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Extended Abstract**

Flood Risk Management in Small Urban Catchments

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1 Introduction (≤ 0.5 pages)

This project focuses on the present practice of flood management and non-structural flood measures in small urban catchments (SUCAs) and on providing decision-making tools for flood managers. It intends to contribute to the development of a European framework of flood management for small urban catchments and will be part of a European Flood programme compatible with the Water Framework Directive. Based on the use case studies in Bradford, Manchester, Gloucester, Glasgow, Hamburg and Paris, the effectiveness and efficiency of non-structural (NS) measures to reduce flood damage is evaluated and analysed with respect the following:

- the feasibility of assessing and adapting to flood risk from hidden watercourses and culverts in urban areas;
- the possibilities and ways to implement effective, non-structural solutions (such as raising flood awareness, regulations in spatial planning, temporary storage basins and wetlands in open spaces) to minimise flooding from these sources

Specific aspects of non-structural flood management are addressed in the following work packages:

- Relevance and Requisites of the Societal Environment for Non-structural Flood Measures (societal structure, cultural conditions and stakeholders' "risk culture", level of flood risk awareness and response to the socio-economic situation, applied information policy and the administrative regulations)
- Structure and Efficiency of Non-structural Measures in Small Urban Catchments (efficiency of various methods of flood information in engaging with, stakeholders' awareness of risk and interest in responses and mitigation strategies.)
- Flood Risk Management Strategies for SUCAs (hydrological sensitivity of urban catchments in terms of their climatic, geomorphological, ecological and hydrological characteristics)

Methods (≤ 1 page)

Originally very extensive work program has been summarised and partly reduced to the basic issues due to lack of resources and data availability in the partner countries. The themes were developed at a project workshop in Manchester, June 2007, after initial survey and literature work in the partner countries had been reported. The main methods can be summarised as:

I. Survey and analysis

1 Empowering the public

Detailed study of socio-economic indicators in case study areas (by the means of the Interactive Learning Groups (ILGs), interviews, detailed meetings, workshops and questionnaires survey); analysis of public flood risk awareness, flood risk information available to the public and strategies used in engaging with the public

2 Making institutions work and the role of planning in minimising flood risk.

A detailed cross-country comparison of all regulations covering flood risk management; an evaluation of the effectiveness of building regulations and interviews with responsible authorities.

3 Professional attitudes and cultures to non-structural measures.

Analysis of professional stakeholder attitudes and cultures.

4 Warning and emergency responses.

Analysis of meetings, workshops and questionnaires surveys, interviews with emergency service agencies. Analysis of flood warning systems. Cross-country comparison of the effectiveness of emergency services.

5 Flood preparedness by individuals

Analysis of the public's risk awareness by meetings, workshops and questionnaires survey; assessment of the effectiveness of resilience measures to existing buildings and to new build; analysis of the effectiveness of alternative drainage systems; evaluation of the value of day-lighting culverted urban watercourses.

6 Hydrological sensitivity

A study of the physical and geomorphological aspects influencing the management of flood risk in small urban catchments involving a literature review and understanding of channel morphology modelling; GIS studies in the case study areas; consideration of the appropriate non-structural measures to reduce hydrological sensitivity

7 Decision making and implementation

Development of guidance for policy makers, Local Authority planners, utility companies and environmental regulators.

II. Assessment of the results regarding efficiency and effectiveness of NS in Small Urban Catchments

The results from the survey and data analysis will be interpreted with the intention to determine the effectiveness of non-structural measures to reduce the flood risk. The dependencies between the socio-economic factors, physiographic conditions of the catchment, the predicted climate change and the flood risk will be presented and the efficiency of non-structural measures compared to traditional more infrastructural oriented measures assessed.

III. Recommendations and Guidelines

The results of the analysis and assessment will be compared between the case study areas of the different countries to show similarities and differences. On this basis, general guidelines will be given and the relevance of national and regional influences will be shown. Those guidelines will be presented in a form of decision trees or tables with concrete recommendations for the course in SUCAs for the given conditions.

2 Results and Discussion (≤ 4 pages)

The project meetings and discussions showed that there is an inconsistency in the basic terminology the most significant being with the term *non-structural measures (NS)*. There is a necessity to set up a glossary or a kind of “knowledge base” where all key terms are precisely defined in the partner countries.

Case studies analysis brought the following most important scientific results:

German Case Study:

Based on case studies of urban river catchments of the cities of Hamburg, Cologne, and Dresden, the effectiveness and efficiency of non-structural measures to reduce flood damage is being analysed and evaluated.

Empowering the public: A thorough study has been undertaken in the Kollau catchment area, Hamburg. An open public workshop followed by the Interactive Learning Groups (ILGs) in form of series of workshops have been organised with the overall goal to raise risk awareness among the stakeholders. In the interactive learning process, based on the Kolb’s cycle¹ the stakeholders, with the accent on the residents, should identify and accept their responsibilities, and learn why and how to protect they properties in a cost effective way.

The workshops together with the corresponding questionnaires showed that the residents had neither understanding of the hydrologic background of the urban flooding nor were aware of the changes in the legal framework that postulate the self mitigation measures. A shift from “blaming the authorities” to “acceptance of self responsibility” by the residents has been observed throughout the workshop series. This shift was initiated by bringing together the residents and the authorities to a discussion table and by the learning aspects of the ILGs. The outcomes of the ILGs showed that a systematic approach is necessary in “educating” the public. On the other hand, it is quite time intensive and requires corresponding infrastructure and resources that should be provided by the authorities.

Flood Animation Centre² has been further developed, by improving the visual, audio and tactile features and as such presented to the stakeholders.

Making institutions work and the role of planning in minimising flood risk: In Germany, the *Water Act to Improve Preventive Flood Control* by the German Federal State (2005) establishes a legal framework on the assessment and mitigation of flood risks on a national level, that results in high requirements for the management of watercourses in urban environments. It causes substantial changes in the Regional Planning Act (ROG), the German Water Act (WHG) and the German Statutory Code on Construction and Building (Baugesetzbuch). New

¹ Kolb, D. A., Fry, R. (1975): Toward an applied theory of experiential learning, in C. Cooper (ed.) *Theories of Group Process*, London: John Wiley.

² E. Pasche, C. K pferle, N. Manojlovic "Capacity Building of Spatial Planners for Flood Risk Management in Urban Environment through Decision Support Systems and Interactive Learning", International Symposium on New directions in Urban Water Management, Paris, September 2007

urban developments in inundation areas of 100-year probability are prohibited. Exceptions are only permitted if no other alternatives exist and a couple of strict requirements are fulfilled, e.g. no isolated new developments, no changes in surface runoff and no increase of risk. The hydrological effects and necessary mitigation measures need to be studied on a catchment level².

As German system is rather decentralised, the Federal States (Länder), have the legal and administrative authority for all water related affairs that have to comply with these legal frameworks. The differences in implementation in the Länder can be reflected in concrete definitions such as in the one of the design criteria for the mitigation measures. For the study areas in Hamburg, the design criteria is set to 30- year flood event, whereby for the areas in Dresden (Saxony) the protection level is set at 100 year flood. For the catchments in Dresden flood action plans already exist but are not completely put into force yet.

Based on those Acts, the development plans (Bebauungsplan), as the main legal instrument to manage urban growth, are defined.

In Hamburg, the boroughs (Bezirksämter) have been given more responsibilities regarding the management in small urban catchments since January 2007. Still there are some ambiguities and conflicts when defining the interface between authorities on the city and on the borough level as well as the one with the storm water utility. In Hamburg the Authorities on the city level can assert a claim on a development plan and push it forward even without consent of the relevant borough (so called Senatsplan). Current practice shows that there is still lack of cooperation and common language between the spatial planners and water managers on the local level. In order to make the institutions work together, the capacity building of spatial planning is necessary. It can be performed through Decision Support Systems and Interactive Learning².

According to the Water Act the flood hazard maps for the urban catchments should be available till end of 2010. However, the implementation procedures as well as the responsibilities are not set yet.

Professional attitudes and cultures to non-structural measures: The professional attitudes are to be assessed through interviews with the key stakeholders being the authorities, insurance, residents and the storm water utilities. Till now, interviews were held with the authorities, both on the borough and on the city level. Generally, they support the measures whereby the improvement of controlling and management of the retention basins as well as creation of the temporary retention areas are set as ones of the priorities.

In Germany, the insurance of buildings in the flood prone areas of small urban catchments is in its initial phase. At present insurance companies define without proof a zone of 100 m adjacent to the urban watercourses as risk zone in which no insurance of the buildings is given. However the insurance companies have started to determine flood prone areas based on mathematical models, for which they rely on their own methods and models.

In Germany the interviewed insurance companies showed no interest in fostering the adaptation of the built environment to flood through financial incentives or a reduction of the prime rate.

On the other hand, the experience from the Switzerland with the NSV insurance company (Nidwaldner Sachversicherung, canton Nidwalden) shows a rather positive attitude to the NS measures.

Warning and emergency responses: Although for the Hamburg region the term "catastrophe" as well as the procedures in case of emergency are defined, it is in

practice not applicable for the small catchments. A lack of systematic approach is observed and the boroughs develop their own ways to cope with such cases.

In case of flood hazards, the responsibility is split among the fire brigade, the storm water utilities and the boroughs. At the moment there is no superior body that is in charge of coordination of the institutions involved.

Also, there are no additional services (e.g. hot line, sms, alarming) provided to the residents.

The warning systems for pluvial flooding in Hamburg have been analysed within the URBAS project⁴ with the objective to extend the existing warning systems to the case of flash floods.

Flood preparedness by individuals: A detailed survey of the affected households in the Kollau catchment showed that the people are mostly aware of the problem, but at the same time the measures were mostly taken on an ad-hoc basis. Both, good and bad examples were identified. In general, there is no systematic approach in selection of appropriate mitigation measures.

During the third workshop as a part of the ILGs, the protection concepts for individual properties were developed and discussed together with the participants (that are at the same time the homeowners). The most important criteria for their acceptance are the financial, followed by the operability and the requirements for their maintenance.

Hydrological sensitivity: In order to assess the influence of the hydrological, climatological and morphological characteristics of a catchment on the efficiency and effectiveness of the NS measures in SUCAs, the relevant parameters are analysed and correlated. This study will end in a matrix supporting the selection of appropriate mitigation measures to reduce flood probability. A scenario study in which the parameters are systematically varied and their impact on the flood probability quantified through mathematical models would be the ideal method of analysis. However, the definition of new data models for the mathematical simulation with Rainfall-Runoff-models and hydrodynamic fluvial models was beyond the scope of this project. Only for those case study areas, which have been already modelled this scenario study has been carried out. In all other cases GIS based approaches have been applied in which similar to the method of Wackermann⁵ the physiographical parameters are correlated to characteristic parameters of observed flood hydrograph (such as concentration time of the flood peak, specific discharge of the flood peak and the runoff coefficient of the flood wave. From these studies value results could be gained on the effectiveness of SUDs and fluvial retention measures to attenuate floods in SUCAs. By comparison with natural catchments with little urban developments the impact of urbanisation on the runoff characteristics could be demonstrated.

Manchester case study

1 Empowering the public: The public feel unprotected and vulnerable; flood victims are afraid to leave home when storms are imminent and stress levels are high. There are strong socio-economic variations in the public's ability to cope

⁴ Project URBAS Forecasting and Management of the Flash Floods in Urban Areas
<http://www.urbanesturzfluten.de/>

⁵ Wackermann, R. (1981): Eine Einheitsganglinie aus charakteristischen Systemwerten ohne Niederschlag-Abfluss-Messungen; Wasser und Boden H 1 (1981), 23-28

with repeated flooding. Risk communication is poor and many sectors of the public are unaware of self help mitigation strategies. Much flooding is not reported because of property value concerns. The Environment Agency (EA) flood risk maps do not have to include, and possibly cannot include, pluvial flooding and many parts of the study area which have experienced repeated pluvial flooding are not shown to be at risk on these web based maps. This is a limitation because these maps strongly influence property transactions. Householders are given poor advice from professionals when purchasing properties and there is an argument that some aspects of flood risk should be included in the Home Information Packs. The public desire a single agency (a single responsible party, point of contact or 'one-stop-shop') able to deal with their concerns. This agency may coordinate the efforts of the EA, local authorities, water companies, emergency services and others and act as the public face. These concerns need to be addressed also at local level, perhaps by extending, and financing, the remit of the local authority.

2. Making institutions work and the role of planning in minimising flood risk

There is no strategic flood risk assessment or catchment management plan for the case study area despite repeated serious pluvial flooding.

There is confusion over responsibility for urban watercourses: (EA is for riverine flooding in main rivers and high density streams and the Local Authority or the riparian landowner for small urban ordinary watercourses) and Planning Policy Statement 25 places reliance on developers to install costly flood remediation infrastructure but this could delay regeneration in old industrial areas. Also many property owners do not generally fully appreciate their personal responsibilities with regard to their own drainage systems in England (from 2010 the sewage undertakers will become responsible for many existing private sewers, but at present they do not generally know their location and condition). The OFWAT KPI DG5 requires protection against internal sewage flooding to 2:10 years. In practice however, most utility companies provide a 1:30 year standard. Capital investment by the utility company is restricted by their regulator OFWAT to areas where the risk of flooding is greater than 1:20 years and it is unclear over what time span the intensity of the 1:20 year storm is measured and to what extent climate change is already affecting these assessments.

3. Attitudes to non-structural measures

There are substantial variations in stakeholder attitudes to NS, professionals are suspicious of the long term reliability of 'soft' systems. These vary in attractiveness depending on the stakeholder group, with municipalities being the most interested. Also insurance company reactions to flood related claims and refusals to offer further insurance have resulted in blighted properties. The insurance industry needs to take a more pro-active approach to the promotion of flood risk mitigation measures amongst all stakeholder groups.

4. Warnings and emergency responses.

Pluvial flooding does not feature in the typical Flood Response Plan prepared by the LA's Emergency Services. Emergency services need to respond more rapidly, in particular in closing down roads and in avoiding splash by heavy vehicles risking the flood. A single agency responsible for urban flood risk could best inform emergency services.

5. Flood preparedness by individuals.

The public experiencing pluvial flooding are generally unaware of self-help mitigation methods.

Several homeowners were found in surveys to have taken measures to mitigate the risk to their property. However, this appears to have been taken on an ad-hoc basis with little independent advice being available to homeowners. The emerging increases in premiums and excesses following flood incidents has not resulted in flood resilient repair being adopted by insurance providers. The maximum flood depth experience in the case study was one metre. It is therefore likely that the route for managing risk to the property would be to develop a dry proofing strategy for SUCAs. There is a need to link this with building specific aspects and precise site location and risk. However, by developing an overarching strategy for property protection and seeking site specific considerations it is considered that much of the damage potential can be reduced.

The code of practice, Sewers for Adoption 2006, recommends using SUDS. There are strong arguments in favour of SUDS although these are no more effective for the largest storm events than traditional piped drainage systems. However, the utility company does not have to adopt the ongoing maintenance of non-piped systems and the Local Authority has no budget for them. Furthermore much paving of front gardens in the study area has increased impermeable surface areas increasing runoff. A wider range of types of drainage system including SUDS need to be given more prominence when selecting appropriate systems. It should also be recognised that SUDS systems also provide both water quality and amenity benefits. Restrictions on increases in impermeable areas should be mandatory in the planning process.

Hydrological sensitivity. The flood events in the case study area were caused by drainage overload where increased urbanisation resulted in increased runoff. Many privately owned sewers do not feature in the utility company's records, however, with the adoption of many private sewers from 2010, there will be both better records and also mandatory performance standards for these. Because of their legal obligation to accept surface water and sewer connections, utility companies should be statutory consultees in the planning process.

Decision making and Implementation: The UK case study has already been of value to the local Utility Company and a Local Authority's emergency services. A workshop based on the Manchester case study with delegates from the utility sector, Local Authorities, Environment Agency, the insurance industry and hydrological consultancies was held on September 20th.

A diverse mixture of different types of organisations has responsibility for surface water and riverine/coastal flood defences in the UK, France and Germany. The EU Water Framework Directive (WFD) and subsequently the Flood Directive may be the most appropriate tools to link urban runoff with riverine and coastal flood risk and provide for the development of coordinated local flood risk management. The WFD also requires water quality issues to be considered with flood risk. In the UK there are arguments in favour of a single agency to manage urban flood risk and a reappraisal of the methodology for assessing storm severity and sewer capacity in the light of climate change.

Glasgow Case study – following major flooding in 2002

Empowerment the public: Although there has been excellent engagement between the various key stakeholders (municipalities, sewerage undertaker,

Scottish Environmental Protection Agency) with consensus built to produce a Glasgow Strategic Drainage Plan (GSDP) – effective engagement and empowerment with/of the public and communities has been limited so far. Local key stakeholder FLAGS (Flood Liaison Advisory Groups) are coordinating and successful but do not include the public.

Institutions and planning: As elsewhere, there are a number of constituent institutions: Scottish Water (SW) as sewerage undertaker; Scottish Environmental Protection Agency (SEPA) for flood warning and river quality; local authorities for planning strategies, contingency planning and watercourse maintenance and flood risk management. However, actually raising a flood alleviation scheme from conception to final approval (requiring Scottish Parliamentary legislation) takes several years.

The GSDP is the basis on which development planning is underway as water issues are the main limitation in allowing development. Regeneration funds are being used to resolve some of the flood risk issues as part of redevelopment. In some areas (Renfrewshire) INTERREG funds have allowed stormwater management plans based on GIS to be developed.

Attitudes to NS: There is scepticism on the part of the sewerage undertaker that anything other than 'structural' is likely to be sustainable or robust in the long term. However, at an intermediate scale, the local authorities are already implementing certain NS measures, especially emergency responses as part of contingency planning processes. There is broadly an openness to consider NS measures as part of a portfolio of measures provided these can be seen to be cost-effective. As yet no engagement with the public or communities has explored their attitudes to NS measures.

Warnings and emergency response: SEPA have the primary main river warning function. There are no pluvial flood risk warnings, although SW did have a sewer flood warning system (now abandoned due to lack of interest). Many dwellers, however, do not sign up for the warnings even where available. The emergency responses are typically set up by local 'champions' who seem to feel responsible individually for their effectiveness.

Flood preparedness by individuals: There is no evidence that there are any higher levels of preparedness than elsewhere in the UK, although there is more interest and acceptance of SUDS systems. Institutionally, Glasgow, as for the rest of Scotland, has overall guidance by the Scottish Executive, in response to the only legislation requiring a sustainable approach to flood risk management enshrined by the '4As': awareness; alleviation; assistance; avoidance. There are published criteria and indicators which may be used to guide FRM to ensure 'sustainable' solutions are developed. The GSDP reflects this approach.

Hydrological sensitivity: Glasgow is at risk from coastal, river and local pluvial flooding and combinations thereof.

The first two reports have been produced for the Glasgow case study. An additional case study, Longlevens in Gloucester, which suffered two flooding incidents in summer 2007 has a number of useful facets to add breadth to this study.

Favourable feedback based on the above preliminary findings has already been received from stakeholders such as the general public, Local Authorities and the utility company. The prospect of meeting our objectives is good.

Large workshop has been held in Manchester on September 20th, a report on the workshop is being prepared. The project is currently at the half way stage and it is progressing to plan. Academic papers are planned and guidance notes for SUCAs will follow.

French case study:

1) Chevilly la Rue city

This site was chosen due to an experiment performed at a district scale that aims to mitigate floods due to runoff and network saturation. This district is mainly occupied by cottages, to which it is proposed to manage retention tanks of 300 to 800 litres. The main difficulty is to explain the dual function of these tanks as tools to both save drinkable water and reduce wastewater sent to the sewer system. There are some conflicts between the two, e.g. you need to half empty the tank before a storm.

Up to now, collected data correspond to:

- an interview with the vice-mayor of Chevilly la Rue in charge of urban planning and environment,
- a meeting with the main representatives of the Val de Marne county Water Authority to collect documents framing and following up the experiment, as well first hydrological data sets.

2) La Bièvre river

For centuries this Seine tributary in Paris had been used as effluent of domestic and industrial wastes. Due to this pollution, it became downstream a cesspool, which had been progressively culverted. This section integrally belongs now to the sewer system. Nevertheless, this stream constitutes a major element of the valley identity. Therefore, for the last twenty years several associations and institutions have been involved in the prospect of daylighting of the Bièvre river.

A major issue is the question of floods of this river. Indeed, the "overflows of this small river" have been reported for a while (Champion 1858-1864), but also two recent major events in 1982 (21-12/07, 96,2 mm within 1 hour in Vélizy-Villacoublay) and 2001 (6-7/07, 126 mm within 15 hours in Cachan), lead to a governmental investigation with two reports (Klinger and Rostagnat 2006; Martin, Guinaudeau et al. 2006). Another complex element is that Bievre is managed by a complex and scattered system of authorities. This is rather in opposition to the strong interactions between the various sections of this river, e.g. the domino effect in critical cases. This also made the data collection a bit difficult, since it required contacting many actors.

3) Seine Saint-Denis county

Meetings with representative of this county water authority have helped to collect or to have access to organisational and physical data: authority structure and financing, geographical, geological and hydro-meteorological data, modelling techniques, water management policy, coordination with other authorities. A review of various hydraulic-hydrological models has been carried.

4) Ile de France Region

The objective is to analyse how in the Seine plan procedure are taken into account the scientific, technical and socio-economical questions related to

reduction and management of small catchment floods, especially by runoff reduction and more generally source monitoring.

Short term prospects

They mostly correspond to the exploitation of the collected data, in particular along the following axes:

1) Chevilly la Rue city

A questionnaire directed to the district inhabitants have been elaborated and is presently tested. It should help to evaluate how to, as well as the experiment impacts on the water cycle as well as on its representations and the relationship of inhabitants to water. In parallel, a multiscale analysis of rainrate time series should lead to a more objective evaluation of local hydrological risks.

2) La Bièvre river

The politico-societal analysis of Bievre daylighting is focussed on the project of the Coteau green park. The hydrological analysis is focussed on radar archives studies complementary to that done by (Martin, Guinaudeau et al. 2006).

3) Seine Saint-Denis County

The politico-societal investigation is focussed on in-deep interviews of water authority representatives and agents. For hydrology, the investigation is focussed on the contribution of multiscale nowcasting methods using rain radar data and that of hydraulic-hydrological modelling to better evaluate the role of the natural and man-made infiltrations.

4) Ile de France region

The last version of Seine plan clearly takes into account non structural measures, especially in the program of flood prevention actions for various basins. However, it rarely takes into account the small urban catchments, although a particular attention is paid to that of Essonne. The Bievre basin role is being considered.

Dissemination to scientific community (published papers, conferences):

International Journals

(Macor, Schertzer et al. 2007)

(Schertzer, Veysseire et al. 2007)

- Conferences with conference proceedings

- Journées Doctorales en Hydrologie Urbaine (JDHU), 17-18/06/06, Nantes, (Macor, Schertzer et al. 2007).

- Aquaterra, World Forum on Delta and Coastal Development: Managing Risks and Creating Opportunities, 7-9/02/07, Amsterdam, (Schertzer, Tchiguirinskaia et al. 2007),

- International conferences

- European Geosciences Union, General Assembly 2007, Vienne, Autriche, 15 – 20 Avril 2007: Macor, J.; Schertzer, D.; Lovejoy, S: Multifractals methods applied to the rain forecasting using radar data.

- PhD Thesis

(Macor 2007)

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