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FLOOD RISK MANAGEMENT PLAN. CASE STUDY FOR THE AREA OF POTENTIALLY SIGNIFICANT FLOOD RISK ON TUR RIVER, DOWNSTREAM NEGREȘTI - OAȘ

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ABSTRACT
Currently, Romania finds its self at the end of the first implementation cycle of the Floods Directive 2007/60/EC, more exactly the development and finalization of the following three steps imposed by this Directive to all Member States, namely Preliminary Flood Risk Assessment (PFRA), Flood Hazard and Risk Maps Elaboration (FHRM) and Flood Risk Management Plan Elaboration (FRMP) for all River Catchment Administrations. In this first cycle of implementing the Directive were determined 37 Areas with Potential Significant Flood Risk (APSFR) from River Catchment Administration Someș – Tisa. One of those areas with potential significant flood risk is located on Tur River, downstream Negrești - Oaș, on a 141.2 km long sector. The paper briefly describes the area of study, the major flooding and damage that occurred and the measures proposed in the Flood Risk Management Plan (proposed measures applicable at River Administration level and the studied APSFR level). The measures required to reduce flood risk are both structural and non-structural measures, focusing on measures to mitigate flood waves, bearing in mind that riparian settlements are located in the floodplain and existing works do not meet the minimum degree of protection for this area. This paper presents an evaluation of these measures and their prioritization, as a justification for the promotion phase of the work required.

Keywords: Flood Risk Management Plan; objectives; measures; flood.

1 INTRODUCTION

1.1 Description of the case study zone

Tur River is located in the north-west of Romania and is included in the Someş - Tisa catchment area and flows into Tisza River in Hungary. In a previous phase, convergence to Someş River and was achieved by activating Poarta Oraşu Nou, currently suspended.

Tur River catchment area in Romania is 1144 km^2, length 68 km and the main tributaries being Valea Rea, Talna and Turțul Rivers.

Tur River flows from Gutâi Mountains at about 1050 m and has a length of 66 km Romania, with a flow direction from east to west. River slope values are high in the mountainous area, with values around 20 ‰, while in the lowlands slopes of 2-6 ‰ are encountered, reaching under 1 ‰ near the border area (Sofronie et al., 2013).

After passing the gate that closes Oaș intra-volcanic depression and goes forward to the plains River Tur is splitting, amid falling slope, into two main branches and other secondary branches which shows great instability of the riverbed that's in full phase of silting up. Subsidence from contact with the plains is well highlighted on the area between Egher and Talna by its marshy and eutrophic bogs. Lowland sector of the reservation is characterized by the presence of numerous channels communicating with rivers and creeks in the area.

Main river generally has a major bed widely developed and strong meandering river channels and numerous side branches. Riverbed is composed of boulders in the upper sector, gravel and sand in the lower sector. Tributaries of the upper catchment of the Tur River are most affected by the erosion of the riverbed and banks, especially Valea Rea River, Valea Alba River, Talna River upstream sector.

Along Tur River are more pronounced erosion areas only in the upstream Călinești reservoir, in areas with banks made of weak cohesive rocks (gravel, boulders). Tur River water management scheme is presented in Figure 1.

The stream has a series of hydraulic works (storage, regularisation, banks consolidation, rapids - falls and embankment works), most of which where done after the floods that took place in 1970, whose general characteristics are:

- the upstream sector, due to the high speeds, erosion of banks and thalweg and destruction of bottom sills and bank protection are observed;

- the downstream sectors deposits and silting of the riverbed occurring, reducing leakage and reducing sections of transit capacity and exceeding the flow of flood dykes.

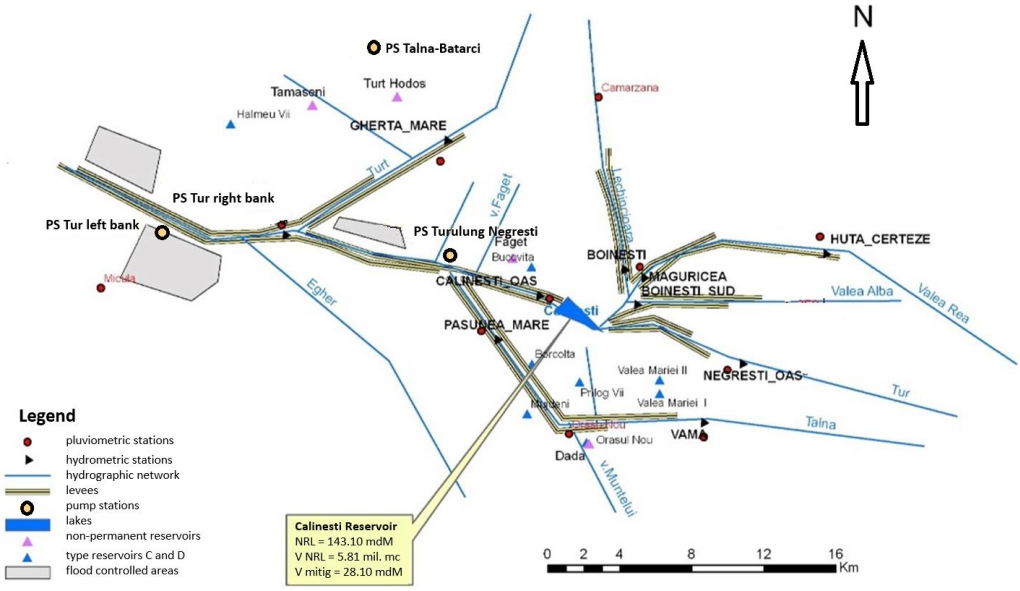

Figure 1. Water management scheme of Tur catchment

1.2 Historical floods in the study area

The flood that took place, in May 1970, on Tur River was first detected at Negreşti staff gauge (located approx. 10 km from the springs) when the waters began to rise, reaching a peak of 112 cm. Although this level was maintained constant for several hours, has brought particular problems because city residents are almost 70 cm below the flood threshold. However, occurrence of the flood wave in the upper part of Tur River catchment was a warning for areas located downstream (Sofronie C. et al., 2013).

In 1974 during June-July floods occurred due to rainfall that exceeded the average annual rainfall in the catchment Tur, Someş.

The 1980 floods were due to excessive rainfall over a water saturated soil from rainfall that exceeded the critical threshold, exceeding defence thresholds on most watercourses in the catchment area. Tur River danger threshold was exceeded by 4 times. The major floods occurred in July when the weather station Sighet registered 178.6 l/m^2, Ocna Şugatag 158.6 l/m^2, 146.5 l/m^2 at Negreşti Oaş rain gauge, 137.5 l/m^2 at Vama rain gauge and 116.9 l/m^2 at Turulung rain gauge. On the lower course due to small slope floods lasted up to 7 days. A special role in flood protection was played by reservoirs that have limited the damage taken by the community attenuating the flood waves (Sofronie C. et al., 2013).

Also major floods have occurred in November 1998, March 2001 and 2006, but the effects were mitigated by existing hydraulic works in the area.

During the 1998 flood water level exceeded:

- in the reservoir by 20 cm over Defence Phase II (flood threshold) on 30.10.1998;
- at the hydrometric station Calinesti Oas by 20 cm over the dykes danger threshold on 30.10.1998;
- at the hydrometric station Turulung by 60 cm over the dykes danger threshold on 30.10.1998.

During the 2001 flood water level exceeded:

- in the reservoir by 37 cm over the Defence Phase III (danger threshold) on 5-6.03.2001;
- at the hydrometric station Turulung by over 100 cm over the dykes danger threshold on 05/03/2001 (the dykes danger threshold has been exceeded for 5 days).

2 METHODS

2.1 Floods Directive 2007/60 / EC requirements on the development Flood Risk Management Plan

Floods Directive (Directiva 2007/60/CE) requires all member states to go through the following three steps:

- Preliminary Flood Risk Assessment;
- Flood Hazard and Flood Risk Mapping;

- Flood Risk Management Plans.

2.2 Details on Flood Risk Management Plan development in Someş - Tisa River Catchment Administration

During the Flood Risk Management Plan elaboration for Someş-Tisa River catchment the following steps were performed as described below (Studiu I.N.H.G.A., 2012).

- ***Preliminary Flood Risk Assessment***

The main objective of the first stage was to identify areas with potential significant flood risk. In Romania were identified 399 such areas. In Someş - Tisa River Catchment Administration territory were determined 37 areas with potential significant flood risk (presented in Figure 2.) and approximately 10% of total APSFR sites identified at national level

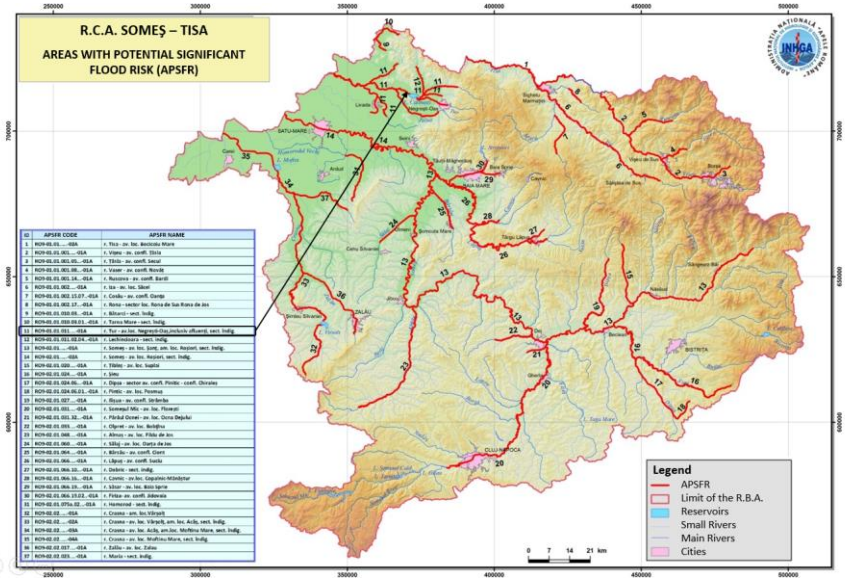

Figure 2. Areas with Potential Significant Flood Risk (APSFR)

- ***Elaboration of the Flood Hazard Maps and Flood Risk Maps***

The method used to compile the hazard maps for Someş - Tisa River Catchment Administration, under the National Plan for Prevention, Protection and Mitigation of Flooding Consequences on river catchment area (Sofronie C. et al., 2012) (developed during period 2007-2015) is based on complex studies and comprises two components:

I) Topographic and geodetic surveys:

- Scan the ground by airborne means using LIDAR technology (Light Intensity Detection And Ranging).
- Processing the data after scanning LIDAR resulting in a primary digital terrain model (DTM).
- Field activities aimed at improving the DTM's results from the previous stage (geodetic network, cross sections, structures engineering surveys, topographic works for infrastructure facilities longitudinal bathymetric measurements).
- Processing and editing Digital Terrain Model. It was obtained a DTM that for the considered area has a very high resolution (± 10 to 15 cm vertically - detail level A) and high resolution (± 15 - 20 m vertically - level detail B) and corresponds to LIDAR method supplemented by classic surveying methods for the engineering structures on watercourses (bridges, culverts, damming work, defense works, etc.), and for the remaining catchment area the MDT based on vectorization of available topographic maps (level of detail C).

II) Hydrological and hydraulic studies:

- Hydrological modeling was used to calculate the discharge hydrographs for each sub-catchment area, their mittigation and composition on the main rivers and tributaries.

  Basic hydrological data refers to maximum discharges in the current runoff regime under different probabilities of exceeding 10%, 1%, 0.5%, 0.2% and 0.1%, resulting discharge hydrographs for each event.

  A couples method, hydrologic - hydraulic, has been used applying MIKE 11 U.H.M. model using the S.C.S. - C.N. (Soil Conservation Service - Curve Number), which calculates the rainfall runoff.

Calibration and validation of the model was done using the values of maximum discharges recorded during historical floods.

- The hydraulic modelling of river reaches identified as potential flood using dedicated software consisted in simulating one-dimensional (1D) and two-dimensional (2D - QUASI 2D) models on the water courses analyzed in the current catchment area. To generate the flood maps MIKE Flood (DHI) and ArcGIS were used.

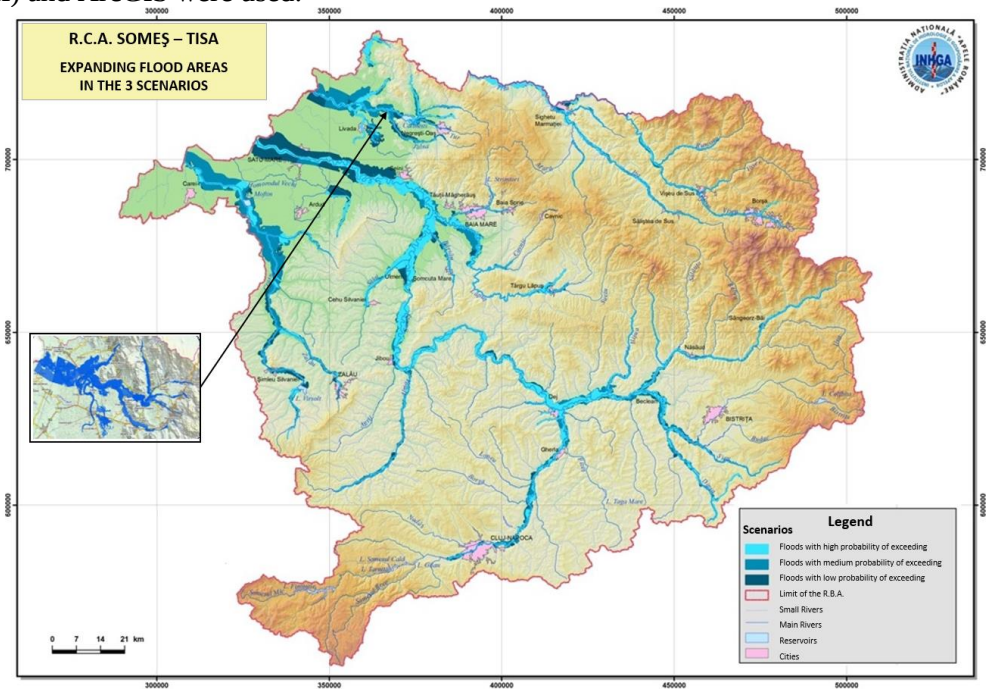

Figure 3. Flood Hazard Map

Someş - Tisa River Catchment Administration made hazard maps for a length of waterways measuring 7837 km, of which 37 areas in total length of 1519 km, declared as areas with serious potential risk to flooding within the first cycle of implementing Floods Directive (submitted to E.C. - March 2012), benefiting from the hazard maps made under the program mentioned above. The hazard maps submitted to the European Commission are covering river sectors with a total length of 1519 km.

The hazard map is divided 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). To assess the flood risk in the first round of reporting Directive 2007/60/EC, there has been opted for a qualitative assessment of the flood risk, which involved identifying risk receptors and then assessing vulnerability of the identified objectives and their flood risk taking into account water depth and the potential damage to flooded objectives, namely the impact on the considered risk receptors.

The first two steps mentioned above have been completed and reported to the European Commission for all River Catchment Administrations.

- ***Flood Risk Management Plan Elaboration***

Romania reported within due time, deadline required by the European Commission (22.03.2016) along other 13 Member States (out of 28 MS) the third stage of Floods Directive 2007/60/EC, namely the Flood Risk Management Plans for all River Catchment Administrations.

In order to define the most suitable measures, the Catalogue of Potential Measures was designed at national level (Metodologia – cadru, I.N.H.G.A., 2015). The proposed potential measures aim at the five areas of action that are closely related to the flood risk management cycle: Prevention, Protection, Awareness, Preparedness and Recovery.

There are 23 types of measures proposed and for each type of measure examples are provided (the list is not exhaustive).

3 RESULTS AND DISCUSSION

An important aspect is connected with the fact that measures (indicated in the Catalogue of Potential Measures) are classified into three categories, according to the application level respectively, measures being

implemented at national level, catchment area level (River Catchment Administration) and A.P.S.F.R. level (local).

3.1 Applicable measures at national level

The measures implemented at national level, are applicable in each River Catchment Administration being a key point in building a good organizational framework for achieving integrated flood risk management, a very important objective which depends on the involvement of all partners and the efficient use of available resources.

3.2 Applicable measures at Someş - Tisa River Catchment Administration level

For all 37 APSFR areas declared at Someş - Tisa River Catchment Administration, in the first implementation stage of Directive 2007/60/EC, were identified flood risk reduction measures, according to the Framework Methodology (Metodologie – cadru, I.N.H.G.A., 2015) for developing the Flood Risk Management Plans for all 11 River Catchment Administrations.

As a result of the above considerations, the most important types of measures proposed to reduce flood risk in Someş – Tisa River catchment area, it summarises as follows:

- RO_M04-4 – Watercourse banks rehabilitation (vegetative protection): 33 measures proposed;
- RO_M08-3 - Increased conveyance through local works of unsilting and bed reprofilation: 28 measures proposed;
- RO_M09-2 – Build new, nonpermanent, small reservoirs: 18 measures proposed;
- RO_M10-1 – Increasing the safety of existing hydraulic structures (rehabilitation: modernization, measures to limit infiltrations etc.): 9 measures proposed;
- RO_M11-3 – River bed stabilisation measures – river bed recalibration, parapets, retaining walls, bank defenses: 33 measures proposed;
- RO_M13-4 – Watercourses bed maintenance and bottlenecks, obstacles removals: 38 measures proposed.

3.3 Proposed measures for the area with significant flood risk potential on Tur River downstream from Negreşti – Oaș

To minimize the flood risk on Tur River and its tributaries downstream from Negrești-Oaș 25 measures were proposed 9 non-structural measures and 12 structural measures, supplemented by 4 additional measures (Planul de Management al Riscului la Inundaţii, Administraţia Bazinală de Apă Someş - Tisa, 2016).

The most relevant measures proposed to reduce flood risk in this sector are:

- *creating new wetlands* (RO_M04-1) to increase flood wave mitigation and transit capacity.
- *reconnecting and restoring floodplain* (RO_M04-2) - increased capacity to mitigate and transit the flood - restoration of Tur river floodplain, downstream Călinești - Oaș reservoir, near its confluence with Turţ River.
- *return to nature watercourse banks (vegetative protection)* (RO_M04-4) applies in areas with active erosion by environmentally friendly paper, made from its own resources and consists of planting willow cuttings, furrows and grids. Through these works it pursues a dual effect: renaturation banks and stabilize them.
- *watercourses bed maintenance and bottlenecks, obstacles removals* (RO_M13-4) in areas where leakage is reduced section and increases roughness of the riverbed, through works of the riverbed by removing bottlenecks aims to increase transit capacity flood flows by increasing the drainage section, reducing roughness and development of hydraulic unclogging.
- due to the strong torrential characteristic of most natural watercourses found in Someş - Tisa River catchment dynamic river beds are encountered, with frequent changes of its being necessary works to reduce erosion, stabilise the riverbeds both for direct defence of banks and riparian objectives and to ensure the flow in the river and the safety of existing buildings that achieve flood protection is assured, there has been identified *river bed stabilisation measures – river bed recalibration, parapets, retaining walls, bank defenses* (RO_M11-3).
- *building new polders and ensuring the functionality of existing polders* (RO_M09-1):
  - Tur River polder, right bank, upstream Turt River confluence;

- Tur River polder, left bank, upstream Talna River confluence.

- *build new, nonpermanent, small reservoirs* (RO_M09-2):
  - Negreşti reservoir on Tur River, upstream Negreşti - Oaş;
  - Valea Rea reservoir, upstream from Huta - Certeze;
  - Brada reservoir on Talna Mare River;
  - Talna Mica reservoir;
  - Turţ reservoir, upstream Turţ.
- *to secure Calinesti-Oaş dam* (RO_M09-2), as justified by:
  - changes in the characteristics of flood waves from commissioning due to changes in land use, deforestation and due to climate change;
  - implementation of the National Strategy for flood risk management in the medium and long term (H.G. nr. 846 din 2010) for changes in the annual probability of exceedance for computed discharges of flood defense works.
- proposing an Integrated Project Plan for Tur River, downstream from Negreşti - Oaş, including tributaries, Satu Mare county that encompasses all measures proposed for this area with significant potential flood risk.

The existing and proposed works for Tur River are found in Figure 4.

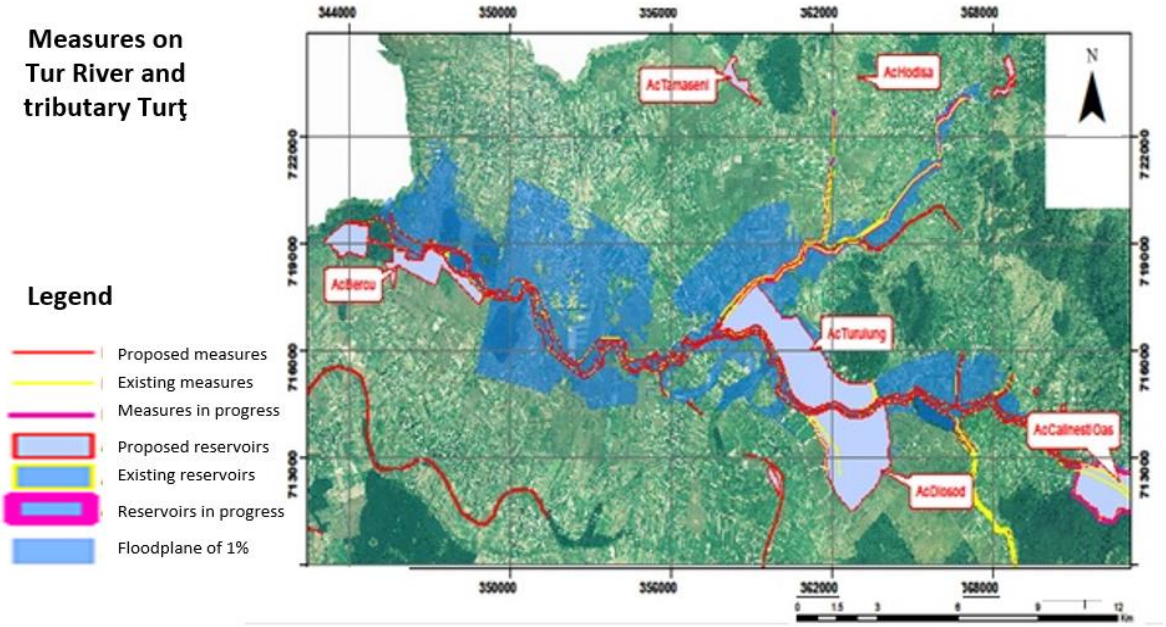

Figure 4. Map with the existing and proposed works for Tur River

3.4 Proposed measures prioritization

Prioritization of the different types of necessary works for flood risk management in the river catchment and, especially for a sector with serious potential risk from flooding as Tur River is, was not a simple operation and a multi-criteria analysis was required, based on a uniform methodology not only at river basin level, but at national level. (Metodologia de prioritizare, I.N.H.G.A., 2015).

The prioritization degree of the proposed works was quantified on a benefits score / cost score report, on which a ranking of these works was done, in small, medium and high priority classes.

To identify the major projects, given the large investment compared to available funding, prioritization included the following mandatory criterias:

- Population falling under the risk;
- Location of the project in areas with massive incidence risk;
- The possible economic damage;
- The positive effect integrated project.

Thus, in each sector with serious potential risk from flooding, an analysis was done of the main communitites or groups of communities potentially affected, situated in the 1% flooding band, based on a nationally defined criteria, taking into account the potentially affected population (at least 150 inhabitants

potentially affected per community) and the main measures of significant flood risk reduction (the most relevant measures in terms of flood risk reduction) in those areas. This analysis took shape in the form of a matrix that provides a qualitative view of the main communitites / groups of communities defended (in terms of the number of inhabitants potentially affected) and the most significant / effective measures (structural measures - hard and soft, significant in terms of their effect).

3.5 Public information and consultation

According to Floods Directive requirements (Articles 9 and 10, Annex - A.II.2) a series of steps were taken for informing the public and consulting them to encourage the active involvement of stakeholders in Flood Risk Management Plan development:

- national level (national coverage, including at central level)
- catchment area level (river catchment and Basin Committees level)
- local and county level (the counties, municipalities, towns which are subject to risks and can be affected by the negative effects of floods).

These actions were aimed at both preliminary activities, taken upon the development of FRMP through the Communication Plan at river catchment level, but also throughout its drafting through regular briefings, working methodology presentations, fixed information points, consultations, distributing and disseminating questionnaires, regular meetings, posting regular process of drafting on Someş-Tisa River Catchment Administration website, press releases etc.

4 CONCLUSIONS

Romania, generally, and Someş-Tisa River Catchment Administration in particular, have been hit by devastating floods in recent times. In 2005, 2006, 2008, 2010 and 2014 have been widespread catastrophic floods.

According to a national methodological approach, the next objectives were followed in Someş-Tisa River F.R.M.P. development: (Metodologie – cadru, I.N.H.G.A., 2015)

- Avoid / prevent new risks;
- Reduce the risks;
- Increasing resilience;
- Public awareness.

This approach allowed not only to establish the set of measures and work necessary for flood risk management within Someş- Tisa River Catchment, but also as a case study for a sector with significant flood risk potential, on Tur River, and their prioritizing and ranking.

Monitoring the national measures and their overall coordination will be developed by the ministries with competencies in flood risk management, with annual reporting to the Ministerial Water Council. The measures applicable at Someş – Tisa River Catchment Administration and at the Areas with Potential Significant Flood Risk (APSFR) levels will be monitored under National Administration „Romanian Waters" / River Catchmen Administration with annual reporting to Ministry of Environment, Forestry and Waters and within the Catchmen Committees.

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