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FLOOD RISK MANAGEMENT PROFILE. A CASE-STUDY OF STRUCTURAL MEASURES AND COMMUNICATION TOOLS DEVELOPMENT

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Abstract

Hydrometeorological hazards, flood and drought especially, stand nowadays as some of the most frequent and disturbing danger phenomena. Flood risk management and flood risk communication are key terms in dealing with floods in our century, as we have been facing major flood events with massive damage in recent years. Flood risk communication with authorities and population at risk is getting increasingly important for flood risk management, especially as a precautionary measure. Besides the build environment, all stakeholders need education and organization adapted to their own social and economic particular features. For the Romanian territory, the historical 2006 spring flood was one of the most important and the starting point of unprecedented legislative, research and operative projects.This study aimed at gaining insight into the perception of flood risks along the Danube within the Dolj County. It is conducted ten years after this key moment and it focuses on the territorial administrative units located along the Danube, in Dolj County. The research starts from the examination of present flood management strategies and it discusses their understanding and effectiveness in decreasing flood damage and evaluation of flood resilience. Besides the technical and statistical analysis, a social survey conducted within the rural communities of the area aimed at assessing the relevance of communication tools and means implemented for the key stakeholders and at obtaining information on knowledge and perception of risk in a rural flooding area. As such, the authors identified certain levels at which change may be integrated in flood risk communication, as part of increasing the overall coping capacity.

Keywords: Danube floodplain, Dolj County, flood risk management, local development

1 INTRODUCTION

1.1. Flood risk management

Risk management is oriented towards "a systematic approach and uncertainty management practices in order to minimize potential loss and prejudice" (2013 UNISDR). Present-day preventative flood risk management is aimed at fully controlling floods, mainly through technical measures such as embankments. However, there is growing awareness that this strategy may cause fundamentally unpredictable flooding in cases of discharge above the design capacity (Blackwell and Maltby 2006).

Preventive measures for flood risk reduction include flood control, spatial planning and raising awareness. Technical measures are, for example, the construction of dams, embankments and river channel normalisation, while natural flood defence measures are directed at enlarging the resilience of the river floodplain system (Blackwell and Maltby 2006). In order to ensure that multiple benefits of such an integrated river basin management are achievable in the most effective way, a holistic approach comprising a mixture of structural and non-structural measures is required (Kundzewicz and Menzel 2005; Scheuer et al., 2010 quoted by Shober et al., 2015).

Flood risk management and flood risk communication are key words in dealing with floods in our century, as we have been facing major flood events with massive damage during the last decades (Hagemeier-Klose and Wagner 2009). Flood risk management includes three main aspects; precaution, coping, and recovering (Kienholz and Krummenacher 1995). In this context, precaution is the most effective protection against flood damages. Flood risk communication is used to inform the population about flood risks, flood protection, and personal safety measures. Risk communication is defined as an interactive information exchange between individuals, groups or institutions, about the nature of risks, risk related opinions, anxieties and coping strategies (Wiedemann and Mertens 2005 quoted by Hagemeier-Klose and Wagner 2009). Risk communication is closely linked to risk perception, as only perceived risks are

communicated and communication influences the perception of risks. Moreover, risk communication plays a significant role within risk management (Hagemeier-Klose and Wagner 2009).

Flood risk management strategies must provide an acceptable balance between the restriction imposed by flood risk reduction measures and the conditions needed for economic, social and environmental development in areas at risk of flooding (Blackwell and Maltby 2006). Keating et al. (2017) present a framework and tool for measuring community level resilience to flooding. Questionnaires can be used to reveal information on public knowledge, attitude, perception, experience and preparedness levels in relation to natural hazards. When this information is combined through a mixed methods approach, robust results can be obtained, which are both comprehensive and quantifiable, adding an invaluable perspective to the development of appropriate risk mitigation and adaptation strategies (Bird 2009).

In recent years, the concepts of *vulnerability* and *resilience* have (again) become popular in environmental hazard and risk management (Fuchs et al., 2017). According to UNISDR (2009), resilience stands for the ability of a community or society that is exposed to hazards to resist, absorb, adjust and recover in a rapid and efficient manner after a crisis. In recent years, an increased number of studies have been conducted in connection to adaptive governance, co-management and resilience, community resilience to natural hazards and disasters, and social vulnerability to hazards. It can be stated that community resilience arises from four main sets of adaptive capacities, i.e. economic development, social capital, information and communication, and community competence (Norris et al., 2008).

Dressler et al. (2016) approach the challenge of demographic transitions with an ageing society, frequent out-migration and low birth rates in disaster risk management. They discuss how such population dynamics affect the performance of rescue services and how in particular rural areas are less resilient in terms of management performance. This is particularly the context of the present study area.

As most low and middle income economies significantly rely on agriculture, there is a numerous population exposed to multi-hazard risk (large vulnerable age groups, poor population that lacks access to various resources, including information, knowledge and technology (Cutter 2003), the accomplishment of this goal – collective resilience – being a major challenge in real terms.

Romania is an ICPDR member since 1995, when the *Convention on Co-operation for the Protection and Sustainable Use of the River Danube* was ratified through the *Law No. 14/1995*. In 2002, the *International Commission for the Protection of the Danube River* decided to establish the *Action Programme on Sustainable Flood Protection in the Danube River Basin*, the general goal of this action framework being the achievement of a long-term and sustainable approach for flood risk management in order to protect people and their property, while encouraging conservation and improvement of water related ecosystems. The *Danube Declaration*, adopted in 2010, states once more that the prevention and protection against floods represents a high-priority long-term action and it commits to concentrate all efforts for the implementation of the *Floods Directive* (60/2007/CEE) at the level of the Danube, as well as for the achievement of a *Flood Risk Management Plan for the Danube River Basin* in 2015.

The aim of this study is to highlight the role structural measures and communication tools in the flood risk management within the Danube floodplain, Dolj County (Romania), as a premise of sustainable development.

1.2. Study area

In most of the large river systems worldwide, a tremendous reduction of floodplain area has occurred in the last 100 years and this loss continues due to pressures such as land use change, river regulation, and dam construction. In the Danube River Basin, the extent of floodplains has been reduced by 68% compared to their pre-regulation area (Hein et al., 2016).

The Romanian Danube Floodplain covers a surface of ca. 530.5 thousand hectares between Gruia (downstream *Iron Gates II*) – kilometre 851 and Isaccea – kilometre 108 (*PMRI Dunăre* 2015). Within the Dolj County, the floodplain of the Danube and of its main tributaries extends on a surface of about 83,000 hectares, although the area analysed in the present paper is almost double (i.e. ca 173,000 hectares) and it corresponds to the level of the nineteen territorial-administrative units (TAUs) located along the Danube (Figure 1).

No settlement is situated in the floodplain proper, but a chain of villages of average and large demographic size (as classified in the Romanian literature) border the northern floodplain – terrace contact (Licurici 2011). As the area is a profoundly rural one, with extended agricultural terrains (the arable fields register 65% of the total surface) and almost no industry, people and cultivated land or agricultural assets are the most important elements at risk (Ionuș et al., 2015).

Both historical evidence and more recent scientific evidence suggest the fact that the area under study was subject to various forms of human-induced stress, but its level was maintained at very low levels

at least until two centuries ago, when cereal cultivation becomes extended on the great river terraces. At the narrower space of the floodplain proper, a significant human footprint is to be noticed during the last half of century, when the most extended environmental transformations take place, being induced by the construction of cascade dammed precincts, of a complex network of canals, and by the important changes occurred within the land use and land cover system, with the extension of agricultural surfaces. In the framework of the important post-communist socio-economic transformations, to which the significant local effects of the global climatic changes are to be added, local communities have been severely exposed to two risk phenomena that seem paradoxically opposed: drought and flood.

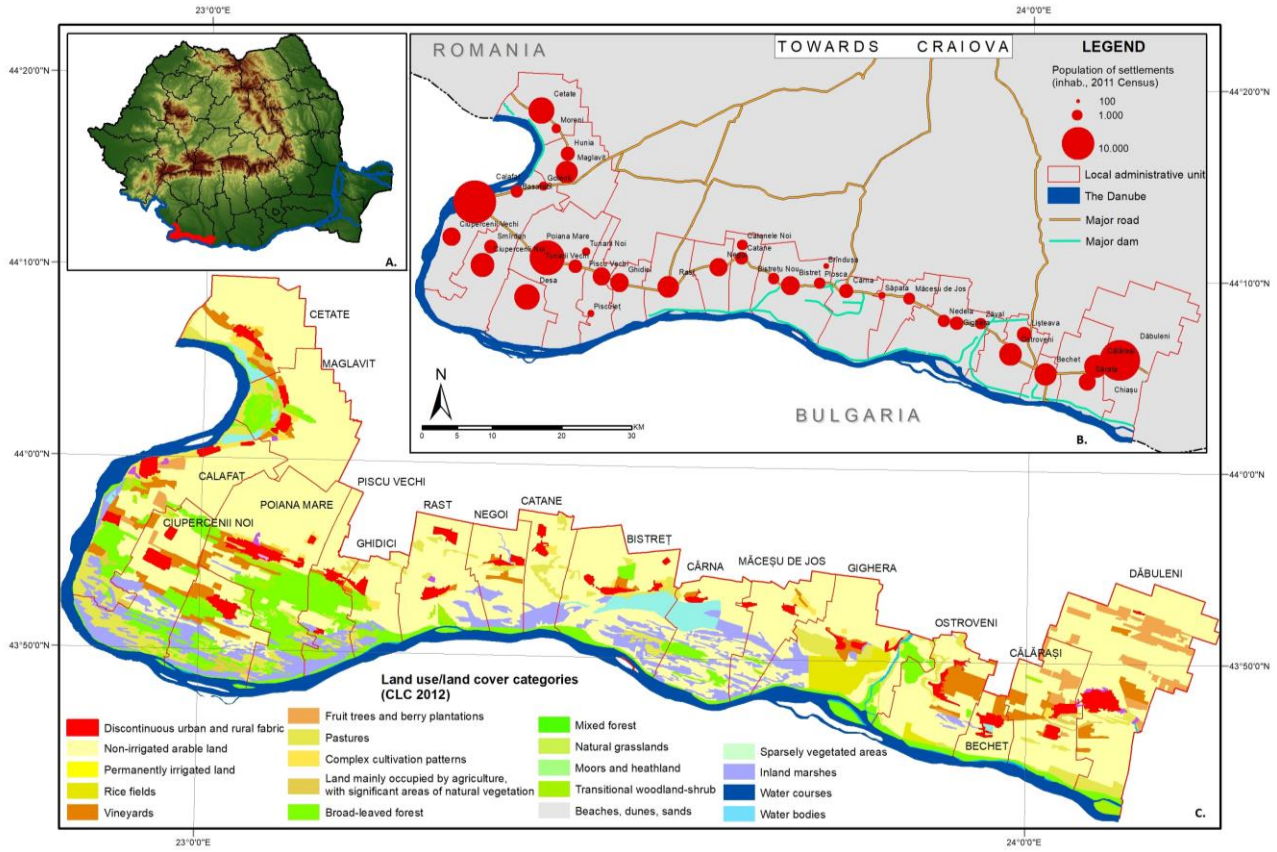

Figure 1. Location and main characteristics of the study area: A. Location in Romania, B. Main demographic and accessibility features, C. Land use and land cover features (Source of the processed data: www.insse.ro, www.geo-spatial.org, www.land.copernicus.eu)

For the small local owners, it can be stated that the inadequate land use displays much more evident effects after 1990, in the framework in which a generally old population, lacking expertise and production means, dwells on a subsistence agriculture despite the more frequent and extended manifestation of hydrometeorological phenomena. At present, these risk phenomena induce the most important changes at the level of floodplain geosystems, which have been weakened by the human-induced changes in the socialist period, as well as by the degradation, destruction or abandonment processes occurred in the post-communist times (the clearing of protective tree screens against deflation and the dismantle of the irrigation systems are just two eloquent examples).

In natural conditions, frequent floods took place in this floodplain sector, the Danube supplying the ponds with water and clogging them at the same time; the inundation was both direct and indirect (Licurici et al. 2011). The April 2006 historical high flood – with consequences persisting during May - registered a maximum flow rate at Calafat, i.e. 15,800 cubic m/s, this representing the highest flow value registered during the hydrometrical measurements and observations period. The important exceedance of the flood levels all along the Danube (on various intervals comprised between 27 and 69 days) led to severe infiltrations, affected the stability of levees and subsequently induced their destruction, as well as that of three precincts within Dolj County: Ghidici-Rast-Bistreț, Bistreț-Nedeia-Jiu, Jiu-Bechet and Bechet-Dăbuleni (*PMRI Dunăre* 2015).

Population represents one of the most sensitive categories to flood. According to the data provided by the *National Institute of Statistics*, in 2016, the TAUs located along the Danube within the Dolj County accounted for 99,720 inhabitants, which can be regarded as direct or indirect elements at flood risk.

The elements exposed to risk within the study area could be quantified through the number of persons who live/activate within or near the floodplain (rural environment and poverty for the most part), through the existing types of assets, through the economic enterprises and activities. The vulnerability specific to the elements exposed to various hazards needs to be assessed and brought to the knowledge of all interested stakeholders within the study area (Licurici et al., 2013).

2 METHODS

In order to evaluate the structural measures and communication tools development, we used official documents issued by regional and national institutions in connection to flood risk management, as well as data provided by the official web sites of the local administration, especially concerning the voluntary services in case of emergency situations. In order to have a clearer assessment of the socio-economic exposure to hazards, in the framework of certain distinct vulnerable groups within the local communities, for whom special communication tools and measures must be deployed, there were selected, processed (*Microsoft Excel,GIS environment*) and analysed statistical data extracted from the *Tempo On-line* database of the *National Statistics Institute* (2006 - 2016) and from the *Population and Household Census* (2011).

The perception of the inhabitants within the study area regarding flood risk status and preparedness was evaluated through multiple field campaigns stretched over the last decade, as well as through recent face-to-face discussions during 2018 spring and summer.

3 RESULTS AND DISCUSSION

3.1. Existing structural measures

According to *UNISDR* (2009) recommendations, hazard mitigation measures can be divided into structural and non-structural ones, each category including a number of decision levels.

The main structural measures taken for flood risk reduction in the Dolj sector of the Danube Floodplain concern the defence levees constructed along the Danube and its tributaries, the Jiu and the Desnățui. In this framework, the 1962-1970 period must be mentioned, as this is the decade when levees were raised to protect the flood prone area along the Romanian Danube. In the Dolj County, the levees were constructed between 1961 (the Jiu-Bechet levee, Bechet settlement) and 1988 (the Duvalmu levee, Piscu Vechi settlement) (*PMRI Dunăre* 2015).

According to *the Jiu Basin Water Administration*, within Dolj County, most of the levees raised along the Danube (the Cetate-Gighera sector) correspond to 1% flood occurrence probability. The morphometrical dimensions of the levees (length - L, height - h, and width - B) vary depending on local characteristics. The levee of the Bistret-Nedeia-Jiu precinct is the longest (39.2 km) (being designed for the protection of the elements at risk within the settlements of Bistreț, Cârna, Goicea, Măceșu de Jos, and Gighera), while its height is 6 m. The Ghidici-Rast-Bistreț precinct is protected by a local levee that is 18.8 km long and 6 m high. Among the elements exposed to flood risk, the arable fields account for the most extended surfaces (as, for example, 6,800 ha - Măceșu de Jos; 5,790 ha - Bistreț and the same for Cârna; 5,500 ha - Gighera), followed by grassland (150 ha - Catane and 100 ha - Ghidici) and forest areas (100 ha - Ghidici and 42 ha - Rast) (Table 1).

In the eastern part of Dolj County, on the territory of other four settlements, there have been raised levees in the framework of the Jiu-Bechet precinct (L=19.4 km, h=3 m, B=35 m) - Ostroveni settlement and of the Jiu-Bechet-Dăbuleni precinct (L=19.4 km, h=3 m, B=35 m) – Bechet town, Călărași settlement and Dăbuleni town; these levees have been raised against flood phenomena with 2% occurrence probability. Thus, the following elements at risk are protected within the above mentioned settlements: 400 ha agricultural field (the Danube), one bridge, 100 ha agricultural field (the Jiu), one bridge, 80 ha agricultural field (the Jieț) - Ostroveni; Bechetul Vechi, Bechet Port, Bechet Douane, 250 ha agricultural field, the Jieț Pumping Station, 3 km of road (the Jieț) – Bechet; 4,600 ha agricultural field, one km of road - Călărași; a drainage system and 4,277 ha agricultural field – Dăbuleni (*County Defence Plans*, the Jiu Basin Water Administration).

Protection levees against flood phenomena with 5% occurrence probability have been raised on the territory of the settlements of Cetate (in the *Mill/Moara* area: L=2.0 km, h=1.5 m, B=8 m), Calafat – Ciuperceni village (L=1.0 km, h=4 m, B=25 m), Ciupercenii Noi (L=240 m, h=1.5 m, B=9.5 m; L=150 m, h=0.8 m, B=4 m) and Desa (L=50 m, h=2.5 m, B=8 m; L=150 m, h=1 m, B=7 m), for the following elements at risk: 25 ha agricultural field, 20 households and the Cetate Port (Cetate); 25 households, 300 ha arable field (Ciuperceni village); 466 ha grassland surfaces, 1.6 ha arable field (Ciupercenii Noi); 17 ha hay fields,

100 ha grassland surfaces, 400 ha locust forest surfaces, 200 ha agricultural field, 20 livestock pens (Desa) (*County Defence Plans*, the Jiu Basin Water Administration).

Certain elements at risk are located in TAUs with no flood protection levees, such as Maglavit (250 ha of communal pastureland and 250 ha of forest), Poiana Mare (100 ha agricultural field) and Piscu Vechi (950 ha agricultural field); thus, significant agricultural and forest surfaces located in the Danube Floodplain could undergo temporary moisture excess in case of high flood.

The levees raised along the tributaries of the Danube are characterized by less important dimensions, i.e. L=11 km, h=2.5 m – the Jiu and L=10 km, h=2.5 m – the Desnățui; they were designed to protect elements at risk located in the settlements of Bistreț, Cârna, Goicea and Gighera (Table 1).

The implementation of a radical choice, i.e. to totally transform the flood-prone area along the Danube, induced an important rise of the flow rates at high waters, as well as the risk of download flooding. Although some of these negative effects were anticipated, they were considered acceptable at that moment because of the advantages for agricultural production. Reasonably, that decision is seriously challenged by the flood phenomena occurred during recent years: April – May 2006, February – March 2010 and April 2013, to name only some of the most important such events.

The identification of the structural and non-structural measures at the Danube level took as baseline the Catalogue for potential actions at national scale (according to *Annex 2* of the *Framework Methodology for the Elaboration of Flood Risk Management Plans*, within the Basin Water Administrations), proposed by the National Institute of Hydrology and Water Management. Thus, for the Danube Floodplain in Dolj County, there were delineated measures for the insurance of drainage capacities, their completion term being 2021/2017: drainage systems within the Ciuperceni-Desa and Bistreț-Nedeia-Jiu precincts (*PMRI Dunăre,* 2015).

Table 1. Elements at risk and existing defence hydrotechnical works

Settlement	Elements at risk located in flood-prone areas	Existing defence hydrotechnical works (lengths, heights, accumulated volumes)	Probability
Cetate	SC Năvodarul Calafat Fishery fund	Levee *SC Năvodarul Calafat*: L=10 km, h=4.5 m, B=41 m	1%
Maglavit	Firm head office and Fishery fund	Fishery protection levee: L=10.4 km, h=4.5 m, B=41 m	1%
Termo Calafat	Precincts and facilities	Precincts protection levee: L=0.615 m, h=3.5 m, B=21 m	1%
Ghidici	100 ha agricultural land 100 ha grassland, 100 ha forest	Ghidici-Rast-Bistreț dammed precincts L=18.8 m, h=6 m, B=35 m	1%
Rast	25 ha agricultural land, 42 ha forest	Ghidici-Rast-Bistreț dammed precincts L=18.8 m, h=6 m, B=35 m	1%
Negoi	300 ha agricultural land, 50 ha grassland	Ghidici-Rast-Bistreț dammed precincts L=18.8 m, h=6 m, B=35 m	1%
Catane	1,200 ha agricultural land, 150 ha grassland	Ghidici-Rast-Bistreț dammed precincts L=18.8 m, h=6 m, B=35 m	1%
Bistreț	5,790 ha agricultural land Bistreț polder, Fishery fund (the Desnățui)	Bistreț-Nedeia-the Jiu dammed precincts L=39.2 km, h=6 m, B=35 m Bistreț Polder protection levee L=10 km, h=2.5 m, B=17.5 m	1% 1%
Cârna	5,790 ha agricultural land Bistreț polder, Fishery fund (the Desnățui)	Bistreț-Nedeia-the Jiu dammed precincts L=39.2 km, h=6 m, B=35 m Bistreț Polder protection levee L=10 km, h=2.5 m, B=17.5 m	1% 1%
Goicea	300 ha agricultural land 100 ha arable land, 5 bridges, 8 km of road (the Desnățui)	Bistreț-Nedeia-the Jiu dammed precincts L=39.2 km, h=6 m, B=35 m Bistreț Polder protection levee L=10 km, h=2.5 m, B=17.5 m	1% 1%
Măceșu de Jos	6,800 ha agricultural land	Bistreț-Nedeia-the Jiu dammed precincts L=39.2 km, h=6 m, B=35 m	1%
Gighera	5,500 ha agricultural land 1 concrete bridge, 50 ha agricultural land (the Jiu)	Bistreț-Nedeia-the Jiu dammed precincts L=39.2 km, h=6 m, B=35 m Levees along the Jiu: L=11 km, h=2.5 m, B=16 m	1% 1%

Source: *County Defence Plans*, the Jiu Basin Water Administration

3.2. Non-structural measures and stakeholders involvement

Non-structural measures, such as the preservation or restoration of floodplains, are considered by the EU Floods Directive as an effective tool for reducing flood risks.

In Romania, the *Romanian Waters National Administration (RWNA)* and the *National Institute of Hydrology and Water Management* represent the main institutions with responsibilities in the national transposition of the *Flood Directive*. In 2011, as important partners, RWNA (*the Jiu Water branch*) and the Ministry of Environment and Forests (designation of the authority at that moment) elaborated documents addressing the complex issue of flood risk management and sustainable development within the Danube Floodplain: *Redevelopment of Danube floodplain. Scenario study for development of floodplains between Ghidici and Zăval*, as well as *Ecological and Economic Rescaling on the Romanian sector of the Danube Floodplain. Hydrological scenarios within the Danube Floodplain, by using the hydraulic model of the Danube* (Danube Delta National Institute for Research and Development, Tulcea). In the same framework, in 2017, WWF Romania together with *Invisible nature* (an environmental and sustainability consultancy) elaborated the study with the title *Lower Danube river corridor – floodplain restoration, opportunity, analysis*.

Concerning the assessment of the flood risk along the Danube, there is to be mentioned the *Atlas* comprising *The Danube Flood Hazard and Risk Maps*, which represents an important output of the international project *DANUBE FLOODRISK - Stakeholder oriented flood risk assessment for the Danube floodplains* (South - East Europe Transnational Cooperation Programme). The project was conducted between 2010 and 2012 and the Romanian Ministry of environment was Project Leader, while RWNA was an important national partner.

In order to assist the Danube sector and that of its main tributaries, within the *WATMAN* project – *Informational System for the Integrated Water Management* (2013 - 2015) six Rapid Intervention Centres were founded and endowed with intervention materials and equipment; one of them is located in Craiova Municipality.

All these projects underlined the importance of the territorial system understanding in order to define local development patterns, which would also imply an adequate management of the hydrometeorological risk.

Including in 2018, the *Romanian Ministry of Internal Affairs*, through the *General Inspectorate for Emergency Situations*, conducts the project *Disaster Risk Management*, which comprises a section regarding flood risk. The same institution, technically supported by the Special Telecommunication Service, conducts the national implementation of the RO-ALERT warning system for the population in case of emergency situations; the system allows the transmission of Cell Broadcast messages in major emergency situations, aiming to warn and alert the people so that they could adopt the proper behaviour for self-protection.

At regional level, the main institutions that deal with flood risk management are the *Jiu Basin Water Administration* (provides the *Flood Risk Management Plan for the Cerna- the Danube - the Jiu hydrographical space*) and the *County Inspectorate for Emergency Situations* (provides the *Leaflet concerning the Proper Actions in Flood Situations*; the *Risk Coverage and Analysis Plan for Dolj County*); it also participates in the RO-BG cross-border project with the title *Coordinated and Efficient Authority Reactions in Emergency Situations within the Dolj-Vratsa Region*.

The *Flood Risk Management Plan for the Danube* (Romanian territory) is provided by the *Dobrudja Littoral Water Administration* and, as in the case of the regional plan, it can be analysed on-line, on the official institutional site.

The *Dolj County Council* represents the main institution with attributions in the sustainable development at county level and in cross-border perspective. On its official site, the institution provides the *2014 – 2020 Strategy for Social-Economic Development within Dolj County*. In the same framework, there are to be mentioned the projects conducted by the local authorities within the southern part of the county and mainly concerning the promotion of social inclusion, the fight against poverty and against any form of discrimination (Bistreț, Ghidici and Negoi).

Between May 2012 and November 2013, in the framework of a project concerning the *Assessment of the Natural and Technological Hazards in the Danube Floodplain, at the Romanian – Bulgarian Border: Calafat - Vidin - Turnu Măgurele – Nikopole sector (ROBUHAZDUN)*, a complex team comprising academics from the University of Craiova and researchers from the Geography Institute of the Romanian Academy conducted field campaigns in order to raise the awareness and inform the population living near the Danube. The information aimed to help mitigate the effects of hazards at local level, was tailored for every target group (mainly population in schools and town halls).

The local authorities of the 19 TAUs located near the Danube (16 rural, 3 urban) maintain official web-sites that include a *Public Services* section with a special category entitled *Voluntary Service for Emergency Situations*. There can be noticed a low degree of information by using this communication tool, as only 3 of the targeted sites have the above service available, stating within this section: necessary measures after flood water withdrawal (Desa), preventive measures in case of flood (Poiana Mare), and preventive measures in case of emergency situations (Gighera). Most of the information comprises advices for the protection of human life and assets, thus aiming the flood risk mitigation. In the social-economic framework, the main development priorities of the local authorities concern the creation of new jobs through the attraction of investments for

the capitalization of agricultural land resources; from the viewpoint of the local infrastructure, the interest goes towards road rehabilitation (asphalt coverage for county roads, gravel – for communal ones), introduction or extension of utility networks (drinking water, gas), and development of medical services.

3.3. Socio-demographic vulnerability

The vulnerability of the exposed elements is enhanced by the social-economic conditions, as well as by the often unwise environmental management (land use, agricultural systems and flood-protection structures). Within the local communities, the most important social and economic issues connected to an enhanced vulnerability to hazards refer to significant aged population groups, to a high unemployment rate and general low income, to a deficient access to important resources such as education, medical services and information (Licurici 2011; Licurici et al., 2013).

Although most member states define their flood risk management objectives in a qualitative manner, in order to monitor their achievement it is recommended to use data and *indicators* as *quantifiable targets*.

The age structure of the population brings extremely important input in the vulnerability evaluation at community level; the persons situated at the extremes of the age spectrum (elderly, children) often display reduced mobility and they can have various needs that must be addressed during a flood crisis, thus increasing the burden of responsibility for the other members of the community (Cutter et al., 2003b).

Within the study area, the demographic ageing represents a relatively generalised process, which is both obvious in 2006 and in 2016 (Figure 2). Eleven of the 19 TAUs under study account for values higher than 20% of the population over 64 years old, the most severe situations being characteristic to Măceșu de Jos (32.4% in 2016), Cârna and Ostroveni (both with more than 29% in the same year).

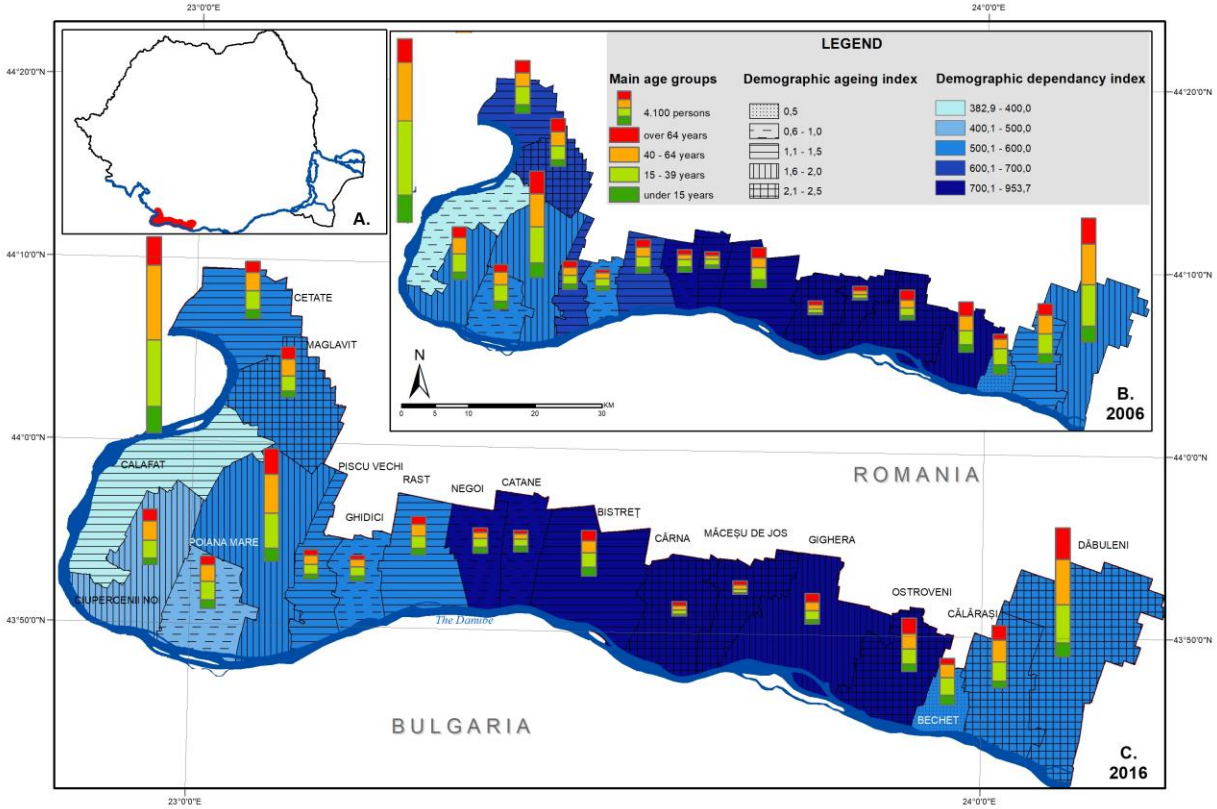

Figure 2. Main vulnerability features connected to the age structure of the population (Source of the processed data: National Statistics Institute of Romania, 2018, www.insse.ro)

The demographic ageing index (comparing the elderly with the young segment of the population) displays over unitary values in 14 of the 19 TAUs under study; the analysed demographic data reveal severe situations in 8 TAUs (including urban ones), where the value of the index reaches or surpasses 2 elderly persons/young inhabitant: Poiana Mare, Călărași, Ostroveni, Dăbuleni, Măceșu de Jos (with raising values between 2006 and 2016), Gighera, Maglavit, Cârna. The vulnerability of the elderly significantly depends on certain individual characteristics (age, health state, personal abilities and responsibilities etc.), but, generally, the eviction and sheltering of this demographic segment are rather difficult, not only by reason of their living

conditions, but also because they tend to be against living their household (Morrow 1999; Licurici et al., 2013), as clearly underlined by the situation of Rast village community after the 2006 catastrophic flood.

The demographic dependency index displays rather high values, surpassing 500 dependant persons/1,000 adults in 84% of the TAUs under study; the administrative units of Negoi, Gighera, Bistreț, Catane, Cârna, Măceșu de Jos, and Ostroveni account for values above 700 dependant persons/1,000 adults. The high values of this index are associated with increased vulnerability and responsibility burden for the adult population in the affected communities.

The educational level of a population is closely connected to its access to resources - primarily informational ones - and, in this framework, to the vulnerability of the socio-demographic system to hazards.

The analysis of the 2011 Census data shows that 5,198 persons of the local population aged 10 and above did not graduate any formal education level, 44.5% (i.e. 2,314 persons) of them being illiterate (Figure 3). Sixteen of the 19 TAUs under study accounted for illiteracy rates of 1% or above, the most severe situation being registered in Rast (6.7%, i.e. 198 persons), Poiana Mare (6.5%, i.e. 643 persons), Bechet (5.7%, i.e. 176 persons), and Negoi (4.1%, i.e. 78 persons). Moreover, at the level of most TAUs under analysis, the illiteracy rate displays higher values for the feminine population, reaching more than double figures as compared to the male inhabitants in Rast (9.5% - female versus 3.8 – male population), Negoi (6.1% versus 1.9%), Ghidici (3.1% versus 1.5), Dăbuleni town (2.9% versus 1.2%), Ciupercenii Noi (2.6% versus 0.7%) etc. It is generally accepted that it can be more difficult for the feminine population to cope with hazards, especially because of the specific activity sectors, of the low wages and of the family responsibilities (Cutter et al., 2003a; Morrow, 1999; Licurici et al., 2013). As the information means are significantly limited by illiteracy, to deal with the daily needs of the family members becomes an even greater challenge, especially for women.

School can play an active and important role in the proper anti-hazard education of the young segment of the local population, which can subsequently help to increase the resilience of these communities weakened by poverty, demographic ageing, as well as by lack of knowledge carefully tailored for each social group. To serve this purpose, schools must firstly attract students and keep them interested in frequenting classes. As shown by the analysis of the statistical data, during the 2011 – 2015 interval the number of enrolled schoolchildren and that of the graduates declined in most TAUs under study, the ratio between two elements displaying the lowest values in Negoi, Catane, Desa, Ghidici, Bistreț, and Rast administrative units (under 10%).

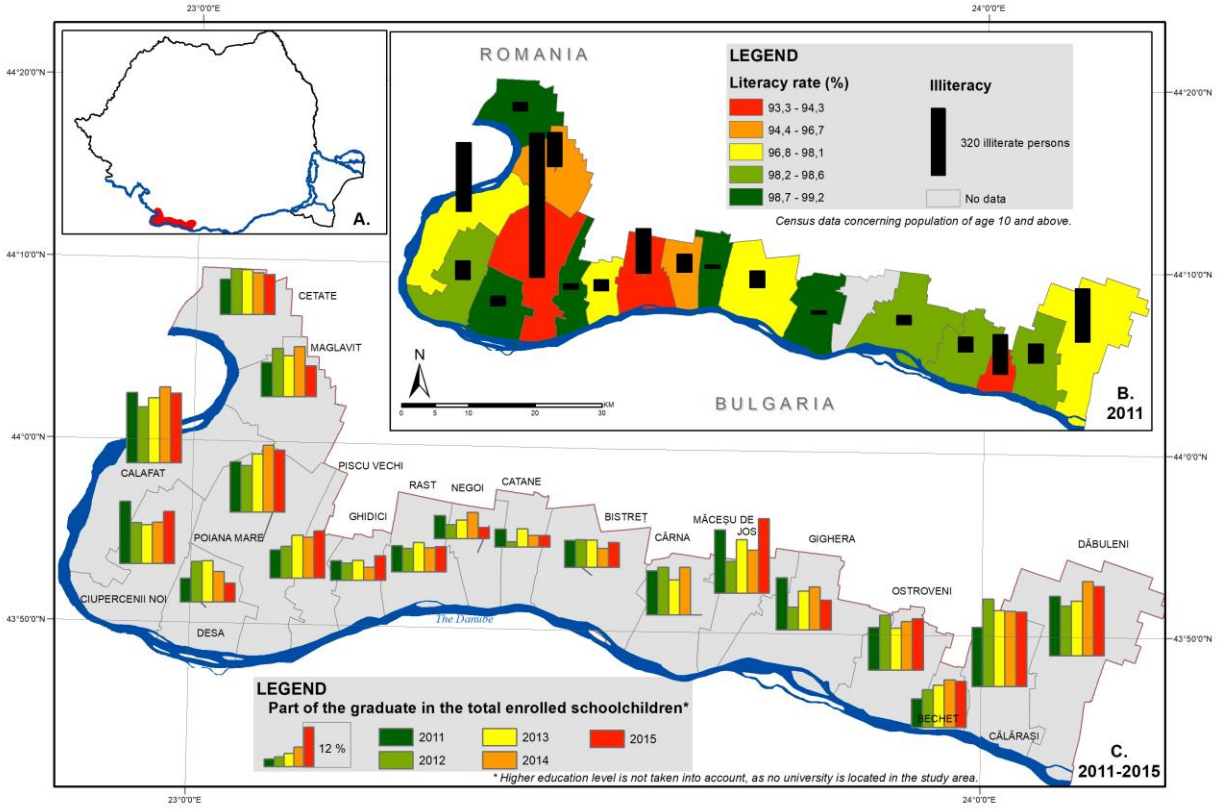

Figure 3. Main vulnerability features connected to education and literacy (Source of the processed data: National Statistics Institute of Romania, 2018, www.insse.ro)

Raising the awareness about hazards is regarded as a key-factor for the actual disaster risk reduction. Within the area of interest, population receives most information through mass-media canals (generally television), from neighbourly discussions and from education institutions.

During April, May and June 2018, the authors conducted the latest field campaigns in the Dolj settlements located neat the Danube, with the aim of recording the perception of the population with regard to flood risk. The target settlements were Pisculeţ (totally located within the Danube Floodplain), Rast (the settlement that undergone the heaviest damage in 2006), Cârna (village situated on the northern shore of Bistreţ Lake; material damage was also registered in 2006), and Bechet (urban settlement of cross-border interest).

The discussions with the local population concerned issues related to the following:

- the flood events registered along the Danube, material damage and emotional trauma;
- the current state of the hydrotechnical flood protection works, confidence degree and criticism;
- the state of the household (house and annexes), the demographic and economic situation of the family;
- the personal experience with informative means concerning hazards and related actions conducted by the authorities;
- the measures known or/and applied for flood risk mitigation.

In this framework, Table 2 summarises the questions that raised difficulties or those at which unexpected answers were received.

Table 2. Examples of particular questions and answers related to flood risk perception within the settlements located near the Danube, in Dolj County

Question	Answer
In your opinion, what are the most important dangerous phenomena for the area in which you live/activate?	Poverty, high number of old persons, poor health state
What are your chief means of information concerning the problems of the settlement?	Television and discussions with neighbours
Where did you learn the adequate actions to be taken before, during and after a flood crisis in order to limit the effects?	I do not know certain precise rules; if a flood occurs, I deal with it following on-spot decisions.
What kind of information related to flood risk mitigation do you want to be provided with?	I want to be alarmed in time in case of flood occurrence.
Where do you hope to receive help from in case of flood occurrence?	Family, neighbours, local authorities, the Inspectorate for Emergency Situations.
What kind of help do you think that you would receive after a flood crisis?	Medical care, construction materials.

The integrated analysis of the received answers underlines that the most important issues perceived by local population are the current ones (poverty, old age, bad health), while the responsibility for mitigating the possible future effects of hazards is almost entirely transferred to the authorities.

The field data suggest that large-scale flood protection infrastructure creates a sense of security that is associated with a lower level of preparedness.

3.4. Proposed measures to increase resilience

The development of the capacities is a requirement in a typically rural space, with a problematic infrastructure, such as the floodplain area under study. The information, the communication tools and the implemented measures must be adequate to each category of the local population.

The mitigation of the loss induced by flood starts with individual awareness and action. The adequate informative actions concerning risk reduction allow people and families to better resist or to adapt to the effects of floods.

Informing and educating are different concepts, as concrete information is required in order to describe a policy, a programme or a process, a decision that has already been conducted. Information is also necessary when the acceptance of a proposal is necessary before making a decision, when an emergency situation or a crisis occurs and immediate action must be taken. Moreover, information plays an important part in the preparation for future implication.

To discuss or to involve represent two types of action that result in exchange of information. If the organizer wishes to encourage discussions with and among interested stakeholders, he can establish a common agenda and open time intervals for debates over the issues. If the institutions are ready to assume the part of mediators and there is agreement in the implementation of the solutions generated by

stakeholders, this means that the first whish to empower the interested parts to manage the process, while the latter accepted the challenge to develop their own solution.

The following proposals are made in order to improve the communication tools and the informative process (Figure 4):

- A. Info Points:
  - ✓ could be organised in local town halls and at local police headquarters;
  - ✓ informative materials could be used in schools and they could be disseminated with the occasion of various school events or during optional classes;
- B. Workshops/round tables and scientific presentations:
  - ✓ information could be transmitted and explained by academics and researchers within scientific conferences that could take place locally (in schools) and to which local authorities and farmers should be invited;
  - ✓ local stakeholders, respectively those with technical profile should be involved, because the dissemination of information is done at a different level;
- C. Mass-media communication:
  - ✓ campaigns aiming to inform and raise the awareness could be conducted through adequate articles issued in the central and local press;
  - ✓ the local or central mass-media (radio, television), could broadcast series of interviews with experts of the regional authorities, explaining and exemplifying data related to floods and flood risk mitigation;
- D. On-line communication:
  - ✓ all official sites of the local authorities should display up-to-date information (even in brief form, such as the electronic leaflet) concerning the adequate actions to be taken in case of flood crisis; the involvement of social networks could be beneficial in the same framework;
  - ✓ on-line surveys for local stakeholders or other on-line tools for public participation could provide important insights in the flood risk perception, local vulnerabilities and current preparedness state.

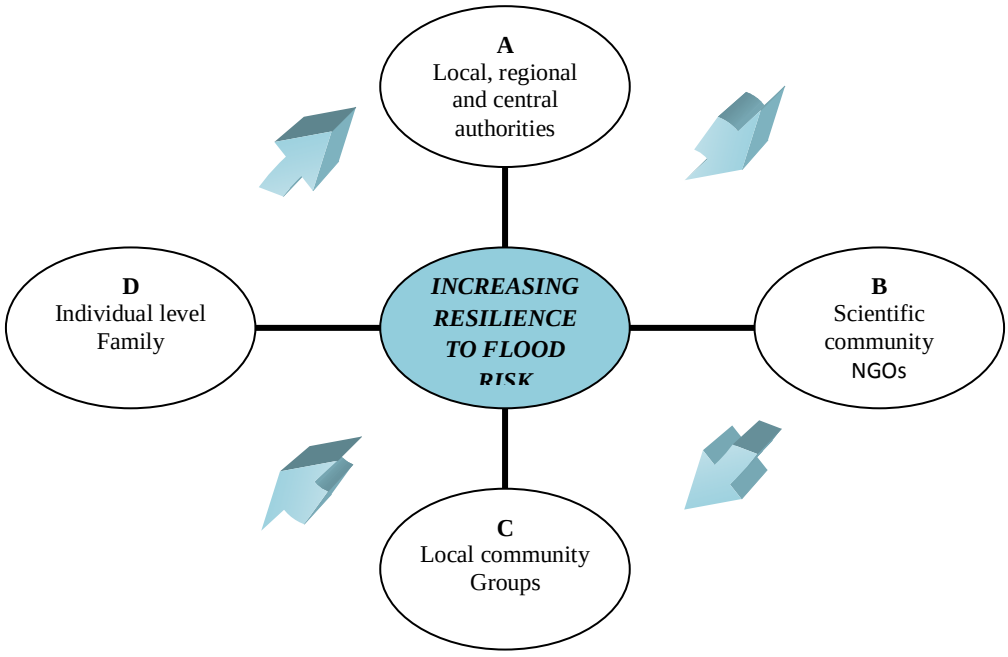

Figure 4. Stakeholders involved in activities aiming to increase resilience to flood (communication/raising awareness)

The current warning-alarming system for the population living in Dolj settlements situated near the Danube is based on the local sirens, most of them being old and technically obsolete. The RO-ALERT project is currently in testing stage, but local issues, such as poverty or illiteracy, diminish the beneficial impact of the information thus transmitted. The public information and warning must include support for public-private partnerships that could result in concrete measures and in a more efficient communication of hazard mitigation actions. As already stated, an adequate informative process concerning the flood risk mitigation actions reaches its best effects if both traditional mechanisms (such as community meetings) and modern communication tools (mass-media, web sites, smartphone applications etc.) are used.

Another proposed measure concerns the participatory approach involving interested stakeholders and it could lead to positive effects such as: the improvement of the strategic capacity of the decision-makers; changes in the perception and conceptualization of the social context; changes within the traditional power and conflict relations; reinforcement of democratic practices and involvement of inhabitants in the public decisions; an increased trust in the institutional actors.

The promotion of flood risk reduction in the settlements located near the Danube could be also supported by a national preparation campaign conducted with the goal of raising public awareness and of motivating inhabitants to develop capacities of social adaption before the occurrence of a flood crisis.

Raising public awareness and an adequate pre-disaster education represent key-elements in the flood risk mitigation within the southern area of Dolj County and, in the current framework of the settlements under study, this goal can be supported by more active involvement of local authorities, trusted leaders and institutions, by boosting social empowerment and citizen implication in solving community issues, as well as by using the adequate tools to ensure efficient communication among all stakeholders.

4 CONCLUSIONS

The subject is important and actual, as floods have an increasing trend, while their correct evaluation is still extremely difficult and vulnerability of elements at risk is more and more emphasized.

The present research is aimed to be a starting point and a focused scientific support for the local and regional decision makers who are involved in flood risk management and in the identification of the best sustainable development strategies for the Danube Floodplain communities.

This research proposes a holistic approach to flood risk management that combines quantitative and qualitative aspects for the Danube floodplain within the Dolj county (Romania), where priority are rural localities and *Natura 2000* sites. In order to be efficient, the measures that aim increasing resilience should encourage efforts to raise the standard of living of those exposed to flood risk. Development (which includes a stronger, better informed and more economically diversified community) and flood resilience should be complementary. For example, the incentives taken by public and private decision-makers in order to use local human and natural resources in a sustainable manner, adequate to present times, should decrease the dependency on agriculture, rise and diversify incomes and, indirectly, create a more resilient community.

We conclude that there is an urgent need for the continued development of theoretically anchored, empirically verified and practically applicable disaster resilience measurement frameworks and tools. The availability of such frameworks will deepen the understanding of key components of disaster resilience and enhance the ability to quantify resilience over time. In the future, one of the more significant pillars for an increased resilience of the local communities should be represented by risk transfer through insurance policies, which could play the role of a rapid capital source for reconstruction (Hanger at al., 2018).

Finally, an active involvement of all interested parties in the production, review, and updating of the flood risk management plans is desired.

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REFERENCES

Bird, D. K. (2009). The use of questionnaires for acquiring information on public perception of natural hazards and risk mitigation–a review of current knowledge and practice, *Natural Hazards and Earth System Sciences*, **9**(4), 1307-1325.

Blackwell, M.S.A. and Maltby, E., Eds. (2006). *Ecoflood Guidelines: How to use floodplains for flood risk reduction, European Commision, Directorate-General for Research Sustainable Development, Global Change and Ecosystems*, 144 p.

Cutter S.L. (2003a). The Vulnerability of Science and the Science of Vulnerability, *Annals of the Association of American Geographers*, **93**, 1, 1-12.

Cutter S.L., Boruff B.J., Shirley W.L. (2003b). Social Vulnerability to Environmental Hazards, *Social Science Quarterly*, **84** (1), 242-261.

Dressler, G., Müller, B., Frank, K., Kuhlicke, C. (2016). Towards thresholds of disaster management performance under demographic change: exploring functional relationships using agentbased modeling, *Natural Hazards and Earth System Sciences*, **16**, 2287–2301.

Fuchs, S., Keiler, M., Glade, T. (2017). Editorial to the special issue on resilience and vulnerability assessments in natural hazard and risk analysis, *Natural Hazards and Earth System Sciences*, **17**(7), 1203-1206.

Hagemeier-Klose, M. and Wagner, K. (2009). Evaluation of flood hazard maps in print and web mapping services as information tools in flood risk communication, *Natural Hazards and Earth System Sciences*, **9**(2), 563-574.

Hanger, S., Linnerooth-Bayer, J., Surminski, S., Nenciu-Posner, C., Lorant, A., Ionescu, R., & Patt, A. (2018). Insurance, Public Assistance, and Household Flood Risk Reduction: A Comparative Study of Austria, England, and Romania, *Risk Analysis*, **38**(4), 680-693.

Hein, T., Schwarz, U., Habersack, H., Nichersu, I., Preiner, S., Willby, N., Weigelhofer, G. (2016). Current status and restoration options for floodplains along the Danube River. *Science of the Total Environment*, **543**, 778-790.

Ionuş, O., Licurici, M., Pătroescu, M., Boengiu, S. (2015). Assessment of flood-prone stripes within the Danube drainage area in the South-West Oltenia Development Region, Romania. *Natural hazards*, **75**(1), 69-88.

Keating, A., Campbell, K., Szoenyi, M., McQuistan, C., Nash, D., Burer, M. (2017). Development and testing of a community flood resilience measurement tool, *Nat. Hazards Earth Syst. Sci.*, **17**, 77–101.

Kienholz, H. and Krummenacher, B. (1995). *Schweizer Bundesamt fur Umwelt,Wald und Landschaft: Symbolbaukasten zur Kartierung der Phanomene*, Bern, Switzerland [in German].

Kundzewicz, Z.W. and Menzel, L. (2005). Natural flood reduction strategies - a challenge, *Int J River Basin Manage*, **3**(2):125–131.

Licurici, M. (2011). Human-Induced Environmental Changes and Floodplain Restoration Necessity along the Danube, on the Drobeta-Turnu Severin-Bechet Sector. *Forum Geografic*, **10**, 350 – 363.

Licurici, M., Ionuș, O., Popescu, L., Vlăduț, A., Boengiu, S., Simulescu, D. (2013), *Evaluarea și reducerea hazardelor naturale și tehnologice* [*Natural and technological hazards assessment and mitigation*], Editura Universitaria, Craiova, 110 p. [in Romanian]

Morrow, B.H. (1999). Identifying and Mapping Community Vulnerability, *Disasters*, **23**(1), 1-18.

Norris, F.H., Stevens, S.P., Pfefferbaum, B., Wyche, K.F, Pfefferbaum, R.L. (2008). Community Resilience as a Metaphor, Theory, Set of Capacities and Strategy for Disaster Readiness, *American Community Psychology*, **41**,127-150, doi: 10.1007/s10464-007-9156-6.

Scheuer, S., Haase, D., Meyer, V. (2010) Exploring multicriteria flood vulnerability by integrating economic, social and ecological dimensions of flood risk and coping capacity: from a starting point view towards and end point view of vulnerability, *Natural Hazards*, **58**, 731–751.

Schober, B., Hauer, C., Habersack, H. (2015). A novel assessment of the role of Danube floodplains in flood hazard reduction (FEM method). *Natural Hazards*, **75**(1), 33-50.

Wiedemann, P.M. and Mertens, J. (2005).Sozialpsychologische Risikoforschung Technikfolgenabschätzung, *Theorie und Praxis*, **14**(3), 38–45. [in German]

*** (2006). Planuri județene de apărare, Administrația Bazinală de apă Jiu [*County Defence Plans, the Jiu Basin Water Administration*], 38 p. [in Romanian]

*** (2007). EU Flood Directive – Directive 2007/60/EC of the European Parliament and the Council of 23 October 2007 on the assessment and management of flood risks.

*** (2007) National Strategy for the Flood Risk Management. Prevention, Protection and Diminution of Flood Effects (Romanian Ministry of Environment).

*** (2009, 2013). UNISDR Terminology on Disaster Risk Reduction (online), Publisher: United Nations International Strategy for Disaster Reduction, Geneva, Switzarland (accessed - March 2018).

***(2012). ICPDR - Danube Floodrisk Project - Summary report. website: http://www.danubefloodrisk.eu/2012/10/materials/ (accessed - January 2016).

***(2015). PMRI Dunăre - Planul de Management al Riscului la Inundații – Fluviul Dunărea [*The Danube FRMP - Danube Flood Risk Management Plan*], 179 p. [in Romanian]