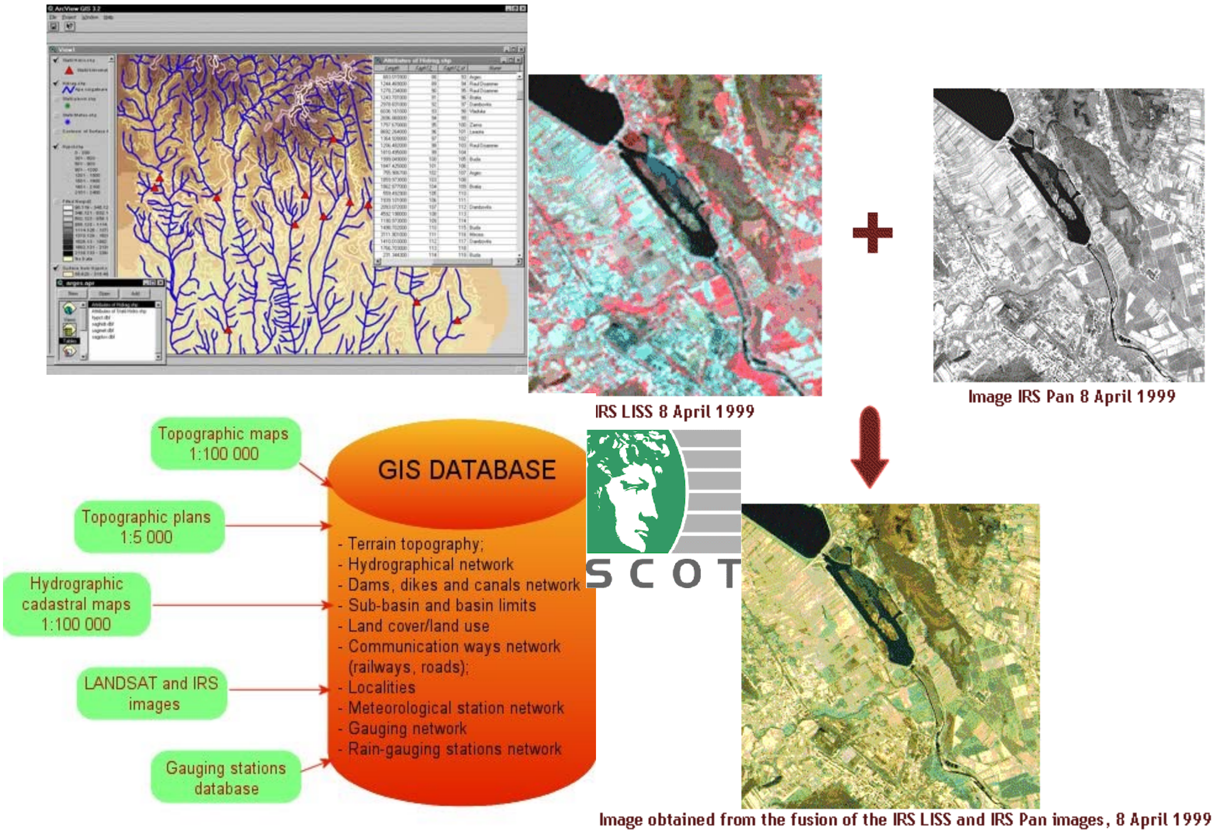

Figure 5. GIS database and IRS satellite images.

Applying the classification of land cover by parcels the following nine classes have been obtained: winter crops, summer crops, forest, water, large buildings, villages, bare soil, uncultivated soil and vineyards. The procedure and the map of the land cover/land use are shown in Figures 6,7.

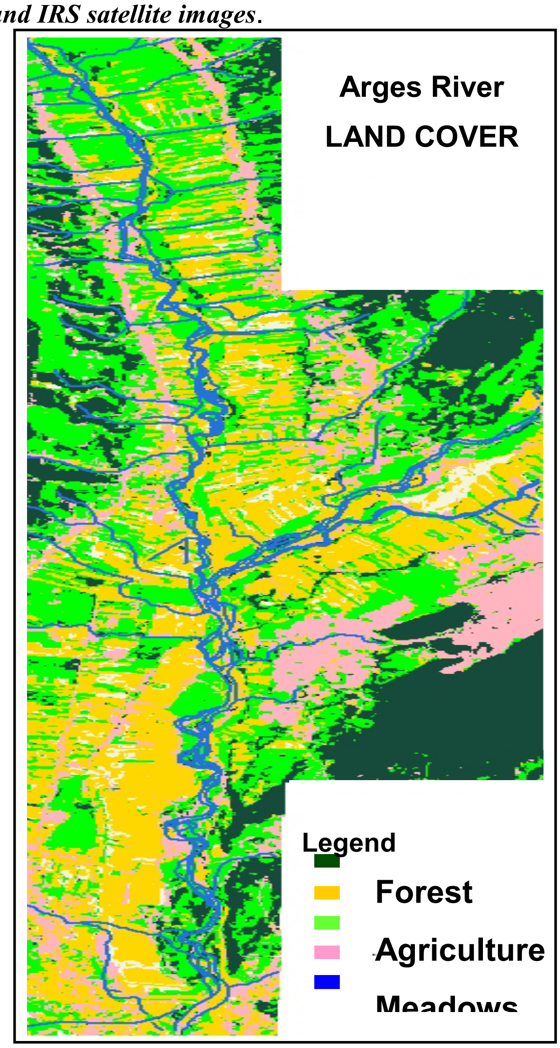

Figure 6. Land cover in Arges Basin

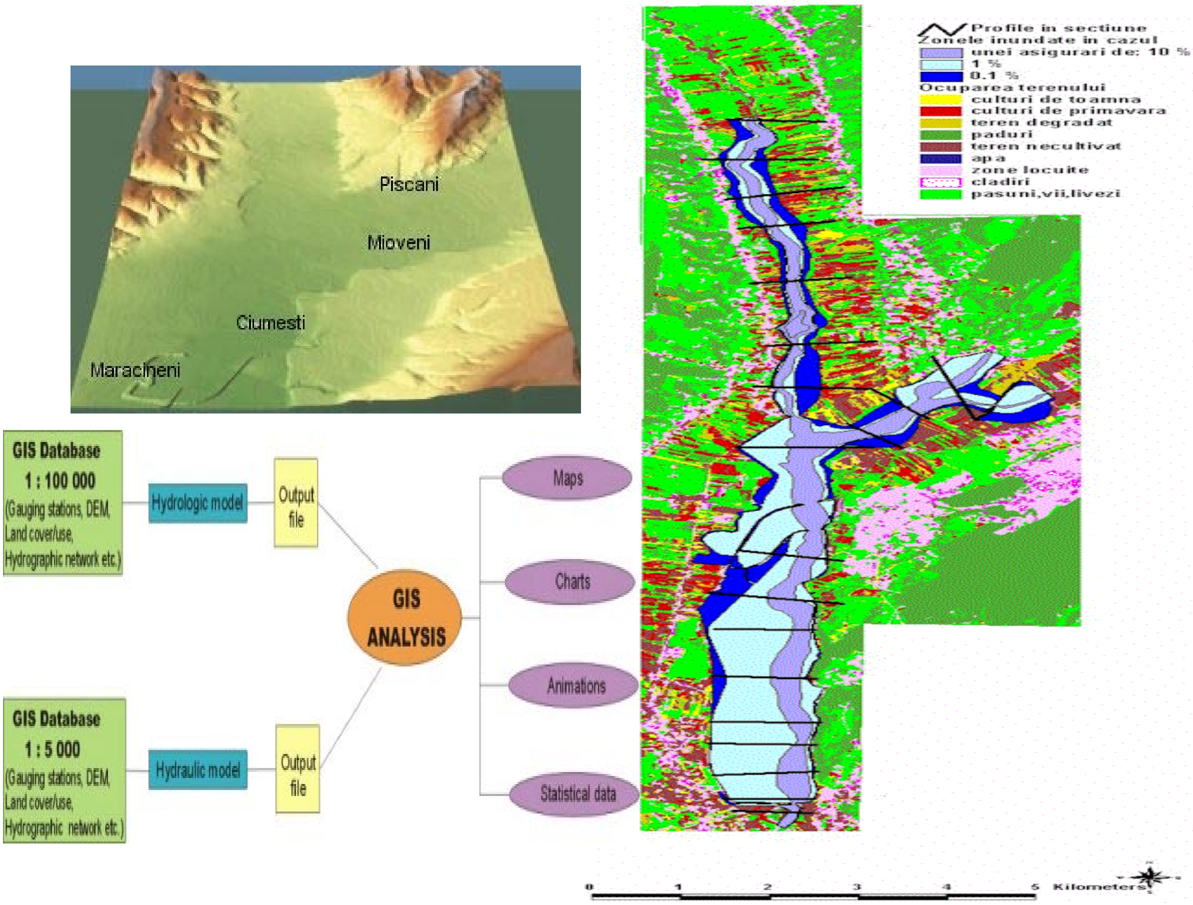

Figure 7. Arges River-GIS procedure for classification of the land cover/land use by parcels.

The maps of the flood hazard and of the vulnerability are the constitutive elements of the flooding risk map. The risk map is a useful tool of the decision-makers to take the preparedness measures for mitigating the vulnerability of the floodplain area by establishing the optimal spatial distribution of the socio-economic objectives. On the other hand the risk map may be used to substantiate from economic and environmental points of view the prevention flood defence measures which are to be performed. Therefore, the development of a complex methodology aiming to establish the flood hazard and the vulnerability maps as well as for drawing up the map of the flood prone areas at risk is also considered as a major objective of the project. Both a Romanian and a French methodology (Cemagref Lyon) are considered and a comparison of them is envisaged. Finally, all there achievements will be incorporated into a coherent system helping to optimally substantiate the structural and non-structural measures which are undertaken for flood defence and flood management Figure 8.

In order to determine the vulnerability map the land cover/land use map determined by GIS application was used.

The flooding risk map is performed on the one hand, by identifying the parcels located in the contingency of the river bed that are able to be flooded with a given frequency and considering the “assumed” frequency of flooding, on the other.

If the accepted frequency (probability of exceedance) is smaller than the assumed frequency the parcel is considered endangered and conversely.

In the figure 9 on the right side the satellite map of the land-cover encompassing the five categories of uses is shown. The following five categories of the land cover are deemed: the forest, agriculture terrain, meadow and orchard zones, urban areas as well as the riverbeds. For the assumed probabilities the following values have been considered: forest area - 20%, agriculture terrain - 10%, meadows and orchards - 20%, dwelling in rural areas - 5%, communication ways - 1% dams and levees - 0.1%.

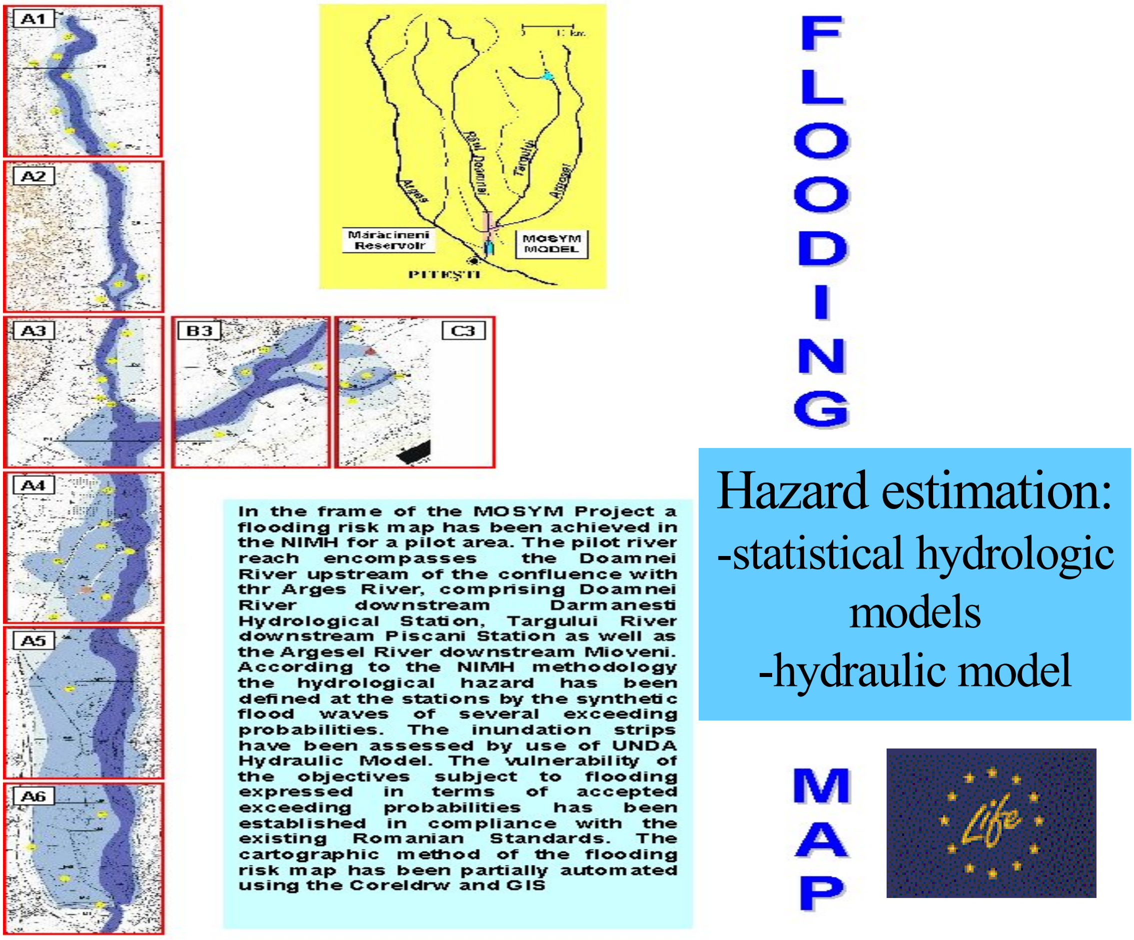

Figure 8. Flooding maps in pilot area of MOSYM Project

The land uses located in the studied area in general satisfy the attribute of "protected" zone at inundation except two very critical zones concerning the communication ways which are located by circles marked in red colour on the map bellow, namely:

- The intersection of the modernized way Mioveni-Piscani with the railway Pitesti-Campulung, the flooding originating from the flood pain of Argesel River, downstrem the bridge 06.
- On the road linking Ciumesti and Mioveni, after the high passage over the railway towards the bridge O1.

These two points are of an outstanding economic importance having a significant impact both on the railway circulation to and from Pitesti City (capital of the Arges County) and the Dacia-Renault industry of cars. In the range of the transited floods the Maracineni non-permanent water storage achieves to satisfy its designed role. At the 1 % flood it performs a peak discharge mitigation of 25%, without jeopardising the agriculture terrain from upstream of the water storage.

The inner levee of the storage is not overflowed unless the probability of exceedance is less than 5%.

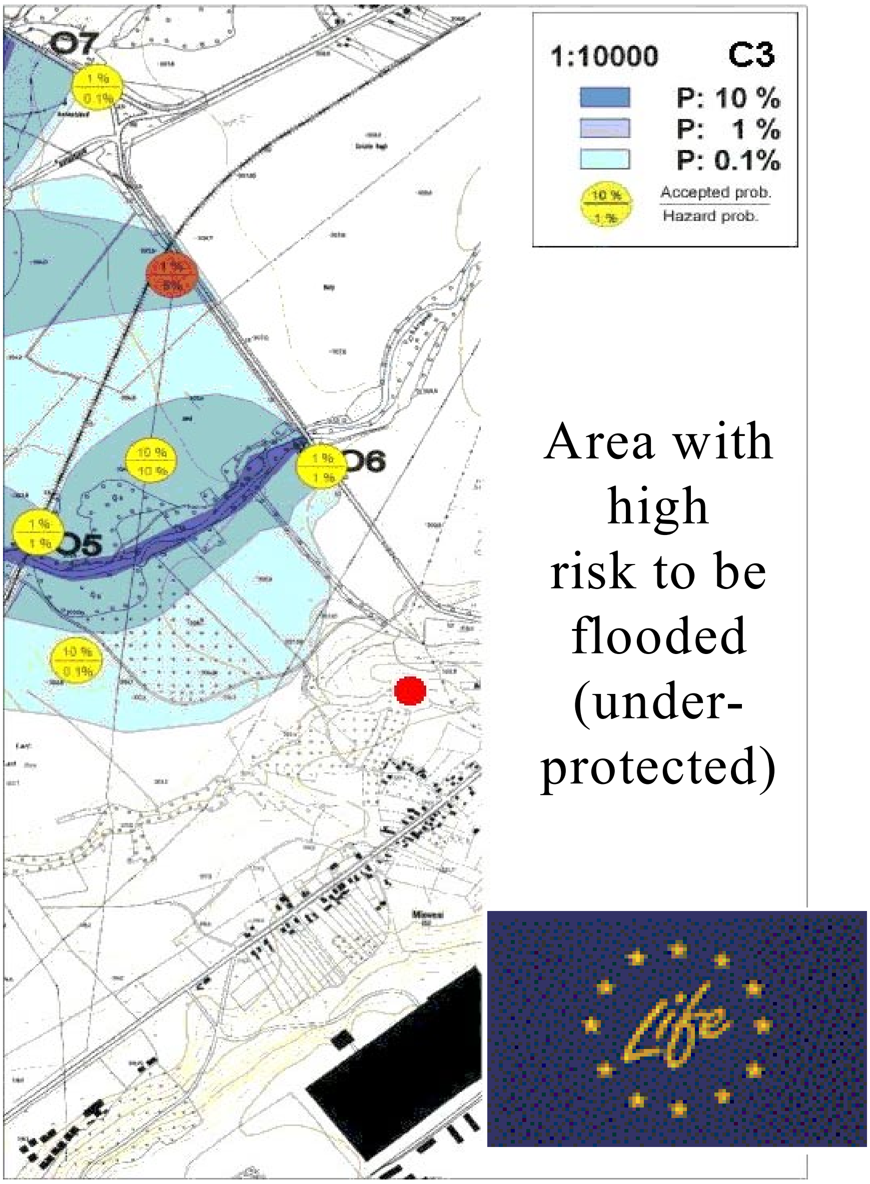

Figure 9.

Such a system is conceived to offer to the decision-makers a comprehensive and well-structured and organised information on flood so that it has to constitute the major support in taking out the best decisions in the process of the flooding management.

Conclusion

Thus, the MOSYM Project is conceived to build the entire chain of information system starting from the automatization and the optimisation of the observing and measuring system of the flood triggering factors and of the flood characteristics, continuing with the automatic procedures of primary processing and hydrological modelling for flood forecasting. This first branch of the system allows for the timely and quantitative cognisance of the inherent danger. On the second branch of the system, the flooding risk maps aim to help decision-makers to develop solutions to their specific problems in flood risk preparedness and prevention. Both branches converge towards the achievement of a useful tool for decision support for flood management and damage mitigation with accepted European standards –Figure 10.

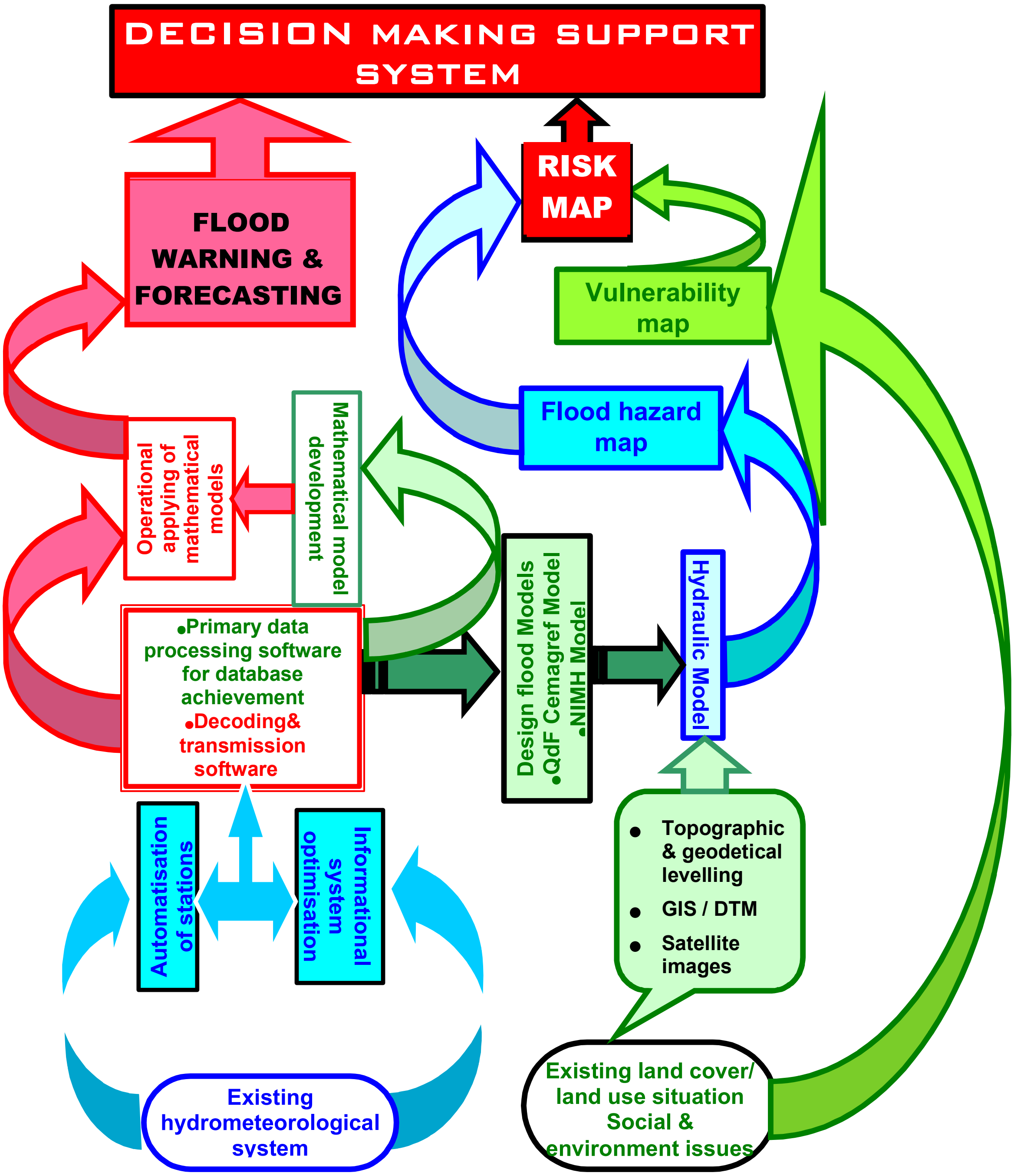

Figure 10. Internal structure of the MOSYM Project

The main actors in the MOSYM Project are presented in Figure 11.

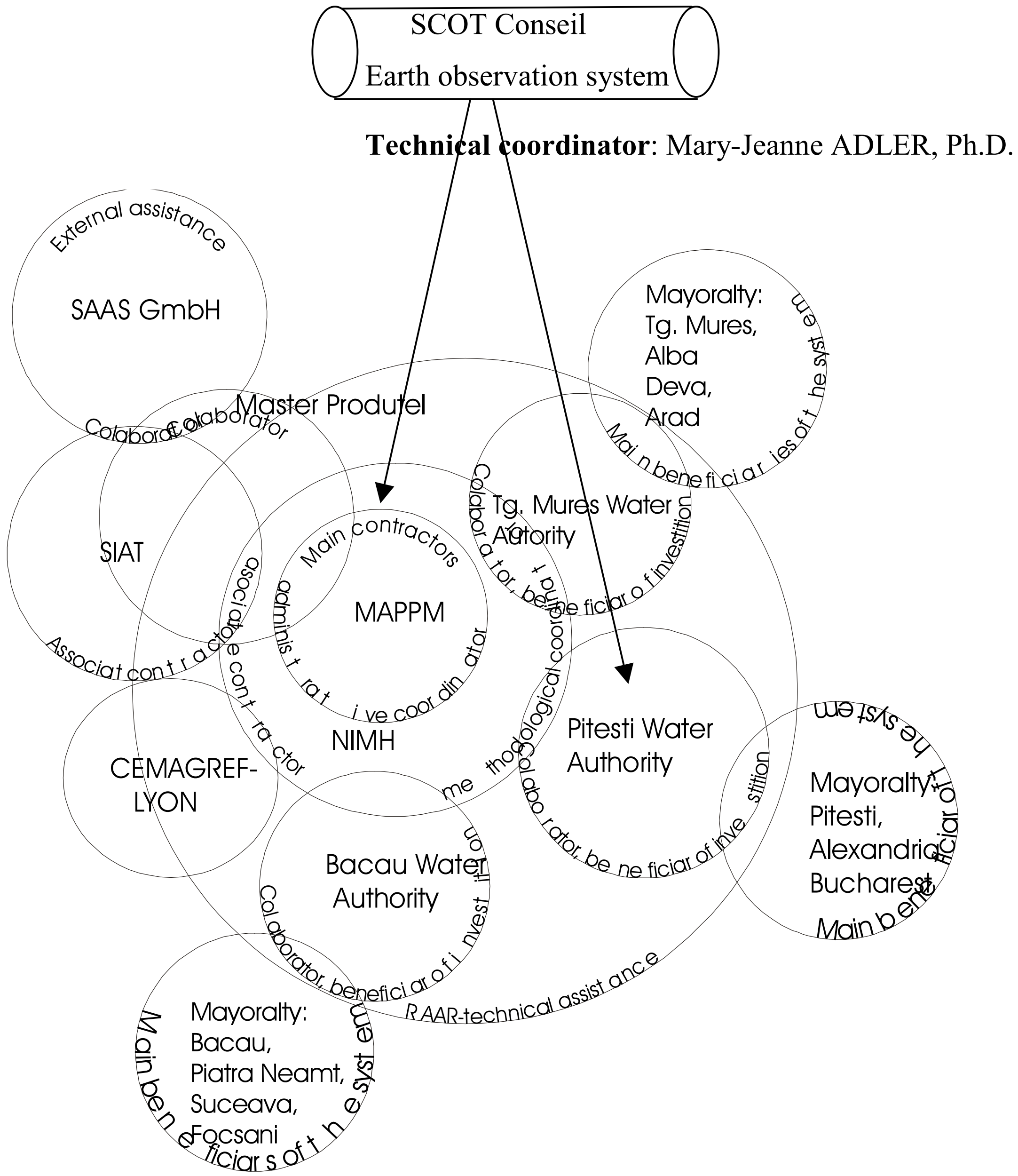

Figure 11. Actors of the MOSYM Project

Bibliography:

Andach, K (1998) Managing Hydro-geological Disasters in a Vulnerable Environment, CNR Publication No. 1900, GRIFO Publishers, Perugia

Djokic, D (2000) Hydrologic and Hydraulic Modeling Suport with GIS, ESRI Press

Dooge, J. C. I. (1973) Linear Theory of Hydrologic Systems. USDA-ARS Technical Bulletin no. 1468, U. S. Department of Agriculture, Washington D. C.

Şerban, P., Corbuş, C. (1987) Contributions to the numerical simulation of the flood routing along the river reaches. Hidrotehnica, vol. 32, no. 4, Bucharest

Şerban, P., Stănescu, V. AL., Roman, P. (1989) Dynamic Hydrology. Ed. Tehnică, Bucharest