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Risk assessment

AN OVERVIEW OF THE EU ACTIONS TOWARDS NATURAL HAZARD PREVENTION AND MANAGEMENT: CURRENT STATUS AND FUTURE TRENDS

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Abstract. Earthquake, landslide and flood (ELF) hazards present trans-boundary consequences pose a serious problem to communities, form a roadblock to sustainable development and can lead to disasters when combined with vulnerability and insufficient capacity to reduce the risk. Key elements for an effective natural disaster mitigation are hazard identification and risk assessment, which must be based on scientifically sound methodologies and reliable and accurate data. The problem in the European Union (EU) and in the Black Sea area is widely recognised and a lot of efforts has already been made towards ELF disaster mitigation, evident by the numerous EU bodies formed, organisations established and projects funded. A brief review of the already applied and ongoing research shows a lag in the systematic ELF hazard assessment at local scales. ELF hazard assessment at these scales can provide results which can be directly used to make decisions regarding preventive measures and to plan effective post-event management actions. The proposed way to proceed is by ensuring applied research and technology transfer among partners from different countries, through the solution of problems such as the lack of reliable information and the lack of a 'common ground' in terms of methodologies used to assess ELF hazards and mitigation procedures adapted. The successful addressing of the afore-mentioned problems will provide the ability to systematically assess ELF hazards on regional and local scales, even in cross-border areas by providing comparable hazard maps which will support decision-making regarding the necessary mitigation measures.

Keywords: landslides, floods, earthquakes, hazard assessment, hazard mitigation.

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AIMS AND BACKGROUND

Natural hazards especially in the form of earthquakes, landslides and floods (ELF) pose a serious threat to societies and block sustainable development in the European Union (EU) and the Black Sea area[1,2]. These natural hazards can lead to natural disasters if combined with insufficient capacity to reduce the risk. The problem is widely recognised by the EU and a lot of efforts has been spent on disaster mitigation which is the ongoing effort to reduce the impact of disasters on people and property. Disaster mitigation as a management process is usually divided into: pre-event measures – actions taken during and immediately following an event; and post-disaster measures, all classified into four basic stages – prevention, preparedness, response and recovery. Pre-event measures are the most cost-effective, provided that they are based on accurate and reliable hazard identification and risk assessment and the same stands for the rest of the mitigation process stages. As it therefore appears, hazard identification and risk assessment provide the background needed for an effective natural hazard prevention[3,4]. The great importance of these parameters in all stages of hazard mitigation stages underlines the necessity for their assessment which must be based on accurate and reliable data and scientifically proven (after being adapted to local conditions, tested and accepted) methodologies. Aim of this paper is to provide an overview of past actions and assess the current and future trends regarding ELF hazard mitigation in the EU and in neighbouring countries in the wider area of the Black Sea. Within this context, the EU policies, organisations established and research projects funded by various funding instruments have been overviewed.

EARTHQUAKE LANDSLIDE AND FLOOD HAZARD MANAGEMENT IN THE EU – CURRENT STATUS ASSESSMENT

ELF hazards in the EU and the neighbouring Black Sea countries pose a serious threat to life, property and infrastructure. One of the main challenges the EU is facing, is due to the fact that the member states are at different risk levels regarding various natural hazards and especially the ELF ones, so cohesion problems arise[5]. As vulnerability to ELF hazards is continuously increasing due to population growth and the expansion of societies assets (urban, infrastructure, industrial) there is an urgent need for the EU to find solutions to the problem by promoting disaster mitigation[6].

EU ACTIONS: RESEARCH AND MAJOR NETWORKS

As far as the research and implementation are concerned, a lot of efforts have already been spent with very positive results by the EU and by individual countries. An indicative list of the EU bodies created, organisations established and international agreements, includes: the EUR-OPA Major Hazards Agreement[7], the

European Advisory Evaluation Committee for Earthquake Prediction (EAECEP), the European Warning (Alarm) System and its part, the Euro-Mediterranean Seismological Centre (CSEM/EMSC)[8], the Joint Research Centre (JRC)[9], the European Flood Alert System and the European Flood Awareness System (EFAS)[10], and those provided by the European Exchange Circle on Flood Forecasting (EXCIFF), the European Exchange Circle on Flood Mapping (EXCIMAP), the Flood Mitigation Action and international framework agreements such as the UNECE Water Convention and the Associated Programme on Flood Management (APFM)[11].

EU POLICIES AND INITIATIVES

The EU actions have already been already taken towards three general axes: policies, cooperation and research and implementation. The EU policies have been promoted through the EU directives, strategies, bodies formed, organisations established and funding programmes, which led to the implementation of several research projects.

The related to ELF hazard mitigation strategies, the EU Directives issued include the Strategic Environmental Assessment–SEA (Directive 2001/42/EC) which, although it addresses environmental protection issues, it implies natural hazard mitigation actions. The Directive urges the member states to consider disaster risk reduction. A serious problem in implementing the directive is the lack of a common pan-European methodological approach to hazard assessment and risk mapping, so comparable results can not be produced and preventive measures especially in cross-border areas can not be planned.

The Convention on the Protection and Use of Transboundary Watercourses and International Lakes – Water Convention (1996) has led to forming capacity building activities like the 'Task Force on Flood Prevention and Protection' which in turn led to the adoption of the 'Guidelines on Sustainable Flood Prevention' at the Meeting of the Parties to the Convention in 2000. As a follow up to that action, the Guidelines which were complemented by the Model Provisions on Transboundary Flood Management (2006), led to Directive 2007/60/EC of the European Parliament and of the Council (23.10.2007) on the assessment and management of flood risks[12,13]. The Flood Directive[14] is being applied but at this stage it covers only preliminary flood risk assessment, which has a more or less descriptive character[15]. According to the Directive provisions, flood risk assessment on a river basin basis will take place at a later stage providing valuable information, as long as comparable results from all member states are provided. This requirement makes harmonisation of flood risk assessment methodologies and data, as well as systematic data acquisition, absolute necessities.

As far as earthquake risk is concerned, the Euro codes developed by the European Committee for Standardisation, provide a basis for construction and engineering contract specifications and form a framework for creating harmonised technical specifications for building construction. Euro code 8 in particular[16], which addresses design of structures for earthquake resistance, is actually a preventive measure for earthquake risk mitigation. Earthquake-related is also the Report of the 'Committee of Energy, Research and Technology' on the establishment of a European research area and regional planning measures for protection against earthquakes (European Parliament, DOC_EN\RR\244\244682, 31.01.1994) (Ref. 17).

Various interventions by the EU in the form of thematic strategies were also attempted. The Soil Thematic Strategy (STS) which attempts to address soil erosion and landslide hazards aims at identifying high risk areas and establishing programmes to reduce the risk. STS is 'struggling' for many years to become a 'Directive' but to no avail as yet, so there is a gap in the implementation of the strategy. Having said that, land use planning, which is a pre-requisite for effective ELF hazard risk mitigation, is lacking an EU related policy.

Funding programmes like the European Observation Network for Territorial Development and Cohesion (ESPON) programme, the Copernicus[18] (previously known as GMES – Global Monitoring for Environment and Security) provide the basis for preventive actions planning as does the INSPIRE (Ref. 19), 'natural risk zones' section which provides the framework for natural hazard related data reporting. A proposal for a Directive on protecting European Critical Infrastructure[17] has been made in 2006, but the framework for deciding about the priority of sectors to be protected and the selection of relative criteria have not been foreseen.

Additional actions including the International Strategy for Disaster Reduction expressed by the Hyogo framework[20] for Action 2005–2015 (Kobe World Conference, 2005), the International Council of Science-ICSU natural and human-induced environmental hazards (2006–2012 plan) and the International year of Planet Earth (UNESCO) and the GEO – Group of Earth Observation – 10 year GEOSS implementation plan), have also been taken by the EU in cooperation with other international organisations.

A series of structural funds and cohesion policies have also been used to promote research for ELF hazard mitigation. The European Regional Development Fund (ERDF) under the European Territorial Cooperation programmes including the 'EU Strategy for the Danube Region' were used to promote cohesion among member states as well as risk mitigation. Although ELF hazard prevention seems to be getting more attention, an EU framework or even guidelines to support risk preventive or mitigation measures, is lacking. The European Union Solidarity Fund (EUSF) which was created following the extensive floods in Central Europe in 2002, was established to respond to major natural disasters and to provide assistance to member states[21]. Since 2002, it has funded the recovery of 56 disasters including floods, forest fires, earthquakes, storms and drought. On the other hand, funding efforts towards prevention actions are very limited.

Additional funding instruments include the LIFE+ and the Civil Protection Financial Instrument (CPFI) programmes, which proved to be limited in terms of resources to support ELF hazard prevention strategies. The EU Framework Programmes (FP) on Research and Development have funded a series of Research Projects related to ELF hazards[22], during the period from 1998 up to date. After each programme implementation period, result assessment and evaluation led to the identification of the targets to be investigated in ELF hazard mitigation. These issues, in all cases became the main targets of the next programme, so there seems to be a continuity in FP programs from FP5 to FP6 and then to FP7. It is interesting to note that, during the first two programmes (FP5 & FP6) the attempt to investigate the flood issue, focused mostly on analysing historical and real-time information on floods but still, it was recognised that work needed to be done in developing European databases, including extreme events and consequences[23,24]. The potential priorities for future research, after the implementation of FP6 programme, included the study of phenomena as sediment/debris generation and propagation in extreme floods; probabilistic real-time risk forecasting of multi-hazard events; feasible extreme flood-management options; non-intrusive technologies to measure infrastructure defenses against floods and the performance of storm sewerage systems under intense rainfall or wave over-topping. The FP7 which followed, as well as projects funded by other EU Bodies and financial instruments (ENPI, IPA), focused at exactly on the afore-mentioned targets, providing valuable results on natural hazard mitigation and especially on flood forecasting, on hazard assessment methodologies and on the use of new technologies for hazard assessment. During the years 2008–2009, the EU Commission focused on enhancing disaster response capacity. Several Projects (more than 50) were also funded by the 'Community Research and Development Information Society (CORDIS)' under different calls (programmes) that targeted on Climatology, Natural disasters and Risk assessment and reduction. Many projects have been and are also funded by the European Neighbourhood and Partnership Instrument (ENPI) and the Instrument for Pre-accession Assistance (IPA) including Inter-regional Projects (INTERREG, Black Sea basin JOP 2007-13).

The outcomes of implemented research projects funded by all the afore-mentioned Programmes, as they were delineated by the European Commission, suggest that there is a need for an integrated approach to ELF hazard disaster prevention and management in a way that the full natural hazard mitigation cycle – prevention, preparedness, response, recovery – should be considered[6,25]. The proposed approach to hazard mitigation, also suggests that prevention is the primary target accompanied by impact assessment in a way that preventive measures leading to effective preparedness and response can be planned[5].

The specific objectives set for the future by the EU Commission, include actions falling into three axes: developing knowledge-based prevention policies; linking actors and policies throughout the disaster management cycle, and improving the effectiveness of existing financial and legislative instruments. The European Parliament resolution of September 2010 provides support to the Commission priorities: improved knowledge of the risks, improved coordination of all actors and effective and innovative financing.

The 'Staff Working Paper on Risk Assessment and Mapping Guidelines for Disaster Management' which was issued by the Commission (2010) suggests that risk assessments '*are crucial for enhancing disaster prevention and preparedness activities and contribute significantly to planning and capacity building*'[25]. The main aim of these guidelines and the greatest challenge, is the improvement of coherence among the risk assessment carried out in the EU Member States at national level, at all stages of the hazard mitigation cycle, in order to make these risk assessments more comparable between Member States. This approach is expected to lead to greater transparency in terms of hazard related communication and will make cooperation in efforts to prevent and mitigate shared risks feasible. Such risks as cross-border risks are still very difficult to mitigate due to the lack of comparability of ELF hazard assessment results. As it therefore appears, the European Parliament and Council has set, as the fore-most priorities, the ones related to hazard prevention, risk assessment and risk mapping by improving existing sources of information on ELF hazards[26].

Those priorities foreseen by the EU Parliament and Council for the next years include: (i) a programme of best practices, aiming to lead to the EU guidelines on minimum standards for disaster prevention (2012); (ii) overview of the major risks the EU may face in the future (2012); and (iii) supporting of this governance tool as part of the EU cooperation in disaster risk management with the cooperation of the European Commission with UNISDR and OECD (2013) (Refs 4 and 27).

IMPLEMENTED RESEARCH PROJECTS

A brief overview of completed and ongoing research projects funded by the EU, is indicative of the implementation which followed the afore-mentioned policies and initiatives. Project information regarding basic targets, implementation and outcomes were collected from various sites including but not limited to, the EU Commission Framework Programmes (FP5/CORDIS, FP6, FP7), JRC, INTERREG web sites. Within this context, more than 50 projects related to ELF hazard mitigation were overviewed and classified based on their targets and outcomes as seen from a wider perspective. The acronym of the projects per classification category is presented in Table 1. Each of the projects appearing on this Table is referred to, only once for each of the ELF hazards.

Table 1. EU funded research projects classified by main target and outcomes

Basic targets of the Project	Hazard investigated		
	earthquakes	landslides	floods
Communication, cooperation	CHRISHOPE, NERIES, REAKT, SERIES	CAPHAZNET, MATRIX, PERPETUATE	CRU-ERANET, RIVERCROSS, CivPRO, MONITOR II, FLAPP, DANUBE Water Integrated Management, CapHazNet, CIRCE, CORFU, FLOOD-WISE
Hazard and vulnerability assessment	SHARE, SYNER-G,	LAMPRE, SafeLAND	SPHERE, DANUBE FLOODRISK
Designing prevention measures			Plan for preventing flood, protection and mitigation in Dobrogea Littoral, Flood-ProBE
Preparedness and disaster management	TEFER, CATALYST	SENSUM, RiskLIDES	TEFER, RIBAMON, VULMIN FLINKMAN, ECOFLOOD, FLIRE, FLOODRELIEF, DESWAT, RO_FFG, FREEMAN, MEDIATION, SMARTeST, STAR-FLOOD
Early warning systems	SEAHELLARC,	GALAHAD	EFFS, FLOODMAN, OBSERVATION ON ERYTHROPOTAMOS, EVROS…, ARDAFORECAST, FLIRE, HYDRATE (on Flash Floods – FF), FLASH, URBANFLOOD
Study of related phenomena	TRANSFER	IRASMOS, RUNOUT	FLOODsite, IMPRINTS (FF)
Development of methodologies	LESSLOSS, SAFER, MOVE, MATRIX	LESSLOSS, MOVE, RAMSOIL	MOVE, ACTIFF, CONHAZ, MATRIX

From the 'temporal' evolution of the implemented projects scopes and targets, it is evident that research and implementation during the past twenty years, has progressed from the initial stage of establishing a cross-border cooperation between the EU countries, to the development of methodologies in order to assess each of the ELF hazards and then to the development of more effective management plans, and finally to the development of early warning systems and the use of contemporary technologies.

One basic issue which seems to be missing, which is normal considering the time and money needed to implement it, is the 'preventive measures' design.

Effective preventive measure designing requires hazard assessment on a local scale and the projects already implemented may include, in some cases, such an implementation, but it is limited to cover only small areas[28,29] as presented in many case studies carried out in the wider area[30]. There is no systematic hazard assessment in local scales.

Earthquakes are a major natural hazard especially for the southern part of Europe including the Mediterranean and Black Sea countries. The EU has recognised the importance of the seismic risk mitigation and has actively supported the EU countries by legislating and by funding projects which led to significant scientific and technological achievements. The problem which still remains is the cross-border cooperation issue which is common among efforts to mitigate any of the natural hazards. A future goal in this respect, could be the development of policies to enhance cross-border cooperation in respect to Earthquake Hazard Mitigation strategies (including Prevention and Management). To that end, policy-making is essential at governmental level in order to legislate accordingly to each of the participating countries. There is also need for technology transfer, aiming at the improvement of rescue methods and the development of new technologies to help reduce the impact disasters have on life and property. There is also a need for land use planning. The Earthquake Hazard identification in any case plays an important role, so it has to be assessed by the use of widely accepted-reliable and accurate methodologies and supported by equally reliable and accurate data.

Towards a more practical solution, earthquake hazard could be assessed not only as an estimation of the ground motion parameters (i.e. peak ground acceleration (PGA), peak ground velocity (PGV), etc.) but as an assessment of the impact the ground motion has, on the ground itself in terms of geotechnical hazards caused. Potential hazard maps including liquefaction, lateral displacement and ground settlement maps can be created and used to effectively make decisions about taking preventive measures needed to avoid the problem, about potential land uses, about construction related legislation and also to raise public awareness.

The extensive list of flood-related projects funded by the EU indicates the extent of the problem throughout Europe including the Black Sea area. Cooperation has been established, methodologies have been developed and the use of contemporary technologies led to the development of early warning systems. Floods in large rivers have been investigated thoroughly and management plans have been developed. What seems to be lacking is the systematic flood hazard assessment on a local scale in order to design custom preventive measures. Another issue not fully addressed, is the flash flood issue. Flash floods are typical in the Mediterranean countries and the most frequent type of flooding in the central and the southern part of the Black Sea area. They are sudden and violent phenomena which endanger life, property and infrastructure. The problem with assessing flash flood hazard is that the streams that cause flooding are usually ephemeral with little or not water at all during most of the time and the respective watersheds are usually of limited extent and with a steep morphology, so, this type of flooding has to be addressed by applied research on a local scale.

As a result of landslide relate projects implementation, European guidelines for relict landslides recognition have been prepared in order to support decisions about land-use planning. New technologies as remote sensing (RS) and geographic information system (GIS) are widely applied to assess landslide susceptibility through the evaluation of geological, hydrogeological and morphometric parameters affecting slope stability. Various modelling methods have been proposed in order to assess the landslide hazard in a more reliable and accurate way, some of them applied within the wider Black Sea area[31,32]. The EU funded projects have examined the relationships between rainfall, land use, land cover and the event of slope failure and extensive erosion. Climate change impact on landslide occurrence has also being investigated. The final scope of all efforts regarding landslide hazard is to develop methodologies that can predict the occurrence and impact of landslides.

Additional remaining problems in respect to ELF hazards are related to information gaps, comparability of assessment results and problems in dealing with cross-border issues. Having said that, the unavailability of required data, is a two-fold issue: either there are no accessible data at all or the available data do not cover the entire required range (in terms of standards, inconsistencies in measurements, time-series, etc.) or finally, the available data are not comparable due to the different way data are recorded, processed or even coded by different researchers. Only two of the research projects overviewed, examined or have attempted to set up guidelines for data harmonisation within their wider aims, but at large, this issue still remains unresolved.

Most of the afore-mentioned problems have also been recognised by the European Commission[5].

CONCLUSIONS

An overview of the EU actions related to earthquake, landslide and flood hazards prevention and management, reveals numerous actions taken, regarding legislative and structural measures, as well as funding a large number of research projects. These projects have helped to establish cooperation, to better understand processes during these natural phenomena, to develop ELF hazard modelling methodologies and to implement applied research in many cases. Earthquake and landslide hazard problems are mostly tackled on a state basis where each country focuses mostly on relief and recovery measures. Earthquake hazard assessment on a local scale has been implemented in a few cases in the form of microzonation studies, but there is no systematic hazard assessment, nor preventive measures implemented in most of these cases due to the economic cost.

Applied research on flood hazard has focused mostly on riverside floods, probably because this type of flooding which is frequent in the central European countries, causes severe damage. As a result, effective measures have been planned for all mitigation stages and even early warning systems have been developed. On the other hand, only a few efforts have been made to tackle the problem of flash floods which cause severe damage in southern EU and Black Sea countries.

Another serious problem comes from the different methodological approaches used to assess the ELF Hazards. They lead to non-comparable results and this problem is widely spread as different methodologies are often used by researchers even within the same country. In order to proceed with concrete solutions regarding a reliable and accurate hazard assessment, this problem has to be addressed as soon as possible. The achievement of a consensus among the scientific community regarding data and methodologies used to assess ELF Hazards is in this case absolutely essential because it will help create a large network of potential partners with the same scope: to tackle ELF Hazards. Moreover, it will give them the means to communicate transparently regarding related scientific problems.

Management strategies should also be harmonised as fully as possible. Hazard Management must follow all four steps of the risk management cycle. Cross-border cooperation especially when considering flood hazard, is necessary at every step of the process, because it will greatly help to effectively tackle the problem for the greater benefit of all partners. Cooperation in any case, helps to enlarge the number of available solutions, to strengthen the knowledge and information base shared between partners and to select the more cost-effective mitigation strategies. The problems that arise when considering cross-border cooperation in flood hazard mitigation are usually connected to the lack of a legal framework for cooperation, the lack of capacity and resources, differing institutional structures, the lack of political will and lack of public awareness and participation. There is a need to address those problems.

To sum up, cross-border cooperation, harmonisation of methodologies used to assess ELF Hazards, easy or even free access to reliable and accurate harmonised data and reliable and accurate hazard maps on a local scale are needed in order to effectively design preventive measures, to plan an effective management strategy and finally to raise public awareness, in order to reach an efficient ELF hazards mitigation.

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