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Designing Decision Support Systems for Flood Emergency in the Timis-Bega Basin

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Abstract: To better monitor the progression of a major flood and its likely impact on people andproperties, Romanian Water Boards are in need to build sophisticated Flood Emergency Decision Support Systems (DSS). The aim of such a DSS is to integrate the hydrologic, hydraulic and GIS "flood intelligence" assessed over the last years (for example 10 years) and extract and present vital flood emergency decision making information during an actual event.

This paper outlines the DSS strategy and show how the DSS should extract and display all thevarious components of information to various groups which are required to respond to a flood emergency. Examples are provided of how the DSS interprets the basic hydraulic and hydrologic inputs and GIS data to provide flood intelligence such as: Flood Affected Properties – overfloor flooding associated with a predicted flood level; Evacuation and Exit Routes – the predicted depth and relative timing along evacuation routes to and from evacuation zones and nearest evacuation centers; and Flood Damage – post flood spatial assessment of the distribution of likely damage.

1 INTRODUCTION

1.1 *Background*

Floods remain one of the most frequent and devastating natural hazards worldwide. While existing forecasting and warning systems can significantly contribute to the reduction of losses, the potential for further prevention of avoidable losses with the technological advances through system improvements remains considerable.

Flood modeling can help to understand flood generation and identify the potential areas to be inundated, thus allowing for planning to reduce the damage caused by floods by giving early warning to communities downstream, especially in floodplains which will be affected. At the same time, modeling can be used to evaluate various flood mitigating measures in order to determine which alternative will be economically and environmentally feasible given the prevailing conditions.

Timis and Bega rivers of Banat region in Romania, are lately, more and more subject to floods, showing the need of a Decision Support System for a flood forecasting system, a system which can support operational water management under extreme conditions when actions have to be taken quickly. This paper presents the design of such a system for the mentioned catchement. Timis and Bega rivers were considered jointly, since their hydrodynamic responses are conditioned by operation of existing hydraulic structures used for water transfer between them. The main use of the system is for forecasting rising and high river water levels.

Romanian Waters (The National Agency responsible for overall water resources management) follows the legislation compatible with the EU regulations regarding water resources management and the preservation of aquatic ecosystems and water areas. In this respect, this agency is responsible for the ways in which the surface and ground water resources on the Romanian territory are used.

In terms of flooding problems one of the most vulnerable regions in Romania is in the West. Furthermore, many rivers in this region are of trans-boundary nature. Most of the rivers from the western side of Romania are having their basins in either Romania and Serbia, or, Romania and Hungary. Any event occurring on these rivers is advected downstream to the neighbouring country. A typical example of this situation is the river Timis, which in recent past caused some severe flooding in the two

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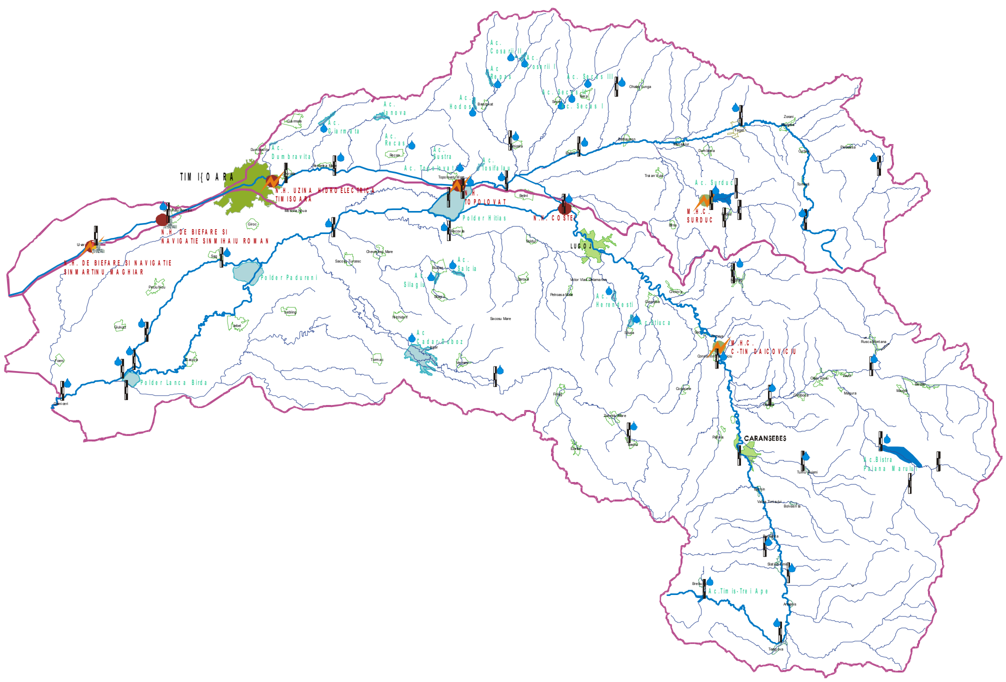
neighbouring countries of Romania and Serbia. In the past many dikes have been constructed along the river for flood protection, which in return made the downstream flood propagation quicker, causing severe flood damages.

1.2 *Basin description*

Timis Bega basin is located in south-west of Romania in Banat province, it lies between latitude 44°30' and 46°, and longitude 20°20' and 22°40'.The climate is temperate continental with influences from the Mediterranean basin and also under the Carpathian Mountains protection, east and north, which diminish the climate influence of Eastern Europe The basin is depicted in Figure 1. Timis – Bega hydrographical basin



The climate is characterised with northerly cold winds in the winter and moderate westerly winds coming from the Atlantic in the summer. At altitudes higher than 1000 amsl, in the Banat Mountains, the intersection of the two influencing zones generates heavy snowfalls. In January, which is the coldest month average temperatures range from -4°C to 0° C. During the summer, the highest temperatures recorded in the Danube Valley are 34°C, in July.

The main rivers in the Timis - Bega basin discharge water in Serbia beyond Romanian borders. Bilateral agreements between the two countries specify the discharge and water quality conditions downstream of the border.

The river Bega starts at the junction headwaters of Bega Luncanilor and Bega Poieni. After starting of to the north, the river bends to the west at Coşava, finally entering the low Banat plains. Since this is the area that was frequently flooded in the past, the Bega canal was constructed with a length of 114 km, parallel to and existing canal (Bega Veche – 97 km). These two canals are connected downstream in Serbian territory. The Bega canal runs through the city of Timişoara and continues to the south-west. It has a draining area of 2,878 km².

The Timis River is 359 km long, rising in the Semenic Mountains (southern Carpathian Mountains) Caraş-Severin County, Romania. It flows through the Banat region and flows into the Danube in northern Sera. The drainage area covers 13,085 km² (in Romania 8,085 km², in Serbia 5,000 km²). After entering Banat, the river becomes slow and meandering, causing floods in rainy years. Especially devastating were the floods of 2005, when the villages Boka and Jaša Tomić, which are in Serbia, were badly damaged.

In the Timis Begа catchment technical measures for relieving the lowlands of this area from recurring floods have already been initiated 250 years ago. Flood regulation has been achieved through the regulation of several measures: correcting the path of some water courses; dykes construction; several permanent and non-permanent reservoirs on the watercourses or aside them (polders); drainage of swamps; development of a drainage canals network, together with pumping stations. An important measure was the establishment of double connection between Timis and Bega Rivers, consisting of hydro technical joints and canals that allow gravitational flow diversion into one of the two rivers depending on the flow conditions. Under normal flow conditions water flowing form Timis to Bega ensures minimum water supply for the city of Timişoara, while under high-water conditions on Bega, water is diverted from Bega to Timis ensuring flood protection of Timişoara.

1.3. DSS System

To better monitor the progression of a major flood and its likely impact on people and properties, the Banat Water Boards needs to concentrate in building a Flood Emergency Decision Support System (DSS) for floods in the area. It is anticipated that the DSS will engender a clearer understanding of flood behaviour and its impacts within the non-engineering community, and most importantly provide Council's Counter Disaster Unit with the tools to plan for and respond to flood events.
The aim of the DSS then, is:

• to integrate the hydrologic, hydraulic and GIS "flood intelligence" assessed over the last years,

• to present design and historic flood results integrated with property, infrastructure and community data and thus assist in the preparation of emergency disaster plans,

• to generate a flood surface for an actual event by interpolating from a library of pre-computed surfaces, or by running a flood model in real time using the predicted hydrograph for the event and converting the results, • to extract and present vital flood emergency decision making information during an actual event

2 STRUCTURE OF A FLOOD EMERGENCY DSS

2.1. Design description of a DSS system

In essence a DSS is a Windows application

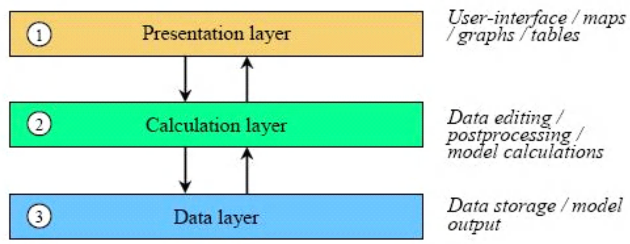


Figure 1: Three layers concept DSS

that connects the property, infrastructure and community GIS databases to the predicted flood surface and updates the various flood affected fields within those databases. This information can then be presented to support emergency response or planning decisions as thematic maps and tabular summaries.

A key element in the DSS is simplicity of use for emergency response personnel whilst maintaining flexibility in the variety of views and integration with any number of GIS layers.

The DSS integrates all this information, including the automatic execution of flood models based on predicted hydrographs, to provide to the authorities in charge needed to respond to a flood emergency. The static pre-computed library of flood surfaces is being built in parallel to the real-time system so that it can be used in case the real-time system malfunctions.

The main structure of the DSS is depicted in figure 2, and its details are presented in figure 3.

The processing capability of the DSS includes the interpolation of a predicted flood surface from the library of design surfaces based on predicted peak flood levels at one or more gauges.

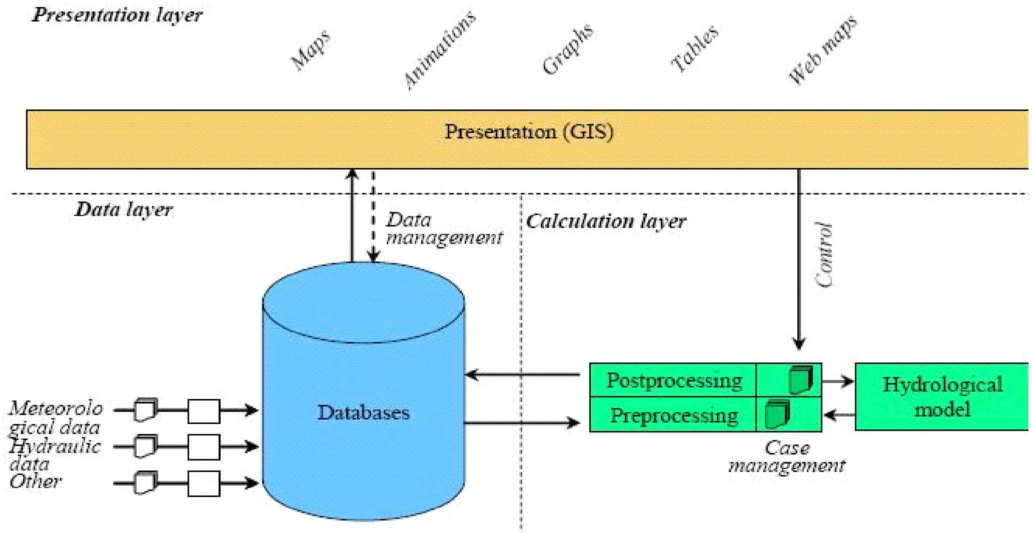


Figure 2: Conceptual framework of a DSS

In its real time mode, the DSS reads the predicted rainfall runoff hydrograph provided electronically by a database of models and converts it to a suitable format for the implemented hydraulic flood model. The flood model is then automatically run by the DSS and when finished, the DSS then converts the results onto the flood surface spatial framework. In this case all timesteps at a pre-selected interval are converted to generate a time series of the evolving flood
surface.

Once the peak flood surface has been generated, either from the library or through real time modelling, the fields in the various integrated GIS layers can then be updated. This analysis typically includes the transfer of flood levels, the determination of flood depths relative to say a floor level or a road level, the determination of air space under bridges, and with the time series data, the anticipated time when key facilities such as evacuation routes, will become affected.

2.2 The use of DSS in Emergency Response Planning

The initial preparation of the DSS should include a set of draft evacuation zones and routes.
These should be later refined as part of a flood disaster planning process. The flood visualisation component of the DSS will enabled Emergency response units staff to become familiar with the potential behaviour of flooding including rates of rise, evolving flood extents, areas of high flood hazard and lead times prior to roads being cut.
Although design floods rarely represent real events, they nonetheless provide a good indication of potential flood coverage, and they often replicate the rising stages of a major flood when the evacuation process is underway. The preliminary evacuation zones ill be each scrutinised in detail with respect to :

- coherency for issuing warnings,
- lead time prior to evacuation routes being cut,
- identification of alternate evacuation routes,
- areas where evacuation route upgrades may be required,
- the need for on-site refuge,
- the traffic interplay with other zones along common evacuation routes,
- the flood conditions likely during any rescue operation,
- the distribution and size of facilities requiring managed evacuation, and
- the distribution of the elderly demographic where more assistance may be required.

However, one of the major benefits of a tool such as the DSS and its associated databases is the capturing of knowledge for training and passing on to future generations of emergency personnel.

2.3. The use of the DSS in Real Time Flooding

The two key elements of flood intelligence that are essential for an effective emergency response are knowing the eventual outcome or the area at risk, and having some idea of the rate at which flood waters are rising and likely to rise.

The runoff hydrographs will be generated by a hydrological model, where a rainfall. Analysis is done, whilst the subsequent flood modelling and data processing by the DSS can take up to several hour. The outcomes will still provide many hours of advance notice of flood conditions. In the event of any modelling failure, the "pre-computed" library of data, which takes only minutes to process can be relied upon. Library design floods with similar rates of rise can be used to predict the short term impacts and assist with prioritizing resources.

I n real time use, the DSS will assist in graphically identifying the community at risk and the magnitude of the impacts and thus identify the scope for any evacuation. Subsequently as the flood progresses, the DSS can be used to indicate the flood impacts in the near future (say 1 to 2 hours), enabling emergency response priorities and resources to be appropriately assigned.

3 CONCLUSION

The development of a flood emergency decision support system brings together hydrologic and hydraulic modelling into a platform where it can be integrated, as needed, with spatial databases on the community, properties, infrastructure and the environment.

The tool has the ability to analyse and then graphically present the impacts of any flood on the community during the event so that an appropriate response can be mounted with as much advance notice as possible.

The DSS will also provide useful baseline data and analysis capabilities in the area of landuse planning.

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