RS AND GIS APPLICATIONS IN FLOOD FORECASTING

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1. Introduction

In recent years there have been a number of significant riverine floods all around the World which caused enormous damage both in terms of loss of life and economics. In the past decade thousands of lives have been lost directly or indirectly from flooding. In fact, of all natural risks, floods pose the most widely distributed risk to life today. It is also clear that no mitigation measure can offer a hundred percent security against floods. There will always be the possibility that thresholds are surpassed and that floods will occur. Another problem is that the higher the level of security due to mitigation measures (dams, dikes, storage compartments…) the safer people feel living and working in potentially dangerous areas. We have nowadays so much faith in our defence systems that alluvial plains are among the most densely populated areas in the world with a large accumulation of valuable property.

2. Objective

This contribution intends to demonstrate how Remote Sensing and Geographical Information Systems can be used in the assessment of flood risk. Up-to-date information on the development of the landscape is required to assess the flood hazard and to estimate the potential impact of a flood when it occurs. It will be shown how Remotely Sensed data can be used at various stages of the flood forecasting process and the successive risk assessment.

3. Flood Forecasting

Assessment of the flood impact is a complex problem that can only be solved through interdisciplinary research and a stepwise approach. The first step is to estimate the dimensions of a possible (likely) flood. Through the application of 1-dimensional flood models, design hydrographs can be constructed that give an indication of possible discharges for a given catchment at a certain location for a predefined climatologic event. The second step is to assess the consequences of such a (peak-) discharge for an areas of special interest – e.g. for a city along the river. For this kind of study a 2-dimensional model is required to characterise the flood hazard in terms of maximum flow velocity, water depths, warning time, duration, sedimentation and erosion, etc. The final step is to estimate how the flood interferes with human activities in the affected area. How many people will suffer from the floodwater by losing their life,
their health, their home or their livelihood? What will be the damage to crop yield, industrial production or to houses? Also aspects of civil protection need to be considered, like when people need to be evacuated and which transportation lines are still available in the inundated area.

4. Use of Remote Sensing for Flood Risk

All three steps in the flood risk assessment process require up-to-date and accurate information on the terrain topography and the use of the land. Remotely sensed images from satellites and aircrafts are often the only source that can provide this information for large areas at acceptable costs. Digital Elevation Models can be constructed quickly or can be improved by using e.g. the Aster images. Furthermore all kinds of parameters that are important for hydrological modelling is related to the land cover, e.g. permeability, interception, evapo-transpiration, surface roughness, etc. And since land cover mapping using satellite images is already common practice, the spatial distribution of these values can be easily estimated. However satellite imagery is not only useful to derive input data for the hydrologic models, but offers also good possibilities to validate the output of the models when a flooding disaster has struck. The observed extent of the flood can then be compared with the modelled prediction. Perhaps the most promising application of RS is its use for elements at risk analysis. High resolution images offer great opportunities to identify individual structures. Recognition of the function of these structures is important for the assessment of their vulnerability and their importance and value. Especially for cities that experience fast and uncontrolled expansion into hazardous areas like floodplains, this offers an opportunity to monitor the increasing risks and impacts and to use it in their decision making process.

5. Flood Hazard Assessment: Modelling & GIS

This presentation will give examples how satellite images can be used for hydrological modelling. Some results will be shown of the application of a two dimensional finite element propagation model that was specially designed to simulate riverine floods. This model – SOBEK – is very suitable for modelling flow over initially dry land and complex topography. The model output, water height and flow velocity distribution at hourly time-steps, were imported into a GIS (ILWIS) and transformed in seven indicator maps that characterise the various aspects of flood hazard: maximum water depth, maximum flow velocity, maximum impulse (amount of moving water), maximum speed of rising of the water level, duration, arrival time of the first floodwaters and sedimentation and erosion.

6. Flood Risk Assessment

The flood hazard indicators are independent of the land-use. To assess the impact of the flood, additional information is needed on the tolerance to floods of the various land-use units in the inundated territory and their value. Some examples will be shown how high resolution images are used for elements at risk mapping. For each of these
elements relationships have to be established between the flood hazard parameters and the degree of damage that they cause. Such flood risk modelling can best be done within a GIS environment to maintain the spatial component of the flood risk distribution. If the value of the exposed elements is known, the risk can be expressed in monetary terms and the total damage can be estimated. However the value of many elements go beyond the direct value (e.g. hospitals, energy plants) or cannot easily be expressed in monetary terms (e.g. human suffering).

7. Conclusion

Through the examples in this presentation I hope to have demonstrated how Remote Sensing and GIS techniques are vital for flood risk assessment studies, especially in areas where data is scarce or outdated. New developments within catchments and on alluvial plains can change the flood hazard and the flood risk. The use of flood models can help to prevent undesirable side effects of the developments and can assist in implementing mitigation measures. This could help avoiding that a dramatic event like a flood turns into a disaster because of unwise land use. Furthermore, the visualisation power of flood simulations will help to bridge the gap between the scientific community and the responsible authorities. For non-experts it is usually hard to imagine what could be the extent of a potential flood. Simulations can be a valuable communication tool to visualise the flood hazard in terms of magnitude, area affected and return intervals. The integration of flood hazard and the vulnerability and value of the various land-use units into a flood risk assessment is crucial but requires still a lot of research work. However it can be safely stated that high resolution images will play a central role in the elements at risk analysis. Further studies are needed and require the cooperation of interdisciplinary experts and responsible authorities.