Annals of the Academy of Romanian Scientists
Series on Engineering Sciences
ISSN 2066 - 8570 Volume **4**, Number **1/2012**

ASSESSMENT OF DIRECT OR POTENTIAL PERCENTAGE DAMAGES AFTER FLOODS

Lorand Catalin STOENESCU[1]

Rezumat. *Identificarea infrastructurii critice în domeniul apelor şi hărţile de risc la inundaţii pentru managementul bazinelor hidrografice au în componenţa lor valoarea pagubelor directe şi potenţiale ce se pot înregistra la producerea unor inundaţii majore. În prezent această componentă este evaluată prin metode aproximative care prin aplicarea pe suprafeţe mari dau rezultate suficient de imprecise pentru a conduce la luarea unor decizii sub sau supraevaluate. La nivel naţional se impune a fi utilizată o metodă de evaluare individuală a pagubelor procentuale în special datorită eterogenităţii utilizării suprafeţelor de teren. Astfel, evaluarea pagubelor se face pentru fiecare obiectiv social-economic în parte iar rezultatele obţinute sunt mult mai precise decât prin metodele actuale.*

Abstract. *Identification of critical infrastructure in water sector and flood risk maps for watershed management is composed of direct value and potential damage that can occur after major floods. Currently, this component is evaluated through approximate methods which are applied to large areas can generate sufficiently vague results that leads to under or overestimated decisions. At national level it must be used a method of individual assessment of percentage damage mainly due to heterogeneity of land use areas. Thus, damage assessment is made for each of the socio-economic objective and the results are more accurate than current methods.*

Keywords: risk maps, potential damage, damage assessment, flood effects

1. Introduction

Floods are natural phenomena caused by excessive rain or melting snow and manifest by sudden discharge overflowing the banks of the watercourse and destruction. The process of flood wave propagation involves turbulence and transport phenomena (depending on water level and velocity can be driven by concrete blocks, rocks, tree trunks, cars, etc.) who have a severe impact on things along the way.

Most often, the impact is a negative one because socio-economic objectives, systematic land, harvests (if flooding occurs during the harvest season), social activities etc. are destroyed. Further development of communities of people and concentration of a number of increasingly large populations in urban areas, especially those located near rivers, are making the need for flood protection to determine the development of novel solutions and implementation of long life structural measures.

[1]Ph.D. Eng., Technical University of Civil Engineering of Bucharest, Hydrotechnical Department, (catalin_l_81@yahoo.com).

These decisions will be taken after a techno-economic analysis which, in addition to effective technical solution, will take into account the impact of measures on the area.

One of the crucial components of this impact is the financial value of damage avoided through the implementation of structural measures.

The more objective this values is approximated, structural measures will be scaled to actual requirement of the area, so economic efficiency is calculated without the intervention of the subjective factors that can influence the decision of investment value for obscure purposes.

2. The negative effects of flooding

Negative effects of flooding can be grouped into three broad categories: social effects, environmental effects and economic effects (see fig. 1).

Fig. 1. Flood effects on communities.

Social effects include:

- the potential for casualties;
- the need for evacuation of population for short or long term;

- state of panic among the population created by the flooding;
- development of outbreaks of epidemics in affected areas;
- interruption of the educational process;
- destruction of cultural values of the affected community;
- isolation or shortness of food and water supply ;
- decrease in investor interest in these areas and hence the rate of development of affected areas etc.

The ecological effects are given negative impact on the environment or food chain termination. The effects can be:

- pollution of water or affected lands;
- persistence of excess moisture;
- deposit of alluvial excess material on the affected lands;
- the occurrence of landslides;
- changing flooded areas biotope etc.

Negative economic effects are expressed by the damage that can be made direct or indirect.

Direct damages are represented by the value of destructions or damage caused to objectives cumulated with the expenses in the amount of flood operations.

Among them we can mention:

- loss or damage to buildings;
- loss or damage to the industrial and agricultural objectives;
- impairment of communication lines, telecommunication and power lines;
- breakage or damage to oil, gas or water pipeline networks;
- destruction of hydro facilities;
- loss of animals and birds etc.

Indirect damages, represented by the unrealized goods value because of flooding, delays in delivering products to the contractual terms, of the health care expenditure, expenditure on transport costs and additional damage costs for objectives restoration, can be:

- disruption of production processes;
- expenditure incurred to defend against floods;
- transport delay;
- expenses for the normalization of life after accidental flooding;
- cost of property insurance;
- additional transport costs and so on.

Table 1 lists some of the most significant adverse effects recorded after flood in terms of damage and casualties recorded in the world of all time.

Table 1. Some of the more Significant Floods – Damages and Human Casualties

Date	*Country/Region*	*Total Losses (US$-M)*	*Deaths*
1421	Holland	-	100,000
1530	Holland	-	400,000
1642	China	-	300,000
1887	Yellow River, China	-	900,000
1900	Galveston, Texas, USA	-	5,000
1911	Yangtze River, China	-	100,000
1931	Yangtze River, China	-	145,000
1935	Yangtze River, China	-	142,000
Jun.-Sept. 1998	India, Bangladesh, Nepal	5,020	4,750
May-Sept. 1998	China	30,000	4,100
Oct.-Dec. 1997	Somalia	-	1,800
Jul.-Aug. 1997	Europe	5,900	110
Jun.-Aug. 1996	China	24,000	3,048
Jul.-Aug. 1995	North Korea	15,000	68
Jan.-Feb. 1995	Europe	3,500	28
3-10 Jan. 1995	USA	1,800	11
4-6 Nov. 1994	Italy	9,300	64
20-31 Dec. 1993	Europe	2,000	14
20-28 Sept. 1993	Europe	1,500	16
Jun.-Aug. 1993	USA (Mississippi)	16,000	45
Jun.-Sept. 1993	China	11,000	3,300
Sept.-Oct. 1992	India	1,000	1,500
May-Sept. 1991	China	15,000	3,074

3. Evaluation of direct or potential damages currently

Currently, at world level, methods to assess damage are developed by different institutes in water sector. Direct damage assessment takes into account the recorded post-disaster damage inventory (an example is the table above), while assessing the potential damages is made based on „stage-damage” curves (see fig. 2).

Approximations introduced in the two processes are evident and can now be considered relatively accurate because:

- for post-disaster assessment, the human factor is responsible for the said amount of loss percentage in time of valuation. Without the existence of an initial inventory of existing securities and real estate in one household, may introduce bias in assessing the economic value calculations to generate unjustified investment reality;

- ”stage-damage” curves can also introduce under or overvalued results, because the method relies on the existence of flood studies according to which, as criteria, damages are assessed by groups of water heights. Then, each objective identified in a specific area is assigned a percentage of loss multiplied by the market value which will give a value corresponding indemnity. But socio-economic objectives have not a homogenity of assessments to determine the correspondence with reality. Especially in areas with high heterogeneity,

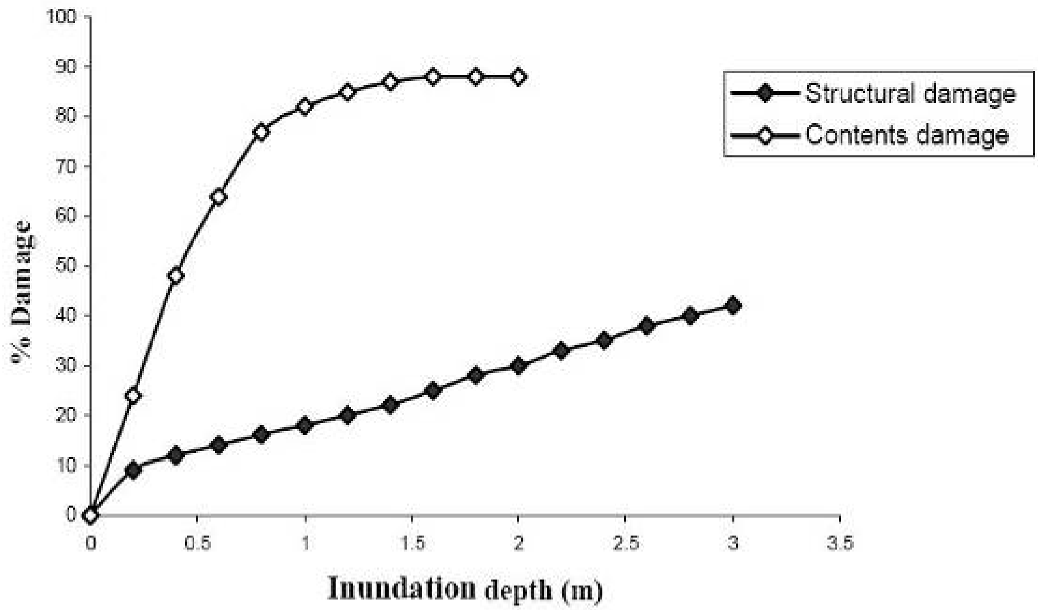

Fig. 2. Stage-damage functions for structures and contents.

British system of direct or potential damage assessment is based on curves given by the product of water depth and velocity in a point. Depending on the value of this product there are three categories of damage (see fig. 3):

- total destruction;
- partial destruction and
- solely due to flood damage.

Total destruction is recorded at speeds > 2 m/s and product $d \times v$ > 7m^2/s. Partial destruction fall into the category speeds > 2 m/s and $d \times v$ product within 3-7 m^2/s, and damage due to flooding takes effect only if the speed is < 2m/s and product $d \times v$ < 3 m/s.

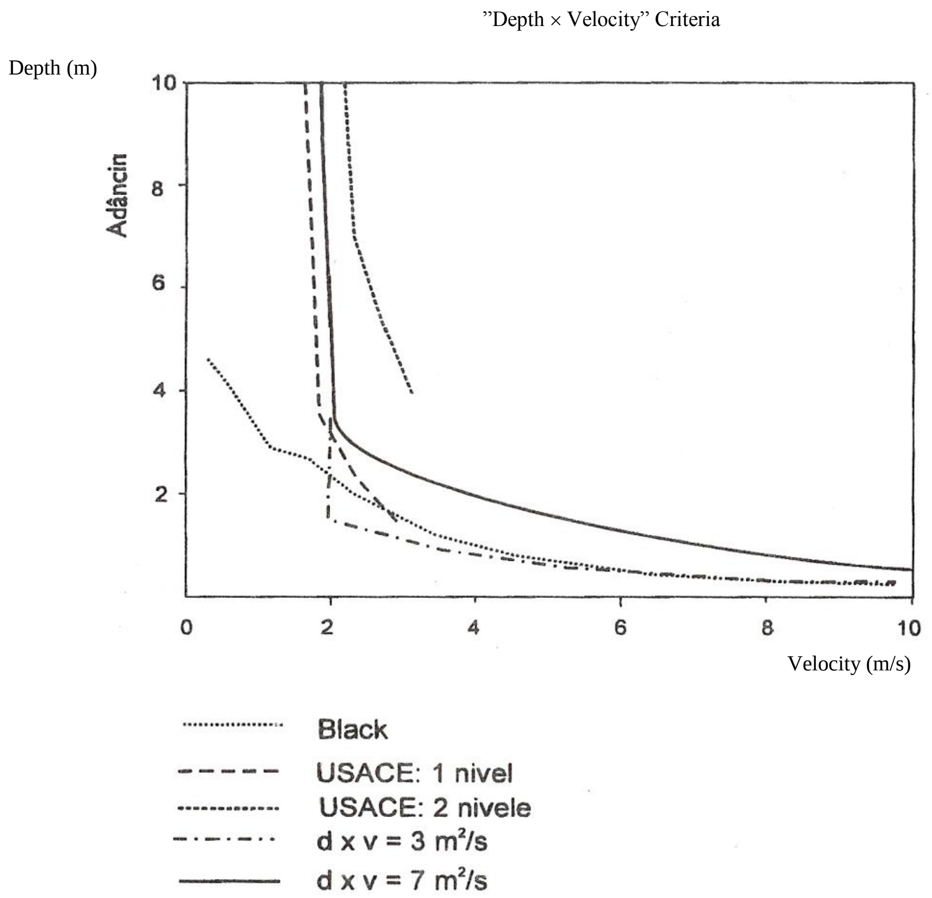

Fig. 3. Delimitation of flooded areas by ”d × v” product.

Using these curves has the main assumption on the homogeneity of socio-economic objectives on relatively flat land.

However, in developed areas without a long term vision and where owners could build any type of construction, the assessment methodology does not give satisfactory results.

An example of this are many cities in Romania, situated along water courses where the application of such methodologies would be in vain. The degree of destruction is different for two nearby buildings but with different structures and number of levels on the same level of flood.

In such cases, for a correct assessment, flood's impact should be calculated for each socio-economical objective basis. Computers today allow development of applications to process a large number of operations, so the challenge for engineers and programmers is launched.

4. A method of individually evaluation of direct or potential damage percentage assessment

European Directive on water policy calls for beneficiaries/directors involved carrying out flood risk maps and other natural phenomena. This implies that the Romanian authorities carrying out the potential damage from floods with different probabilities of exceedance for each river basin basis.

The current data are summary records made by local and National Administration "Romanian Waters" after the occurrence of floods. As mentioned above, there is a certain bias cannot be controlled in such cases. In any case, these data are relatively small, in most towns on the rivers there are no reliable reports and ratings.

This lack of a good database developed and maintained cause damage assessment for risk maps to be sufficiently laborious.

A comprehensive evaluation method customized at national or basinal level is the one called “method of individual assessment of the damage percentage”. This consists of the following steps:

1. Identification and categorization of each building in the flood zone, depending on destination and type of structure;
2. Determining ground floor level based on land data;
3. Interpolation of "water depth x velocity" curves with collapse functions of each construction;
4. Assessment of percentage of damage;
5. Creation of a centralize database containing damages depending on the percentage of destruction or responsible authority needs.

The first step is very laborious, which consists primarily in setting the criteria for classification of buildings. After establishing these criteria, can be made assumptions about the value of household assets that can be expressed as a percentage of building replacement value.

This is one of the most important steps to achieve the assessment, the degree of detail of the database being linked to the accuracy of the final evaluation.

For example, the database can be achieved by: use of buildings, height class, type of construction material that is made etc. (see fig. 4).

The second step involves the existence of field data or, failing that, the aerophoto, topographic maps, etc. Based on them, "zero level" of the building will be established, to which the response of the construction to the impact of water is linked.

Interpolation of "water depth x velocity" curves with collapse functions lies primarily in the existence of collapse curves for classes of buildings. In our country there are no such curves, for which they have to be realised through field and laboratory studies.

Fig. 4. Classification of socio-economical objectives based on data-base.

Globally, collapse curves problem is developed in the U.S. by USACE (United States Army Corps of Engineers), but, of course, for their types of existing structures. In figure 5 some collapse curves of concrete structures up to three levels are presented.

Each curve represents the limit of 100% damage. If d x v product is below the curve, the impact can be interpolated in the range of 0% -99%. If the product exceeds the curve, the impact is 100%.

Such curves can be determined in Romania also, the parameters of which depend on being available from two-dimensional hydrodynamic modeling: water depth, water velocity, total time of the flooding, alluvial material load factor during the flood.

Information obtained so far constitute the input data for *assessment of percentage of damage*. Effective use of this information leads to the standardization of damage ranges from values of 10, 25 or 50 percent. In flood affected areas results may be processed such as those presented in Fig. 6.

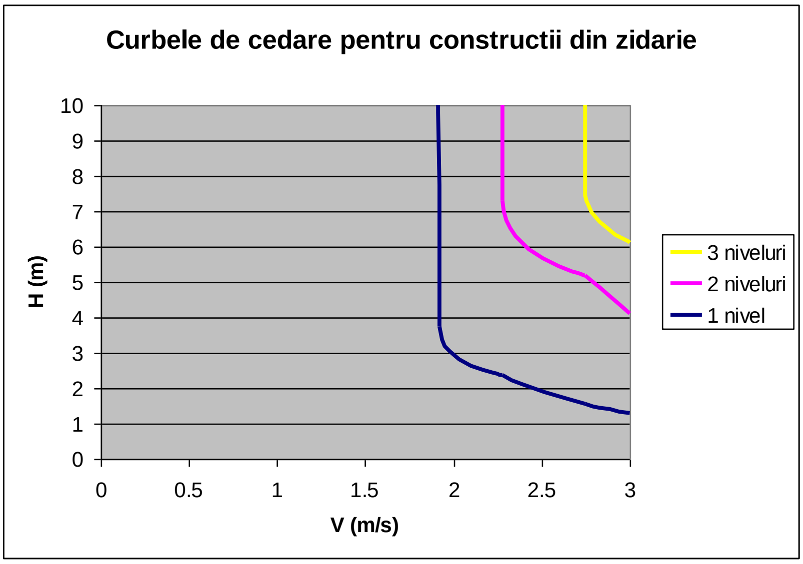

Fig. 5. Collapse curves for concrete structures.

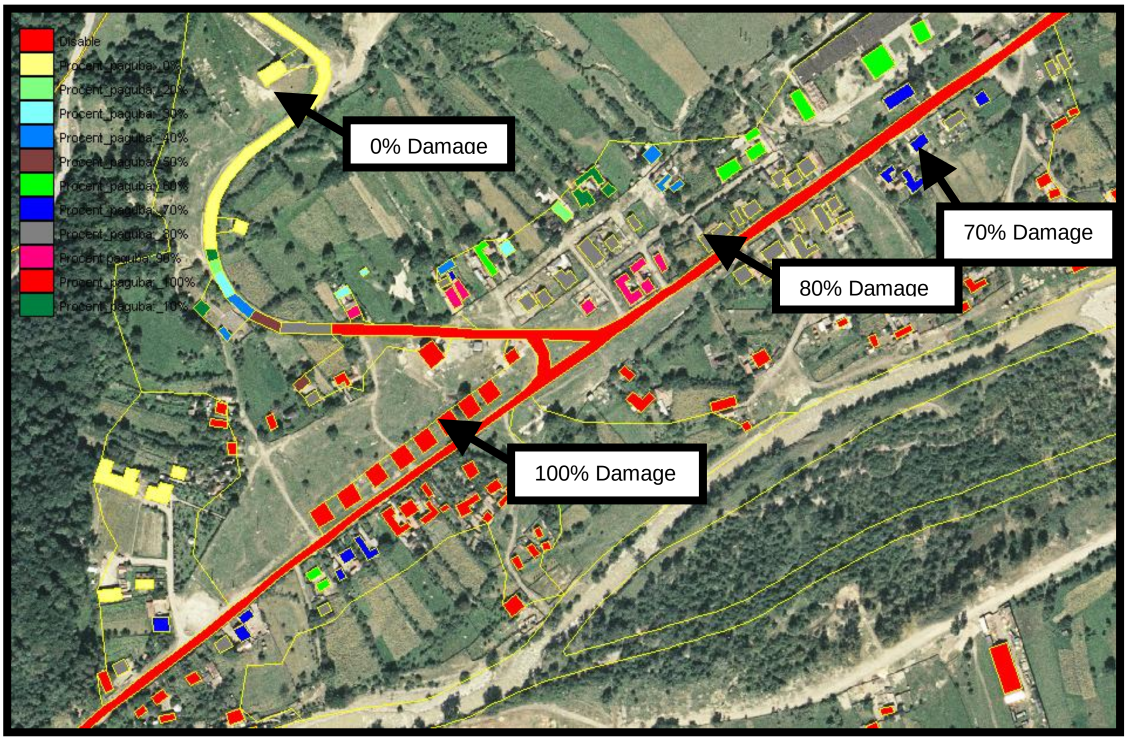

Fig. 6. Identification of individual damage percent for each structure.

The fifth step centralizes the obtained results. Their centralization is based on the criteria set by the beneficiary authority and can have the form presented in table nr. 2.

Table 2. Example of damage percent centralization after an accidental flood

Nr. Crt.	Folosinta	Numar total inainte de accident	Afectat in proportie de (%)										
			100	90	80	70	60	50	40	30	20	10	0
1	Biserica;_2_niveluri;_lemn	1	-	-	-	-	-	-	-	-	-	-	1
2	Centru_de_distractie_si_recreere;_1_nivel;_beton/zidarie	6	3	-	-	-	-	-	-	-	-	-	3
3	Centru_de_distractie_si_recreere;_2_niveluri;_beton/zidarie	1	1	-	-	-	-	-	-	-	-	-	-
4	Gradinita;_1_nivel;_beton/zidarie	1	-	-	1	-	-	-	-	-	-	-	-
5	Industria_grea;_1_nivel;_beton/zidarie	6	1	-	-	-	-	5	-	-	-	-	-
6	Industria_grea;_1_nivel;_lemn	11	10	1	-	-	-	-	-	-	-	-	-
7	Industria_grea;_1_nivel;_metal	9	6	-	-	3	-	-	-	-	-	-	-
8	Industria_grea;_2_niveluri;_beton/zidarie	1	-	-	-	-	1	-	-	-	-	-	-
9	Locuinta_unifamiliala;_1_nivel;_beton/zidarie	125	19	17	35	16	14	11	5	-	6	-	2
10	Locuinta_unifamiliala;_1_nivel;_clasic	120	88		2		3	3	2	-	13	1	8
11	Locuinta_unifamiliala;_1_nivel;_lemn	67	22	3	5	3	4	1	1	10	4	12	2
12	Locuinta_unifamiliala;_1_nivel_cu_fundatie;_beton/zidarie	4	4	-	-	-	-	-	-	-	-	-	-
13	Locuinta_unifamiliala;_1_nivel_cu_fundatie;_lemn	6	6	-	-	-	-	-	-	-	-	-	-
14	Locuinta_unifamiliala;_2_niveluri;_beton/zidarie	4	1	-	-	-	-	1	-	1	-	1	-
15	Locuinta_unifamiliala;_2_niveluri;_lemn	1	1	-	-	-	-	-	-	-	-	-	-
16	Locuinta_unifamiliala;_2_niveluri_cu_fundatie;_beton/zidarie	6	-	-	1	-	-	4	-	-	-	-	1
17	Magazin_mixt;_1_nivel;_beton/zidarie	2	1	-	-	1	-	-	-	-	-	-	-
18	Scoala_1-8;_1_nivel;_beton/zidarie	1	-	-	1	-	-	-	-	-	-	-	-
	TOTAL	372	163	21	45	23	22	25	8	11	23	14	17

The damage percentage so calculated, financial compensation can be find out (for insurance) by multiplying the replacement value of objective with the recorded percentage of loss.

This is very simple to assess the risk to a community that is subject to flooding with different insurance: multiplying the probability of flood occuring by the amount of flood damage recorded.

Conclusions

Flood risk maps are a requirement of the European Community that must be completed with maximum results until 2013.

Their development requires an institutional collaboration between government, the implementation authority and companies involved in elaboration of flood management plans.

One of the components of risk refers to the damage caused by a natural exceptional event.

Currently, assessment of such damage is quite approximate, methodologies based on the introduction of homogeneous features on large areas of land being available.

These methodologies can be improved by creating an individual account for each part of the socio-economic objective.

The method of individual assessment of the damage percentage is making an individually approach of damages, taking each objective separately and calculating the degree of destruction from the simulated event.

The degree of destruction being a percentage of the replacement value of the objective can be easily calculated monetary value of damage recorded in the production of the event.

Using such a method, subjectivity of persons involved in direct or potential damage assessment can be avoided.

The condition for applying the method subjectivity to be removed is the involved database methodology to be quite detailed as to provide information for analyzing the behavior of a large number of objectives with different characteristics.

In this way the collapse curves are created for as many types of objectives and do not require extrapolation of a limited amount of data, process that involves assuming of some errors.

R E F E R E N C E S

[1] Stoenescu L.C., *Contributions to evaluation of damages resulted from flooding caused by dam failure* (Ph.D. Thesis, U.T.C.B, Bucharest, Romania, **2009**).

[2] World Meteorological Organization, Global Water Partnership, *Conducting Flood Loss Assessments. A Tool for Integrated Flood Management* (The Associated Programme on Flood Management, **2007**).

[3] Stematiu D., Ionescu St., *Risk and Safety in Hydrotechnical Constructions* (Ed. Didactica si Pedagogică, Bucuresti, Romania, **1999**).

[4] Rosu C., Cretu G., *Accidental Floods* (H.G.A. Ed., Bucuresti, Romania, **1998**).

[5] Drobot R., Stanescu V. Al., *Masuri Nestructurale de Gestiune a Inundatiilor* (H.G.A. Ed., Bucuresti, Romania, **2002**).

[6] Schawthorn C., Flores P., Blais N., Seligson H., Tate E., Chang S., Mifflin E., Thomas W., Murphy J., Jones C., Lawerence M., *HAZUS-MH Flood Loss Estimation Methodology. II. Damage and Loss Assessment* (Natural Hazards Review, ASCE, **2006**).