A Floodplain Inventory for the Danube River Basin based on GIS and Satellite technologies, with a Special Focus on geo-referenced Digital Videography

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Wetland, Estuarine and Floodplain Inventories based on Remote Sensing (satellite, conventional CIR/BW/color aerial photography) and GIS technologies have been extensively developed for many parts of the United States, Canada and Australia. In addition, over the past 15 years there has been a growing range of applications using aerial videography (mostly analogue) for surveillance and monitoring purposes. In the case of Europe though, aerial video technology has not been widely used. However for the Central and Eastern European countries a large range of survey and monitoring tasks (environment, agriculture, disaster, infrastructure i.e. pipelines, power lines) could be readily performed using current Digital Videography (DV) incorporating a GPS reference system. DV would offer a highly flexible and cost effective image acquisition system which would complement or in certain cases could replace expensive conventional aerial surveys (multispectral scanners – CASI etc.,) or high resolution satellite images covering large areas (e.g. Ikonos).

Floodplains and wetlands are some of the most threatened habitats in the world and the vital importance of their ecological and ecosystem services has only belatedly been recognised within the last decade. In Central-Eastern European countries approximately 15 % of the original habitats are still intact compared to an alarmingly low 3-5% in Western Europe. It is internationally recognised that the Danube Basin hosts some of the most valuable areas such as the Danube Delta, the Romanian-Bulgarian islands, the Kopački Rit, the Danube National parks in Hungary and Austria and some other floodplains/wetlands along the Drava, Sava and Tisa rivers. In fact, as of today, no systematic floodplain inventory has been realised, although the ICPDR inventory (International Commission for the Protection of the Danube River) covers certain protected areas or possibly proposed areas as "green spots" within the Danube catchment basin.
This deficiency has to be seen in light of numerous existing and future EU directives and initiatives which place strong legislative pressure on present and future member states. For example, the :-

- FFH, Birds Directives with the
- Natura2000 network (or the EMERALD Network for the eastern non-EU countries),
- the Water Framework Directive (WFD) stressing a River Basin management approach
- and the Pan-European Biological and Landscape Diversity Strategy (PEBLDS) which is focused on the riverine corridors including floodplains and wetlands.

The RAMSAR Convention on Wetlands has recently proposed a general framework for Wetland inventories (RAMSAR 2000) making wide use of Remote Sensing data and a flexible adoption of GIS technology according to the technical infrastructure of member states (Finlayson et al. 2001).

In this article we attempt to demonstrate that an inventory based on the comprehensive mapping and monitoring of the Danubian floodplains, including the main tributaries, is realisable within the next 3-5 years centred on a user-friendly GIS-RS-Communication strategy. This leads to a paradoxical situation, where on the one hand the accession process in eastern neighbouring states is related to the implementation of European law (incl. the nature protection low), on the other hand the strong forces for economic development will place greater pressure on the floodplains and many infrastructure projects are supported by the EU within the next years (e.g. WWF 2002).

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The standard Landsat (since 1999 Landsat 7 ETM with a ground resolution of 15 m panchromatic and 30 m multi-spectral) is relatively cheap and has become widely accepted over the past two decades. One scene at 500 € covers 180 x 180 km with the quality, geometric characteristics and with the ease of use being guaranteed. Approximately 15 + 15 scenes (Danube + tributaries) would be segmented and classified to approved methodologies, thus facilitating/permitting a ready exchange with existing classifications in CEE states (using mainly Corine and other Landsat or Spot based landuse and landscape structure inventories).
The first step is the analysis of the riparian corridor, including the river, the floodplain and a buffer zone. The size of this buffer zone depends on the recent and former floodplain extensions and varies from several kilometres up to 50 kilometres (or even more in the Delta). This classification should also relate/share features with special surveys for National Parks or the National Ecological Network mapping where this is applicable. The result is the recent floodplain coverage with the main habitat structures.

The second step is to determine the coverage for the aerial videography, ground and water borne geo-referenced DV. Therefore, satellite remote sensing even though it is a powerful monitoring tool, often lacks the high spatial resolution (at affordable prices) and operational flexibility needed for research and monitoring of floodplain inventories (Slaymaker et al., 1996). For the practical realisation of a floodplain inventory one should be considering up to 50 main habitat types classifications for the Danube basin. About 15 habitats are part of the FFH annex, identified as “habitats of community interest” and about 5 of these are “priority habitats”, that means on the highest protection level.

Fortunately, recent developments in DV combined with GPS technology provide one with high resolution and affordable geo-referenced aerial digital images which are particularly suited for monitoring linear landscape features such as fluvial morphological patterns, habitats, vegetations, embankments, canal systems, etc., (Roberts et al., 1997).
Integrated DV technology is revolutionizing high resolution spatial information acquisition for use in inventory taking, mapping, change detection and impact assessment. It provides near real-time data at the local and regional scales and with small slow-flying aircraft creates a modern do-it-yourself data acquisition tool for everyday field work and ‘ground truthing’ of satellite imagery. The response to this paradigm shift in digital image acquisition is clearly manifested by the latest GIS/Image processing software packages now offering suitable modules and plugs-ins.

The possibility of geo-referenced digital images has far reaching implications for the establishment and up-to-date maintenance of a viable Danubian floodplain inventories. These inventories cover a diversity of low income to high income regions with their corresponding levels of technical know-how and infrastructure proficiency.
We have to exploit the opportunity provided by locally acquired *geo-referenced digital images* whether they are taken at :-

- a low or high altitude, vertical or oblique (*at an angle*) aerial shots,
- on the ground (*car, on foot or bike*)
- on and *under* the water surface

All these geo-referenced images can be conveniently manipulated, incorporated into geo-referenced satellite/aerial photographs, transmitted between local/regional parties and stored in databases.
Many areas of floodplains and associated wetlands are difficult to access for field assessment by vehicle *(apart from being sensitive to damage*) or by foot, due to their biophysical characteristics, past and on going political conflicts ie., border and property disputes, left over land mines etc.,
Therefore, the below listed advantages of geo-referenced DV have to be rapidly and optimized:-

- aerial image acquisition which is rapid and inexpensive with a standard light aircraft or Ultralight (ULM) fitted with a simple window mount or floor aperture
- ground-water borne image acquisition to complement aerial and satellite imagery
- fast turn around times with ‘real-time’ control of image quality and quantity through the DV LCD screen, an attached TV monitor for the pilot or a lap top computer
- steady decreases in camera size and weight with more compact shape facilitating multiple camera mounts
- a continuing increase in spatial resolution together with cheaper prices
- DV/digital cameras (CCDs) are more responsive to subtle changes in electromagnetic energy than analogue video or standard SLR 35mm

- up to 3 hours continuous image capture on one DV tape, 5-6 hour battery life
- redundancy of image acquisition ie., 25 frames per second at 1.2MB to 5MB per frame, providing stereoscopic image viewing under specified conditions
- individual image frames can be captured and stored at specific predetermined geographic positions along the flight path so as to maintain a 60% overlap between exposures for stereo viewing
- cheaper and larger digital storage medium together with improved compression technology
- highly efficient data transmission to PCs using USB or IEEE 1394, compared to earlier analogue video-to-PC capture boards
- wide use of digital processing software incl. freeware such NIH Image with video macros
- the possibility to improve the understanding of aerial imagery and it's dissemination to the local population through the simultaneous capture of oblique images, which are easier for local photo-interpretation - copies onto VHS tape or hard copy on cheap color printers
- cheaper, smaller and more accurate GPS hardware & software facilitating interfacing with digital cameras
- high CIR (color infrared) sensitivity on several models of DV and digital cameras which combined with an IR filter and the night shooting option offers pseudo-CIR capability - professional CIR digital cameras are still very expensive
- recent developments such as the Foveon X3 image sensor offering resolution similar to 35mm film, greatly improved colour quality and cheaper chips, should be available by 2003

The dissemination of image information for promoting and maintaining local/regional participation is fundamental to the successful and long-term management of floodplains. Furthermore, recent EU mandates and other bodies are stressing the importance of 'integration through participation'. Therefore based on the adage of a 'picture is worth a thousand words', one must be prepared to adapt the dissemination techniques of visual information according to the target groups involved with available technical and funding resources. These would range from Internet panoramic visualisations, multimedia, VHS, hard copy didactic materials and tutorials presenting a 'hands on' DIY approach to aerial-ground DV.

The further image processing, the segmentation, classification of satellite and suitable DV images into a flexible GIS system should, as much as possible, share common parameters with existing GIS data in the target countries. This task is affordable and easily manageable with current soft and hardware packages. Naturally all the data layers are to be integrated with national co-ordinate systems. The datasets (Access or Oracle databases) would not only be available for national authorities but also for Nature Conservation organisations operating in all the countries involved, such as the ICPDR, RAMSAR or WWF.

References.

Finlayson, C.M., Davidson, N.C. & Stevenson, N.J. (eds) 2001. Wetland inventory, assessment and monitoring: practical techniques and identification of major issues. Proceedings of Workshop 4, 2nd International Conference on Wetlands and Development, Dakar, Senegal, 8-14 Novemebr 1998. Supervising Scientist Report (in press), Darwin, Australia. pp. xx-xx.

Ramsar Convention Bureau 2000. Strategic framework and guidelines for the future development of the List of Wetlands of International Importance, Wise Use Handbook 7. Ramsar Bureau, Gland, Switzerland.

Roberts A., Bach K., Coburn C. & Haefele M. 1997. Airborne remote sensing of fish habitat, channel and riparian assessments in coastal environments. http://www.sfu.ca/rs/

Slaymaker, DM., Jones K., Griffin C.R. &J.T. Finn. 1996. Mapping deciduous forests in Southern New England using aerial videography and hyperclustered multi-temporal Landsat TM imagery. Pages 87-101 in Gap Analysis: A Landscape Approach to Biodiversity Planning, J.M. Scott, T.H. Tear and F.W. Davis (eds). American Society of Photogrammetry and Remote Sensing, Bethesda, MD, USA.

WWF, 2002: Waterway Transport on European's Lifeline, the Danube. Impacts, Threats and Opportunities. WWF International Danube-Carpathian Programme, Vienna.