FLOOD MANAGEMENT IN FINLAND - INTRODUCTION OF A NEW INFORMATION SYSTEM

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In the near future, the importance of sound flood management is expected to rise in Finland, partly due to the proposed flood directive of the EU. Flood management requires usable and reliable information about produced scenarios and flood history. A national flood information system, based on GIS and Web technology, has been developed to bring together the essential information on floods under a single user interface. The system contains flood hazard maps, water level and discharge scenarios, historic flood maps, hydrological flood observations, and recommended building levels. It promotes flood risk assessment, flood-oriented land use, and rescue operation planning. Evidently, it increases public awareness about flood risk and improves communication, since information can be delivered in a consistent and understandable form via our information networks. Moreover, it helps to distribute flood information across administrative boundaries and performs as a knowledge carrier.

INTRODUCTION

There have been several indications that the importance of sound flood management is expected to rise in the future both nationally and globally. Firstly, climate change studies indicate that risk of flooding is increasing in inlands and costal zones (e.g. Jylhä *et al.* [4]). In order to adapt society to these scenarios we need to be prepared and improve our flood management. Secondly, national and international agendas and agreements require for comprehensive and progressive flood management practices.

National flood defence organisation has recently published an extensive report based on several years of work of flood defence experts and this report includes proposal of actions to improve flood management (Timonen *et al.* [12]), for example formulating general flood defence plans, tightening land use planning and utilizing up-to-date technology in flood prevention and protection. In addition, several national projects, such as flood prevention drills and flood risk surveys, have brought up the need to improve flood management and especially the need for an extensive information system that would fulfil various informational requirements of sound flood management.

Main international motivator to improve flood management in Finland has been the recent development of European Floods Directive, which was proposed by the European Commission 18th of January 2006. The implementation of the directive will produce much information and this information needs to be in feasible form, properly stored and easily accessed by various interest groups. (EU [2])

Recently, a watershed oriented approach has been stronger adopted to flood management, and flood mapping is done increasingly cooperatively between various stakeholders involved within a river basin. It follows that flood information is not spatially restricted by governmental boundaries.

The Finnish environmental administration together with the Finnish rescue service authorities are responsible for flood prevention and protection in Finland. Regional environment centres (REC) look most after flood management and regional rescue services will take charge in the case of hazardous flood. Finnish Environment Institute's (SYKE) role is to do flood research, support regional authorities in and supply tools for flood prevention and protection. It is also responsible for national hydrological monitoring and flood forecasting. At regional level, the municipalities are responsible for land use planning, which indeed is an important means for flood damage prevention.

The Finnish environmental administration has developed an environmental information system called HERTTA to manage environmental data in Finland (Niemi *et al.* [7]). HERTTA consists of a comprehensive group of subsystems covering a wide range of environmental disciplines. Particularly the subsystems hydrological information, watershed modelling and forecasting, river basin management systems, and map service are used in flood management in Finland. The first one supplies important real-time hydrological observations, that is to say water levels, discharge values etc., as described in Puupponen [9] and Keskisarja *et al.* [6]. The second one is a conceptual rainfall-runoff model, which calculates important flood forecasts and warnings for every catchment in Finland (Vehviläinen [13]). The third one is a powerful river basin management tool that is used for multi-objective simulation of discharges and water levels in river basins (Keskisarja [5] and Dubrovin *et al.* [1]). The fourth, Map Service, is an interface to geographical information available in the Finnish environmental administration.

This paper describes ongoing development of a new flood information system which will combine various flood information together and rise to the above mentioned challenge of improving flood management in Finland. The focus of the system is on serving as a comprehensive and easily accessed flood information source for all interest groups in the field of flood management.

DESCRIPTION OF THE FLOOD INFORMATION

Information to be stored in the flood information system has been divided into categories, to which are referred as flood information types (Figure 1). In the system, like in reality, the flood information types are related to each other. For example, observations are used in simulating scenarios, which, in addition to observations, are source data for flood maps. Moreover, all this information is applied in defining recommendations for minimum building site levels. The following paragraphs describe more each flood information type.

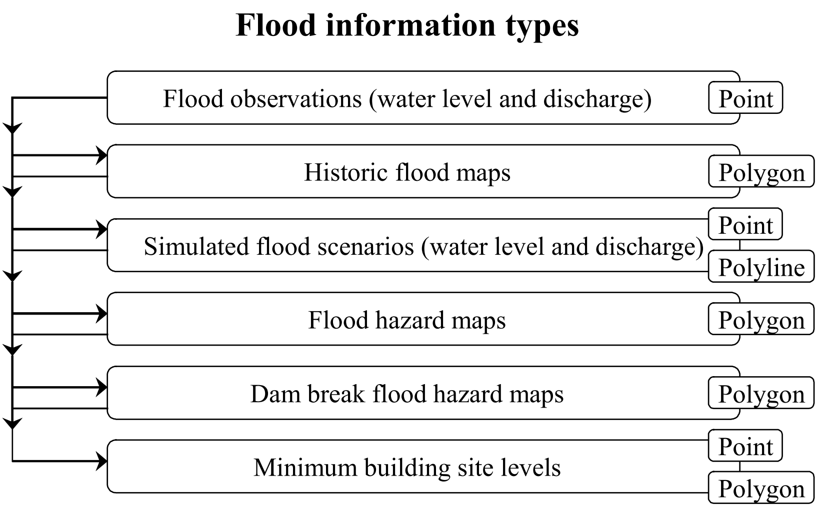

Figure 1. Types of flood information to be integrated into the flood information system and possible GIS formats of the information. The arrows denote the processing of the information in flood mapping and flood management.

During a flood event *the water level and discharge observations* not only at fixed stations of the hydrological information system but also at any location in the inundated area are of interest. It is important to document flood observations, because they are extremely valuable information when establishing flood scenarios.

Another flood information type that documents occurred floods is *historic flood maps*. An inundated area can be derived from remote sensing data (aerial photographs or satellite images) or it can be interpreted from field markings. The former of the methods can be used to produce near-real time flood maps. Afterwards, a flood level can be measured from the historic flood maps with the help of digital elevation model.

One element of risk level involved in certain decisions and actions is the likelihood of flood, which can be expressed by return period (FLOODsite [3]). *Simulated water levels and discharges* corresponding to given return periods can be calculated by using statistical methods or runoff models. In surveys on extreme floods values corresponding to the 100-year and 250-year, and sometimes even 1000-year flood have commonly been used. As for more frequent floods, return periods of 20 and 50 years are the main interests.

Flood hazard map is defined as a map showing the areas where floods must be taken into account including the probability of flooding and the degree of danger (e.g. water depth and flow velocity) (van der Sar *et al.* [11]). Flood hazard maps are modelled for a scenario of water level or discharge which usually corresponds to some statistical frequency interval (e.g. 100-year-flood and 250-year-flood). Flood hazard maps can be made in different scales:

- Detailed scales using the best possible accuracy covering only the most critical flood risk areas
- Coarse scales in a cost-effective way using the accuracy proportional to the supposed damages or loss covering the potential flood risk areas. Coarse scale mapping can also be used to make a general estimate which areas are prone to flooding.

SYKE has recently published guidelines for flood hazard mapping in coarse scale for the use of RECs and consultants (Sane *et al*. [10]). One of the fundamental principles in the manual is the evaluation of the usability, cost and quality of data sources for flood mapping.

Dam break flood analysis explores the risk caused by a suspected dam break. The analyses are carried out at least to the dams which breakage would lead to damage to life, environment or property. An essential output of the analyses are *dam break flood hazard maps*, which divide into flood inundation, flow velocity (v), water depth (d) and damage parameter (v × d) zones.

In Finland the Land Use and Building Act emphasizes the importance of taking the risk of flood or landslide into account in land use planning and building projects. RECs give *recommendations for the lowest permissible building site levels* with respect to floods for inland shores and shores of the Baltic Sea. The recommendations regarding inland waters are typically based on the flood level of the watercourse concerned recurring only once in 50 years on average, added by a discretionary additional height (0.3 m to 1.0 m) and a wave margin (Ollila [8]). In some cases a recommendation can be based on the highest observed flood level or upper limit for reservoir operation. A recommendation can be given as a guideline for an entire lake, or in more specific sense for an individual building site.

Flood information is mainly produced in RECs, where it has so far been filed in a variety of forms including paper archives and maps and different types of digital files. Another inconsistency lies in the quality of information. For example, very old observations on flood extent and elevation may lack exact date information, which is obligatory information in normal case. Each flood information type is associated with a number of supplementary meta data that should not be lost when releasing the new system.

DEVELOPMENT OF THE FLOOD INFORMATION SYSTEM

The flood information system has been developed within the concepts of the Environmental Information System HERTTA and the Map Service. The HERTTA concept uses Web technology and sound software engineering, such as object-oriented modelling and three-tier architecture. Map Service is a Web-based GIS system developed by SYKE, and it contains an interface for users and applications, a connection to environmental administration's geographical datasets, and ESRI's MapObjects server application. All employees in the Finnish environmental administration have access to the systems. Additionally, limited versions are available for Extranet users and Internet versions are in the future plan. A significant advantage of these concepts is that advanced systems are available without anything else but a Web browser being installed on user's workstation.

The data content of the system, i.e. flood information types, can be in a form of maps (polygon data) or point data. The maps are saved in the environmental administration's geographical dataset system as Arc/Info coverage format and the other data, as well as attribute data of the maps, in flood database. The flood database has been designed to meet diverse demands of the flood information types and to link data to each other and to data in other information systems. For example, a simulated water level can be linked to the particular station of the hydrological information system which was used in the simulation. Another example is a link to the official document of the case management system that states a recommended minimum building site level.

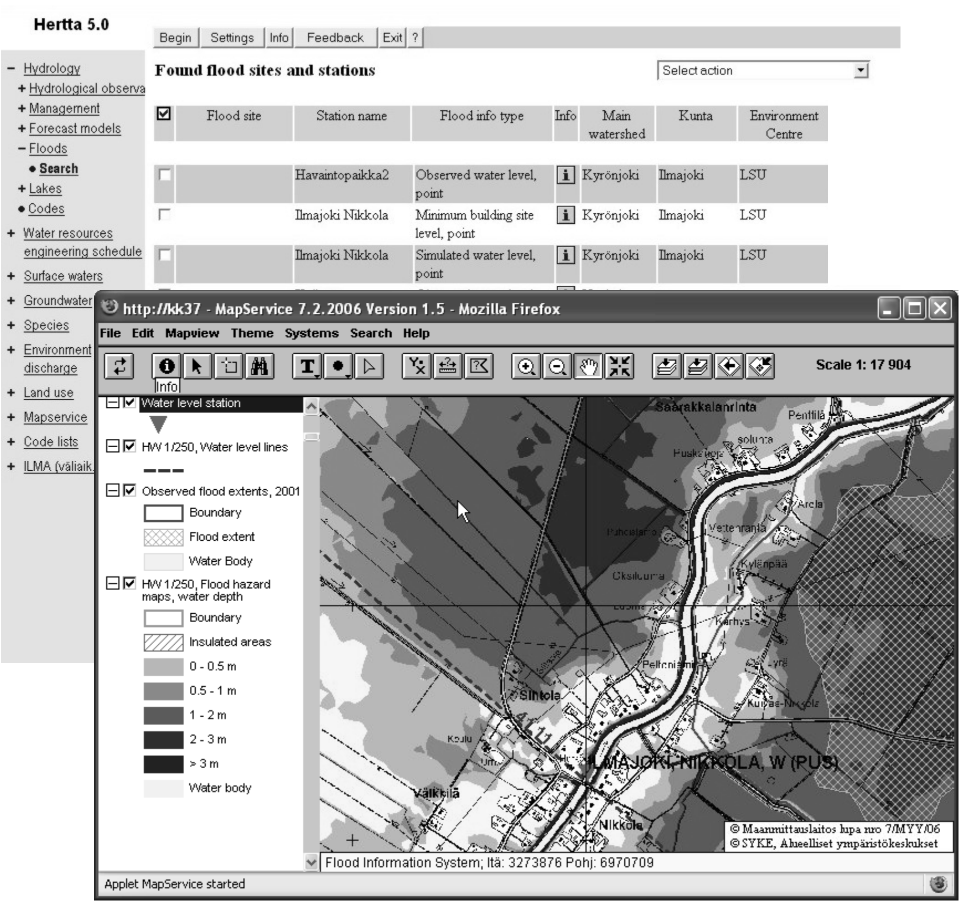

Figure 2. An example of the user interface.

Figure 2 shows an example of the user interface of the flood information system, which is highly collaborative with the Map Service. Namely, the data in the flood database are equipped with coordinate information, hence they can be viewed in the Map Service. Moreover, the flood information system uses the Map Service as an additional interactive user interface. For example, a new data point can be introduced to the system by pointing any desired location in the Map Service tool, which also returns the spatial information related to the location. In the case of minimum building site level the returned data can be related either to a point (individual building site) or a polygon (lake). In addition to the map interface, the flood information, including meta data, can be viewed and maintained via html pages and outputted to versatile file formats for continued handling.

END-USER SERVICES

The flood information of the system is managed by RECs and SYKE. RECs save the point data and send flood maps to SYKE where they are transferred to the system. The other authorities involved can use the Extranet version of the system, or the RECs can disseminate the information to them by other means. In order to provide the public with processed and clear flood information, the flood information system serves as a tool to conveniently create illustrative, standard flood maps and tables to be presented in the Internet as well as in the customary public information channels, such as press releases.

The flood information system is well applicable in the prevention, crisis and post-crisis phases of flood management. Activities in the prevention phase include mitigation of flood peaks, proper land use regulation, structural methods, preparation to emergency and dissemination of flood information. The information system supports decision-making in these activities especially because its information content is used in risk scenario assessment. The rescue service authorities use flood hazard maps in rescue operation planning and establishing evacuation routes. Moreover, the system makes working with the lowest building site levels more efficient and even overlapping work can be avoided as the existing data in the area of concern are conveniently available when new data are produced.

In the crisis phase the system is used together with the watershed forecasting system to estimate the extent, severity and timing of the flood by comparing forecasted flood level with pre-defined flood hazard maps. In this phase, the time is often limited and it is crucial that the information is available immediately from a reliable system. During a flood also flood observations are collected.

In the post-crisis phase it is essential to devote to damage assessment and experience capitalization. The return period of occurred flood is calculated and saved in the system together with flood observations. Thus the gained experience is available for forthcoming enhancement of flood preparedness.

DISCUSSION

In the long run, we may expect that both flood hazard and flood risk are dynamic issues, which are subject to rapid changes in infrastructure, climate, society, and land use. Consequently, there is a risk involved with the system that its content, particularly static flood hazard maps, will not be updated to response to new requirements. Therefore, it is essential to consider flood mapping and use of the system as a continuous process of evaluation and updating. The new system needs also good dissemination and exploitation plans, which include end-user trainings. If this is not done in a proper way, the usability of the system will be diminished.

Once we have flood hazard maps in a system that is compatible with other spatial data, flood damages can be estimated by a simple GIS overlay analysis using various GIS datasets, such as buildings, basic infrastructure, location of population, land use, road networks, industrial establishments, and environmental protection. The system does not currently contain flood risk maps, but the next step will be to develop a GIS-based approach for flood risk mapping by using above mentioned spatial databases. Eventually, produced flood risk maps will be added in the flood information system.

For the time being the flood hazard maps in the system are pre-defined, not modelled or forecasted in real-time due to lack of accuracy in tested real-time maps. However, it is not excluded to extend the system to cover real-time maps in the future.

CONCLUSIONS

It is essential to define, quantify and understand a flood risk before it is possible to manage it effectively. This paper describes a development of a flood information system that merges information on previous floods and flood scenarios into a nation-wide system and thus promotes competent flood risk management. At the time of writing the exploiting of the system is in initial phase, and only test data has been saved in the system. We believe however that the system makes the work with flood information more effective in that a GIS-based system guarantees all desired data from a specific area being considered in one view despite of administrative borders. Bringing the information from various formats and sources into a uniform system also ensures that the experiential flood knowledge is transmitted for the younger generations. Interactivity with other information systems and GIS datasets eases the maintenance and provides a good starting point of addressing the information demands in the future.

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