DOI 10.1051/lhb/2017030 La Houille Blanche, n° 4, 2017, p. 40-45

Flood risk management objectives and Romanian catalogue of potential measures for flood prevention, protection and mitigation

Daniela RADULESCU[1], Mirel Bogdan ION[1], Ramona DUMITRACHE[1] and Cristian Eugen BARBU[2]

[1] *National Institute of Hydrology and Water Management, Romania, daniela.radulescu@hidro.ro*
[2] *National Administration "Romanian Waters", Arges – Vedea River Basin Authority, Romania*

ABSTRACT. – In order to draw up the Flood Risk Management Plans, in Romania have been identified two types of objectives: strategic and operational. In defining the strategic objectives of flood risk management for Romania, the approach agreed at the Danube Commission (ICPDR) was taken into consideration. Furthermore, these strategic objectives set at national level were detailed in specific objectives that cover the 4 major categories of negative consequences established by Floods Directive mentioned above.
In order to facilitate / structural and non-structural measures selection for 11 River Basin Authorities from Romania, a catalogue of potential measures at national level was elaborated. The proposed measures are following main areas of action closely linked to the cycle of flood risk management: Prevention, Protection, Preparedness, Awareness and Recovery.
The paper presents the objectives of flood risk management established in Romania, associated indicators and nationwide catalogue of potential measures. At the same time a case study is presented on potential measures proposed at the level of basin.

Key-words: Flood Directive, Romania, Danube commission

Objectifs de gestion du risque d'inondation et catalogue de mesures potentielles retenues en Roumanie pour la prévention, la protection et l'atténuation des inondations

RÉSUMÉ. – L'établissement des Plans de gestion du risque inondation en Roumanie a été réalisé suivant deux types d'objectifs, stratégique et opérationnel, en lien avec l'approche adoptée par la Commission internationale de protection du Danube (ICPDR) et les 4 principales catégories de conséquences négatives établies par Directive Inondations. Pour faciliter la sélection de mesures structurelles et non structurelles pour les 11 autorités de bassin versant en Roumanie, un catalogue de mesures potentielles au niveau national a été élaboré. Les mesures proposées suivent les principaux domaines d'action liés au cycle de gestion du risque d'inondation : prévention, protection, préparation, sensibilisation et résilience. L'article présente les objectifs de gestion du risque d'inondation retenus en Roumanie, les indicateurs associés et le catalogue national des mesures possibles. A titre d'illustration un cas d'étude de cas est présenté sur les mesures potentielles proposées au niveau d'un bassin.

Mots-clés : Directive inondation; Roumanie; Commission du Danube

I. INTRODUCTION

In agreement with European legislation and international literature, flood risk management means the application of policies, procedures and practices having as objectives risks identification, analysis and their evaluation, treatment, monitoring and reassessment of risks, in order to reduce them, so that human communities, all citizens can live, work and satisfy their needs and aspirations in a sustainable physical and social environment.

Flood risk is characterized by the nature and probability of occurrence, receptors exposure degree (number of population and goods), susceptibility to flood of the receptors and their value, thus it results that the risk can be reduced by acting on his own characteristics

Flood consequences mitigation is the result of a wide combination, between the measures and actions preceding the occurrence of the phenomena (activities of prevention, protection and preparedness), management measures taken during the floods (response actions taken during floods, known as emergency situations management) and measures undertaken post flood (reconstruction and lessons learned as a result of the occurrence of the phenomenon).

Flood risk management plans (F.R.M.P.) addresses all aspects of flood risk management focusing on prevention, protection, preparedness, including flood forecasts and early warning systems and taking into account the characteristics of the particular river basin or sub-basin. Flood risk management plans include also the promotion of sustainable land use practices, improvement of water retention as well as the controlled flooding of certain areas in the case of a flood event.

II. ORGANIZATIONAL STRUCTURE OF "ROMANIAN WATERS" NATIONAL ADMINISTRATION

According to national legislation, Flood Directive implementation is the responsibility of the Ministry of Environment, Water and Forest and Romanian Waters National Administration (R.W.N.A.).

Ministry of Environment, Water and Forest represents the central public authority in water sector which develops strategy and concept in water management, including in flood risk management.

R.W.N.A. is the national authority, under the coordination of Ministry of Environment, Water and Forest, which ensures the implementation of the national policy on water, including flood risk management and it is organized through 11 River Basin Authorities (R.B.A.), one of them being the Arges-Vedea R.B.A. (Figure 1).

Figure 1 : *Romanian River Basin Authorities*

National Institute of Hydrology and Water Management is the public institution subordinated to the National Administration "Romanian Waters", carrying out supporting studies and methodologies for Flood Directive implementation [N.I.H.W.M. Study, 2010-2014]; the institute ensures the scientific coordination of all three steps required by the Directive and the reporting to the E.C. of the necessary information for all 11 R.B.A.

III. DESCRIPTION OF THE FLOOD RISK MANAGEMENT OBJECTIVES

There are many differences in the manner of setting objectives at Member State level. One of the models is setting the objectives first at national level and then, detailing at catchment/ Areas with Potentially Significant Flood Risk (APSFR) level.

In general, it can be identified two types of objectives: the strategic and operational objectives. The first concerns the guiding principles, the second objective, among others, aims to reduce new or existing risks and minimize the negative consequences.

In defining the strategic objectives of flood risk management plan for Romania, it was taken into consideration the approach agreed at International Commission for the Protection of the Danube River (I.C.P.D.R.) level.

Romania is member of I.C.P.D.R. since 1994, when the Danube River Protection Convention (signed in Sofia, from a Romanian government initiative dating from 1985) - the Bucharest Declaration was developed.

The Danube is of huge significance to Romania, since the country is almost entirely within the Danube Basin; covering 237,391 km² and with nearly 22 million inhabitants, the country is almost entirely within the Danube Basin. The Romanian section covers almost a third of the surface area of the Basin, and over a third of the river's length flows through the country.

The first Flood Risk Management Plan for Danube River Basin District (D.R.B.D.) [ICPDR, 2014] is produced with the support of Danube countries, in line with the article 8 (3) of the Flood Directive. It sets out appropriate objectives for the management of flood risk on the level of the international river basin district covering the whole Danube catchment. It highlights the objectives and issues relevant for the basin-wide perspective.

I.C.P.D.R. agreed upon the following objectives of the Flood Risk Management Plan for the Danube River Basin District:

- avoidance of new risks ;
- reduction of existing risks ;
- strengthening resilience ;
- raising awareness ;
- principle of solidarity.

These objectives focus on the reduction of potential adverse consequences of flooding for human health, the environment, cultural heritage and economic activity and address all aspects of flood risk management, taking into account the characteristics of the D.R.B.D.

III.1. The specific objectives of flood risk management

The strategic objectives established at national level have been detailed in specific objectives. The specific selected objectives cover four basic criteria: economic, social, environmental and cultural heritage, as it follows:

- **Economic**:
  - Minimise flood risk to transport infrastructure
  - Minimise flood risk over economic activities
  - Minimise flood risk to agriculture lands.
- **Social:**
  - Minimise flood risk to life and human health
  - Minimise flood risk to community.
- **Environment:**
  - Support the achievement and conservation of good environmental status/ good ecological potential in accordance with Water Framework Directive (WFD) requirements
  - Minimise flood risk to protected areas designated for the abstraction of water intended for human consumption
  - Minimise flood risk to objectives with potential pollution (under incidence of I.P.P.C. - I.E.D. Directive (96/61/CE), Wastewater Directive (92/271/CEE) and Seveso II Directive (96/82/CE);
- **Cultural heritage:**
  - Minimise flood risk to cultural heritage objectives.

Each specific objective has an indicator, a minimum target and an aspirational target

III.1.1. Indicators, minimum and aspirational targets

Although most Member States define in a qualitative way their flood risk management objectives [Hegger, et al., 2014] for achieving them it is recommended to establish and use indicators (as quantifiable targets) [Adamson, Duffy, 2015].

In this regard, it has been established for every objective, a measurable quantitative indicator. The indicators were selected based on:

- available GIS information (GIS datasets) and their relevance in relation to the respectively objective;
- their ability to measure / quantify the two situations: the existing situation (baseline scenario) and the situation when the measure / flood risk management option is implemented.

Minimum and aspirational targets have been set out for each flood risks management objective.

Minimum target was set out as being the minimum acceptable benefit of the flood risk management measure proposed.

Aspirational target has been defined to underline the measures exceeding the minimum target that provides significant additional benefits or multiple benefits than those that meet the minimum target.

In this regard, in the following lines some examples of indicators and associated targets are given:

Economic - Minimise flood risk to transport infrastructure:

• *Indicator*: length and importance of transport infrastructure (roads, railway stations, ports, airports, etc.) exposed to flood risk;

• *Minimum target*: maintaining the current situation for transport infrastructure subject to flood risk;

• *Aspirational target*: reducing at 0 the number transport infrastructure subject to flood risk.

Economic - Minimise flood risk to agriculture lands.

• Indicator: surface of agricultural land at flood risk;

• Minimum target: do not apply;

• Aspirational target: reducing at 0 the number agricultural lands subject to flood risk.

Social - Minimise flood risk to life and human health

• *Indicator:* the number of inhabitants at flood risk;

• *Minimum target:* maintaining the current situation for inhabitants subject to flood risk;

• *Aspirational target:* reducing at 0 the number inhabitants subject to flood risk.

Environment - Support the achievement and conservation of good environmental status/ good ecological potential in accordance with WFD requirements

• *Indicator:* the number of water bodies at risk of not achieving the "good ecological status" or "good ecological potential";

• *Minimum target:* the F.R.M.P. measures should not obstruct the achievement of environmental objectives (good environmental status/ good ecological potential);

• *Aspirational target:* significant contribution of the flood risk measures in reaching the environmental objectives.

Environment - Minimise flood risk to protected areas designated for the abstraction of water intended for human consumption

• *Indicator:* the number of water intakes at flood risk;

• *Minimum target:* maintaining the current situation for water intakes subject to flood risk;

• *Aspirational target:* reducing at 0 the number of water intakes subject to flood risk.

Cultural heritage: Minimise flood risk to cultural heritage objectives

• *Indicator:* number of museums, churches and cultural monuments exposed to flood risk;

• *Minimum target:* maintaining the current situation for cultural heritage objectives subject to flood risk;

• *Aspirational target:* reducing at 0 the number of cultural heritage objectives subject to flood risk.

In the establishment process of the indicators, it was taken into account available GIS geospatial data for the following receptors:

- Population component
  - inhabitants exposed to flood risk;
  - social infrastructure - hospitals; educational units (universities, colleges, schools, kindergartens); municipalities; police stations.
- Economic activity component
  - airports and ports;
  - railways and train stations, roads and highways;
  - major industrial objectives and secondary economic activities;
  - agriculture land.
- Environment component
  - bodies at risk of not achieving the "good ecological status" or "good ecological potential";
  - abstraction points of water intended for human consumption;
  - E-P.R.T.R. and I.P.P.C. installations.
- Cultural heritage component
  - churches, historical monuments, museums.

GIS layers have various sources, mostly from the Romanian Waters National Administration - WIMS database, NAVTEQ geospatial database, Open Street Map and Corine Land Cover. All these layers have been corrected and correlated by N.I.H.W.M., and for a more accurate identification of receptors, a combination of data from multiple sources was necessary.

Indicators and receptors established and used, are the most relevant for evaluating the applicability of a specific objective of the Flood Risk Management Plan (when the evaluation is carried out at A.P.S.F.R. level) and also for the assessment of objectives achievement (when the assessment is performed at measure level and is referring at the receptors from the flooded area, protected by implementing the measure).

IV. CATALOGUE OF NATIONAL POTENTIAL MEASURES

In order to facilitate the establishment of structural and non-structural measures, it has been developed at national level a catalogue of potential measures to meet the specific needs that each River Basin Administrations are facing in their work to reduce flood risk.

Elaboration of the catalogue was based on wide bibliographic documentation. Thus there were consulted international approaches available at this moment, agreed at I.C.P.D.R. and I.C.P.R. [Commission Internationale pour la Protection du Rhin, 2014] level, as well as flood risk management plans from different European states. (Ireland [Halcrow, 2014], United Kingdom [Humber River Basin District, 2014], Germany [Regierungspräsidium Darmstadt, 2014], Austria[Bundesministerium für Land - und Forstwirtschaft, Umwelt und Wasserwirtschaft, 2015]) and European guidelines, among which we mention: „Technical support in relation to the implementation of the Floods Directive (2007/60/CE), a User Guide to the Floods Reporting Schemas, V5.0 June 2013" elaborated in the European Commission framework - D.G. Environment. Also, there were taken into account the EXCIMAP Guide (European exchange circle on flood mapping) Handbook on good practices for flood mapping in Europe, Natural Water Retention Measures – 53 NWRM illustrated (service contract no. 07.0330/2013/659147/SER/ ENV.C1 for the Directorate-General for Environment of the European Commission.), A guide to support the selection, design and implementation of Natural Water Retention Measures in Europe - Capturing the multiple benefits of nature-based solutions.

Subsequently, the catalogue was discussed in working meetings within the system of "Romanian Waters" National Administration and in public debates organised by Ministry of Environment, Water and Forest and also in the framework of debates organised with academic environment.

The measures proposed aim at five areas of action, closely related to the flood risk management cycle:

- **Prevention**
  - category of measure: legislative institutional, organizational measures and it includes measures like defining / improving the legal and technical framework for the implementation of Floods Directive, reviewing and updating flood risk management plans, coordinating territorial planning strategies with F.R.M.P. (in total 3 types of measures);
- **Protection**
  - categories of measures (examples: natural water retention measures - associated to watercourses, wetlands, and natural lakes, change or adaptation of land-use practices, structural protection measure – as new reservoirs development, development of diverting channels, local embankments, measures to increase population resilience, adaptation of the defence structures at the climatic changes, etc. (in total 11 types of measures);
- **Preparedness**
  - categories of measures (examples: measures regarding monitoring, forecasting and flood warning, activities of flood event preparedness exercise with interinstitutional participation, etc.); in total 4 types of measures;
- **Public Awareness**
  - one category of measures with the same name: measures to increase the awareness of the community and it includes adequate public activities of information and promotion of public participation, activities for education and training of the population; covers 2 types of measures;
- **Recovery**
  - categories of measures: emergency response actions, damage evaluation and recovery, improvement of post event documentation and analysis process, etc. (in total 3 types of measures).

There are 23 types of measures proposed; for each type of measure there are provided examples (the list not being exhaustive). This catalogue was very useful in defining at the level of River Basin Administrations the most relevant measures, in a unitary manner.

The fact that all aspects of Flood Risk Management (Prevention, Protection, Preparedness, Awareness, and Recovery) were addressed in the Flood Risk Management Plan is demonstrated by the fact that the measures proposed in the catalogue of potential measures have found a clear correspondence with codes of measures proposed by the European Union.

In Table 1 it is presented a synthesis, summarizing the types of measures for each area of action, outlining non-structural / structural measures. Most measures are within the field of action Protection (11/23 types of measures).The table also highlights the special attention given to non-structural measures, in accordance with European guidelines / recommendations and D.G. Regio D.G. Environment.

The measures (indicated in the Catalogue of measures) are classified into 3 categories depending on the level of implementation, as it follows:

• measures implemented at national level include measures with an essential role in flood risk management, which refer to current water sector legislation, those legislative provisions with impact in this domain (insurance scheme, legislative regulations of spatial and urban planning etc.) or which impose a system of best practices in order to reduce the negative effects of floods, studies, projects, programs, including know-how transfer and experience exchange in order to support implementation of the Flood Directive at catchment and national level, that also involves cooperation between authorities at central level (in areas such as emergency management situations, meteorology, etc.) for their implementation in all River Basin Administrations.

• measures implemented at the catchment level (River Basin Authority) - are related with organizational and technical solutions whose effect aim to improve flood risk management across the whole territory of R.B.A.

• measures implemented/applicable at the level of A.P.S.F.R. - are specific measures "located" either at the level of A.P.S.F.R. or, where appropriate, on the tributary or upstream catchment basin of the respectively sector, having in this situation an effect on sectors/areas with potential significant flood risk (A.P.S.F.R.). If the first two levels of implementation contain measures which are common to all River Basin Administration, the proposed measures implemented at A.P.S.F.R. level are specific to each R.B.A.

For each type of measure, the responsible authorities have been identified.

V. CASE STUDY ON POTENTIAL MEASURES PROPOSED AT THE LEVEL OF ARGES-VEDEA RIVER BASIN AUTHORITY

In Romania there are 11 R.B.A. and all are engaged in Floods Directive implementation, in a very unitary and similar way/manner.

The main result of the first stage/step - *Preliminary flood risk assessment* - consisted in identifying areas with potential significant flood risk. In Romania 399 such areas were identified. On the territory of Arges-Vedea River Basin Authority were determined 34 areas with potential significant flood risk (Figure 2), respectively almost 10% from the total APSFR identified at national level.

For the 2nd stage/step - *Development of flood hazard and flood risk maps*, the maps of flood hazard for 3 scenarios

Table 1 : Measure types summary

AREA OF ACTION (5)	TYPES OF MEASURES (23)	STRUCTURAL vs NON-STRUCTURAL MEASURES
PREVENTION	3	3 NON-STRUCTURAL MEASURES
PROTECTION	11	1 STRUCTURAL MEASURE 10 NON-STRUCTURAL MEASURES
PUBLIC AWARENESS	2	2 NON-STRUCTURAL MEASURES
PREPAREDNESS	4	4 NON-STRUCTURAL MEASURES
RESPONSE AND RECOVERY	3	3 NON-STRUCTURAL MEASURES

(representing high, medium and low probability of exceeding) in Arges-Vedea R.B.A. (Figure 3) were carried out under the National Programme *Plan for Prevention, Protection and Mitigation of floods effects*, and with the scientific support of the National Institute of Hydrology and Water Management (N.I.H.W.M.). Program started for most of the R.B.A. at the end of 2006 - early 2007, after severe floods from the 2005-2006 years, with a budget financed through state budget and Environmental Sectorial Operational Programme. In the case of Arges – Vedea R.B.A. the program started in 2011.

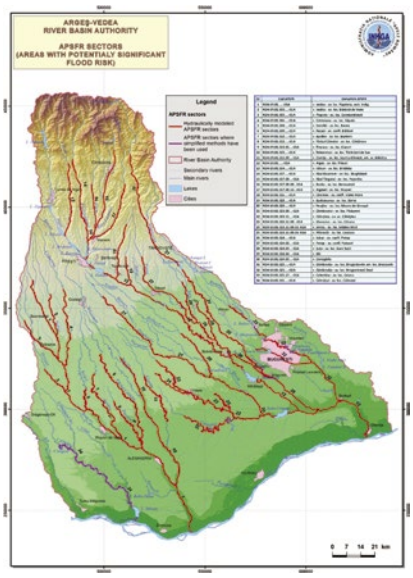

Figure 2 : *Areas with potentially significant flood risk identified in Arges–Vedea R.B.A.*

Hazard map is structured into three depth classes (depths of less than 0.5 m, depths between 0.5 and 1.5 m and depths greater than 1.5 m). Based on flood hazard maps and on the flood risk assessment methodology developed under N.I.H.W.M., flood risk maps were developed for all 11 R.B.A. (http://gis2.rowater.ro:8989/flood/).

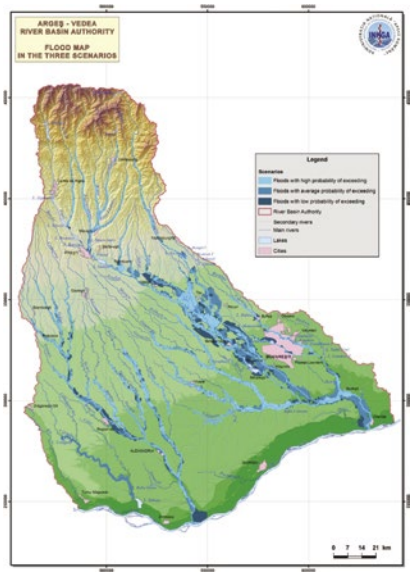

Figure 3 : *Flood hazard map for Arges-Vedea R.B.A.*

Elaboration of flood risk maps was based on a qualitative approach; this has assumed first the identification of the risk receptors and after vulnerability evaluation of identified objectives and exposed to flood risk, raking into account water depth and potential damages to the flooded objectives, respectively the impact over the risk receptors considered.

Flood risk maps published are elaborated for 3 scenarios of flooding (10 year flood, 100 year flood and 1000 year flood) for the next indicators**:**

• approximative number of affected inhabitants (statistical method used)

• indicators, related to other types of consequences: economic, environment, cultural heritage

For each class of depth, it was assessed the magnitude of hazard and it has been assigned three classes with the following meaning: class 1 - less than 0.5 m; class 2 - 0.5 to 1.5 m; class 3 - less than 1.5 m, resulting in three areas: areas with high risk - represented in red, medium risk areas - represented with orange, low risk areas - represented by the yellow colour. (Figure 4).

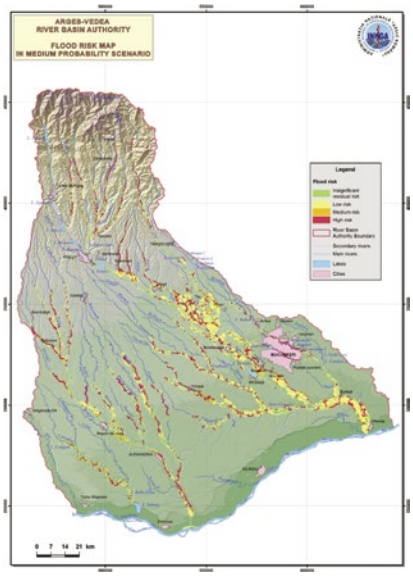

Figure 4 : *Flood risk map for Arges-Vedea R.B.A.*

The first two stages were finalised and reported at the European Commission for all River Basin Authorities.

Elaboration of the Flood Risk Management Plans (F.R.M.P.) in Romania – it started based on the F.R.M.P. Development Framework Methodology, elaborated by N.I.H.W.M. with experts contribution from R.W.N.A. and R.B.A.

Arges–Vedea River Basin Administration is one of the most important R.B.A. in the country, in terms of surface - 21 479 sq. km (approximately 9% of the country), in terms of population - 4 million inhabitants (20% of the total population of the country), and also because of the numerous hydraulic works specific to water management activity.

The most important cities to be protected through proposed FRMP are Bucharest (the capital of the country), Pitesti and Campulung (more than 2.115.000 inhabitants, from witch 1.9 million live in Bucharest)

The proposed measures within F.R.M.P. of Arges - Vedea R.B.A. are grouped according to the level of application presented in Chapter 4, respectively: measures at national level (23 measures), measures at R.B.A. level (24 measures) and measures at A.P.S.F.R. level (146 measures – Table 2).

Table 2 : Measure types summary

Measures	No of Measures
Re-naturalization of the river banks (vegetative protection)	1
Increasing the river conveyance through local dredging works.	23
Dike relocation	2
Restoration / Increasing of attenuation volumes for existing reservoir (permanent/ temporary) through dredging works	5
Development of new temporary small reservoirs	5
Safety improvement of existing hydraulic structures (dams rehabilitation: modernizations, retrofitting measures to limit infiltrations etc.)	13
Conducting the necessary maintenance works for safe operation of existing hydraulic structures and related equipment (maintenance and current repair, etc.)	8
Development of diverting channels	2
Riverbed stabilization measures – recalibration of riverbeds, parapets, retaining walls, river bank defences, riverbed stabilization	34
Protection measures along the river stretches through local embankments	16
Measures of modernization, consolidation of hydro-technical constructions for development of water courses	2
Maintenance of existing flood protection infrastructure	5
Water courses riverbeds maintenance and bottlenecks, obstacles removal from water courses.	30
Total Measures	**146**

VI. CONCLUSIONS

The catalogue of measures was a very useful instrument in defining the potential measures that can reduce flood risk, mainly due to the wide range of potential measures, from which each R.B.A. have chosen the appropriate type of measure.

An important set of measures for flood risk mitigation in Arges-Vedea R.B.A. is represented by the measure that has as purpose the Safety improvement of existing hydraulic structures (dams rehabilitation: modernizations, retrofitting measures to limit infiltrations etc.) – 13 measures proposed. Taking into consideration that most of the reservoirs with a complex use have been built in Arges-Vedea R.B.A. between 1980 – 1990, through these measure are proposed to be made works for safety improvement of existing structures like rehabilitation: modernizations of the hydraulic and hydromechanics, equipments, retrofitting measures to limit infiltrations etc. These measure represents a priority for the defence activity of RBA, taking into account main purpose of the reservoirs: flood wave mitigation and ensuring volumes of water for public water supply and industry.

From the 145 measures proposed to reduce flood risk in Arges-Vedea R.B.A. a number of about 71 measures are proposed to be made with own funds, while the remaining 74 measures are proposed to be financed with funds from the State budget or European Funds.

Definition of the specific objective and associated indicators will act like a mirror in reflecting at the level of each Responsible Authority the progress made in the process of transposing the measures from the paper in the field, thus reducing the negative consequences over human health, economy, environment and cultural heritage.

VII. BIBLIOGRAPHY

Adamson M., Duffy R., Cfram Consultants (2015) – Option appraisal and the Multi-Criteria analysis Framework, Version Rev. C. *National CFRAM Programme Guidance note*, **28**.

Bgs Landschaftsökologie Planung (2014) – Regierungspräsidium Darmstadt. *Maßnahmensteckbrief –Hochwasserrisikomanagementplan für die Gersprenz*.

Bundesministerium für Land - und Forstwirtschaft, Umwelt und Wasserwirtschaft (2015) – *Nationaler Hochwasserrisiko – Managementplan Sicher Leben mit der Natur, Wien*.

Commission internationale pour la protection du Rhin (2014) – *Plan de gestion des risques d'inondation dans le District Hydrographique*.

Humber River Basin District (2014) – *Consultation On The Draft Flood Risk Management Plan, October 2014*.

Halcrow (2014) – *Lee Catchment Flood Risk Assessment and Management Study (CFRAMS), Final Report*.

Hegger D., Van Herten M., Raadgever T. Adamson M., Näslund-Landenmark B., Neuhold C. (2014) – Report of the WG F and STAR-FLOOD Workshop on Objectives. *Measures and Prioritisation Workshop*.

International Commission For The Protection Of The Danube River (I.C.P.D.R.) (2014) – *Flood Risk Management Plan for the Danube River Basin District, Version 2*.

N.I.H.W.M. Study (2014) – *Studies for implementation of Directive 2007/60/CE on the assessment and management of flood risks (2010-2014)*.