Use of risk information and risk maps in spatial planning

Experiences and lessons learned of pilot actions of the DANUBE FLOODRISK project

Report of Work Package 7.3

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"Thanks a million for all your engagement and it was a pleasure working with you!"

1 Introduction

In the project DANUBE FLOODRISK, 7 pilot actions and one pilot study were implemented in four different Partner countries: Austria, Bulgaria, Italy and Romania. The project Danube Floodrisk is mainly focusing on developing a joint methodology for flood hazard and risk mapping and on creating flood hazard and risk maps for the Danube River. The maps will later be used for the development of flood risk management plans, as described in the EU Floods directive 2007/60/EC. In these, adequate and coordinated measures are defined to reduce the flood risks. Municipalities and regions will have to work with the hazard and risk maps and implement the defined measures.

In the pilot actions the involved project partners were aiming at:

- testing of new methods and approaches in small pilot areas,
- providing the hazard and risk maps for the local level,
- involving stakeholders and develop local-level flood protection measures jointly.

With these goals, the pilot actions were addressing different issues covered by the Floods Directive and hence delivered different experiences regarding its implementation as well as a good added value for the transnational discussions in the Danube catchment area, but also for the discussions on Member State levels. To receive a large variety of experiences, the pilot actions were realized in different countries and regions and at various spatial scales, which are summarized in Table 1.

Figure 1: Location of pilot activities in the Danube river basin; Map source: ICPDR

Analogous to the above mentioned aims, the pilot actions can also be clustered according to their main aims:

- Two pilot activities dealt with the **development and testing of new methods and tools**: on the one hand in an urban region, in Galati, Romania and on the other hand in the Alpine river basin of Drava, Italy (see also red circles in Figure 1).
- The pilot actions in Bulgaria and in Cernavoda, Romania focus on **providing risk and hazard information for the local level:** for cities and urban regions on the one hand and for the nuclear power plant Cernavoda on the other hand (see also blue circles in Figure 1).
- Two pilot actions were focusing on **hazard and risk information for the local level and local stakeholder dialogues** in areas with high flood risk: in the city of Krems, Austria and the city of Giurgiu, Romania (see also green circles in Figure 1).

Table 1: Overview of pilot actions: Focus, country, region and spatial scale of implementation as well as partner organization.

Focus of pilot actions	Country	Pilot Region	Spatial scale	Implemented by
Development and testing of new methods	Italy	Drava river	Alpine river basin	ISPRA, Italy
	Romania	Galati	City and surroundings	Technical University of Civil Engineering of Bucharest, Romania
Providing risk information for the local level	Bulgaria	Lom, Nikopol /Belene and Ruse	Cities	Ministry of Environment and Water, Bulgaria
	Romania	Cernanvoda	Nuclear power plant	Danube Delta National Institute for Research and Development, Romania
Stakeholder dialogues	Austria	Krems	Two city quarters: one residential, one industrial	Umweltbundesamt Austria
	Romania	Giurgiu	City	Danube Delta National Institute for Research and Development, Romania

In the following chapter, the pilot activities are each shortly summarized. After that, the experiences made and lessons-learned from the pilot activities are put together, as discussed by the involved project partners in the Working Group meetings. Furthermore, the partners have discussed and elaborated joint conclusions and recommendations from their experiences, which are the basis of future activities.

2 Short summary of the pilot activities

2.1 Austria: Krems

Location

The pilot action was implemented in the area of the City of Krems, 70km upstream of Vienna. The city of Krems is located on the left bench of the Danube downstream the Wachau, it has 24.000 inhabitants and the old city centres of Krems and Stein are UNESCO world cultural heritage. Relevant economic sectors are industry and tourism, but Krems is also well-known for education (university) and the fairs. It has partly an RHQ protection, and partly mobile defense structures to protect the area of Krems-Stein until Krems, being used from about HQ30 on. The harbor is protected by a gate. Downstream of the gauge station Thallern there is a polder on the left bench of the Danube which fills up when an HQ100 is exceeded. Also located near the polder area is the tributary Krems, which has an HQ100 dyke. In the northern and north-western direction settlements and industry from Krems can be found.

The pilot location was chosen, because the area of Krems, esp. around Krems-Stein, is flooded from time to time, so that the population is already used to flood risk management measures, including private ones. Moreover, the communication of extended and residual risk is considered a very sensitive issue by the persons politically responsible for flood protection, regarding population as well as economic activity. This was considered special and a special challenge regarding stakeholder involvement and required a careful step-by-step approach and an accorded process between Umweltbundesamt and the city of Krems.

Problem / starting position

Within the discussion process with the City of Krems, four not yet investigated scenarios were identified as potential threats:

Scenario 1: In a medium flood event, a failure of the mobile defense structures at a time when the second defense line between Stein and Krems is not yet erected would lead to a flooding of the inner city.

Scenario 2: In a medium flood event, a failure of the closing mechanism of the harbor gate would lead to a flooding of the harbor where a.o. chemical industry would be affected by flooding.

Scenario 3: A medium flood event on the Danube main stream leads to backflow in the tributary Krems. An additional frequent flood event on the Krems might lead to an overtopping of the dykes of the tributary.

Scenario 4: an extreme flood on the Danube might lead to overtopping of several flood protection measures along the Danube and maybe along the Krems

Each scenario would mean affected people and affected economic activity, maybe also the risk of contamination because of industrial activities involving hazardous substances.

The following goals were set for this pilot project:

- Raising awareness of expert stakeholders
- Communication of flood risk to broad public
- Deliver a basis for future emergency management
- deliver information for future preparedness measures

Activities / Stakeholder involvement

First, hazard maps were created for the above mentioned scenarios 1 and 2, which were seen as the most relevant ones. The maps for scenario 1 considered two cases, one with an additional second defense line being erected, the other one, if no second defense line were in place. The results of the hazard mapping were used for risk mapping. In the process of designing the risk maps local stakeholders were involved. The involvement took place in two areas of the city, involving different stakeholders:

A Workshop with different responsible stakeholders (from administration and emergency management) and a public participation event with the public from the residential area affected by scenario 1 was organized. In the workshop, different map designs were shown to ask the emergency management and city administration for their feedback regarding easily readable and helpful display of hazard and risk information (water depth classes, affected population, property damage). In the public participation event, the hazard and risk maps were presented, explained and discussed. Feedback regarding communication of residual risk was received. In the harbour area, affected by the second scenario, the companies situated there were involved in several Workshops. In these workshops, issues like plausibility of the hazard maps, questions regarding potential hazardous substances, risk perceptions, adequate risk assessment for the harbour area accounting for the different characteristics and vulnerability of the companies, risk management and risk reduction measures were addressed.

Results - Usage of / gain from results

The participation process in the residential area investigated was very well received. The maps raised awareness with the responsible persons from the municipality but also in the public that the flood protection installations might not always function. If the mobile defense line fails, the flood water extends quickly into the inner city. For the administration it was reconfirmed that the existing 2nd defense line is important to protect the city. The simulations showing the effects of the missing 2nd defense line may be used to make the public better understand its vital role. The emergency management also reacted on the results: the so called "Hochwassereinsatzplan", a local emergency management and operations plan, may be revised. Also, the local fire brigade plans to use the maps for exercises in the affected area.

To ensure longer-term awareness of the public, the administration thought about showing the maps openly, e.g. in the town hall. Furthermore, it is hoped, that since the results of the pilot action were communicated, the usage between 1st and 2nd defense line will change slowly so that assets in the ground floor will decrease or at least remain stable.

In the harbor area, the awareness of the companies was already very high and regular exchange meetings take place on the topic, if there is a flood on the Danube. The trust in the harbor gate is very high, as there are several securing mechanisms in place that prevent a malfunction of the gate, unlike assumed in scenario 2. Furthermore, some companies have already implemented private precautionary measures on their buildings.

Figure 2: Flood risk map for the harbour area in Krems, Austria for scenario 2. Map Source: Environment Agency Austria et al.

Nevertheless, further weak points could be identified in the workshops and an inoperative flood protection wall will be part of future flood management activities and other preventive flood protection measures will be implemented.

All together, the participatory process was well received and the municipality gained by the communication of residual risk, against their initial skepticism. The word has spread: The town of Ybbs, which is situated close to Krems, has shown interest in the approach and asked the Krems municipality and the Umweltbundesamt to show them the maps and discuss with them the experiences made

Lessons-learned

The pilot action showed that a lot of time and patience is necessary to discuss the topic of residual risk with a municipality. With an intensive preparation and lots of discussions, the discussion of residual risks with the public administration, with the affected public and even with private companies was successful. For this, a “door-opener”, i.e. a person from the municipality and/or from a private company, who supports the project, is needed. Additionally, a non-technical person with social / political / communication background might be very helpful when it comes to issues beyond technical questions.

A further lesson learned from the public participation event is, that flood hazard maps are easier understood than flood risk maps, in which the economic assessment for private property requires lots of explanation. Maybe local actors like house owners prefer to see the flood extension, the water depth and the chance of being flooded rather than an economic assessment for their own property. Moreover, the damage assessment per m² seems to be easier understood by the broad public, including the emergency management, than the assessment per building. However, the display of population affected and of other risk information was well received and understood.

Figure 3: Working with the maps at the Workshops in Krems. Source: Stickler

2.2 Bulgaria: Lom, Nikopol/Belene and Ruse

Location and starting position

For its pilot activities Bulgaria has chosen three pilots on the grounds of their specificity, the importance of the region and the critical situations experienced by the municipalities of **Lom, Nikopol** and **Ruse** during the inundations in 2006.

- The municipality of **Lom** was chosen as a pilot because of the frequent floods in the last decade, the regional importance of Port Lom and the insufficient protective infrastructure.

  A binding point of the European transport corridors No7 and No4 the region is of national importance, but of transboundary as well since the past floods in this area affected not only the Bulgarian but also the Rumanian territory. The pilot area includes one of the main tributaries of the Danube - the Lom River and gives an opportunity of studying the reciprocal impact of both the rivers.

- **Nikopol** came within the BG pilots for its insufficient protective infrastructure, the poor technical condition of the drainage systems of the municipality and the presence of the National Park "Persina" including flooded forests and swamps, protected areas and habitats. Among the reasons for choosing this region for a pilot are also historical monuments of national significance, threatened by inundation. The water level of the Danube influences the level of the Osam River at a distance of 35 km.

- The city of **Ruse** is the fifth largest city in Bulgaria. According to the population census, conducted it 2011, Ruse's population is estimated to be nearly 150 thousands of people. The city is a big economic and cultural center in Northeast Bulgaria. The Rusenski Lom River, one of Danube's large tributaries on the territory of Bulgaria, flows through the city. Being a part of the Ruse - Gurgu Euro region this pilot project is of transboundary significance.

  A part of the industrial area of Ruse where considerable building and economic activities occur is situated along the Danube. Ruse is a point of intersection of the European transport corridors No7 and No9.

Figure 4: Flood in Ruse 2006, Source: EAEMDR-Ruse

Activities / Stakeholder involvement and results

The DANUBE FLOODRISK project and the three pilot projects were introduced on several stakeholder meetings held in Pleven on 13.03.2012, in Veliko Tarnovo on 20.03.2012, in Ruse on 21.03.2012, in Montana on 27.03.2012, in Sofia on 29.03.2012, in Belene on 04.10.2012 and in Ruse on 24.10.2012. The meetings were attended by representatives of the local authorities such as members of the municipal councils, district governors, emergency response and rescue team members, NGOs, business and IPPC organizations - more than 260 participants.

On the meeting in Pleven when discussing the goals of the pilot projects the municipality of Belene asked to be included in the analysis. The project team discussed and considered an extension of pilot project Nikopol so as a potentially threatened area of Belene, appointed by the representatives of the municipality (part of the dike) to be included.

Figure 5: Impressions from the Workshops in Lom, Nikopol/Belene and Ruse. Source: MoeW, BD-Pleven

The overall goal in the different pilot regions is to test common methodology for hazard and risk mapping in the defined pilot areas. The specific activities were defined together with the stakeholder in the local workshops. The results show:

The pilot activities in **LOM, NIKOPOL/BELENE** and **RUSE** include precise flood extend defining and detailed flood hazard mapping based on orthophoto and combined with cadastral information, this way supporting the local authorities with regard to spatial planning and infrastructural development as well as flood risk management in the region.

As a consequence of the stakeholder meetings and consultations also GIS-projects for flood hazard visualization and stakeholder and end-users trainings for their application were contracted and provided.

Lessons-learned

- Close cooperation with locals experienced in dealing with floods is essential in shaping the pilot's scope and activities - they have "flood maps in their heads".
- The stakeholders preferred basic flood hazard maps to advanced application s specific for the different user groups.
- Flood risk mapping is a new issue for Bulgaria and requires adaptation of stakeholders' understanding. This is a time -consuming process and needs specific guidelines for use and interpretation of the information.
- Stakeholders value the importance of the flood maps as strategic spatial planning instrument.
- Not only maps but also data especially local ones acquired and produced in the project are necessary for the stakeholders in their future activities.
- Common point of interest in all pilots is the use of hazard maps for emergency management

2.3 Italy: Drava river basin

Location

The Italian study-pilot area is the basin of the Drava (German: Drau; Italian, Croatian, and Slovene: Drava; Slovak: Dráva) river, one of the main tributaries of the Danube, draining through the Lienz outlet before the confluence with the Isel River. The pilot area covers 670 km^2: about 25% in Italy and the rest in Austria. The sources of the Drava are in Toblach/Dobbiaco, Italy, from where the river flows east through West Tyrol and Carinthia in Austria, into Slovenia, and then southeast, passing through Croatia and forming most of the border between Croatia and Hungary, before joining the Danube near Osijek. The Drava, Spoel, Slizza and some minor catchments draining in the Inn river basin, are the only rivers originated in Italy which drain into the Danube basin.

The studied basin area is a typical alpine catchment characterized by pastures, conifers, natural grassland and mountain areas, with only small areas in the first bottom in which we find light city patterns with small towns. Some towns are located at the bottom of narrow valley areas whose main economic activities are tourism, agriculture and small industry. A big effort is made for safeguarding and maintaining the environment and its biodiversity.

Problem / starting position

According to the general concept of the Danube Flood Risk Project it was important also to investigate the mountainous areas and not only the main stream river network, although only as a study area. The Drava basin has two important characteristics in the general overview of the project: it is a transnational and mountainous catchment, with different hydraulic conditions (different type of events) and different scale of study respect to the Danube main stream. In particular, following the Italian Legislative Decree for the adoption of the Flood Directive (N.49/2010), special attention has to be paid to floods with high volume of sediment transport and debris flow which are more influenced by climate change.

Both these aspects have been investigated on the Italian pilot area with different approaches and results. In particular, for some of the activities applications and tools integrated within the framework of GIS have been developed, or improved under Free and Open Source license and are available for download.

Figure 6: An example of a debris flow on a tributary of the Drava river in the study area; source: Event Cadaster ED30 Provincia Autonoma di Bolzano

Activities / Stakeholder involvement

Data collection and harmonization between the two countries, Italy and Austria, were the first step for all the activities related to the study-pilot area. Thanks to the local administrations and to the project partners, the data of DTM and other important layers where collected and harmonized. The most important issues in this process were related to the individuation of the local services in charge of data updating and distribution and of the precision of the available data. Obviously, the integration of data with different accuracy results in a uniform layer of the minimum accuracy between the two. Luckily, between the two local administrations there are some important agreements for data collection and exchange, which facilitate the integration of the different type of data. After this first important step, the analysis of the state of the art has been completed with some basic geomorphological analysis integrated and validated by field survey. Some tools for digital field mapping has been developed and improved, in particular, an application for tablet-PC and tablet Android which allows the usage of personal digital data in the field and the collection of geonotes (like georeferenced Post-it) containing text, audio and images.

Following the indication of the EU Flood Directive, the next activity was to understand the main historical events occurred in the area. Thanks to the previous work done by the local administrations, the past events were integrated in a centralized database. Using past events, the geomorphological analysis and the field data collected, it was possible to define the expected phenomena on the whole catchment. Before starting with hydraulic modeling and in consideration of the area extension, the main issue was to understand the degree of study of each small basin inside the study area, where a debris flow could occur. To do this evaluation, which is the most important to define the models that can be used for hydraulic simulations of water level and debris accumulation, a big effort was made in analyzing the scientific state of the art of the studies on debris flow and extracting a common practical methodology.

The methodology for hazard mapping on debris flow fans is summarized on the Guidelines "The triggering of landslides and debris flow and their mapping", written in collaboration with professor Rigon of the University of Trento. These guidelines represent one of the main outputs of this study activity of the project. Following the indications of these guidelines, it is possible to calculate for all the alluvial fans of the entire study area the input liquid and solid discharge to be used in hydraulic models. The tools developed within GIS framework consider as input some maps derived from DTM analysis, the statistical elaboration of the rainfall measured data, and some geological parameters defined during the field surveys and detailed geological investigation both in field and in laboratory. They give as output the evaluation of the maximum expected solid discharge for each return time. The evaluation of the liquid discharge is done using the Peakflow model (Rigon et al., 2011); the solid available discharge for debris flow is evaluated using a methodology based on Shalstab model (Montgomery and Dietrich, 1992) and the concepts of propagation and runout distance of Vandre (1985). Given the morphology of the alluvial fan and the total input discharge is then possible to model each fan and to elaborate the hazard maps.

Figure 7: Digital field mapping on Drava river

Hazard levels for debris flow can be defined on the basis of a number of intensity classes (3-5) each corresponding to a different destructive potential for the event. The threshold values for torrential phenomena consider not only the physical quantities of velocity and depth of the flow, but also the thickness of the debris deposition outside the river and the depth of scouring. Hazard classes are then evaluated considering the probability of the event (return period) and the intensity using a matrix. The complete hazard map is then drafted by assigning to each cell the highest hazard value relative to all return periods.

The hazard classification of the different areas obtained with the described methods must be analyzed, taking account of the working hypotheses used and evaluating the possible influence of buildings and structures on flooding events and on the modelling simulations. The critical analysis of the maps can bring to very important observations that need to be highlighted: unusual behavior of the flows; qualitatively similar areas with different risk levels; areas with continuous characteristics (e.g. same slope, same granulometry, etc.) presenting discontinuities in the results.

Results - Usage of / gain from results

Important and tangible outputs are, from one side, the guidelines of hazard mapping for debris flow "The triggering of landslides and debris flow and their mapping", by Prof. Rigon of the University of Trento, and, on the other hand, practical tools integrated in a GIS: The developed tools are available for download at the project site www.jgrasstools.org. Regarding the digital field mapping tools, the developed extension for uDig (http://udig.refractions.net/) is available at http://code.google.com/p/beegis/. Furthermore, the method was disseminated in an expert's Workshop and in relevant newsletters.

The state of the art of hazard mapping for Debris Flow events is to integrate an expert judgment into the liquid flood hazard mapping. With the new method, the hazard mapping is improved significantly because simulations consider the simultaneous presence of both liquid and solid from the beginning (triggering processes). This is a major benefit for the Drava river basin; but the method developed is also transferable to other river basins. It is envisaged, to provide training courses on the method and tool for experts and engineers in cooperation with the local Universities.

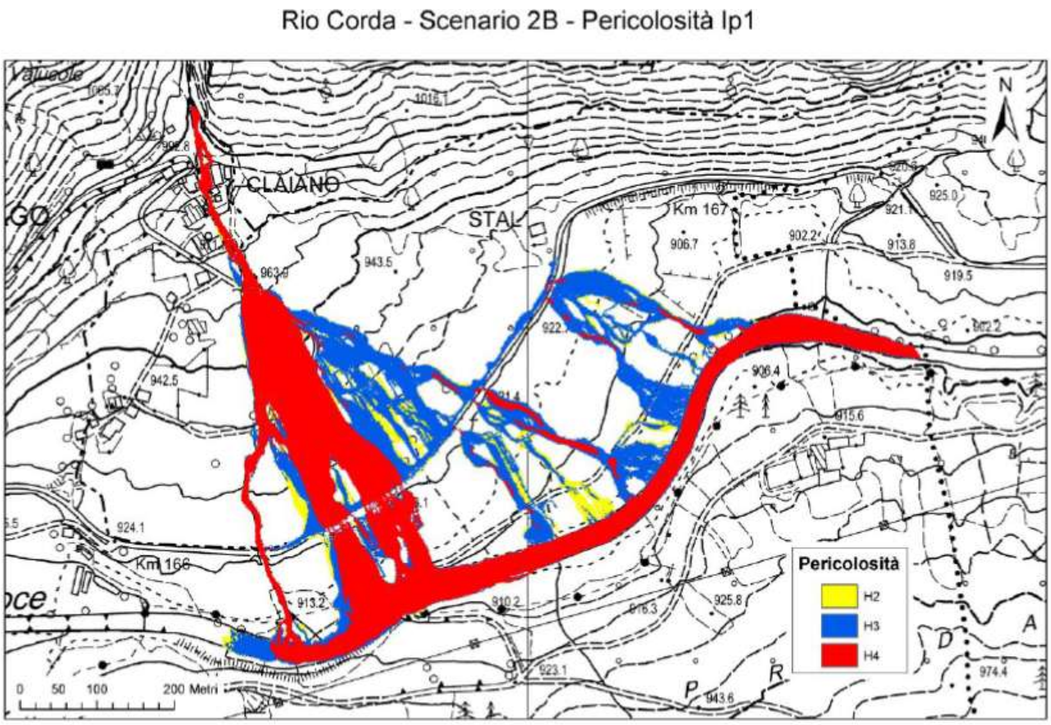

Figure 8: An example of the application of the method on a basin in Province of Trento: hazard map of debris flow on Rio Corda; source: HydroloGIS.

Lessons-learned

The first important aspect handled during the activities in the study area is the need of a common database and approach for hazard and risk mapping in case of transnational basins. This is important not only for big basins, but also for the smaller ones, where the problems are different but the effects of a flood event will affect population (local and tourists), structures and the general ecosystem.

There is a big need for the involvement of the scientific world in the process of hazard and risk mapping to assure that the methodologies and the models used are the most valid ones with the most reliable results. Furthermore, it is important to show the benefit of the method to the experts, e.g. the engineers designing protection sites. Some damages that occurred in the Drava basin could have been estimated and some works could be designed, if the tools would have existed earlier.

2.4 Romania: Galati

Location and problem / starting position

The case study for Galati area was defined between Vadul Oii and Isaccea hydrometric stations, having a length of approx. 140 km along Danube river. The river banks on the Romanian side are protected by dykes on a length of 1100 km. During flood period in the modified regime an increase of more than 1m of the water level compared to the natural regime occurs in Braila and Galati town.

The floodplain is divided by transverse dykes into agricultural zones which could be used as polders for storing water during high floods. Based on economic criteria, a number of 13 polders with individual volumes in the range 40-780 million m^3 were selected for this purpose.

Activities / Stakeholder involvement

In the pilot action two new methods were tested:

- The development of a decision support tool to simulate the effects of regional flood protection measures.
- Use of remote sensing in flood risk assessment.

A Decision Support Tool (DST) was developed in order to evaluate the hydraulic consequences (water level, maximum discharge) for different scenarios of polders accidental or deliberate flooding. A special sub-model for breach development (breach elevation and length evolution) was set up. For the flood propagation a simplified hydrologic model was used. After parameters calibration and validation, based on registered exceptional floods in 2006 and 2010 different scenarios of polders inundation were tested.

The use of remote sensing in flood risk assessment was tested. The goal was to identify main vulnerable assets in Galati area and to assess potential damage. For this, the aerial images for the Galati area and damage functions (BEAM) were used. The images were segmented and classified with algorithms. The next step was to label the objects according to their attributes, such as shape, color and relative position to other objects. This is typically followed by another segmentation step to yield more functional objects. This cycle is repeated as often as necessary. The classified images were exported from eCognition in shapefile format and corrected in ArcGIS. A correction is needed because of RGB aerial image having no multispectral band information. The final result of the editing process in ArcGIS indicated 15130 buildings in Galati area (including the town).

Figure 9: Final result of the image classification: buildings in Galati area. Source: Maria Cheveresan

Results - Usage of / gain from results

The main conclusions of the model runs of the Decision Support System were the following:

- The inundation of small or medium volume polders (less than 200 million m^3) has small effects on water level decrease
- The large polders should be inundated during floods peak, not before, in order to obtain the maximum effect downstream. Thus, a forecast of at least 7 days (including the main tributaries: Olt and Siret) is a must. Anyway, the water level decrease is quite reduced even if flooding some of the selected large polders. If flooding all selected polders, with a total storage volume of 4.5 billion of m^3, the water level decrease in the most favorable conditions will be maximum 62 cm.
- The polders inundation is efficient only for large floods (more than 15,000 m^3/s) in order to use at the maximum extent the polders storage volumes.
- Local protection measures in Galati area should be initiated instead of expecting the decrease of water level by flooding some of the upstream polders.

For the development of a new method to use remote sensing for flood risk assessment, the pilot project showed the following:

- Combining the damage function with value per square meter of building the total damage could be assessed in Galati area.
- The analysis showed that 16,5 kilometres of roads are affected in the port area and at the confluence with Siret river, where water depth exceeds 1,5 meters.

Lessons-learned

The pilot projects produced two methods / tools which are fully transferable to other regions. The remote sensing methodology can even be applied for large river basins with thousands of square kilometres.

The calculation of the decision support tool for the Galati area showed specifically:

- It is still a subjective decision which measure is chosen to prevent flood damages; in future economic values should be integrated into the tool, so that the decision can be more objective.
- Local protection measures in Galati area should be initiated instead of expecting the decrease of water level by flooding some of the upstream polders, as the amount of decrease they can provide is very limited.

2.5 Romania: Giurgiu

Location

Giurgiu City is situated in the extreme south of Romania, on the left bank of the Danube, in a marshy area, 65 km south of the capital Bucharest, forming a Euroregion with neighboring Bulgarian city, Ruse. The city lies both in Burnazului Plain and the Danube Meadow, the soil being sandy. It is located at the intersection of River Pan-European Corridor 9 and Auto Pan-European corridor 7. Town area is 47,6 km². Its population on July 1, 2001 was 71.915 inhabitants and the density: 1. 538 inhabitants/km².

Giurgiu is a major transit center by road, rail and river and point of contact with Ruse City (Bulgaria) through road and rail bridge (2 200 m long) constructed over the Danube in the years 1952-1954 (inaugurated on June 20, 1954). It is also an important crossing point (customs) for goods and passenger traffic. In 1996 it was founded the Autonomous Administration of Free Zone (AZL) situated in the South-East of the town (on the shore of the Danube River). The presence of AZL has created new possibilities for the development of all economic activities. The AZL's facilities offered to attract the interest of Romanian and foreign investors through leasing and rental consisted as premises for activities in production, trade and services. Since then the town became an important road, railway and river transit center.

Problem / starting position

This region has had to struggle with increasing flood risks and actual floods, which have created much damage, particularly in the last few years. Because the Danube was recently channelized and enclosed by dikes, there is hardly room for the reduction of peak flow during rainy periods or for the development of nature along the river. Due to climate change and large-scale deforestation, these peak flows are occurring not only more frequently, but they also carry a greater volume of water over a shorter time. The river foreland of the Danube at Giurgiu has insufficient capacity to relieve the peak flows, as seen during the summers of 2004 and 2005 and spring 2006 when a large part of the region flooded and required large-scale evacuations.

The aim of pilot action was to provide hazard and risk information for the local level and discuss the information with stakeholders. The Giurgiu stakeholders first had to get familiar with the maps and were then asked to work out measures to reduce the flood risks.

Activities / Stakeholder involvement

For a good approach of the participatory method it was necessary to use maps of the studied area in order to have a better perspective of the place. The used maps contained data that were available and important for the studied area. There were four thematic maps agreed on:

a) Map of the Studied Area Location: This represented the topographic map of the municipality. It has all the elements needed to identify an overview of area and its main known issues by the stakeholders in the area. This was the starting point of the discussions and enabled to draw the main subjects that we had to deal with them later in the discussions.

b) Map of Networks and Communications: This map illustrates the communication grid throughout the municipality such as railways, electrical network, streets and clearly pointed out the Giurgiu's harbor. Since the city's most important economic activity is the harbor and the free zone, the communication arteries within the land represent a high priority to be considered. One of the elements presented on the map is the electrical grid throughout the city. Other elements that composed the map were the shape of the roads, bridges and railways. All these items overlaid on top of an orthophoto of the municipality.

c) Flood Extent Map: This map illustrates the communication grid throughout the municipality such as railways, electrical network, streets and clearly pointed out the Giurgiu's harbor. Since the city's most important economic activity is the harbor and the free zone, the communication arteries within the land represent a high priority to be considered. One of the elements presented on the map is the electrical grid throughout the city. Other elements that composed the map were the shape of the roads, bridges and railways. All these items overlaid on top of an orthophoto of the municipality.

d) Map of Vulnerable Elements to Floods: The map contains vulnerable elements to floods and they are displayed in such manner that the user can quickly estimate whether is a high or low risk area. The map shows all the buildings (residential, industrial and administrative plus the statistical repartition of the population) within the municipality. Additionally, the map contains also the water bodies and streets that aid the reading of the map.

For the involvement of local stakeholders from the pilot area, a two day Workshop was held. The workshop started with a plenary session with an introduction of the pilot project and aim of the Workshop. Further, the participants were divided in 3 (three) groups with following topics: spatial planning, flood risk & socio-economic development. The members for each group were chosen taking into consideration their field activity. The groups discussed the flood risks and consequent problems, but also opportunities of Giurgiu regarding the topic of their Working Group. On the second day, two working group sessions were held that worked out solutions for the identified problems. For the Workshop, local stakeholders from different discipline came together: spatial planners, water management experts, administration from cultural, social, infrastructure sector.

Figure 10: Impressions from the Workshop on the 1st day (pictures above) and final sketch of the Working Group „Flood risk“ (map below); Source: DDNI

Results - Usage of / gain from results

The results of the discussion on the problems and opportunities were put together as a conclusion of the first Workshop day. It became apparent, that several common problems, independent from the topics discussed, were identified. These were put together in a SWOT analysis, see Figure 11.

Figure 11: SWOT analysis of strengths and weaknesses, opportunities and threats; Source: DDNI

The collected solutions from the second day of the participatory workshop are the following:

“Non-structural” measures:

- Raising public awareness can be achieved through education, trainings, and courses among population (children are an important target) on flood topic;
- Inter-Institutional collaboration: can be done by organizing regularly (mainly before the flood season) meetings between responsible departments for flood emergency from different institutions (from local, regional to national and trans-boundary level).

"Structural" measures:

- Dams' Technical expertise: Regarding the flood protection measures, the main problem identified was that the dams are undersized and not well maintained (the dams resistance is quite low and in case of flood the structure is vulnerable, since they are used for heavy transportation, and there are some serious problems caused by the rodents galleries and vegetation);
- Identify safe areas and temporary shelters: in the western and northern part of the city at HQ30 and in the western part is the only place where the safe area is at even HQ1000. These areas can be used in case of emergency supplying them with sanitary and other basic necessities or can be designed for future town development (new housing area). A possible safe route (the existing railway) from the flooded areas to those safe in the northern part was identified.
- Identify wetlands as water stocking: 2 islands (Mocanu & Mocanasu, 246 ha) in S-E part of Giurgiu.
- Modernization of sewerage network and protection of critical infrastructure: vital lifeline facilities (roads, water supply, electricity network, telecommunications) needs reparation and integration; Using the "location of the studied area map" and the "network and communications map" was identified a major problem regarding the lack of infrastructure and the poor quality of it.
- Land use planning and regulations: as a possible solution was proposed the reevaluation of land use. Land use legislation enables the establishment of development and protection of land in such a way as to minimize the risk to the population and prevent the natural resources from being destroyed during the flooding;
- Reforestation: Deforestation and loss of vegetation on the dams is known to increase the weakness of these structures enhancing the risk of dam breaking at high water levels; as a result of these actions, erosion will be prevented;
- Maintenance of navigation channel: floods change navigation on the Danube. Depending on water levels, the transport rules are different and require adaptation. Transport on the Danube is one of the main activities of the town and channel maintenance is a necessity in managing flood risk. Was raised also the issue of navigation, that is considered to be a sensitive issue, when considering the flood risk (was discussed the problem of procedures and operations during high levels of Danube).

The participants of the Workshop were very interested and active; The Workshop was very successful, as awareness was raised among the stakeholders and also the relations between the stakeholders was strengthened. The municipality was also very satisfied with the results of the workshop and the maps prepared; they will continue to work with the maps. Integrative maps for the feasible measures, mainly the long- or medium-term measures, will furthermore be finalized for the municipality.

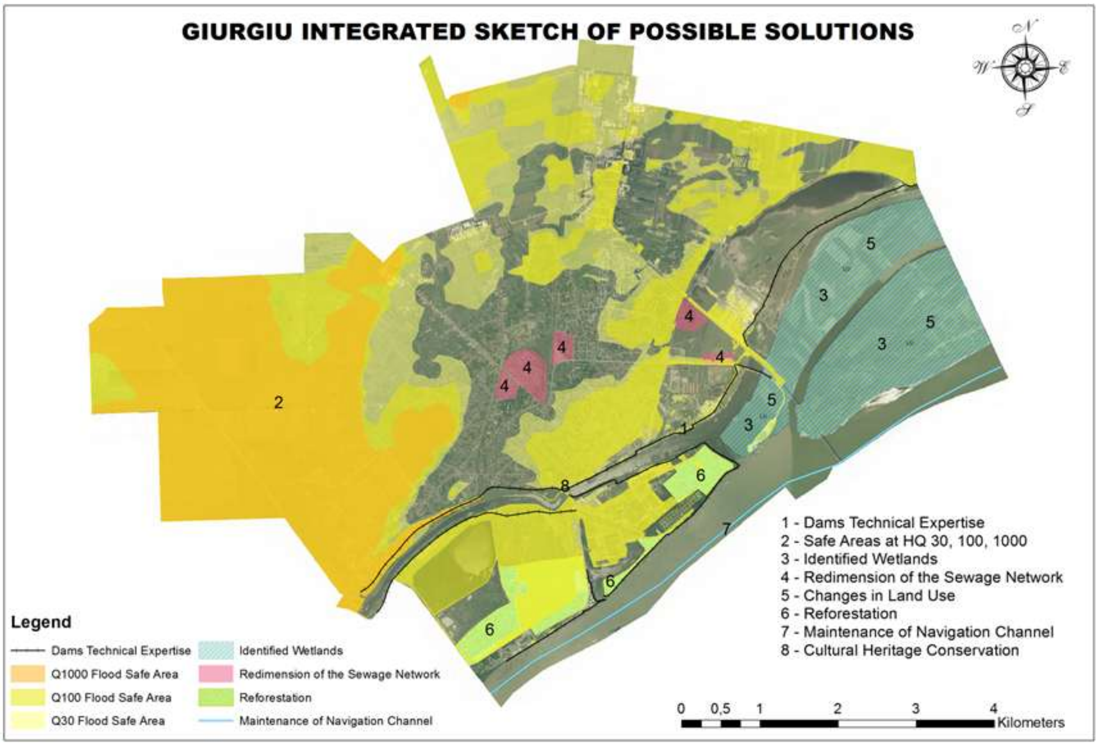

Figure 12: Integrated sketch of possible solutions in Giurgiu as worked out in the Workshop; Source: DDNI. The map will be further used by the Giurgiu municipality.

Lessons-learned

The Workshops success was influenced greatly by the intensive preparation of the Workshop, mainly the development of the thematic maps. It became also apparent, that the well-considered selection of participants was worthwhile.

Problems discovered can be assigned to the fact, that for the preparation of the thematic maps, too little data was available. During the Workshops time was a little short.

2.6 Romania: nuclear power plant Cernavoda

Location

The only nuclear plant in Romania is located in Cernavoda. Two units operate currently in Cernavoda and produce together cca 18% of electricity consumption of the country. Cernavoda Central Power Plant is based on the Canadian system CANDU (Canadian Deuterium Uranium) and having an installed capacity of 706 MW for each of the 5 reactors. The structure of a CANDU reactor consists of a horizontal cylindrical container with bars for fuel tubes and for coolant (heavy water) placed horizontally. Putting into service the first unit of Nuclear Center – Electric in 1996 entered Cernavoda between the large energy producers of our country. The original plan, dating from the early 1980s, provided the construction of five units. Unit I was completed in 1996, has an installed electrical power of 706 MW and produces annually about 5 TWh. Unit II was started on May 6, connected to the national energy system on August 7 and operate at normal parameters.

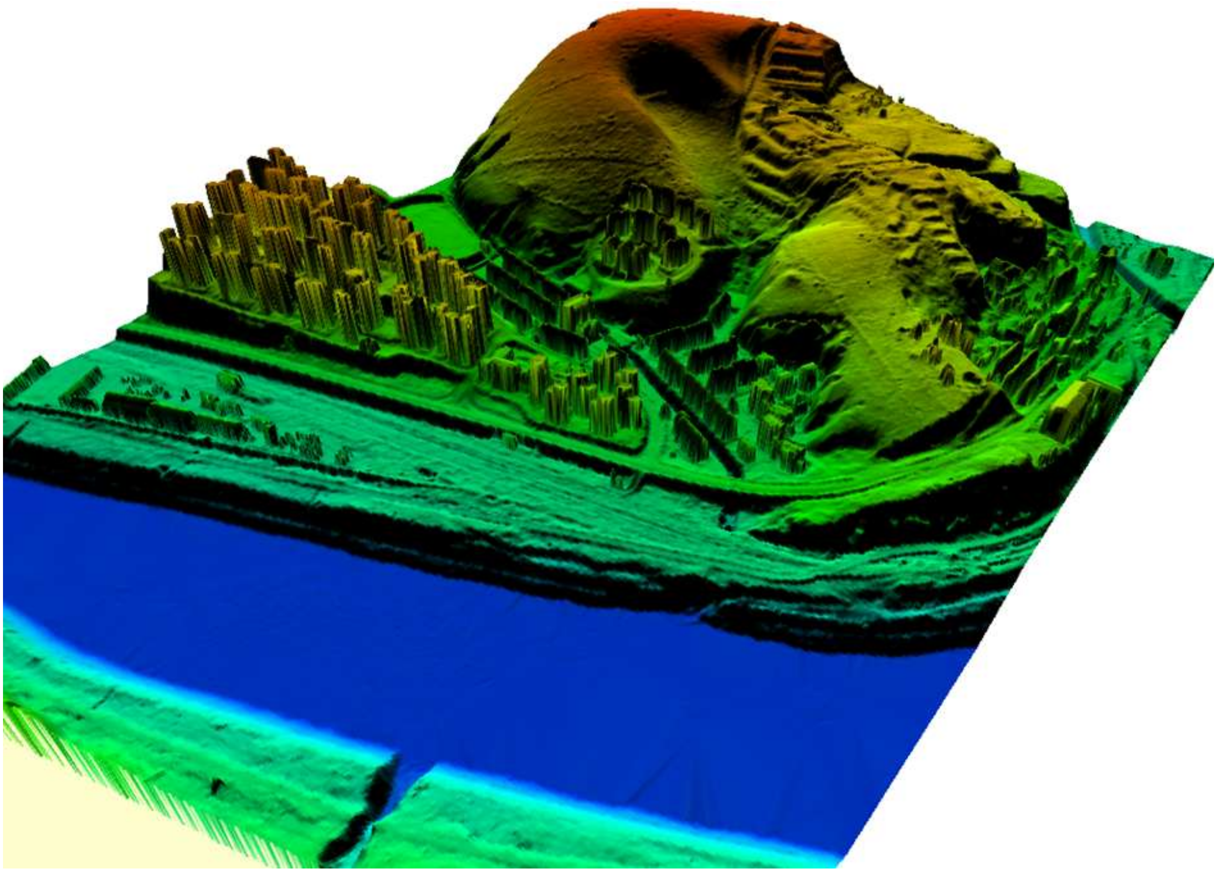

Figure 13: Digital terrain model of the Cernavoda area. Source: DDNI

Problem / starting position

Over time were conducted a series of studies on the possibility of flooding in the Cernavoda Nuclear Plant Platform site. These studies, conducted in accordance with existing standards and methods when carrying had two types of objectives:

(i) Demonstrate that measures made during location and designing are sufficient for safe operation of nuclear facilities, and are not affected by the flood;

(ii) Demonstrate that the Danube water flow and Danube water level provide economic parameters of reactors operating at nominal power units.

In the context of EU requirements, revaluation of design limits for nuclear units, generated by extreme events that have severely affected the functioning of the units at Fukushima, it was necessary to upgrade these studies for CNE Cernavoda, to ensure validity of that inputs data used and touch the actual standards and methods of analysis. The study considers the following natural phenomena that have the potential, at least theoretically, to lead to site flooded:

- Increase of the Danube;
- Heavy rainfall.

Activities / Stakeholder involvement and results

The pilot project was defined in close cooperation with the nuclear power plant administration, several meetings were held. Hydrological calculations were done on the basis of a digital terrain model of the area (Figure 13).

The calculation show that the power plant is well protected again “normal” flood (protection level: maximal probable flood level). Some problems might arise from low water, as the water from the Danube is needed for the cooling cycle of the plant. Surface runoff after extreme rainfall events might be an issue in the future as well.

A report was written, summarizing the calculations and assumptions of the pilot project as well as indicating the results. The report also contains suggestion for measures to decrease the risk of flash floods.

Lessons-learned

One central conclusion was that from time to time, emergency plans need to be revised. This is due to several reasons, e.g. due to sediment accumulations or due to climate changes. The pilot project was chosen as dealing with critical infrastructures is crucial in flood risk management. Though, many restrictions and “secrets” made the implementation of the pilot project difficult.

Moreover, as in future heavy rainfall event are likely to increase, in the protection level of a power plant also maximum precipitation should be considered.

3 Comparison of experiences made in the pilot projects

The pilot actions were defined in the initial phase of the project implementation of Danube Floodrisk. A scoping study was prepared to find topics which are suitable and relevant for being addressed in pilot projects, contributing to different issues of the Floods Directive, and designed for delivering transferable lessons and deliver experiences regarding its implementation. To receive a large variety of experiences, the pilot actions were realized in different countries and regions and at various spatial scales. This was aimed to serve as added value for the transnational discussions in the Danube catchment area, but also for the discussions on Member State levels.

Therefore, a high value was set to the exchange between the Project Partners responsible for the pilot projects implementation. The pilot projects were presented during different stages of their development at the Danube Floodrisk Working Group meetings, see Table 2. During these meetings the following criteria were used to compare and evaluate the pilot projects:

- Pilot projects' results
- Lessons-learned
- Recommendations
- Transferability

Table 2: Overview on meetings, amongst others for the presentation and discussion of the pilot actions;

Date	Location, Country	Description of meeting
4.10.2011	Trento, Italy	Short updates on pilot activities in project management meeting
9.3.2012	Vienna, Austria	Working Group meeting: Workshop on the common features of the pilot projects; discussion and collection of all relevant joint issues.
5.-7.9.2012	Bucharest, Romania	Working Group meeting: small discussion groups about the pilots summarizing results and lessons-learned of each project.
10.10.2012	Bucharest, Romania	Final conference: session on pilot activities with presentation of results and discussion.

To evaluate the pilot projects' impact regarding the flood risk management plans the following questions were discussed (see also Figure 14):

- For which parts of the risk cycle do you consider the hazard and risk maps useful and why?
- For which stakeholder groups do you consider your pilot project useful regarding flood risk management planning?
- What were the flood risk management planning results?

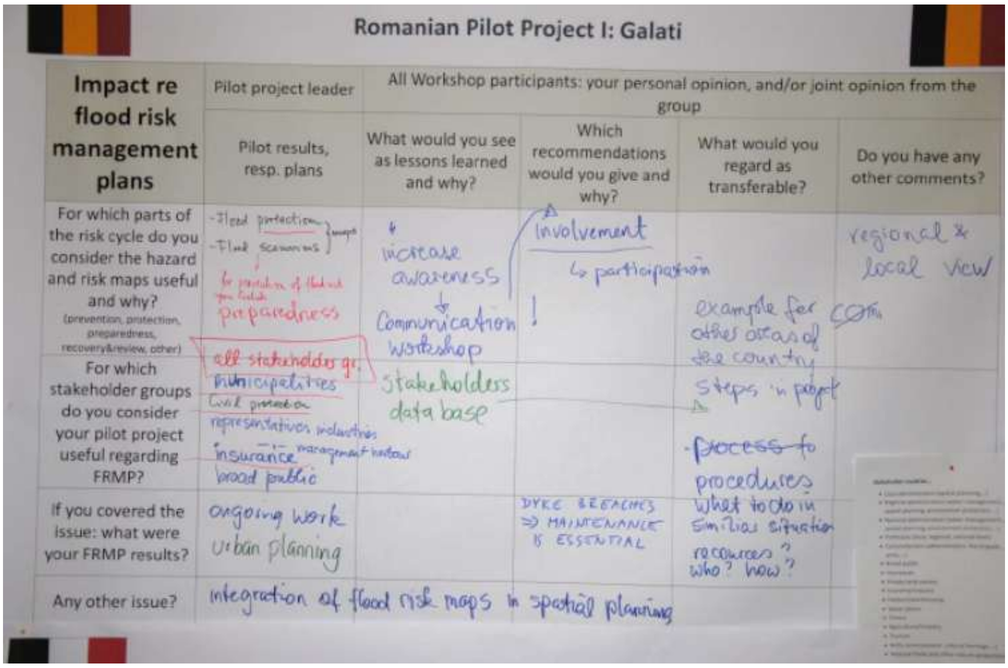

Figure 14: Exemplary output from brainstorming at the Workshop on the common features of the pilot projects in Vienna, 09.03.2012

One of the joint aims of the pilot projects was to involve stakeholders and the end users of flood hazard and risk maps to bring the risk information and risk maps to the local level. As the pilot actions focused on different spatial scales and topics, see Table 1, also different approaches of the involvement of local stakeholders were chosen.

For the pilot projects focusing on the development and testing of new methods, the mainly involved group was experts. Discussions were held in order to receive feedback on the ideas, on feasibility and transferability issues. Also, the close contact with the further experts is crucial for the later dissemination of the developed methodologies.

For the pilot projects dealing with urban areas and cities, the local administration played an important role: stakeholder from different disciplines and sectors were approached. Discussions were held at the initial project phase as well as for working out solutions to the identified problems in the respective cities.

In the Cernavoda pilot project only one stakeholder was approached: the operator of the power plant. Although data availability was limited and requirements for confidentiality were high, the consultation process with the operators was very important for the pilot project implementation.

The different approaches of the involvement of local stakeholders are summarized in Table 3.

Table 3: Stakeholder involvement in the pilot projects

	Krems, AT	Lom / Nikopol & Belene / Ruse, BG	Drava river, IT	Galati, RO	Giurgiu, RO	Cernavoda, RO
Stakeholder groups involved	Administration, private companies, affected public	Local administration	Experts	Experts	Administration, experts, responsible persons from spatial & traffic planning, economy, culture, energy	Plant operators
Project stage of involvement	Discussion of problems and working out solutions	Project development and results presentation	During project and method development	During method development	Discussion of problems and working out solutions	During project development and results presentation
Forms of involvement	Workshops; development of local protection measures;	Workshops, discussion with local competent authorities , stakeholders trainings	Discussion with experts; Workshop	Discussion with experts	Workshops; development of local protection measures;	Consultations with local operators
Benefits of approach	• Raising awareness • Measures developed by local stakeholders have higher chance of implementation	• Projects are defined according to local problems • Stakeholders feel committed from beginning	• New method fully transferable • Experts revised their judgment in dialogue • Experts integration for dissemination	• New methods fully transferable • Experts integration for dissemination	• Raising awareness • Measures developed by local stakeholders have higher chance of implementation	• Information exchange
Problems emerged	• Lots of preparation needed before work at local level could start • At project start: “door-opener” needed	• Lots of time needed for introduction and preparation	• Data acquisition and harmonization across borders	Decision Support Tool: • Decisions still very subjective • More data input necessary to gain objectivity	• Data acquisition / more data would have been needed • Lots of time needed for introduction and preparation	• Confidentiality requirements • Data missing

4 Summary of Lessons learned and transferability

4.1 Lessons-learned

As described in chapter 3 the lessons-learned and transferability of the pilot projects results were discussed in the Working Group meetings and beyond. It was found, that there are some lessons-learned common to most pilot projects and some that are specific to the pilot area. The common lessons are specified subsequently, whereas the specific lessons-learned are described in the respective summary of the pilot project (chapter 2.1 to chapter 2.6).

The **time** needed for the preparation and implementation of the pilot projects was for most pilots underestimated, especially for the pilots cooperating with municipalities. In the first phase the local situation has to be assessed and the problem defined. The early integration of the local stakeholders in the process of defining the activities was found to be essential.

For many situations, a **door-opener** is needed from the local level that helps to identify the right stakeholders and persuades them to work together. This door-opener can be a company, a department or a person in charge, e.g. in the pilot project Krems in Austria a member of the city council welcomed the idea of the pilot project, which contributed significantly to the success of the pilot.

Furthermore, in most projects the **data availability and acquisition** caused problems and took additional time in the starting phase of the projects. There are different aspects that caused difficulties:

- Data was available but not publicly accessible; the obtaining of the data was time-consuming
- Data was available but private and confidential
- Only very limited data was available, so that alternatives had to be found

In the pilot project of the Drava river basin, harmonized data for the cross-border catchment between Italy and Austria was already available; this was very appreciated and useful for the pilot implementation. It can be followed, that also in small trans-boundary catchments efforts should be taken to harmonize data across borders. This is an important prerequisite for flood hazard and risk mapping and for providing risk information to the local level.

It was also found that **maps** are a good basis for discussion. It helps local stakeholders to identify their region or city on a map, which in turn facilitates the discussion and participation process. For this the maps have to be prepared on a higher **scale**: E.g. in the pilot project of Giurgiu the scale of 1:5.000 was chosen for the thematic maps produced and the Krems pilot even prepared maps on the scale of 1:2.500. Lots of time and effort was spent to prepare the local maps, but the thorough preparation was in all cases necessary.

During the Workshops and discussion with the local stakeholders it was observed, that hazard information on the **flood hazard maps** was easier accessible and understandable for the local stakeholders. The reason is that on the one hand, in many countries there are no risk maps yet, so the stakeholders are not acquainted to them. On the other hand, the damage assessments in the risk maps were hard to comprehend, as the calculation is composed of more than one variable.

Though, for decision-making it was found that the economic assessment on flood risk maps can be very useful, as it makes decisions more objectively. The experience also showed that the damage assessment per m² was easier understandable than the damage assessment per household.

4.2 Transferability of the pilot projects' results and lessons

These lessons from the pilot projects are in any case transferable to further pilot projects dealing with the context of flood risk information and risk maps in spatial planning. Furthermore, the new methods and tools developed are also transferable to other areas and river catchments, when the respective input data is provided.

Even the results of the single pilots showed their high value and appreciation on the local level. For example, the neighboring municipality to the Austrian town of Krems, Ybbs, heard about the pilot project and the results, the prepared hazard and risk maps as well as the participation process of the affected stakeholders. The city of Ybbs asked as a follow-up for further information on the pilot and for a presentation at the municipality.

A second example is the Giurgiu pilot project: Here the thematic maps prepared and the final maps of possible solutions were very much appreciated by the municipality. They will use the maps further for communication and awareness raising activities and will disseminate it to other departments not involved in the pilot project.

5 Joint conclusions and recommendations

Following the comparison of the experiences and the summary of lessons-learned from the pilot projects, several joint conclusions and recommendations can be drawn:

The Stakeholder involvement during all stages of a pilot project is crucial:

- → At the project definition phase: The Projects are defined according to local problems; The stakeholders feel committed to the project from the beginning.
- → During the implementation phase: It raises awareness and input and feedback from local experts can be obtained.
- → For the finding of results and the working out of measures: Measures developed by local stakeholders have higher chance of implementation.
- → For dissemination of findings and methods and to create follow-up activities.

Getting started:

- → The time needed for initiation and preparation of a pilot project is often underestimated.
- → It is wise to get local support: a door-opener helps to approach the right stakeholders.

Collection of data and creating maps:

- → Be flexible about the input data.
- → Harmonized data is needed, even on local scale and in small trans-boundary catchments.
- → Maps are a good basis for discussion: the Preparation of maps to be used in spatial planning and other sectors by the local administrations is very recommended; the joint work on the maps has proved useful for the communication process.
- → Hazard maps are easier understandable than risk maps: Therefore, start to introduce the stakeholders with the basic maps and hazard information first and then introduce the damage assessment and risk maps for the decision-making process regarding local protection measures.

The pilot projects can be a great success when win-win situations are created and a real dialogue can be established, so that the learning process works mutually.

When looking into the future, a joint conclusion from the Danube Floodrisk project is that after the flood hazard and risk maps for the Danube River have been finalized and a joint methodology for flood hazard and risk mapping has been agreed upon, this information needs to be provided to the local level. More pilot project should be implemented, that work on the involvement of stakeholders, to integrate the risk information in the spatial planning and to develop local-level flood protection measures.