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(EUR-OPA)

EUROPEAN AND MEDITERRANEEN
MAJOR HAZARDS AGREEMENT
(EUR-OPA)

RESEAU DES CENTRES EURO-MEDITERRANEENS SPECIALISES DE L'ACCORD EUR-OPA RISQUES MAJEURS
PROGRAMMES COORDONNES EN 2010

NETWORK OF SPECIALISED EURO-MEDITERRANEAN CENTRES OF THE EUR-OPA MAJOR HAZARDS AGREEMENT
2010 COORDINATED PROGRAMMES

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OBJECTIVE OF THE PROJECT

Global objectives :

Long-term.

- Acquisition by the population of the Republic of Armenia of the required knowledge and fundamental skills in properly reacting when informed and warned about an imminent hazard and in the case of specific risks. Achieving this goal requires the recurrent holding of the nation-wide and municipal Campaigns.
- Usage of the experience, gained in training of the population of the Republic of Armenia in skills of behavior when informed and warned about imminent hazard and in times of disasters, shared by the Southern-Caucasus countries and adjacent states at organizing the similar Campaigns in neighboring countries with taking into account their specific geographical and ecological-climatic conditions.
- Basing on the Armenian expertise development of a regional informing and warning system for the populations of the Southern Caucasian countries and adjacent states about trans -frontier emergencies..
- The methodology and plan for action aiming to develop and hold of the National and municipal Campaigns on informing and warning all social groups of population about emergencies at national, regional and municipal levels presented in this project can be (after being appropriately polished up) submitted as an essential component for the development of regional and national informing and early warning systems for other interested countries and regions.
- Profound mitigation of consequences and reducing of losses which likely to be caused by trans - frontier emergencies.

Short term.

- Developing Methodology and Plan for actions aiming to develop and hold national and municipal "Campaigns" on informing and warning the populations about emergencies.

- Developing and holding municipal and nation-wide Campaigns on informing and warning of the populations about emergencies in order to keep the population of the Republic of Armenia informed on possible risks (natural, ecological, industrial, nuclear, transport) threatening each particular country region and about what to do when informed and warned on an imminent hazard and in the case of a particular disaster.
- As local governance bodies are the first who must protect the population, this Project has to be implemented at the both: central and municipal (local) levels. Leaders of local governance bodies, heads of schools, hospitals, policlinics, industrial enterprises, offices and mass media are called to be engaged into the development and realization of this Project.

DURATION 2005-2010

PREVIOUSLY OBTAINED RESULTS

The pilot Project: "National and Municipal Campaigns on informing and warning the population about emergencies at central and municipal levels: basis for a regional early warning system for Southern Caucasian countries and neighboring states in trans-frontier emergencies" is being developed by the European Interregional Educational Centre for training rescuers (Yerevan, Armenia) under the support of the European and Mediterranean Major Hazards Agreement of the Council of Europe.

This work is being carried out in line with the priorities for action in the field of disaster risk reduction in the European and Mediterranean space set under the resolutions of the leading authorities of the "Agreement", in particular those responding to the priorities for action set by the "Medium- Term Plan 2007-2011".

The Project is being developed within the "Agreement's" coordinated Programmes. Basing on the outcomes of the activities performed within the Project 2006, the comprehensive Activity Report (containing 27 pages) that includes the detailed description of the performed activities together with analyses of some challenges for development and especially for practical implementation of the Project has been prepared . The ways to resolve the above challenges have been considered as well as some corrections during the Project development and implementation phases have been made.

The Activity Report 2007 had been focused on the basic outcomes with references if necessarily to the results of analyses 2006.

In 2008 the draft variant in English of "The Methodology and Plan for action aiming to develop and hold National and Municipal Campaigns on informing and warning the population about emergencies at central and municipal levels: basis for a regional early warning system for Southern Caucasian countries and neighboring states in trans-frontier emergencies" has been elaborated.

The final variant in English of below given *basic information materials* has been elaborated:

- Information Leaflet: What to do first"
- Brief information for the population what to do first when warned on an imminent disaster
- The priorities for action to be undertaken by the population when warned on an imminent disaster or in case of disasters likely to occur in Armenia

The draft variants of the *information materials for municipalities at special risk* in English have been prepared: one for municipalities at a possible radiation risk, another for the municipalities in whose territories some hazardous substances are being produced, used or stores; and the third one for the municipalities, located in flood -prone vicinities adjacent to high pressure dikes.

In 8-9 September 2008 in collaboration with the Director of European Centre of Technological Safety (TESEC) Kyiv, Ukraine and corresponding leading officials and specialists of the Emergency Management Ministry of the Republic of Armenia and other concerned Ministries and Departments a Round Table has been organized into town of Metzamor-the partner-town of the Armenian NPP.

The discussion outcomes have been presented at the International Workshop "Learning from Chernobyl legacy to make European nuclear energy safer: role of local communities, authorities and central governments in emergency preparedness and management" in Kiev in 22-23 September 2008.

In 2009 the pursued goals corresponding to the *Administrative Agreement were supplemented and corrected*, drawn on the new priorities and requirements of the guidelines of the EUR-OPA Major Hazards Agreement and the actual events that have taken place. The need to insert these supplements and amendments has also been dictated by the significance of the issues discussed during the International Workshops held under support of the EUR-OPA and attended by EUR-OPA representatives in line with ECRM specialists as presenters and panelists.

By taken into account the above, the new priorities and requirements of the guidelines of EUR-OPA , in particular, ensuring the provision of equal opportunities for the most vulnerable segments of populations: the children, elderly and people with disabilities (the disabled) to education, informing, warning and relevant public services in regard to the observance of their rights, equitable access to meeting their needs in the field of disaster risk reduction , the protection of life and health, the administration of first aid and first psychological aid in emergencies, the Yerevan European Centre (ECRM) in 2009 within the present Project : "National and Municipal Campaigns" has conducted some additional researches addressing the above venues.

In particular, there was analyzed the text of "The Standard Rules on the equalization of opportunities for people with disabilities" (adopted by the UN's General Assembly) in the Appendix to Resolution 48/96 of 20 December 1993 and there have been given some suggestions to supplement the texts of the Standard Rules addressing the above direction.

In a part dealing with ensuring the provision of equal opportunities in the above area to the disabled of all age groups requires in line with resolving legislative and other strategic goals, there have been prepared some suggestions aimed at meeting the above three important objectives:

- To educate emergency and relief managers and workers about the special and heterogeneous needs of the people with disabilities (including, the preparing and publication of correspondent information materials)
- To bring the people with disabilities to the emergency management table with the first responders to introduce the two sides to each other:

➢ *to educate first responders to work adequately with disabled, to ensure adequate preparedness and equip rescuers and related to them the personnel servicing the disabled to rescue and search the disabled and show them first aid and first psychological assistance*

➢ *to make people with disabilities active participate in disaster planning and preparedness, teach them how to survive in emergencies , encourage them to cultivate creative skills, first - and self -aid skills included.*

- For the people with disabilities to be insured equal rights and enhanced education and preparedness, the development of relevant information materials assigned to them and their training should be implemented through regular organizing and holding national and municipal Campaigns on informing and warning the population about emergencies.

The research outcomes have been submitted by ECRM specialists at the following International Workshops held by the support of EUR-OPA in 2009:

- "Human rights in Disasters: Search and Rescue operations in disasters, especially for vulnerable people"
- (5-6 November 2009, Athens, Greece)
- "International Workshop on disaster education/training
- (23-24 November, 2009, Antalya, Turkey")

The suggestions drawn on the outcomes of the above researches as supplements and amendments have been mainstreamed into methodological and informational materials developed within the given Project :"National and Municipal "Campaigns", being briefly quoted in the relevant sections of the present report.

In 2009 the final universal variant of "The Methodology and Plan for action" has been prepared . Simultaneously, by given the above , a number of sections related to the Methodology and Plan for action" have been supplemented and corrected .

Some substantial supplements have also been made to Section 4 , in Sub-section 2.6: "Specific target groups of the population" (pages (27-29) .

The latter notes, that "from the specific targeted groups of populations, the primary focus in national and municipal "Campaigns" will lie on the most vulnerable layers of population, including the children, elderly and disabled.

Based on a brief analyses of the challenge, there were made some concrete proposals on how to create relevant information materials.

The final variants in English of the following informational materials assigned to the municipalities at special risks have been prepared in 2009:

- A manual for the population on how to act when *radiation pollution* is real or seems imminent (the priorities for action to be undertaken by the population)
- A manual for the population on how to act when *a flood* is real or seems imminent (the priorities for action to be undertaken by the population)
- A manual for the population on how to act when *chemical pollution* is real or seems imminent (the priorities for action to be undertaken by the population)

Given, that the Armenian terrain and the entire Southern Caucasus region are exposed to high seismic risk as well as by taking into account of the lessons learnt from the devastating Spitack earthquake that hit Armenia on 7 December 1988 , the listed three additional information Modules and the updated final version have been developed:

- A manual for the population on how to act when *an earthquake* is real or seems imminent (the priorities for action to be undertaken by the population)

The above materials are being submitted to the Agreement´s Secretariat:

The final variant of a first aid pocket book in Armenian has been created and forwarded to rescuers for their feedback in forms of comments and suggestions.

The final variant of "The basic Tests and general Recommendations designed for school administration and parents to assess and increase safety for educational institutions" has been edited and polished.

RESULTS OBTAINED IN 2010.

The Activities in the framework of the 2010 Coordinated Programs have been fulfilled in accordance with the corresponding Administrative Agreement.

In general 2010 specific objectives are following:

- ongoing further developing, discussing, editing and polishing of final variants of general and supplementary information materials together with other materials included into "The Methodology and Plan for action aiming to develop and hold National and Municipal Campaigns on informing and warning the population about emergencies at central and municipal levels: basis for a regional early warning system for Southern Caucasian countries and neighboring states in trans-frontier emergencies" for the use of the municipalities at special risks and *special targeted groups of the populations;*
- ongoing further developing, discussing, editing and polishing of final variant of the "The Methodology and Plan for action…"

At the same time the pursued goals were supplemented and corrected, drawn on *the new priorities and requirements to the documents prepared and approved at the* 12-th Ministerial Session of the European and Mediterranean Major Hazards Agreement (EUR-OPA) on September 28, 2010 (Saint Petersburg).

First of all, this refers to two priority directions especially noted in the "Draft Medium Term-Plan 2011-2015" and in the "Draft Resolution 2010-2 " On Ethical Values and Resilience to Disasters", namely:

"Special attention will be given to victims and vulnerable group" (Medium Term Plan) and "… focusing in particular on vulnerable people…" (Draft Resolution 2010-2).

"The Agreement will also continue promoting the creation of national platforms, supporting as appropriate states, which want to create them and helping their networking in the framework of the European Forum for Disaster Risk Reduction". (Medium Term Plan)

"Special attention will be paid to further integrating the activities of the national platforms into to work of the Agreement…"(Medium Term Plan)

a. Within the first priority direction drawn on analyses of relevant international documents we developed in 2009 some "Suggestions on the equalization of opportunities for people with disabilities" (see more detailed ACTIVITY REPORT 2009).

These results were presented at the international workshops held by the support of EUR-OPA in 2009,) in particular:

- "Human Rights in Disasters: Search and Rescue operations in Disasters, especially for vulnerable people " (5-6 November, 2009 Athens, Greece); and
- at the Meeting of the Working Group on Ethics (17 January, 2010, Paris)

The suggestions drawn on the outcomes of the above researches as supplements and amendments have been mainstreamed into methodological and informational materials developed within the given Project :"National and Municipal "Campaigns" (partially in 2009, finally in 2010).

Some substantial supplements have also been made to Section 4, in Sub-section 2.6." Specific targeted groups of the population" of the "Methodology and Plan for action" aimed to develop and hold national and municipal "Campaigns" on informing and warning the population about emergencies at central and municipal levels".

However, main work done in 2010 is the development of a Pilot Project for one of the information materials targeted for vulnerable people:

" MANUAL ON PREPAREDNESS AND RULES OF BEHAVIOR FOR PEOPLE WITH DISABILITIES IF AN EARTHQUAKE IS REAL OR SEEMS IMMINENT" .

On the one hand, the above brochure being one of the information modules from the unique set of information materials developed during 2006-2009 and finally polished in 2010, has the similar construction principle, unique emblem, basic scenario and motto .

On the other hand, it is larger in size and more complex in its composition.

First of all, proceeding from the specifics typical of the people with disabilities, including children, as well as by taking into account that this brochure is a first from an array of information materials addressed to people with disabilities, it contains more extensive introduction part.

More over, it is designed to three categories of people with disabilities, including children:

- People with impaired mobility
- Who are blind or have impaired vision and
- Who are deaf or have impaired hearing.

Simultaneously, it is designed to their family members, guidance, neighbors and administration and personnel of specialized educational and other institutions where they are take care of.

The next step anticipated to be made in 2011 could be the formation and creation of a separate informational brochure aimed at disabled children who are taken care in specialized educational and other institutions.

Alongside, in 2010 there were edited and updated *the final variants of the information materials assigned for the municipalize at special risks:*

- A manual for the population on how to act when *a n e a r t h q u a k e* is real or seems imminent (the priorities for action to be undertaken by the population)
- A manual for the population on how to act when *r a d i a t i o n p o l l u t i o n* is real or seems imminent (the priorities for action to be undertaken by the population)
- A manual for the population on how to act when *a f l o o d* is real or seems imminent (the priorities for action to be undertaken by the population)
- A manual for the population on how to act when *c h e m i c a l p o l l u t i o n* is real or seems imminent (the priorities for action to be undertaken by the population)

b. The updated and edited final variant of the "Methodology and Plan for action aiming to develop and hold national and municipal "Campaigns" on informing and warning the population about emergencies at central and municipal levels" was submitted to the Ministry of Emergency Situations of Armenia for discussions to elaborate the draft Plans on developing policy aimed to prepare and hold regular national and municipal "Campaigns" in the Republic of Armenia.

However, the development of a draft Plan was delayed till the National Platform on disaster risk reduction is built, as it is supposed that one of the main tasks of the National Platform will be the development of proposals on the creation and updating the system of informing and warning the population about emergencies.

Some initial steps addressing this venue have already made in 2009 and continued in 2010. In particular ordered by the Minister of the Emergency Situations dated August 4, 2010 a Commission on the creation of National Platform on Disaster Risk Reduction was set up that began developing suggestions connected to its establishment.

The Director of the European Interregional Scientific and Educational Centre on disaster risk management (ECRM) was included into the composition of the Commission. Drawn on the analyses of international experience gained in the creation of national platforms, the materials of the Meetings dealing with the above issue organized under support of EUR-OPA in the office of UNESCO in Paris, an extensive paper was created:"

Building and strengthening of national platforms on disaster risk reduction as an effective tool for bi-, multilateral and regional cooperation (the case of Armenia).

This document underlain the presentation of the Minister of Emergency Situations of the Republic of Armenia made on the 12-th Ministerial Session of the EUR-OPA on September 28, 2010 in Saint Petersburg.

At present the relevant documents on the creation of a National Platform in Armenia are being submitted to the Government of the Republic of Armenia for consideration.

COASTLINE AT RISK: METHODS FOR MULTI-HAZARD ASSESSMENT (CERG - EUROPEAN CENTRE FOR SEISMIC AND GEOMORPHOLOGICAL HAZARDS, STRASBOURG)

Aims of the project

The interest for coastal hazard issues has recently significantly increased due to disasters which have been occurring with increasing frequency, even as a result of climate change (but not only), in different parts of the World, including Europe. In this respect the recent tragedy occurred in Italy at the island of Ventotene (20 April 2010), where two students were killed on a beach due to a rock fall, is emblematic. It should be noted that the volume of fallen material that caused these fatalities was extremely small (2-3 m^3), witnessing that even small-sized landslide events can be extremely dangerous and should not be overlooked in the process of hazard assessment. On the other hand, it is worth mentioning that the event was defined as "unpredictable" by the media, whilst a preventive detailed investigation of the area might have highlighted the danger there present. Actually, nowadays the availability of surveying and monitoring methods and tools, which are becoming more and more accurate and reliable, can render hazard assessment promising and effective, in terms of predictability and mitigation of hazardous phenomena. The means for preventing such tragedies are clearly available, nonetheless this kind of research is seldom adequately promoted and supported, which determines damages and casualties that could be otherwise avoided.

The research project on "Coastline at risk: methods for multi-hazard assessment" deals with the study of slope instability in critical coastal areas of France, Portugal and Malta. This issue has been until now only partially dealt with, despite significant risk issues, as witnessed by a series of accidents and/or damages recorded after landslide events.

The project is managed by the European Centre on Geomorphological Hazards (Centre Européen sur les Risques Geomorphologiques, CERG). It is funded by the EUR-OPA Major Hazards Agreement during the period 2009-2011 and co-funded by the project "Multidisciplinary research in the open-air laboratory of the island of Malta: an international network for landslide hazard assessment in coastal areas", co-ordinated by the University of Modena and Reggio Emilia.

The project is co-funded by the Fondazione Cassa di Risparmio di Modena, by the French National Research Action (ANR, Project SISCA: Integrated Monitoring System of landslide crises (e.g. acceleration, fluidization of large muddy landslides) and, also by the FP7 project Safeland: Living with landslide risk in Europe.

In the frame of the project, a collaboration with the OPA Euro-Mediterranean Centre on Insular Coastal Dynamics (ICoD) has been established and the results obtained in 2009 and 2010 have been presented at the *Third International Conference on the Management of Coastal Recreational Resources* (Grosseto, Italy - 27-30 October 2010) which was organized by ICoD in collaboration with the University of Malta.

The research outputs are expected to provide a significant opportunity for scientific discussion based on the comparison of data regarding instability situations in the context of multi-hazards assessment. The latter has been until now slightly dealt with the coasts of Malta, Normandy and Portugal on which the investigations will be focused, despite significant risk issues there present, as evidenced from a series of accidents/damages recorded after landslide events.

The aims of the project are pursued through multidisciplinary investigations which foresee geomorphological and engineering-geological approaches. Integrated avant-garde research techniques, both traditional and innovative, will be applied with special reference to mapping, monitoring and modelling of coastal instability phenomena. The final objective is to propose a method for coastal multi-hazard assessment that can be used to face and manage coastal hazards.

Investigated Coastlines at Risk

Investigations are focused on coastal landslides in three different morpho-climatic European environments: Malta (Mediterranean coastline), Lower Normandy (Channel coastline) and Central Portugal (Atlantic coastline).

These coastline are affected by extensive landslides of different type and size, locally favoured by coastal erosion, which induce hazard situations that urge to be investigated in order to prevent risk for population, buildings and infrastructures.

It is clear how the study of similar instability phenomena occurring in different morpho-climatic conditions will provide a significant opportunity for scientific discussion based on the analysis and comparison of data in the context of multi-hazards assessment. The following research phases are envisaged within the project:

- Retrospective analysis of landslide occurrence;
- Interpretation of multitemporal aerial photographs and satellite images;
- Analysis of predisposing and triggering factors;

- Geomorphological survey and mapping;
- Landslide monitoring;
- Proposal of method(s) for multi-hazards assessment.

Integrated research methods and techniques are applied with special reference to mapping and monitoring of coastal instability phenomena along the coastlines. The studied areas can actually be considered as natural laboratories for the study of landslide phenomena and their geomorphological hazard and risk implications.

In fact, the distinct geological conditions, especially the super-imposition of lithotypes having different mechanical behaviour and the marked jointing of the rock masses, determine the development of a series of landslides, sometimes closely associated each other, which determine the onset of exemplary complex landslides.

Landslide hazard assessment in the Island of Malta

The research focuses on coastal instability phenomena occurring on the north-western stretch of the Island of Malta where widespread active lateral spreading is occurring due to the presence of rock masses showing different litological and geomechanical characteristics. The geological sequence is in fact made up by jointed coralline limestones (Upper Coralline Limestone formation, Upper Miocene) overlying clays (Blue Clay formation, Middle Miocene). This geological situation, as well as the presence of a series of horst and grabens, plays a direct control upon the surface topography and landform evolution. At the edge of the limestone plateaux a series of landslides have been recognized, which are favoured by the rock spreading processes above mentioned. High-risk conditions and exemplar instability phenomena are present in particular at Il-Prajjet (Anchor Bay) and Ghajn Tuffieha Bay, where detailed investigation is in progress. The study area (Fig. 1) can actually be considered as a real natural laboratory for the study of landslide phenomena and their geomorphological hazard and risk implications.

During the second year of the project (2010), multidisciplinary investigations that foresee a geomorphological and an engineering geological approach have continued, finally aiming at landslide hazard assessment. Integrated research methods and techniques have been applied with special reference to mapping and monitoring of coastal instability phenomena along the north-west coast of Malta.

After the completion during the first year of the project (2009) of the ***retrospective analysis of landslide occurrence*** within the research area during historic times, further research phases have been completed during the second year of research.

This is the case of the ***collection and analysis of climatic data*** which have been obtained from the Luqa meteorological station to determine the relationship between the identified landslide events and particular meteorological conditions. Data regarding the total annual amounts of rainfall for the period 1929-2006, the average monthly precipitation for the period 1922-2006 and the maximum monthly precipitation for the period 1922-2006 have been collected and analysed.

The ***interpretation of multitemporal aerial photographs*** has also been completed with special attention given to landslide phenomena. To achieve this aim both the traditional stereoscopic techniques and digital photogrammetry techniques have been used. The study of landforms represented in a sequence of images corresponding to different years, enabled to reconstruct the evolution of the coastal stretch under study. Aerial photographs available for the NW coast of Malta have been selected and are being analysed. Particular attention has been given to the first and last series of aerial photographs available (1957 and 2008).

Detailed ***geomorphological survey and mapping*** has been carried out and completed for the entire NW coastal region of the Island of Malta. This phase of the research has also included a check of the existing geological map, as well as investigations aiming at the recognition of ductile and fragile deformation features, which are of topical importance for the stability of the slopes. This phase has finally lead to the production of a detailed geomorphological map, which will be submitted to a journal for publication, together with the related explanatory notes.

Landslide monitoring has been continued and strengthen with the implementation of new instrumentation (extensometers) and is still in progress along the north-west coastline of Malta, at Il-Prajjet (Anchor Bay) and Ghajn Tuffieha Bay (Fig. 1). Monitoring techniques include GPS, consisting in 2 reference stations and more than 20 benchmarks spread all over the unstable areas and wire extensometers which have shown that rock spreading phenomena are active with local displacements up to a few centimetres per year. In order to guarantee the repetitiveness of the surveys, this project is meant to continue the GPS measurements. Moreover, this has been accompanied by the installation of wire extensometers to monitor in continuous the displacements along the most active fractures. Additional benchmarks have been placed along the selected fractures and the first measures have been made manually by means of a wire extensometer.

The research team has also tried to identify strategies to involve and sensitize technical and administrative staff from public institutions responsible for the protection of the environment, as well as academic staff, towards aspects of landslide hazard and risk.

During the last year of the project (2011), the research will be focused on the completion of landslide monitoring (and interpretation of related data) and on ***landslide hazard assessment***.

The research team has also tried to identify strategies to involve and sensitize technical and administrative staff from public institutions responsible for the protection of the environment, as well as academic staff, towards aspects of landslide hazard and risk. For this purpose a series of meetings have been organized in Malta with stakeholders.

Conferences/meetings in which the research carried out in Malta has been specifically presented during 2010

1) Workshop on "The Geography of Unstable Landscapes: The role of geology and geomorphology in slope instability management" (National Museum of Natural History, Mdina, Malta, 5 January 2010).

2) XI Reunion Nacional de Geomorfologia de la Sociedad Española de Geomorfologia (Solsona, Spain, 20-24 September 2010).

3) Third International Conference on the Management of Coastal Recreational Resources (Grosseto, Italy, 27-30 October 2010).

Papers

GONZÁLEZ DÍEZ A., BRUSCHI V., BONACHEA J., REMONDO J., SOLDATI M., PASUTO A., MANTOVANI M., PIACENTINI D., DEVOTO S. & CORATZA P. (2010) - *Propuesta de una metodología para el análisis de la evolución temporal de laderas mediante el uso de fotogrametría digital*. In: X. Ubeda, D. Vericat & R.J. Batalla (eds.), Avances de la Geomorfologia en Espana 2008-2010. XI Reunion nacional de Geomorfologia - Solsona, 20-24 Septiembre 2010. Sociedad Española de Geomorfologia, 51-54 (ISBN: 978-84-693-4551-1).

SOLDATI M., MAQUAIRE O., ZEZERE J.L., PIACENTINI D. & LISSAK C. - *COASTLINE AT RISK: METHODS FOR MULTI-HAZARD ASSESSMENT.* JOURNAL OF COASTAL RESEARCH (SUBMITTED).

Abstracts

SOLDATI M., BONACHEA J., BRUSCHI V.M., CORATZA O., DEVOTO S., GONZALEZ DIEZ A., MANTOVANI M., PASUTO A., PIACENTINI D., REMONDO J. & SCHEMBRI J.A. (2010) - *A comprehensive approach to investigate Maltese coastal landslides.* In: Third International Conference on the Management of Coastal Recreational Resources, Grosseto, 27th-30th October 2010, Grosseto, Tuscany, Italy. Euro-Mediterranean Centre on Insular Coastal Dynamics, Institute of Earth Systems, University of Malta, p. 59.

SOLDATI M., MAQUAIRE O., ZEZERE J.L., PIACENTINI D. & LISSAK C. (2010) - *COASTLINE AT RISK: METHODS FOR MULTI-HAZARD ASSESSMENT.* IN: THIRD INTERNATIONAL CONFERENCE ON THE MANAGEMENT OF COASTAL RECREATIONAL RESOURCES, GROSSETO, 27TH-30TH OCTOBER 2010, GROSSETO, TUSCANY, ITALY. EURO-MEDITERRANEAN CENTRE ON INSULAR COASTAL DYNAMICS, INSTITUTE OF EARTH SYSTEMS, UNIVERSITY OF MALTA, P. 60.

Assessment of Coastal Landslide Hazard: The Villerville-Cricqueboeuf Landslides (Normandy Coast, France)

Investigation in France focuses on the Atlantic Channel coastline of Lower Normandy, with special reference to the Villerville-Cricqueboeuf landslides (Fig. 2). The 12-km-long Pays d'Auge coast in Lower Normandy is periodically affected by rotational and translational landslides since several centuries. These landslides occurred in marly formations covered by chalks and Quaternary deposits. In January 1982, major landslides have caused several damages to roads and houses, some of which were severely affected. The unstable slopes are the Cirque des Graves at the west of the city of Villerville and the Fosses du Macre at the east of the city of Cricqueboeuf.

The Pays d'Auge Plateau is bordered on the north by high cliffs of up to 140 m. The topography and geology of the cliffs are varied. The main scarp is composed of chalk overlying glauconitic sands. Below, a thick layer of marls is on top of the sandy limestone of Hennequeville which shapes the cliff toe and constitutes a reef flat between Trouville and the Pointe du Heurt. Below the scarp, the slope is more gentle and composed of an accumulation of thick superficial heterogeneous materials (blocks and debris of chalk and flints, loamy sands). These formations have been placed during the Upper Pleistocene period.

The research carried out so far in Normandy is based on a methodology to reconstruct the recent geomorphological evolution (since 1830) and to assess the values, the trend and the spatial distribution of surface deformations in the Villerville and Cricqueboeuf coastal landslides, through geomorphological and engineering-geological investigations.

Integrated techniques have been applied with special reference to mapping and monitoring of instability phenomena. In particular, a ***retrospective analysis on landslide occurrence*** during historic times, as well as bibliographic and archival research have been carried out (at public institutions and on newspapers).

A ***multi-temporal analysis of aerial photographs*** (traditional stereoscopic techniques and digital orthorectification) from several series of aerial photographs available (1955 to 2006) - accompanied by a multi-temporal analysis of maps, cadastres etc. - has been performed. ***Geomorphological survey*** has been carried out at a scale of 1:2000 with production of a detailed geomorphological map.

This map has been completed and modified on the base of the Digital Elevation Model (DEM) derived from LiDAR

data interpolation (April 2010 with the support of the Safeland project, FP7). **LiDAR DEM** made possible to access to the detailed morphology of the slope. The major scarps were already mapped but the morphology and the modeling of details were not possible in some areas covered by dense shrub vegetation (brambles).
The LiDAR survey identifies a succession of secondary scarps and clarifies the limits of the active zone for the both landslides. The limits of the active zone have been modified and/or expanded in the western part of the Villerville landslide and in the eastern part of Cricqueboeuf landslide.
Finally, ***geophysical investigation*** by means of ground-penetrating radar along the main road in order to assess the vertical displacements has been made.
The combination of the preliminary results obtained by each method allows assessing the transformation and displacements of the landscape along the permanent landmark observables as slope morphology, frame, infrastructure or fences. Since 1830, the displacements reached 32-38 m in the east part of the Cirques de Graves, and only 16 m in the west part close to the Pointe du Heurt.

Conferences/meetings in which the research carried out in Normandy has been specifically presented during 2010

1) European Geosciences Union General Assembly 2010 (Vienna, 2-7 May 2010).
2) Third International Conference on the Management of Coastal Recreational Resources (Grosseto, Italy, 27-30 October 2010).
3) International Conference 'Mountain Risks: Bringing Science to Society' (Florence, Italy, 24-26 November 2010).

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Coast of the Caldas da Rainha Municipality (Central Portugal)

Research on the Atlantic morpho-climatic environment focuses on the coastline of the Caldas da Rainha Municipality (Central Portugal) (Fig. 3) where coastal sandy systems (beach - dune and beach - alluvial plain) and cliff systems are present.
The coastal cliffs within the study area reach 120 meters of height and are subjected to translational rock slides and rock falls. These landslides affect limestones, marls, clays and sandstones of Upper Jurassic age.
The slope instability processes affecting cliffs in the Caldas da Rainha municipality are strongly conditioned by the geological structure. The coastal cliffs are exposed to NW in the same direction as the dip of geological strata. This geometric framework is highly favourable to the occurrence of deep-seated translational slides, whose fronts are extended to the shoreline, even entering the sea. These slope movements have typical planar surfaces, developed on clays and marls, and affecting mainly the overlying limestones, marls and sandstones, which tend to disintegrate during the downslope movement.
The investigation carried out so far in the Portuguese test site included the ***retrospective analysis of landslide occurrence*** aiming at compiling the landslide inventory for the rocky coast of the Caldas da Rainha Municipality. In particular, a stretch of coastline of the length of 925 metres, located northward the Foz do Arelho beach, has been studied and detailed ***geomorphological mapping*** has been carried out. This area is strongly affected by landslides and the tourist pressure is very high, thus originating significant risk. Ten deep-seated translational slides were recognized as well as one shallow translational slide and one rock fall. These landslides have a total area of 79,005 m^2, i.e., around 45% of the study area.
An ***empirical model*** was proposed for the geomorphological evolution of the coastal cliffs in the study area that includes the sequence of the following processes: i) deep-seated translational slide affecting sandstone and limestone

overlying claystone; ii) rock fall originating in the left flank of the translational slides completing the elimination of the upper hard layers; and iii) gully erosion affecting the claystone layer.
Additionally, a multi-hazard map was prepared for the Caldas da Rainha municipality integrating those natural processes that have a higher potential to generate losses and damage to persons, property and economic activities: earthquakes, tsunamis, coastal erosion, landslides and floods. Furthermore, Zones of Coastal Protection were defined and mapped in order to be included in the Portuguese National Ecological Reserve (REN).

Conferences/meetings in which the research carried out in Portugal has been specifically presented during 2010

1) European Geosciences Union General Assembly 2010 (Vienna, 2-7 May 2010).
2) Third International Conference on the Management of Coastal Recreational Resources (Grosseto, Italy, 27-30 October 2010).
3) Congresso *Planeamento Municipal, Balanço e Desafios*, Instituto de Geografia e Ordenamento do Território, (Lisbon, 4-5 November 2010).
4) V Congresso Nacional de Geomorfologia (Oporto, Portugal, 8-11 December 2010).

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HENRIQUES C., CARDINALI M., REICHEMBACH P., SANTANGELO M., GUZZETTI F. & ZEZERE J.L. (2010) - *Relação entre movimentos de vertente e a morfoestrutura na bacia hidrográfica da Tornada (sector Centro-Oeste de Portugal)*. V Congresso Nacional de Geomorfologia, Porto (accepted).

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HENRIQUES C., CARDINALI M., REICHEMBACH P., SANTANGELO M., GUZZETTI F. & ZEZERE J.L. (2010) - *Relationship between slope movements and structural setting in the Tornada river basin (central western Portugal)*. *Geophysical Research Abstracts*, Vol. 12, EGU2010-10593, 2010, EGU General Assembly 2010.

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DAM RELATED RISKS IN EUROPE AND THE MEDITERRANEAN: THREATS AND PREVENTION (GHHD - GEODYNAMICAL HAZARDS OF HIGH DAMS, TBILISI)

OBJECTIVES OF THE PROJECT

GHHD was requested to produce a report on the state of the art in dam related risks knowledge and possible ways to monitor and improve their resilience to hazardous events.

The report, will present in non-technical terms the diversity of dams (illustrated with examples in the Europe and the Mediterranean area) and the main threats they have to face. It will also briefly explore and evaluate the various approaches to better appreciate their potential vulnerability as well as the ways to reduce such vulnerability.

1. Definition of Large Dams

International standards (including International Commission on Large Dams, **ICOLD**) define large dams as higher than 15 meters and major dams as over 150 meters in height. The Report of the World Commission on Dams also includes in the large category, dams, such as Barrages, which are between 5 and 15 meters high with a reservoir capacity of more than 3 million cubic meters.

2. Application areas of dams and their design. Role of preliminary exploration of dam construction area (geology, geophysics)

The dam site selection is one of the main factors in the complex problem of dam safety. Dams can be built successfully even at sites with difficult foundation conditions. Foundations for dams usually require some treatment to satisfy the requirements of stability, deformation, and watertightness. Geologic conditions at a selected dam site are an important but not necessarily the sole factor when deciding on the dam design. The designer must respect the fundamental rule that selection of the dam structures must be governed by the prevailing site conditions, and not try to adjust the site to suit his preferred type of dam. Of course, detailed geological/geophysical investigations are obligatory for selection of safe site for dam construction. Three classes of objectives are addressed by geological/geophysical surveys: the measurement of geologic features, the in situ determination of engineering properties, and the detection of hidden cultural features. Geologic features may include faults, bedrock lows, discontinuities and voids, and groundwater. It should be stressed that application of geophysical methods is necessary to reduce the cost/duration of exploration and increase the reliability of assessments. Applied geophysics can contribute to the solution of most geotechnical engineering and environmental problems. Engineering properties that can be determined in situ include elastic moduli (media velocities from seismic methods), electrical resistivity or, by georadar, the dielectric constant and to a lesser degree, magnetic and density properties.

3. Classification of Dams by Structure

There are several different types of dams (Fig. 2): those built of concrete, stone, or other masonry are called gravity dams, arch dams or buttress dams (For special terms see Glossary). There are also embankment dams built of earth or rocks – 75% of all dams are of this type. The selection of the site and type of dam involves detail assessment of such factors as geology, topography, foundation rocks, hydrology, seismic conditions and the need of construction materials. In narrow valleys with sound rocks it is preferable to build a concrete dam, while in wide valleys with less solid rocks embankment dams are favored. Earth embankment dams are the most common type as they use partly the material excavated from foundation.

Arch dams

In the arch dam, stability is obtained by a combination of arch and gravity action. The most desirable place for an arch dam is a narrow canyon with steep side walls composed of sound rock. The safety of an arch dam is dependent on the strength of the side wall abutments, hence not only should the arch be well seated on the side walls but also the character of the rock should be carefully inspected.

Gravity dams

In a gravity dam, stability is secured by making it of such a size and shape that it will resist overturning, sliding and crushing at the toe. The dam will not overturn provided that the moment around the turning point, caused by the water pressure, is smaller than the moment caused by the weight of the dam. For this type of dam, impervious foundations with high *bearing* strength are essential.

When situated on a suitable site, gravity dams can prove to be a better alternative to other types of dams. When built on a carefully studied foundation, the gravity dam probably represents the best developed example of dam building.

Since the fear of flood is a strong motivator in many regions, gravity dams are being built in some instances where an arch dam would have been more economical.

Arch-gravity dam
A gravity dam can be combined with an arch dam, an arch-gravity dam, for areas with massive amounts of water flow but less material available for a purely gravity dam.
Barrages
A barrage dam is a special kind of dam which consists of a line of large gates that can be opened or closed to control the amount of water passing the dam. The gates are set between flanking piers which are responsible for supporting the water load. They are often used to control and stabilize water flow for irrigation systems.
Embankment dams
Embankment dams are made from compacted earth, and have two main types, rock-fill and earth-fill dams. Embankment dams rely on their weight to hold back the force of water, like the gravity dams made from concrete.
Rock-fill dams are embankments of compacted free-draining granular earth with an impervious zone. The earth utilized often contains a large percentage of large particles hence the term *rock-fill*. The impervious zone may be on the upstream face and made of masonry, concrete, plastic membrane, steel sheet piles, timber or other material. The impervious zone may also be within the embankment in which case it is referred to as a *core*. Rock-fill dams are resistant to damage from earthquakes. However, inadequate quality control during construction can lead to poor compaction and sand in the embankment which can lead to liquefaction of the rock-fill during an earthquake. Liquefaction potential can be reduced by keeping susceptible material from being saturated, and by providing adequate compaction during construction.
Earth-fill dams, also called earthen, rolled-earth or simply earth dams, are constructed as a simple embankment of well compacted earth. Because earthen dams can be constructed from materials found on-site or nearby, they can be very cost-effective in regions where the cost of producing or bringing in concrete would be prohibitive.
A third type of embankment dam is built with *asphalt concrete* core. The majority of such dams are built with rock and/or gravel as the main fill material. Almost 100 dams of this design have now been built worldwide since the first such dam was completed in 1962. All asphalt-concrete core dams built so far have an excellent performance record. The type of asphalt used is a viscoelastic-plastic material that can adjust to the movements and deformations imposed on the embankment as a whole, and to settlements in the foundation. The flexible properties of the asphalt make such dams especially suited in earthquake regions.
A dam must have several main details in order to operate properly. They are the reservoir (lake), spillway, outlet works and a control facility. The reservoir is the feature that stores water. Under normal operating conditions the lake level is managed by the control facility which regulates discharges in the outlet works, consisting of a large tunnel or conduit with control gates. Under flood conditions the reservoir level is maintained by both the spillway and the outlet works.

Fig. 2. Types of Dams: (Risque de rupture de barrage, French Ministry of Sustainable Development, 2003)

The main purposes of these reservoirs are: **38% irrigation, 18% hydropower, ,14% water supply,14% flood mitigation, 8% recreation** and 8 % others (navigation, fish breeding etc).

4. The largest dams in the world, Europe and Mediterranean Africa

The largest dams in the world
The largest dam in the world in the stored water volume is the Three Gorges Gravity Dam (China) –

The largest dams in Europe
The Alqueva dam is the largest dam in the Europe which was built on Guadiana river in Portugal. The Alqueva dam is situated in Alentejo city and it created Europe's largest artificial lake which is 250 square kilometers long. The dam was opened in 2002, for saving the water.

The total European reservoir surface area covers more than 100 000 km^2; 50% of which lies in the European part of Russia. Although there are only a few reservoirs in this area, they are very large. The six largest reservoirs are located in the Volga river system in Russia. The Kuybyshevskoye (6450 km$^{2)}$ and Rybinskoye (4450 km$^{2)}$ are the two largest reservoirs. Of the 13 European reservoirs with an area exceeding 1000 km^2, only the Dutch reservoir Ijsselmeer lies outside Russia and the Ukraine.
The European Council member state with the largest number of reservoirs is Spain (approx. 1200), Turkey (approx. 610), Norway (approx. 364) and the UK (approx. 570). Other countries with a large number of reservoirs are Italy (approx. 570), France (approx. 550) and Sweden (approx. 190).
The largest dam in the Mediterranean Africa

The Aswan High Dam (1960: Start of construction; 1976: Reservoir reached capacity) is 3,830 metres long, 980 metres wide at the base, 40 metres wide at the crest and 111 metres tall. It contains 43 million cubic metres of material. The reservoir, named Lake Nasser, is 550 km long and 35 km at its widest with a surface area of 5,250 square kilometres. It holds 111 cubic kilometres of water.

A panorama of Aswan Dam

Problems accompanying Aswan Dam construction

Damming the Nile has caused a number of environmental and cultural problems. The valuable silt which the Nile deposited ashore in the yearly floods and made the Nile floodplain fertile is now held behind the dam. Silt deposited in the reservoir is lowering the water storage capacity of Lake Nasser. Poor irrigation practices beyond the dam are water logging soils and bringing salt to the surface. Mediterranean fishing declined after the dam was finished because nutrients that used to flow down the Nile to the Mediterranean were trapped behind the dam. There is some erosion of farmland down-river as the river used to replenish its sediment during floods, but now most sediment stays behind the walls of the dam. Erosion of coastline barriers due to lack of new sediments from floods will eventually cause loss of the brackish water lake fishery that is currently the largest source of fish for Egypt, and the breakdown of the Nile Delta may lead to inundation of the northern portion of the delta with seawater, in areas which are now used for rice crops. The delta itself, no longer renewed by Nile silt, has lost much of its fertility. There is significant erosion of coastlines (due to lack of sand, which was once brought by the Nile) all along the eastern Mediterranean. As evaporating water in these areas extracts minerals out of the ground, a layer of salt crystals on the soil is often created, causing salinization and decreased yield. The increased use of artificial fertilizers in farmland below the dam has caused chemical pollution which the traditional river silt did not do. Lack of irrigation control has also caused some farmland to be damaged by water logging and increased salinity, a problem complicated by the reduced flow of the river, which allows salt water to encroach further into the delta. The Aswan Dam tends to increase the salinity of the Mediterranean Sea, and this affects the Mediterranean's outflow current into the Atlantic Ocean (see Strait of Gibraltar). This current can be traced thousands of kilometers into the Atlantic.

5. Hazards, risks and benefits associated with large dams

In large storage dams many different types of hazards are possible – earthquakes, landslides, floods, aging of the dam and its components (a comprehensive overview can be found in the final report published by the World Commission of Dams in 2000). The result of accident can be dam failure and flood wave (the latter is mainly due to either destruction of dam or just overtopping of water): dam failure has a whole spectrum of consequences and creates new types of hazards such as environmental, ecological, economical, financial, social, socio-economic, political, cultural heritage, resettlement of indigenous people etc.

The most important issue is to protect the people and to prevent loss of life, therefore, the main point is to have safe dams. All other issues are much less relevant as long as the life of people is not jeopardized. That is why the design and exploitation of dams should take into account all possible hazards.

Of course, dams are not only sources of hazard: they also bring enormous benefits to mankind.

The main domains of dam benefits are:

i. Water supply for domestic and industrial use

A reliable source of water is needed both to sustain existing civilization and to support future growth. Dams contribute significantly toward fulfilling our water supply requirements. To accommodate the variations in the hydrologic cycle and avoid extinction of groundwater, dams and reservoirs are needed to store water and then provide more consistent supplies during shortages.

ii. Meeting the agricultural demand for irrigation and food supply

“Food grows where water flows” this is a well known saying in many regions of the world. According to estimates 80% of additional food production by the year 2025 will need to come from irrigated land.

iii. Flood control

Dams and reservoirs can be effectively used to regulate river levels and flooding downstream of the dam by temporarily storing the flood volume and releasing it later. Lowering of the reservoir level to create more storage before the rainy season eliminates the risk of flooding.

iv. Hydropower

Water has been used from the ancient times to drive water wheels for various mechanical processes, such as grinding corn, sawing timber or driving textile mills. Since the mid-19th century, water power was used to produce electricity for the first time. Since water is the source, hydropower is a renewable and widely used source of electricity. What is very important is a clean source of power, as it does not involve burning fuel which can pollute the environment.

v. Other

Recreation, navigation, fish breeding.

Dam related hazards and risks

Dams are considered "installationscontaining dangerous forces" under International Humanitarian Law due to the massive impact of a possible destruction on the civilian population and the environment. Dam failures are comparatively rare, but can cause immense damage and loss of life when they occur.

Definitions

Hazard is a danger produced by natural or man-made events. Due to exposure to a hazard people, property, systems, or other elements present in the hazard zones are subject to potential losses – this is considered as vulnerability.

Disaster risk is the product of hazard and exposure and characterizes the potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society due to hazardous event over some specified future time period.

There are the following main types of dam-related hazards:

<u>Technical</u> - defects in the functioning of spillways, outlet works and a control facility, which should regulate the transportation of excess water from the lake; errors during design or construction stages; deficiences in construction materials; ageing of installations and dam materials; water quality issues in the reservoir (water-borne diseases; deterioration of water quality due to organic matter, release of hazardous substances, waste from aquaculture, etc.) affecting people, fishery etc.

<u>Natural</u> – strong earthquakes, excess precipitation or snow melt, landslide occurrence, which can damage the system or cause water overtopping due to rock falls or sliding into the reservoir.

<u>Man-made or human</u> – errors in exploitation (excessive release of water from spillway and sudden fluctuations in release of water from operation of the power plant), , bad service, terrorism. The creation of reservoir may also induce earthquakes due to additional stress of water on the earth crust or to increase of pore pressure in the rocks; this effect (reservoir–induced seismicity or RIS) can be described as triggering of natural event by human interference.

A distinction has to be made between the technical hazards expected in a new project and hazards affecting an existing project.

In the table 1 we present the main hazard and the corresponding protective measures

	PROTECTIVE MEASURES				
HAZARDS	Rehabili-tation	Partial reservoir drawdown	Full reservoir drawdown	Evacuation	Post-event evacuation
Natural hazards					
Floods (overtopping)	A	B		C	
Earthquake (including induced seismicity)					C
Mass movements (landslides, debris-flows, avalanches)	A	B			
Structural hazards					
Spillway gates, equipment failure			C	C	
Differential movement of structure	A	B	C	C	
Embankment piping or seepage		B	C		
Electrical/mechanical failure	A				
Man-made hazards					
Sabotage, terrorism, acts of war		B			C

Comment to table: (A) The internal alert triggered by an unusual situation can be managed and controlled by the dam's staff.

(B) A developing situation exists when the observed incident clearly tends to turn into a serious threat to the dam's safety and the population in the downstream area. At this stage it is not yet known whether the situation can be brought under control.
(C) An imminent situation has developed when it has become clear that the progress of the incident or threat cannot be stopped but its consequences can still be mitigated, such as the evacuation of the population in danger.

Why do dam related hazards occur?

We have to distinguish between hazards from the natural environment and man-made hazards.
Natural hazards occur due to natural large-scale processes (say, earthquakes occur due to movement of enormous tectonic plates) and it is impossible (in case of earthquakes) or very difficult (in case of landslides and floods) to prevent them.
The hazards from the natural environment are site-specific whereas the man-made hazards depend basically on the people's behaviour and actions and are usually not site-specific. In addition to that there are a number of project-specific hazards, which depend on the dam type, the dam design, the dam construction, dam shape and height, foundation conditions, seepage control, reservoir volume and water depth etc.
A very important technical hazard, which is often overlooked is ageing of dam material and missing maintenance.
Hazards are not specifically dam-related; they happen in all projects, however, the nature of the governing hazards is different for different projects.

Where do dam related hazards occur?

Large dam-related disasters with large consequences can occur everywhere in the world. Many dams are erected in narrow canyons, which are as a rule, result of active tectonic motion. In turn, active tectonics means that the area (and dams) should be prone to impact of earthquakes, large landslides and tectonic creep. Large floods also can damage dams, as well as human actions. We can recall, for example, that a large disaster occurred in Vajont (Italy) due to landslide descent, destruction of dams took place during World War II in Germany, and a number of dams failed in India and China due to large floods. However, today there are a number of new projects with a much larger damage potential than the dams mentioned above. Due to population growth, economical development etc. the risks are steadily growing while the safety remains unchanged.

What were the largest dam related accidents in Europe and in the world?

The data on the largest dam accidents in Europe are presented in the Table 2.
The table below shows that even small dams can cause big disasters. Many dams failed soon after completion, which means that errors were made at the design stage: that often leads to overtoppings (underestimating of water intake) or structural failures (defects in construction).

Table 2.

Dam/Type/Height/Year Completed	Year Failed	Location	Cause of Failure/Details	
Dale Dike Reservoir/ E/29 m/1859	1864	England	SF/The newly-built dam, at Low Bradfield on the River Loxley, broke while it was being filled for the  first time. An estimated 3 million m^3 of water swept down the Loxley Valley. The subsequent enquiry found that the flood had wrecked nearly every bridge as far as Lady's Bridge, destroyed 800 houses, and killed 270 people (by other sources 2,501). The conclusion was that the dam construction was defective, and that a small leak in the wall grew rapidly until the dam failed completely. The claims for damages (£0.5m) formed one of the largest insurance claims of the Victorian period.	
El Habra/ R/36 m/	1881	Algeria	OT/ People killed - 209	18

Bouzey/G/15m/1915	1916	France	SF/ People killed - 1501	
Bila Desná Dam/E/17m/1915	1916	Austria-Hungary (now Czech Republic)	SF/Construction flaws caused the dam failure/ People killed - 65	
Gleno /(M/G)/ 44 m/1923	1923	Italy	SF/ People killed - 600	
Eigiau Coedty/G E/11 m/1908-1924	1924	Wales	PI OT/ People killed - 16	1908 1924
Alla Sella Zerbino /G/12 m/1923	1935	Italy	OT/ People killed >100	
Llyn Eigiau dam	1959	Dolgarrog, North Wales, UK	The outflow also destroyed Coedty reservoir dam. Contractor blamed cost-cutting in construction but 25" of rain had fallen in preceding 5 days. This was the last dam failure to cause death in the UK to date (2009).	
Vega de Terra/B/34 m/1957	1959	Ribadelago, Spain	SF/ People killed - 421	
Malpasset/A/61 m/1954	1959	Côte d'Azur, France	F /Geological fault possibly enhanced by explosives work during construction; initial geo-study was not thorough. People killed - 145	
Vajont Dam/A/261 m/1960	1963	Italy	OT/Strictly not a dam failure, since the dam structure did not collapse (it is still standing). Filling the reservoir caused geological failure in valley wall, leading to 110 km/h landslide into the lake, water escaped in a megatsunami. Valley had been (incorrectly) assessed stable. People killed – 2,600.  Photo below shows enormous landslide above the dam immediately after the disaster.	
Zgorigrad (Vratza)/Ta/12 m/	1966	Bulgaria	OT/ People killed - 96	
Tous Dam/R/77 m/1980	1982	Valencia, Spain	OT/ People killed > 206	
Val di Stava Dam/Ta/ 1960-s	1985	Italy	Poor maintenance and low margin for error in design; outlet pipes failed leading to pressure on dam. People killed - 2697	
Belci /E/18 m/1962	1991	Romania	OT/ People killed - c.4810	
Peruča Dam	1993	Croatia	Detonation of pre-positioned explosives by retreating Serb Forces	
Vodní nádrž Soběnov	2002	Soběnov, Czech Republic	Extreme rainfall during the 2002 European floods	

Dam Types: E = earthfill; R = rockfill; G = gravity; M = multi-arch; B = buttress; A = arch; Ta = tailings dam
Cause of Failure: OT = overtopping; PI = piping; SF = structural failure; F = geological/foundation weakness

Below we present the list of largest incidents outside Europe, which shows that the dams, bringing enormous benefits, in case of non adequate surveillance can also be a reason of killing thousands of people and a source of heavy economic losses.

Table 3.

Dam/incident	**Year**	**Location**	**Details**
Iruhaike	1868	Japan	1200 victims
South Fork Dam	1889	Johnstown, Pennsylvania, United States	Blamed locally on poor maintenance by owners; court deemed it an "Act of God". Followed exceptionally heavy rainfall. 2 200 victims.
Walnut Grove Dam	1890	Wickenburg, Arizona Territory, United States	Heavy snow and rain following public calls by the dam's chief engineer to strengthen the earthen structure. 129 victims.
Tigra	1917	India	1000 victims
Llyn Eigiau dam and the outflow also destroyed Coedty reservoir dam.	1925	Dolgarrog, North Wales, UK	Contractor blamed cost-cutting in construction but 25" of rain had fallen in preceding 5 days. This was the last dam failure to cause death in the UK to date (2009).
St. Francis Dam	1928	Valencia, California, Los Angeles County, United States	Geological instability of canyon wall that could not have been detected with available technology of the time, 450 victims.
Malpasset	1959	Côte d'Azur, France	Geological fault possibly enhanced by explosives work during construction; initial geo-study was not thorough. 423 victims
Khadakwasla	1961	India	1000 victims
Baldwin Hills Reservoir	1963	Los Angeles, California, United States	Subsidence caused by over-exploitation of local oil field
Buffalo Creek Flood	1972	West Virginia, United States	Unstable loose constructed dam created by local coal mining company, collapsed in heavy rain
Banqiao and Shimantan Dams	1975	China	Extreme rainfall beyond the planned design capability of the dam
Teton Dam	1976	Idaho, United States	Water leakage through earthen wall, leading to dam failure.
Kelly Barnes Dam	1977	Georgia, United States	Unknown, possibly design error as dam was raised several times by owners to improve power generation.
Machu	1979	India	2000 victims
Lawn Lake Dam	1982	Rocky Mountain National Park, United States	Outlet pipe erosion; dam under-maintained due to location
Opuha Dam	1997	New Zealand	
Big Bay Dam	2004	Mississippi, United States	
Camará Dam	2004	Brasil	
Shakidor Dam	2005	Pakistan	Unexpectedly extreme rain
Taum Sauk reservoir	2005	Lesterville, Missouri, United States	Computer/operator error; gauges intended to mark dam full were not respected; dam continued to fill.
Situ Gintung Dam	2009	Tangerang,	Poor maintenance and heavy monsoon rain

		Indonesia	
Sayano–Shushenskaya power station	2009	Khakassia, Russia;	Poor maintenance, 75 persons were killed. The economic losses amount to several billions USD and repair will last 4-5 years.

One of the largest man-made disasters of 21-th century is the recent accident on Sayano–Shushenskaya hydroelectric power station located on the Yenisei River, in Khakassia, Russia; the plant was opened in 1978. It is the largest power plant in Russia and the sixth-largest hydroelectric plant in the world, by average power generation. 17 August 2009, the station suffered an accident. At first the cause of accident was thought to be a catastrophic "pressure surge" known as a water hammer. Later on the official commission "states that the accident was primarily caused by vibrations of turbine № 2 which led to fatigue damage of the mountings of the turbine, including its cover. The report found that at the moment of the accident, the nuts on at least 6 bolts keeping the turbine cover in place were absent. After the accident, 49 found bolts were investigated: 41 had fatigue cracks. But this was only the final result determined by several factors. Firstly, the vibration of turbine became extremely strong. Besides, on the day of the accident, turbine № 2 worked as the plant's power output regulator and as a result it entered into a powerband, nonrelevant to safe functioning. This is why the bolts, keeping the turbine № 2 cover in place, were broken and under water pressure (about 20 atmospheres) the spinning turbine with its cover, rotor and upper parts of total weight 900 tons jumped out of the casing up to 14 meters, destroying the machinery hall equipment and building. Water immediately flooded the engine and turbine rooms and caused a transformer explosion. Water ducts 3 and 4 collapsed, flooding the station's powerhouse, 75 persons were killed. The economic losses amount to several billions USD and repair will last 4-5 years.

Can the causes of dam related hazards be influenced by human behavior?

As was mentioned earlier, natural hazards are caused by large-scale processes and it is impossible (or very difficult) to prevent them. The only real method of such disaster risk reduction is to design the dam in such way that it can resist or reduce the impact of damaging natural forces. In case of earthquake this is done by detailed study of the construction area – active faults, their seismic potential, recurrence period of earthquakes, site geotechnical properties and erecting the construction so that it will withstand seismic shaking without substantial damage.

In contrast to large-scale natural hazards, the technical and human-induced hazards can be reduced by timely intervention. For example, a good real-time monitoring network measuring dam and foundation deformations can signal that the strains in the system are close to the theoretically predicted critical values, estimated in the process of dam design. In this case the operating staff of the dam can decrease filling/discharge rate to lessen the strain rate.

One of important dam-related hazards caused by human activity is the phenomenon of reservoir-induced seismicty (RIS). This phenomenon was first observed in 1932 at the Quedd Fodda Dam in Algeria. After this event more than 70 cases of increased seismic activity near large dam reservoirs have been documented. There are two main models of RIS: i. impact of direct loading of earth crust by lake weight; ii. Increase of pore pressure of fluid in porous geological formation. In the first case the load can release the normal stress on some types of tectonic faults, thus decreasing the friction resistance to tectonic stresses and facilitating the slip along the fault, i.e. initiating the earthquake. In the second case the friction resistance of the fault decreases due to the increase of pore pressure. As the pressure of the water in the pores of the rocks increases, it "lubricates" the fault's slip planes. This activates faults, which are already under tectonic strain, but are prevented from slipping by the friction of the rock surfaces.

The RIS usually is observed at reservoirs, where the water depth exceeds 100 meters, but some less deep reservoirs also can induce earthquakes. RIS can either increase the existing seismic activity, or generate earthquakes in seismically stable areas. The last case is especially dangerous as in such regions the constructions are not built to withstand intensive shaking. Usually, seismic activity in the reservoir area (within around 25 kilometres of the reservoir) increases several months after the water level has risen to approximately 100 m. Then after several months the main strong event can occur. In following years the RIS usually decays to almost background level. It should be noted that the pattern differs for different reservoirs.

Not all reservoirs increase the seismic activity. If the load of the lake increases the normal stress to the fault slip plane, the seismic activity, in contrast, reduces below background level. This response to reservoir load was observed at Tarbela, Pakistan and some other places.

The strongest earthquake of magnitude 6.3 has been induced by the construction of the Koyna reservoir in India, in 1967. The earthquake stroke some time after filling the lake in the region, which was thought to be seismically quiet. It demolished the village of Koynanagar; 180 people were killed, 1,500 injured and thousands of houses were flattened.

The tragedy connected with one of the highest dams in the world, the Vaiont Dam in Italy is also thought to be related to RIS. In 1963 the 261 m high dam was overtopped due to the descent of rock debris from the mountain to the reservoir. An enormous surge (according to some sources, tsunami) wave of 110 m overtopped the dam and two minutes later covered the small town of Longarone located downstream and killed 2600 of its inhabitant. Why should the overtopping be linked to RIS? The fact is that after impounding the lake seismic activity increased and the debris on the gorge slope began to move towards the lake. After reaching the depth of 130 m the reservoir was drained. As a result, both seismic shocks and slope movement almost stopped. The lake was filled again and the induced seismicity was re-activated. However, engineers assumed that the mass-movement from the mountain would be very slow. Unfortunately, the heavy rains of 1963 and the increased number of shocks (up to 60) accelerated debris flow and 350 million cubic meters of rock plunged into the lake, resulting super high surge wave almost of the height of a 30 storey building. It is difficult to prove, but it seems likely that seismic shocks and strong swelling of the rock mass by heavy rain triggered the giant debris flow.

It is still not clear whether the reservoir-induced seismicity can be predicted with sufficient accuracy, necessary for pro-active measures.

6. Prediction of dam-related hazards and risks

There are different ways in which the hazard can be predicted, namely, time-independent and time-dependent predictions (the latter ones are also referred as forecasts). The time-independent predictions give the information on the areas prone to hazard, their expected intensities and recurrence times. In such way is predicted for example, the seismic hazard; statistical calculations allow assessing the probability of occurrence (or nonoccurrence) of a hazard of a given intensity at a given place in a given time interval. For example, the operating basis earthquake (OBE), i.e. the earthquake that the structure must safely withstand with no damage, is specified as having a 90% probability of nonoccurrence in a 25-year-exposure period. This is equivalent to a recurrence interval of 237 years.

In a similar way can be predicted the flood hazard for a dam: for example, the Inflow Design Flood (IDF*)* is used to design and/or modify a specific dam and its appurtenant works; particularly for sizing the spillway and outlet works, and for determining surcharge storage requirements.

The above predictions are not time-dependent and are based on assumption that the natural processes leading to earthquakes and floods on the long-range time scale are stationary. Such approach is extremely useful in designing the dam resistance to earthquakes and floods. At the same time it is evident that it would be very important to know the time of extreme event in order to carry out operative preventive measures.

Unfortunately, the reliable forecast of earthquake occurrence time is still impossible. The prediction of flooding is more feasible, as the monitoring of meteorological parameters (data on precipitation, temperature, snow cover, etc) allows calculating the volume of discharged water. Then the special outlet works can regulate the floodwater outflow.

The landslide hazard also can be monitored by modern technology (Global Positioning System or GPS, **Li**ght **D**etection **a**nd **R**anging systems or lidars, Inverse Synthetic Aperture **Radar or** InSAR), which return the value of displacement of surface points; regular monitoring of velocity of mass-movement gives a sound basis for prediction of critical state, which can be caused by strong rains, intensive melting of snow cover, etc.

Similar to seismic zoning the “flood zoning” (preparation of inundation maps) is very useful to predict the extent of potential flooding the height of water and the time of front wave arrival (Fig. 12). It is possible to calculate more precisely the time-space flood scenario, using detail digital elevation maps.

Below we present such a detailed flood risk assessment for Enguri High Dam, located on the Enguri River in Western Georgia near the point at which the river leaves the Caucasus Mountains on its way to the Black Sea (Fig. 10). Enguri high dam was built at the beginning of 1970-s by the Georgian Company “Hydromsheni”. This is a huge tall double-curvature arch dam with a crest length of 680 m and height of 271.5 meters. The reservoir could be filled normally to 1,093,000,000 m^3. Modeling programs “**SOBEK**” and **ILWIS** (Integrated Land and Water Information System) as well as Digital Elevation Models (DEM) of the area have been used to quantify the dynamics of a flood event and to run different scenarios to evaluate the consequences of a potential Enguri Dam break.

Here we show the maximum depth of water and the duration of flooding in case of (partial) failure of Enguri Dam as well as the spatio-temporal animation of the flood scenario. Modeling leads to the important conclusion that the flooded area and, consequently, the expected damage are significantly less than in the earlier assessments, which were based on simplified assumptions.

Generally, the technical hazards, such as extreme strains in the body of dam, due to aging or overloading can be monitored and in some cases even predicted by networks of special devices (strainmeters, tiltmeters, etc).

Usually, the safety level of a dam is established at the design stage and depends on the extent of its stability. In its turn, the mechanical stability of construction depends on many factors (e.g. aging, quality of materials, exploitation regime, etc.) but it is mainly a function of loading. Thus, the essence of the mentioned dam-related threat is the risk of the loss of dam’s stability under the influence of many load factors and possibly leading to failure or damage

As a rule, in the case of dam there are pre-defined operational load factors for which the structure has been designed, namely: primarily the horizontal force field caused by the stored water masses; the second main category includes the load of the geophysical environmental processes such as tectonically induced loading, pore pressure variations or fracture processes. Other categories could be abnormal water influx, flood waves generated by landslides or meteorological causes, thermo-elastic effects caused by air temperature variation, interaction of the foundation with the dam, the transfer of stresses between the various zones of the dam, etc.

At certain loading conditions, the visco-elastic dam structure as a whole or its individual elements may respond through time-dependent inelastic deformations. For each deformation there is a corresponding safe (theoretical) limit which must not be exceeded. At larger loading values, extensive deformations may occur which are beyond the safe limit and which may compromise the dam's stability leading to damage and possibly to failure.

Full scale monitoring of dams must include permanent environmental, geotechnical, geophysical, geodetic etc. observations. These include pore pressure measurements using piezometers, measurements of seepage through the foundation and the abutments, and measurement of stresses, temperatures, seismic and ultrasound velocities, etc. within the selected locations in the dam and in the foundation, dam and foundation tilt and displacement monitoring using tiltmeters, plumblines or inclinometers, strainmeters (extensometers) and levelling should be performed. The tilts of dam body (Enguri High Dam, Georgia) respond to the seasonal recharge-discharge cycle of the reservoir; it is evident that tilts (and consequently, strains)increase with loading and than return to the initial values. The hysteresis in the cycle manifests presence of some non-elastic components of strain, which can be used for diagnostics of dam state as the nonlinearity is related to the presence of fractures. If measured characteristics e.g. strains are close or larger than theoretically predicted limit deformations, some preventive measures will be realized, say, decrease of recharge/discharge rate or retrofitting the dam structure. Unfortunately development of such systems, comprising monitoring of all potentially damaging environmental influences (including earthquakes, floods, landslides, etc.) as well as monitoring of dam geotechnical and geodetic data is extremely expensive and a technically difficult task. There are only few successful examples worldwide of development and functioning of such full scale safety systems (e.g. on Diamond Valley Lake Reservoir in Southern California). Such monitoring systems enables to achieve exhaustive real time observation and evaluation of all possible static and dynamic changes in the dam body, caused by environmental influence, as well as possible changes in dynamics of environmental processes, related to the dam and reservoir influence.

7. New methods of dam monitoring and early warning systems

The M. Nodia Institute of Geophysics (Georgia) and European Centre "Geodynamical Hazards of High Dams" at the Council of Europe are developing the real time geotechnical telemetric monitoring system of large dams. This early warning system will be tested on the Enguri Dam International Test Area. The idea is to transmit on the regular basis (in real time) the data on tilts in the body of the highest (in its class) dam in the world Enguri Arc Dam to the diagnostic center in order to compare observed tilts with theoretical values and in case of approaching the theoretical limit critical values to issue a warning for dam administration.

It is hoped that real time monitoring may help to improve the safety situation. Now, as it follows from several decades of experience with warning systems worldwide, the portion of false alarm messages is still rather highs (about 60%).

The main idea of diagnostics is that as a result of dam material/structure damage elastic properties of the dam body diverges from the predictions of the simple linear elasticity. Elastic properties of such materials, which are called inhomogeneous (disordered, diluted) at small concentration of defects (cracks, pores, voids etc) can be calculated by the theory of effective media

<u>Static (Linear Elasticity) Approach - Finite Element Model</u>

The Enguri dam foundation integrated FEM model will be developed using isoparametric 3d elements including anisotropic properties of materials. The FEM will implement the formulation of Zienkiewicz [Zienkiewicz, 2000]. The variation of static strain/tilt components versus strain (water level) can be predicted in the frame of linear elasticity by the theoretical design model will be compared with observed data and the difference between them will be assessed from the point of view of criticality theory.

<u>Time series analysis and forecasting methods</u>

In order to ensure correct statistical and dynamical investigation of dam stability problem, modern methods of linear and nonlinear analysis of strain/tilt time series will be used [Press et al., 1996; Sprott, 2006; Kantz, and Schreiber, 1997; Strogatz, 2000; Marwan, 2003; Sprott,. 2006; Matcharashvili and Chelidze, 2000].

Linear methods besides traditional statistical (moments, distribution testing) will include frequency (power spectrum, autocorrelation function), time-frequency (wavelet transformation) and eigenvalue (singular value decomposition) representations and analysis of appropriate data sets [Press et al., 1996; Sprott, 2006]. According to our experience assessment of stationarity of investigated time series for different length moving windows should be informative. For this autocorrelation function first zero crossing variation technique will be specially developed and used for dam deformation data sets.

Nonlinear methods of time series analysis will include denoising of data sets (nonlinear noise reduction), testing of memory properties of targeted process (long range correlation testing, detrended fluctuation analysis (DFA), multifractal detrended fluctuation analysis; qualitative and quantitative evaluation of reconstructed from measured data sets phase space structures (correlation and information dimension calculation, recurrence plots and recurrence quantitative analysis); assessment of phase trajectories evolution by Lyapunov exponents calculation, Recurrence Plots (RP) and Recurrence Quantitative Analysis (RQA) [Kantz, and Schreiber, 1997; Strogatz, 2000; Marwan, 2003; Sprott,. 2006; Matcharashvili and Chelidze, 2000].

Linear forecasting methods will be based on autoregressive properties testing of investigated data sets [Press et al., 1996; Sprott, 2006]. Nonlinear forecasting will be based on evaluation of topological properties of reconstructed from measured data phase space structures [Kantz and Schreiber, 1997; Strogatz, 2000; Sprott, 2006].

The main merit of the above approach is that nonlinear analysis of one component of system's dynamics can lead to reconstruction of the whole complex of indicators (Peinke et al, 2006; Matcharashvili et al, 2007).

Mesoelasticity (nonlinear elasticity) approach.

The theoretical interpretation of experimental hysteretic stress-strain or tilt-stress dependences can be accomplished by the theory of mesoscopic elasticity (McCall and Guyer, 1994). The matter is that heterogeneous materials (concrete, rocks, etc) are nonlinear and their behavior is very different from this of its homogeneous components. Besides, the stress-strain (or tilt) dependences manifest nonlinear hysteretic elastic behavior. Hysteresis is connected with specific response of so called mesoscopic structural features (mainly compliant microcracks) to stress variation, namely, asymmetric response to load and unload. Real heterogeneous materials contain enormous number (10^9-10^{12}) of such defects in a square cm, which means that macroscopic elastic properties of material depend strongly on behavior of microcracks. The main idea is (like in magnetic hysteresis) that the energy spent for opening of existing or formation of new cracks at increasing stress from P_0 to P_c is not enough to close all of them at decreasing stress from P_c to P_0 as some part of energy is lost on irreversible processes (friction heating etc). The return to initial state requires additional work and this invokes appearance of hysteresis in load-unload cycle. Thus parameters of hysteretic cycle can be used for diagnostics of material: in the absence of cracks the brittle solid manifests linear elasticity, appearance of cracks leads to hysteresis and the opening of hysteresis curve increases with number of defects. If the hysteresis cycle is reversible (curve returns to initial position after reduction of stress) then the system is nonlinearly elastic, but if the hysteresis curve shifts in some direction it can be a sign of appearance of residual strain.

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Formal approximation of experimental annual hysteresis data can be accomplished using Preisach-Mayergoyz (P-M) phenomenological model modified to fit quasistatic stress-strain dependence in heterogeneous materials. In P-M model the system is represented by complex of hysteretic elastic units or hysterons; the unit can exist in one of two states, closed (having the length L_0 at pressure P_0) or open (having the length L_c at pressure P_c). We can assume that $P_c>P_0$ and accordingly $L_0>L_c$, which corresponds to closing of existing cracks at rising pressure P from P_0 to P_c (Fig. 15 a). At decreasing pressure the hysteron opens at P_0 and remains in this state at even lesser pressures. Such approximation means that the change of state of hysteron (namely, of its length L) depends on the pressure history: transition from L_c to L_0 takes place at pressure P_c , but the backward transition from L_0 to L_c occur at pressure P_0 . The heterogeneous material can be modeled by a system of many hysterons with random distribution of parameters P_0 , P_c , L_0 and L_c. The P-M space consists of elements with different pairs of P_c and P_0, thus P_c and P_0 can be considered as XY coordinates of P-M space (Fig. b). The part of elements is located along the diagonal of P-M space, where $P_c=P_0$; these elements close and opens at the same pressure, which means that they are not hysteretic; the remaining hysterons with $P_c \neq P_0$ populate P-M space with varying density of states of open or closed hysterons; the points in P-M space are generated randomly according to some simple rule. The hysteresis in the stress-strain dependence stems from difference in the number of open/closed hysterons at increasing pressure from P_i to P_k, ($i>k$) and decreasing pressure from P_k to P_i . Thus at the same pressure P_i the state of the system and accordingly its elastic modulus is different and depends on the pressure pre-history (Figs 15 c, d). Like in all hysteretic phenomena, this difference in load-unload response is due to irreversible energy losses during the process of crack growth (or generation) at loading from P_i to P_k , so that restoring the population of closed cracks at unloading from P_k to P_i demands application of additional pressure ΔP, which defines the extent of opening of hysteresis loop. On the other hand, the value of ΔP depends on content of defects (hysterons); thus the hysteresis loop opening reflects the level of material damage and can be used for diagnostics purposes. The development of P-M model is inclusion of invasion percolation approach, realized by Guyer and McCall (1996).

a) The P-M hysteron, characterized by a pair of pressures (P_0 and P_c) and corresponding lengths (L_c and L_0). Hysteron length at $P=P_0$ is L_0 and after raising P to P_c it decreases to L_c. i.e. raising of pressure closes cracks; b) The points, representing pairs of (P_c , P_0) in the Preisach-Mayergoyz space; c) The history of pressure applied to a system, containing many hysterons (pressure protocol); d) The hysteretic stress-strain dependence corresponding to the pressure protocol of Fig. c. Note the internal hysteresis loops, generated by the pressure reversals at the points 1 and 3.

The hysteron described above corresponds to closure of (existing) open cracks at raising pressure, i.e this is the case of relatively low pressures. At high pressures, close to material failure, the hysteron pattern is reversed, namely, in this case at $P_c>P_0$ the length of hysteron increases from L_0 to L_c, which corresponds to closing of existing cracks at rising pressure P from P_0 to P_c

The standard P-M model describes the case of reversible hysteresis, i.e. the hysteresis loop begins and ends at the same pressure, which presumes that the initial state of the system can be restored. In real systems very often besides elastic strain there is also residual deformation, which means that at repeating load-unload cycles the shift of hysteresis loops will happen. The shift of hysteresis loops can be used as a measure of residual strain in a given material.

The results of monitoring of tilts of the dam body on three levels of section12 of Enguri dam : The first months the data were collected with the rate once per minute: this allows catching short transient effects, which can be useful in diagnostics. Several effects were observed: tilt oscillations with a period of one to several minutes ("dam tremble"), sudden variations of dam tremble amplitudes, strong solitary peaks with relaxation period of several tens of minutes, stepswise change of tilts, daily variations and slow variations lasting from several days to months. In order to use these data for dam diagnostics it is necessary to monitor them for different levels of lake and establish the nature of these effects.

i. Analysis show that strong solitary peaks marked in Fig. by date and time are caused by power cuts, so these effects will be neglected as artifacts.

ii. Dam tremble is most intensive for both components of device installed close to the dam (X3,Y3) crest (Fig.16 a), but is also visible on other levels also, especially at fast water discharge. The tremble recording does not look as a white noise. It seems to be related to the state of construction, as its amplitude responds to the drastic increase of water discharge, realized through the body of dam at the level 330 m. In Fig. 16 b) the arrows mark moments of water discharge exceeding 200 cubic meters per second. The origin of drastic increase of dam tremble on 17 May (marked by star) is unknown, as the discharge this day was not intensive.

a) Dam tremble – oscillations of Y3 component of tilt in sec versus time in minutes recorder by the tiltmeter in the section 12 at the level 475 m, part of record of 28.08.2010; note variations with a period of order of minutes; b) tilt records (in sec) versus time in minutes from April 4 to May 21.

i. Stepwise change of tilt is evident for both components (X2,Y2) of tiltmeter installed in the middle of dam and is marked in Fig. by a thick arrow. The nature of this effect is not clear at present
ii. Daily variations are well expressed on the recordings of both components (X2,Y2) of tiltmeter installed in the middle of dam and also with less intensity at the lowest level (X1,Y1) (Fig.17). The channels (X3,Y3) at the upper level are too noisy to show daily variations. As the amplitude of daily variation did not change after isolation of device by foam plastic boxes, the direct effect of ambient temperature on the device (artifact) is excluded. These variations can be caused by daily water level variations or thermoelastic response of the dam structure to ambient temperature or earth tides. Further studies are needed to establish source of daily variations.
iii. Middle-term (weeks, months) water level variations.

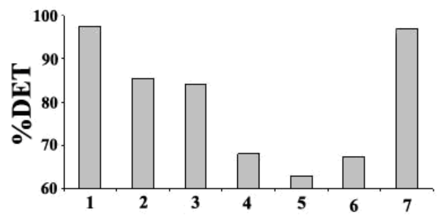
a) water level variations in Enguri reservoir (1-31 May 2010); b) variations of tilts (components (X2,Y2) in the same period. Note daily variations of tilts.

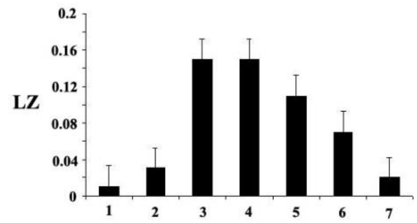
It is evident that water level change and medium-term tilt variations are closely correlated and they can be used for diagnostics of dam response to lake load.

iv. Long-term and annual circles. Comparing outputs of Preisach-Mayergoyz model with annual hysteresis loops of Enguri dam tilts we can mark close similarity between model and observed data, i.e. P-M approach can be used in dam diagnostics. The successive Enguri tilt loops are shifted, which means that load-unload cycles involve appearance of some residual strain and this shift also can be a diagnostic sign (say, to assess aging effect). Of course, nonlinear contributions to stress-strain dependences are not very significant as the dam design is funded on linear approach, which works quite well, but analysis of nonlinear effects can produce promising methods of dam safety diagnostics.

Examples of application of nonlinear dynamics technique to retrospective long-term tilt data sequences

We considered tilt data sets in the following 7 time windows: 1) long before reservoir filling, 2) immediately before and 3) just after beginning of filling, 4) after second, 5) third and 6) fourth stage of reservoir filling and 7) long after completion of reservoir filling. We can illustrate RQA determinism (RQA%DET) and Lempel-Ziv algorithmic complexity measure for mentioned periods. It is evident that for different stages of dam construction and reservoir fill significant quantitative differences have been detected in the recurrence attributes of phase space structures reconstructed from tilt datasets. Note that nonlinear dynamical properties of tilt time series during regular (periodic) reservoir exploitation return to the patterns observed before the dam building and lake fill.Thus these data confirm possibility of detection of man-made effects (i.e. diagnostics) in tilt time series. It is interesting that the local seismicity follows the same pattern in time domain.





a b

a) RQA determinism measure calculated for Earth tilt data series for different stages of observation.
Numbers in abscissa correspond to periods of observation; b) Lempel Ziv complexity measure calculated for Earth tilt data series for different stages of observation. Numbers on abscissa correspond to periods of observation.

8. Prevention and mitigation of dam-related hazards

Many dam-related hazards can be avoided by proper geological, geophysical and engineering investigation of future dam siting. The most important issues to assess dangers correctly are generated by:
- active tectonic faults
- landslides and slope stability
- high permeability of the dam-surrounding rock or soil
- peak flood flows
- silting of reservoir
- impacts on human habitations
- negative impacts on river fisheries, forests and wildlife

Of course, large-scale natural hazards (say earthquakes) can not be prevented; it is possible, however, to make provision of expected strong shaking in dam design. The same preventive measures can be realized against technical hazards by regular inspections or by special monitoring systems (see previous chapter).

Mitigation of earthquake and flooding hazard consequences is possible by taking into account, during the design of the dam the expected intensity of seismic shaking (say, operating basis earthquake, OBE) and the strong flooding probability (say, the Inflow Design Flood, IDF*).* The human settlements should be planned having in mind possible flood wave impact. Installation of monitoring and alarm systems significantly reduces the risk of human losses.

Of course, the correct insurance policy is very important for mitigation of dam related disasters.

What should be done to reduce dam related hazard?

<u>Before:</u>

i. Early detection of signs of distress is critical to effective dam safety. If the weakening of the structure is detected at a very early stage, remedial measures may be taken to repair it and prevent it from becoming a hazard. Even if the detection of structural problems occurs relatively late, action may be taken to mitigate its effects, for example by lowering water levels. Even if it is detected only a few hours prior to a breach, that would still allow for action to save lives and property.

ii. To know the extent of the potential flood area (see Fig.19 a,b). As all kinds of modelling, flooding modelling is a realistic approximation and provides us with a general picture. The simulation software for flood modelling is used to calculate water depths and velocities in case of a dam collapse. The animation shows the simulation results of a dam break (Fig. 12). The results may be used for dam collapse analysis, disaster management, evacuation planning, flood damage assessment, risk analysis and landscape, infrastructure, and urban planning.

iii. To know the elevated sites, where one can seek refuge (hills, upper stories of resistant buildings)

iv. To know the alarm signal (Fig. 15).

<u>During:</u> To reach as soon as possible the elevated site

9. What types of maps on dam-related hazards exist and what are they used for?

In order to identify hazards to which a given dam is prone, the following types of maps are relevant: i. Digital elevation maps for modelling potential flood effects; ii. Geological maps showing the earth material on which the dam is erected; iii. Active tectonic fault maps as possible earthquake and slow deformation sources; iv. Seismic hazard maps, presenting for a given site the expected earthquake impact (intensity I of shaking, peak ground acceleration PGA, spectral acceleration SA, etc); v. Geomorphological maps, delineating possible sources of mass-movement (landslides, debris flows, etc); v. Flood modelling maps, which show the height and speed of the flood wave and the flood dynamics in the time domain (Fig. 20).

The main dam-related hazards are seismic shaking and overtopping due to landslide descent or large flood. The dam should be designed to resist the chosen intensity of shaking (i.e. to the so-called maximum design earthquake MDE). For calculation of the potential seismic impact, first the maps of active tectonic faults of the area are compiled (Fig. 20). Then the intensity and recurrence interval of EQ-s generated by these faults are assessed and lastly the impact of the EQ, namely, the so called Peak Ground Acceleration (PGA) and spectral ground acceleration (SA) on the dam area are calculated. It is important also to take into account the site (soil) conditions and to know the natural frequency of dam, because as at this frequency of shaking the dam is most vulnerable.

If all this information is taken into account during design and construction of the dam the seismic resistance of the dam structure is guaranteed.

The set of maps for peak ground accelerations and spectral accelerations for 50 years exposure time and 1%, 2%, 5%, 10% probability of exceeding and SA maps were calculated for different shaking periods for Enguri dam area. The frequencies that are close to the first mode of the natural frequency of the construction are the most critical for the dam.

The maps of potential flooding downstream of the dam in case of its failure or overtopping can be developed in a similar way using exact digital elevation maps and some guesses on the volume of flooding water (e.g. Probable Maximum Flood, PMF).

Some of these maps can be retrieved from the Internet (e.g. at the web-site PreventionWeb.com).

Digital Elevation Maps (DEM) are available at the corresponding web-pages in the Internet. Geological, geomorphological, active tectonic fault and seismic hazard maps can be obtained from National or Regional Geological Surveys or Universities.

9. Conclusions

“During the coming century, water will continue to be a vital resource for human civilization. An adequate and safe water supply is an essential component to our health, environment, communities and economy. But two major factors will increase the stakes: the incoming climate change, making the water resources more irregular, with drying trends necessitating more water storage; and the world population growth, increasing the demand for domestic, agricultural and industrial water with emphasis on irrigation for food production. Therefore, the crucial role dams played throughout human history will continue during the 21st century. Throughout the history of the world, dams have played a major role in storing and managing water needed to support civilization” (Dams & the World’s Water. International Commission on Large Dams. 2007).

At the same time like any critical engineering infrastructure erection of dams is a potential source of danger: “a failure of a large storage dam would cause tremendous damages to infrastructure, environment and the social network and produce a set back in the development of the region. Dam safety is therefore a foremost prerequisite for a sustainable development of a storage project or for the sustainable operation of an existing storage facility. As a matter of fact, a technology, which is unsafe has no future, and the history of dam construction, spanning over 2000 years, has shown that safety is the basis of sustainability. Keeping the dam in a safe condition requires proper management of all the safety-relevant elements and issues, in particular maintenance of the various structures, rehabilitation of identified deficiencies and aged components, upgrading and replacing instrumentation where necessary, and a periodic review of the emergency concept” (Wieland, 2009).

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Georgian-European Centre "Geodynamical Hazards of High Dams" of the open Partial Agreement of Council of Europe) with consultations of Dr. M. Wieland, Dam and Earthquake Expert, Poyry Energy Ltd., Zurich, Switzerland and Dr. R. Peter Brenner, Independent Dam Consultant, Switzerland.

Acknowledgements

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10. Short glossary

(Source: Dams & the World's Water. International Commission on Large Dams. 2007)

Abutment That part of the valley side against which the dam is constructed. An artificial abutment is sometimes constructed, as a concrete gravity section, to take the thrust of an arch dam where there is no suitable natural abutment. The left and right abutments of dams are defined with the observer viewing the dam looking in the downstream
direction, unless otherwise indicated.

Appurtenant structure The other features of a dam project such as the control rooms, outlet conduit, outlet tunnel, spillways, penstocks, power plants, etc.

Aqueduct Bridges built to carry water across a valley

Bedrock Any sedimentary, igneous, or metamorphic material represented as a unit in geology; being a sound and solid mass, layer, or ledge of mineral matter; and with shear wave threshold velocities greater than 2500 feet/second.

Borrow area The area from which natural materials, such as rock, gravel or soil, used for construction purposes is excavated.

Channel A general term for any natural or artificial facility for conveying water.

Cofferdam A temporary structure enclosing all or part of the construction area that construction can proceed in the dry. A diversion cofferdam diverts a stream into a pipe, channel, tunnel, or other watercourse.

Compaction The mechanical action that increases the density by reducing the voids in a material.

Concrete lift The vertical distance measured in feet or meters between successive placements of concrete
delineated by horizontal construction joints.

Conduit A closed channel to convey water through, around, or under a dam.

Core A zone of low permeability material in an embankment dam. The core is sometimes referred to as central core, inclined core, puddle clay core, rolled clay core, or impervious zone.

Crest length The measured length of the dam along the crest or top of dam.

Crest of dam See top of dam.

Cross section The elevation view of a dam formed by passing a plane through the dam perpendicular to the axis.

Curtain A zone of foundation grouting or piling parallel to a dam axis designed to prevent or diminish seepage beneath the dam.

Curtain grouting Grouting of foundation materials to produce a barrier to seepage beneath a dam.

Dam An artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material, for the purpose of storage or control of water.

Arch dam A concrete, masonry, or timber dam with the alignment curved upstream so as to transmit the major part of the water load to the abutments.

Buttress dam A dam consisting of a watertight part supported at intervals on the downstream side by a series of buttresses. Buttress dam can take many forms, such as a flat slab or massive head buttress.

Diversion dam A dam built to divert water from a waterway or stream into a different watercourse.

Earthfill dam An embankment dam in which more than 50% of the total volume is formed of compacted earth.

Embankment dam Any dam constructed of excavated natural materials, such as both earthfill and rockfill dams.

Gravity dam A dam constructed of concrete and/or masonry, which relies on its weight and internal strength for stability.

Masonry dam Any dam constructed mainly of stone, brick, or concrete blocks pointed with mortar. A dam having only a masonry facing should not be referred to as a masonry dam

Multiple arch dam A buttress dam comprised of a series of arches for the upstream face.

Rock-fill dam An embankment dam in which more than 50% of the total volume is comprised of compacted or dumped cobbles, boulders, rock fragments, or quarried rock generally larger than 3-inch size.

Roller compacted concrete dam A concrete gravity dam constructed by the use of a dry mix concrete transported by conventional construction equipment and compacted by rolling, usually with vibratory rollers.

Design basis earthquake (DBE) The earthquake which the structure is required to safely withstand with repairable damage. For most usage in Reclamation, the DBE is defined to have a 90% probability of nonoccurrence in a 50-year-exposure period, which is equivalent to a recurrence interval of 474 years.

Drain A facility for collecting and diverting water that seeps through a dam or through the foundation of a dam.
Divert To make go another way.
Grout curtain, Grout veil A zone in bedrock beneath a dam and parallel to its length that has been injected with grout to stop or reduce seepage beneath a dam.
Grouting The operation whereby grout is injected under pressure into openings in a dam or in its foundations.
Drainage area or catchment area The area that drains to a particular point on a river or stream (expressed in square miles or square kilometers).
Earthquake A sudden motion or trembling in the earth caused by the abrupt release of accumulated stress along a fault.
Erosion The wearing away of a surface such as the bank, streambed, embankment, or other surface by river flows, reservoir waves, wind, or any other natural process.
Evaporate The process of changing liquid into a gas or vapor which is incorporated into the air
Fertile The very rich soil which is best for producing crops
Flood A temporary rise in water surface elevation of a stream or river as a result of significant rainfall in the drainage area. It results in inundation of areas not normally covered by water.
Flood, Inflow Design (IDF) The flood flow above which the incremental increase in downstream water surface elevation due to failure of a dam or other water impounding structure is no longer considered to present an unacceptable threat to downstream life or property. The flood hydrograph used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works and for determining maximum storage, height of dam, and freeboard requirements.
Flood, Probable Maximum (PMF) The flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the drainage basin under study.
Flood plain The area adjoining a body of water or natural stream that may be covered by floodwater. It is also used to describe the downstream area that would be inundated or otherwise affected by the failure of a dam or by large flood flows.
Flood storage The retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood wave through a natural stream channel.
Foundation The portion of the valley floor that underlies and supports the dam structure.
Freeboard Vertical distance between a specified reservoir surface elevation and the top of the dam.
Gate A movable water barrier for the control of water.
Radial gate A gate with a curved upstream plate and radial arms hinged to piers or other supporting structure.
Slide gate A gate that can be opened or closed by sliding in supporting guides.
Generator The machine that produces electricity
Head The vertical distance between two elevations of water (expressed in feet or meters).
Headwater The water immediately upstream from a dam. The water surface elevation varies due to fluctuations in inflow and the amount of water passed through the dam.
Hydrology One of the earth sciences that deals with the natural occurrence, distribution, movement, and properties of the waters of the earth and their environmental relationships.
Hydrometeorology The study of the atmospheric and land-surface phases of the hydrologic cycle with emphasis on the interrelationships involved.
Impervious core A core in a zoned embankment dam consisting of impervious material
Inflow Design Flood (IDF) The flood used to design and/or modify a specific dam and its appurtenant works; particularly for sizing the spillway and outlet works, and for determining surcharge storage requirements.
Instrumentation An arrangement of devices installed into or near dams that provide for measurements that can be used to evaluate the structural behavior and performance parameters of the structure.
Intake Placed at the beginning of an outlet-works waterway (power conduit, water supply conduit), the intake establishes the ultimate drawdown level of the reservoir by the position and size of its opening(s) to the outlet works. The intake may be vertical or inclined towers, drop inlets, or submerged, box-shaped structures. Intake elevations are determined by the head needed for discharge capacity, storage reservation to allow for silting, the required amount and rate of withdrawal, and the desired extreme drawdown level.
Integrated water management in the river basin The process by which the water stored in reservoirs and the daily amount released is managed in the basin to ensure an adequate and dependable quantity is available. Each dam and reservoir in the basin has a water control plan that outlines discharges from that reservoir based on inflow to the reservoir and downstream needs. Each water control plan is coordinated with other dam and reservoir project within the river basin.
Length of dam The length along the top of the dam.

Low level outlet An opening at a low level from a reservoir generally used for emptying or for scouring sediment and sometimes for irrigation releases.
Maximum credible earthquake (MCE) The largest earthquake that a fault or other seismic source could produce under the current tectonic setting. The seismic evaluation criteria determines which faults or seismic sources are assigned an MCE.
Maximum design earthquake (MDE) The earthquake selected for design or evaluation of the structure. This earthquake would generate the most critical ground motions for evaluation of the seismic performance of the structure among those loadings to which the structure might be exposed.
MW or Mega Watt A unit for measuring power; One MW equals 1 million watts.
Meteorology The science that deals with the atmosphere and atmospheric phenomena, the study of weather, particularly storms and the rainfall they produce.
Minimum operating level The lowest level to which the reservoir is drawn down under normal operating conditions. The lower limit of active storage.
Multipurpose project A project designed for irrigation, power, flood control, municipal and industrial, recreation, and fish and wildlife benefits, in any combinations of two or more. Contrasted to single-purpose projects that serves only one purpose.
Operating basis earthquake (OBE) The earthquake that the structure must safely withstand with no damage. The OBE is specified to have a 90% probability of nonoccurrence in a 25-year-exposure period. This is equivalent to a recurrence interval of 237 years.
Outlet An opening through which water can be discharged from a reservoir to the river.
Outlet works A facility of a dam that provides for the controlled release of water from a reservoir.
Peak flow The maximum instantaneous discharge that occurs during a flood. It is coincident with the peak of a flood hydrograph (expressed in cubic feet per second - cfs or cubic meters per second - cms or m^3 sec).
Penstock A pressurized pipeline or shaft between the reservoir and hydraulic machinery.
Probable Maximum Flood (PMF) See Flood.
Probable Maximum Precipitation (PMP) Theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location during a certain time of the year.
Reservoir The body of water impounded by a dam and in which water can be stored.
Reservoir regulation The process of the compilation of operating criteria, guidelines, and specifications that govern the storage and release function of a reservoir. It may also be referred to as the flood control diagram, or water control schedule. These are usually expressed in the form of graphs and tabulations, supplemented by concise specifications and are often incorporated in computer programs. In general, they indicate limiting rates of reservoir releases required or allowed during various seasons of the year to meet all functional objectives of the project.
Reservoir rim The boundary of the reservoir including all areas along the valley sides at the water surface.
Reservoir surface area The area covered by a reservoir when filled to a specified level (expressed in square miles - miles ^{2} or square kilometers - km2).
Reservoir Storage The retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood wave through a natural stream channel (expressed in acre-feet - ac-ft or cubic meters). Definitions of specific types of storage in reservoirs are:
Active storage The volume of the reservoir that is available for some use such as power generation, irrigation, flood control, water supply, etc. The bottom elevation is the minimum operating level.
Dead storage The storage that lies below the invert of the lowest outlet and that, therefore, cannot
readily be withdrawn from the reservoir.
Flood surcharge The storage volume between the top of the active storage and the design water level.
Inactive storage The storage volume of a reservoir between the crest of the invert of the lowest outlet and the minimum operating level.
Live storage The sum of the active-and the inactive storage.
Reservoir capacity The sum of the dead and live storage of the reservoir.
River basin or watershed The area drained by a river or river system or portion thereof. The watershed for a dam is the drainage area upstream of the dam (expressed in square miles or square kilometers).
Single purpose project A project that provides a single purpose, such as navigation only
Slope Inclination from the horizontal. Sometimes referred to as batter when measured from vertical.
Spillway A structure over or through which flow is discharged from a reservoir. If the rate of flow is controlled by mechanical means, such as gates, it is considered a controlled spillway. If the geometry of the spillway is the only control, it is considered an uncontrolled spillway.

Spillway capacity The maximum spillway outflow that a dam can safely pass with the reservoir at its maximum level (expressed in cubic feet per second - cfs or cubic meters per second - cms or m ^{3} sec).
Spillway channel An open channel or closed conduit conveying water from the spillway inlet downstream.
Spillway crest The lowest level at which water can flow over or through the spillway.
Stability The condition of a structure or a mass of material when it is able to support the applied stress for a long time without suffering any significant deformation or movement that is not reversed by the release of the stress.
Stilling basin A basin constructed to dissipate the energy of rapidly flowing water, e.g., from a spillway or outlet, and to protect the riverbed from erosion.
Tailwater The water immediately downstream from a dam. The water surface elevation varies due to fluctuations in the outflow from the structures of a dam and due to downstream influences of other dams or structures. Tailwater monitoring is an important consideration because a failure of a dam will cause a rapid rise in the level of the tailwater.
Toe of the dam The junction of the downstream slope or face of a dam with the ground surface; also referred to as the downstream toe. The junction of the upstream slope with ground surface is called the heel or the upstream toe.
Topographic map A map with detailed graphic delineation (representation) of natural and man-made features of a region with particular emphasis on relative position and elevation.
Tributary A stream that flows into a larger stream or body of water
Tunnel A long underground excavation with two or more openings to the surface, usually having a uniform cross section used for access, conveying flows, etc.
Volume of dam The total space occupied by the materials forming the dam structure computed between abutments and from top to bottom of dam.
Watershed or river basin The area drained by a river or river system or portion thereof. The watershed for a dam is the drainage area upstream of the dam (expressed in square miles or square kilometers).

16. What to read

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www.earthlearningidea.com – keywords- Landslide - collapse of moraine dam - Dam burst danger. This is a model of dam collapse, which can be done by children www.dur.ac.uk/~des0www4/cal/**dams**/fron/contents.htm

Annex 1.
Large Dams in African Mediterranean

Table . Large dams in Libya

Dam	Reservoir capacity (10^6m^3)	Average annual design storage (10^6m^3/year)
Wadi Mejenin	58	10
Wadi Kaam	111	13
Wadi Ghan	30	11
Wadi Zaret	8.6	4.5
Wadi Lebda	5.2	3.4

Wadi Qattara	135	12
Abu Mansur	22.3	2

The Large Dams in Libya
Currently there are 16 dams in operation with a crest higher than 10 m. The total storage capacity of these dams is 385 million m^3 with an average annual storage capacity of about 61 million m^3 (Table 3).

The Large Dams in Algeria
From the 12.4 billion of surface water in Algeria, only 6 billion could be mobilized by dams. For the moment only four billions are mobilized by nearly 110 dams.
List of the highest Algerian dams

Province	Name	Year of completion	Height of Dam (m)	Capacity of Reservoir (x1000 m3)	Irrigation	Water supply	Hydro electric
Boumerdes	Keddara	1939	108	146000		x	
Chlef	Ghrib	1987	105	280000	x		
Chlef	Oued Fodda	1932	101	228000	x		
Blida	Bou Roumi	1986	100	188000	x		
Mascara	Bouhanifia	1948	99	73000	x	x	
Guelma	H.Meskoutine	1987	93	220000	x		
Chlef	Sidi Yakoub	1987	87	286000	x		
Jijel	Erraguen	1986	82	200000			x
Bejaia	Ighil Emda	1963	76	1600000			x
Biskra	Foum El	1954	73	47000	x		

The Large Dams in Egypt
Aswan Low Dam
Construction was opened on 10 December 1902. The Old Aswan Dam was designed as a gravity-buttress dam. When constructed, the Old Aswan Dam was the largest masonry dam in the world.[5] The height of the dam was raised and now the dam is 1,950 m in length, with a crest level 36 m above the original riverbed.
The Aswan High Dam
The Aswan High Dam (1960: Start of construction; 1976: Reservoir reached capacity) is 3,830 metres long, 980 metres wide at the base, 40 metres wide at the crest and 111 metres tall. It contains 43 million cubic metres of material. The reservoir, named Lake Nasser, is 550 km long and 35 km at its widest with a surface area of 5,250 square kilometres. It holds 111 cubic kilometres of water.
The Large Dams in Tunisia
Big Dams -21, holding 1612 million cub.m.
Dams -65, holding 77.5 million cub.m.
The Large Dams in Morocco
Al Wahda Dam, formerly known as M'Jaara Dam, is an roller-compacted concrete gravity dam (embankment) dam on the Ouergha River near M´Jaara in Sidi Kacem Province, Morocco. It was constructed for flood control, irrigation, water supply and hydroelectric power production. It is the second largest dam in Africa. Construction began in 1991 and was inaugurated on March 20, 1997. The dam is an earthen embankment type made of 28,000,000 m^3 (990,000,000 cu ft) of material and 720,000 m^3 (25,000,000 cu ft) of concrete. It is 88 m (289 ft) tall at its highest point and the main portion of the dam is 1,600 m (5,200 ft) long.
The dam's reservoir though has a high rate of siltation and it is estimated to lose 60,000,000 m^3 (2.1×10^9 cu ft) of storage each year. The silt trapped in the reservoir also doesn't reach the coastal estuary which increases erosion along the coast.

FORMATION CONNAISSANCE ET GESTION DES RISQUES COTIERS (CERCO - CENTRE EUROPEEN SUR LES RISQUES COTIERS, BIARRITZ)

Introduction

Le Centre de la Mer de Biarritz, dans le cadre de son programme CerCo (Centre européen des risques Côtiers), s'est engagé auprès de l'Accord EUR-OPA Risques Majeurs à mettre en place un programme de formation sur la thématique des risques côtiers renouvelable tous les ans. Il s'agit donc de la deuxième édition de la formation qui s'est déroulée du 22 au 26 novembre 2010 au Musée de la Mer de Biarritz. Comme lors de la première édition, il s'agissait, au delà de la formation, de réunir un échantillon de gestionnaires pour rendre compte de leurs attentes et de leurs besoins en termes de formation et d'information. Ce document détaille les observations qui ont été faites concernant l'organisation, le budget, le programme de la formation, les participants (intervenants et stagiaires) ainsi que le suivi post-formation que nous mettons en place pour pérenniser cette initiative.

Organisation

Cette deuxième session a été mise en place, comme la précédente, selon le format "mastère" préconisé par l'accord sur une durée d'une semaine et 36 heures de cours. L'organisation du mastère s'est largement appuyée sur l'infrastructure du musée de la Mer avec la mise à disposition de la salle de cours et du matériel pédagogique (projecteur, ordinateur, rétroprojecteur), machine à café, biscuits et rafraîchissements. La stratégie de diffusion de l'offre du stage s'est basée le réseau des institutions que nous possédons, la liste de diffusion du Réseau Français de Recherche Côtière (RFRC) et le Centre National de la Fonction Publique territoriale (CNFPT), organisme en charge de la formation des agents territoriaux, qui s'est proposé, en plus de la diffusion de l'offre de stage, d'apporter un soutien logistique et financier.

Programme des enseignements

Le programme de la formation est détaillé dans l'annexe I. La formation s'est déroulée sur 5 jours, du lundi 22 au vendredi 26 novembre, le dernier jour étant consacré à une sortie sur le terrain pour présenter les aménagements mis en place par la ville de Biarritz pour lutter, principalement contre le risque d'érosion, depuis les années 80. Le programme s'appuyait sur les retours des participants de l'année précédente et suivait une progression allant de l'approche théorique vers les cas pratiques.

- La première journée a été une journée d'accueil et de présentation théorique des
- risques et des enjeux.
- La deuxième journée traitait du risque de pollutions
- Les troisièmes et quatrièmes journées traitaient des risques d'inondation/surcote et d'érosion.

Une feuille d'évaluation a été distribuée aux participants à la fin de la semaine pour faire états de leur constations par rapport à leurs attentes.

En raison du changement de date de programmation de formation, l'intervention des espagnols d'AZTI Tecnalia a été annulée.

	lundi 22 novembre	mardi 23 novembre	mercredi 24 novembre	jeudi 25 novembre	vendredi 26 novembre
	Journée d'accueil	Qualité de l'eau/pollution	Erosion, recul du trait de côte, risque d'inondation, surcote, risques pour les écosystèmes		Sortie terrain
09:00:00	Accueil : Jérôme Kohl (CNFPT) et Françoise Pautrizel (Centre de la Mer de Biarritz)				
09:15:00					
09:30:00		Pr. Jean-Pierre Vernet : Professeur honoraire de géologie de l'Université de Genève, Président de la Fondation pour la Protection et l'Etude du Patrimoine Lacustre (PATLAC) Les apports du bassin versant	Anton Micaleff : IcoD (Malte) Adaptation à l'évolution du trait de côte	Bérangère Papion : OCEAN Le cordon littoral sableux, gestion du cordon dunaire et présentation de l'association OCEAN	Alain Chauvin : ANTEA Jean-Paul Dugène : Mairie de Biarritz Les aménagements de la côte des Basques. Visite du chantier en cours: renforcement d'un pied de falaise
09:45:00	Pr. Michel Vigneaux : Professeur honoraire de géologie, Bordeaux I				
10:00:00					
10:15:00					
10:30:00					
10:45:00					
11:00:00	Pause/discussions	Pause/discussions	Pause/discussions	Pause/discussions	
11:15:00	Pr. Max Schvoerer : Professeur honoraire, pdt de PACT Risques pour le patrimoine	Michel Noussitou : ARS Qualité des eaux de baignade, les applications de la DCE	Conseil Nationale d'Orientation pour la Prévention des Risques Majeurs Directive communautaire concernant les inondations et les submersions	Yves Ruperd : CETE Caractéristique du risque d'inondation, cartorisques. Plan de Prévention des Risques Inondation	
11:30:00					
11:45:00					
12:00:00					
12:15:00					
12:30:00					
	Pause déjeuner				
14:30:00	Pr. Claude Bobier : Les enjeux du XXIème siècle ; changements globaux et urbanisation du littoral	Matthias Delpey : Rivages ProTech Observations et indicateurs Outils d'aide à la décision	Didier Rihouey : CASAGEC Outils d'aide à la décision	Arnaud Guéna : CEDRE Lutte contre les pollutions Les obligations des collectivités et les outils disponibles	
14:45:00					
15:00:00					
15:15:00					
15:30:00					
15:45:00					
16:00:00					
16:15:00		Pause/discussions	Pause/discussions	Pause/discussions	
16:30:00		Jean-Marie Froidefond : EPOC, Bordeaux I Les outils de la télédétection	Iler Castège : Centre de la mer Biarritz Risques pour les écosystèmes côtiers	Arnaud Guéna : suite	
16:45:00					
17:00:00					
17:15:00					
17:30:00					
17:45:00					
18:00:00					

Liste des intervenants

Intervenant	Qualité	email
Anton Micallef	Professeur de la faculté de Malte, gestion des zones côtières, directeur du Icod[1] (Euro-Mediterranean Centre on Insular Coastal Dynamics)	anton.micallef@fis.org.mt
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Jean-Claude Napias	Ancien directeur BRGM[8] vulnérabilité, hydrologie, France et ancien directeur du CIFEG[7]	
Jean-Marie Froidefond	Professeur de télédétection optique, Université de Bordeaux 1 - Département de Géologie et Océanographie, laboratoire EPOC[3] (UMR 5805)	jm.froidefond@epoc.u-bordeaux1.fr
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Jean-Pierre Vernet	Jean Pierre VERNET Professeur honoraire de Géologie, Université de Genève, Institut F.-A. Forel, géologie de l'environnement, géochimie des sédiments et limnogéologie. Président de la Fondation pour l'étude et la protection du patrimoine lacustre	

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Yves Ruperd	Ingénieur hydrologue - Centre d'Etudes techniques de l'Equipement (CETE), Laboratoire Régional des Ponts et Chaussées de Bordeaux	yves.ruperd@equipement.gouv.fr
1 Centres spécialisés de l'accord partiel EUR-OPA[2] Risques Majeurs		

2 EUR-OPA: Créé en 1987, L'Accord européen et méditerranéen sur les risques majeurs (EUR-OPA) est une plate-forme de coopération entre les pays d'Europe et du Sud de la Méditerranée dans le domaine des risques naturels et technologiques majeurs. Son domaine d'action englobe la connaissance des aléas, la prévention des risques, la gestion des crises ainsi que l'analyse post-crise et la réhabilitation

3 L'UMR EPOC: Environnements et Paléoenvironnements OCéaniques, est une Unité Mixte de Recherche (UMR 5805) commune à deux organismes:
- Université Bordeaux 1
- CNRS, Centre National de la Recherche Scientifique

4 AZTI Tecnalia: organisme de recherche public basque sur la mer et le littoral

5 Rivages ProTech: Centre Technique de la Lyonnaise des eaux destiné à développer pour la France et l'international de nouveaux savoirs faire dans le domaine de la prévision et du suivi de la qualité des eaux de baignades.

6 CRIAA: Centre de Recherche Interdisciplinaire d'Archéologie Analytique

7 CIFEG: Centre International pour la Formation et les Echanges en Géosciences. Fondation créée en 1981, dont le siège est à Paris. Le CIFEG a pour objet de favoriser les échanges dans le domaine des Sciences de la Terre (ressources minérales, ressources en eau, géologie des risques naturels) entre la France, les pays industriels et les pays en développement.

8 BRGM: Bureau de Recherches Géologiques et Minières - Etablissement public de référence dans le domaine des Sciences de la Terre pour gérer les ressources et les risques du sol et du sous-sol

Liste des participants

Nous avons accueilli 13 stagiaires dont dix agents territoriaux et trois étudiants (2 master et 1 doctorant).

Alexandre	Richard	Département de l'Hérault	Chargé d'études littoral
Arnaud	Thibaud	Mairie de Notre Dame de Monts	Secrétaire Général Adjoint
Fanny	Collier	Communauté communes Ile de Noirmoutier	Directrice du pôle environnement
Frédérique	Roman	Syndicat Mixte Vallées de l'Orb et du Libron	Chargée de missions risques
Hugues	Debec	Commune de La Bernerie en Retz	Directeur des services, Mairie de La Bernerie en Retz
Jessica	Etcheverry	Commune de Saint Jean de Luz	Agent territorial
Marie	Mourlhou	Commune de Beziers	Chambre de Commerce et d'Industrie
Marion	Jaud	Plouzane	Etudiante
Mathieu	Lamy	Université de La Rochelle	Etudiant
Olivier	Fouquet	Communauté communes Ile de Noirmoutier	Technicien milieux marins
Pierre	Harmegnies	Université de La Rochelle	Etudiant
Provence	Lanzellotti	Département de l'Hérault	Chargée d'études littoral, EID méditerranée
Stéphane	Averty	Commune de Château-d'Olonne	Agent territorial, chargé des espaces naturels

De nombreux échanges ont eu lieu durant la semaine de formation. Ces échanges, tout aussi importants que les cours eux mêmes, permettent de mettre en regard différentes approches liées aux différentes zones géographiques d'appartenance. Dans ce cadre il a été demandé aux participants d'évaluer les besoins en matière de formation nécessaire à l'application de certaines directive européenne et notamment la **directive européenne inondation,** dans son aspect côtier. Les recommandations des participants sont en train d'être recueillies et seront très prochainement transmises vers les administrations concernées.

Budget

Cf. Annexe II

Conclusions

Cette deuxième session de formation s'est déroulée dans le prolongement de la session 2009 et les participants ont montré un grand intérêt dans les cours qui leur ont été proposés. Les retours des fiches d'évaluation sont positifs et sont représentés par la fiche de synthèse suivante.

Indice global de satisfaction de la formation				
Moyenne sur réponses des intervenants				
1 2 3 4				
1 : Pas du tout satisfaisant / 2 : Peu satisfaisant / 3 : Assez satisfaisant / 4 : Très Satisfaisant				
Support pédagogique & environnement	**1**	**2**	**3**	**4**
Accueil	☐	☐	☐	√
Salle de formation	☐	☐	☐	√
Matériel informatique	☐	☐	√	☐
Support de cours	☐	☐	√	☐
La formation	**1**	**2**	**3**	**4**
Information préalable sur le contenu	☐	☐	√	☐
Contenu adapté à mon niveau	☐	☐	√	☐
Contenu conforme à ce qui était prévu	☐	☐	√	☐
Niveau du groupe homogène	☐	☐	√	☐
Stage correspondant à mon besoin	☐	☐	√	☐
Les formateurs	**1**	**2**	**3**	**4**
Maîtrise du sujet	☐	☐	☐	√
Qualités pédagogiques	☐	☐	√	☐
Compréhension des problèmes	☐	☐	√	☐
Satisfaction globale				
	1	**2**	**3**	**4**
Cette session a-t-elle répondu à vos attentes/objectifs ?	☐	☐	√	☐
Les méthodes et supports de présentation utilisés	☐	☐	☐	√
Vous êtes-vous sentis encouragés à partager vos expériences ?	☐	☐	√	☐
Clarté du contenu de cette formation	☐	☐	√	☐
Votre niveau de satisfaction globale pour cette session	☐	☐	√	☐

Les points positifs retenus sont :

- La participation (des intervenants et stagiaires)
- Le cadre (Biarritz, locaux mis à disposition par le musée de la Mer)
- Le double discours, scientifique et gestionnaire

Les interventions ont généralement été appréciées pour leur orientation vers les applications qui concernent directement les gestionnaires. La théorie a été réduite au stricte nécessaire sans entraver la compréhension des actions à effectuée dans le cadre d'une gestion intégrée des zones côtières.

Une seule intervention a été réalisée en anglais avec des supports traduit en français. Cette méthode a été appréciée des participants qui ont pu suivre parfaitement le cours.

Les points à faire évoluer :

- Ajouter l'intervention d'élus de manière à avoir les trois discours auxquels les agents territoriaux peuvent être confrontés (scientifiques, gestionnaires, élus)
- Accueillir des étudiants étrangers.

Ces deux premières sessions de formation ont montrées, à travers l'intérêt des participants, l'adéquation de notre formule avec les besoins. Il est maintenant nécessaire de communiquer l'offre aux autres pays européens membre de l'accord pour étendre cette formation à des participants européens. L'utilisation de support écrits traduits semble être un moyen efficace de palier au problème de la langue.

ECGS-FKPE WORKSHOP INDUCED SEISMICITY (ECGS - EUROPEAN CENTER FOR GEODYNAMICS AND SEISMOLOGY, LUXEMBOURG)

Description of the workshop

The ECGS-FKPE workshop "Induced Seismicity" was held during three days, from 15 November 2010 until 17 November 2010, at the Hilton Hotel in Luxembourg City. The main objective of the workshop was to bring together leading scientists that work in the field of induced seismicity in order to (1) obtain a comprehensive and state-of-the-art overview on the issue of induced seismicity, e.g. related to geothermal energy projects or carbon capture and storage technology, (2) discuss the problems currently being faced and (3) work towards developing ideas for potential solutions including new research projects.

Sixty participants from thirteen countries attended the workshop (see list of participants), mostly from European countries. It should be emphasized that leading scientists from a wide range of highly esteemed scientific institutions (e.g. the Karlsruhe Institute of Technology, the Swiss Seismological Service, ETH Zürich, NORSAR [Norwegian research institution] or the GFZ German Research Centre for Geosciences) participated at the meeting. In order to provide the best possible state-of-the-art overview on the topic, eight keynote lectures were given (see scientific program). Furthermore, strong emphasis was put on discussion and exchange of ideas among participants, since many issues in data acquisition/processing as well as process understanding of induced seismicity remain to be clarified. For this reason, several "general discussion" time slots were allocated to serve this need. The most important issues were specifically addressed in three debates. The debates were prepared by two participants in order to initiate a lively discussion which was then focused on "Wording conventions for induced seismicity – communicating with the pubic", "How to discriminate induced, triggered and natural seismicity" and "Which new techniques and technologies can we expect in the future". The reported experiences from different countries were very valuable for the participants.

We also put a strong emphasis on supporting the participation of young researchers at this workshop. For this reason, four young scientists received participation grants for the workshop, covering their entire accommodation and travel expenses as well as dispensing them from the registration fees. These four young researchers presented leading-edge results. In total, twenty-four oral and nine poster presentations were given, and there were seven participants from Luxembourg attending the meeting.

Besides the allocated budget from the European Center for Geodynamics and Seismology, the workshop was co-financed by the National Research Fund (FNR) Luxembourg, the Major Hazards Agreement (EUR-OPA) of the Council of Europe, the Landesforschungszentrum Geothermie at the Karlsruhe Institute of Technology (KIT), and the National Museum of Natural History (MNHN).

Scientific program

The workshop started with overviews on the physics of induced seismicity. Then induced seismicity at geothermal power plants followed, because it is the most discussed and most controversial issue at the moment. Following issues were mining induced seismicity, seismicity related to carbon capture and storage (CCS) and seismicity related to natural gas extraction. At the end, instrumentation and observational techniques were presented and discussed (see attached program). Thus, the scientific program of the meeting covered and provided a state-ofthe-art overview on all relevant issues that need to be taken into account when discussing induced seismicity.

Conveners

PD Dr. Joachim Ritter (Karlsruhe Institute of Technology, KIT, Germany)
and
Dr. Adrien Oth (European Center for Geodynamics and Seismology, ECGS, Luxembourg)

Scientific Committee

Dr. N. Cuenot EEIG Heat Mining, France
Dr. B. Dost KNMI, The Netherlands
Dr. S. Husen ETH Zurich, Switzerland
Prof. Dr. M. Joswig University of Stuttgart, Germany
Dr. A. Oth ECGS, Luxembourg
PD Dr. J. Ritter KIT, Germany
Prof. Dr. S. Shapiro Freie Universität Berlin, Germany

Local Organizing Committee

Dr. Adrien Oth (European Center for Geodynamics and Seismology)

Ms. Corine Galassi (European Center for Geodynamics and Seismology)
Mr. Gilles Celli (National Museum of Natural History)
Mr. Eric Buttini (National Museum of Natural History)

Proceedings

The proceedings of the workshop, published in the framework of the Cahiers Bleus du Centre Européen de Géodynamique et de Séismologie, have been prepared in advance of the meeting. Thus it was possible to distribute a personal copy to all participants during the conference, when the proceedings are most needed. The dedicated volume of the Cahiers Bleus contains all abstracts of workshop presentations, nine peer-reviewed articles as well as the scientific program and the list of participants. Considering the fact that the proceedings reflect the extraordinarily high scientific level of the workshop and therefore contain a state-of-the-art summary of research activities in the field of induced seismicity, they will surely be used as a key reference volume for researchers in induced seismicity during the years to come.

Conclusions and major outcomes

The concept of the workshop with keynote presentations (40 min.), regular presentations (20 min.), short poster announcements (5 min.), discussions as well as prepared debates was a great success. There were lively discussions during the whole workshop including during the coffee breaks and the dinners. The participants praised the open discussion atmosphere as well as the perfect organization. Based on this open atmosphere, several scientists will now start to initiate together new research activities, especially between different countries. In that respect, the workshop also proved to be highly beneficial in strengthening the position of Luxembourgish geophysical research within the European community. The proceedings volume will be largely spread within the community working on induced seismicity and cited in upcoming research articles.

Educational aspects – supported young scientists (PhD students)

Katrin Plenkers, Deutsches GeoForschungsZentrum (GFZ) Potsdam
Jörn Groos, Karlsruhe Institute of Technology (KIT)
Patrick Blascheck, Universität Stuttgart
Marco Calo', Université de Strasbourg

RISK OF AND VULNERABILITY TO SEA LEVEL RISE AND TSUNAMI OF SELECTED LOW LYING COASTAL AREAS IN THE MALTESE ISLANDS AND TURKEY (ICOD - EURO-MEDITERRANEAN CENTRE ON INSULAR COASTAL DYNAMICS, MALTA)

1. Introduction

According to EUR-OPA Major Hazards Agreement, Euro-Mediterranean Centre on Insular Coastal Dynamics (ICoD) Malta and Ocean Engineering Research Centre, Civil Engineering Department, Middle East Technical University (METU), Ankara, Turkey collaborated in the "*Risk of and Vulnerability to Sea Level Rise and Tsunami of selected low lying coastal areas in the Maltese islands and Turkey*" project.

This report covers the progress of each task proposed for the 1st year of the project, including the preliminary analyses, maps and produced outputs.

The following tasks are performed in the 1st year:

- Selection of study areas from Turkey and Malta subject to possible effects of tsunamis /SLR.
- Identification of historical events
- Collection of necessary data for the selected sites (near shore bathymetry and topography, distribution of coastal and marine structures and their characteristics, wind, wave and sea level data).
- Public surveys.
- Processing of data and database development for use in the computational tools.

2. Study areas

Global vulnerability studies as well as observations indicate that low-lying coastal areas, especially deltas are the most vulnerable "hotspots" to the impacts of sea level rise. Coastal areas having milder slopes and hosting a variety of human activities such as agriculture, marine transportation, tourism will be affected mostly not only physically but also socio-economically. Thus, the priority of the vulnerability assessment is given to low-lying coastal areas where human activities are densely located.

Description of selected sites for Malta

On the sister island of Gozo the study areas chosen (Xlendi and Marsalforn bays) both represent aspects of low-lying rocky shores and semi-natural environment (negatively impacted from an environmental perspective and positively so from an economic aspect) by a particularly high local and overseas tourism presence in the summer months. These sites are dominated by dense tourism-related accommodation constructed very close to the shoreline, alternating between a poorly occupied environment in the winter months to a largely congested urban environment in the summer months. The high summer population densities, poor urban planning and low-lying nature of these coastlines are aspects that reflect an increased vulnerability to the natural hazards considered by this project.

Of the five study sites located on the main island of Malta (St Paul's bay, St. Julian's bay, the Grand Harbour, Marsascala bay and Marsaxlokk bay), the potential vulnerability is much higher due to the considerably larger permanent residential nature of these areas that compounds congestion by summer tourism. Infrastructural vulnerability of both the Grand harbour area and that of St. Julian's is further increased by the large presence of commercial entities in the grand Harbour and of densely concentrated five star hotels and related recreational establishments in St Julian's bay.

Description of selected sites for Turkey

For Turkey, three coastal regions are selected to comply with the priority set out by the project. Goksu Delta is a major coastal delta that is declared as a special protected area due to ecological characteristics. Delta acts as an important stop for bird migration routes, hosts different endemic plants and animals, and is used as a major agricultural area. Gocek and Fethiye Bay is an indented coast showing different coastal formations from beaches to rocky cliffs, acting as a major tourism spot both for marine and land-based tourism industry. Part of the bay is also declared as specially protected area. Bodrum and Kas area is one of the densely populated tourism areas of Turkey where coastal structures are dominant throughout the shoreline. Not only the density of the tourism infrastructure is high, but during the high summer seasons, the population of the region is very high.

Both Gocek&Fethiye Bay and Bodrum&Kas area will enable comparison of vulnerability at the end of the project since the selected locations in the Maltese islands and these areas show similar intensity and density regarding the use of shorelines. Physical characteristics of these areas are also similar. However analysis of the vulnerability of these sites will enable us to understand the driving concepts (parameters) of coastal vulnerability. Goksu Delta will act as a verification site for the application of the model, since vulnerability of coastal deltas is studied extensively throughout the literature and expected impacts are stated in many reports with very high confidence.

3. Identification of historical events (earthquakes and tsunamis in the Mediterranean Sea)

The investigation of historical tsunami events are necessary and effective tools for appropriate tsunami numerical modeling. Historical documents and geological investigations in the Eastern Mediterranean basin reveal that earthquakes, submarine landslides and tsunamis have been occurred because of the high seismicity, volcanic eruptions and steep slope in Mediterranean region over 3000 years.

The compilation of reliable tsunami database especially for the Eastern Mediterranean region is essential in tsunami-related studies of wave numerical simulation, inundation mapping and risk assessment. Tsunamis in the Eastern Mediterranean were investigated by [1], [2], [3], [4], [5],[6]. Tsunami catalogues for the Mediterranean Sea were compiled by [7], [8], [9], [3], [10], [11], [12]. Recently, [13] compiled historical documents in the Eastern Mediterranean between BC 1410-AC 1999 with inclusion of distant, local, volcanic and landslide generated tsunamis. It includes the list of them with date, region, cause, relevancy, approximate epicenter and magnitude of tsunamigenic earthquakes and other triggering mechanisms. [13] also modified the reliability level classification of tsunamis. Among 130 events, 65 events are well-documented. The list of historical tsunamis occurred in Eastern Mediterranean are given in:

Table 3.1 The list of Historical Tsunamis Occurred in Eastern Mediterranean

Date	Description	Latitude	Longitude
B.C. 1410-1630	1600–1500 B.C., Tsunami occurred because of the eruption of Santorini volcano	36.5	25.5
B.C. 330	Northeast of Lemnos Island	40.1	25.25
B.C. 220/222/227	Rhodes, Cyprus, Corinth	36.5; 36.6	28.0; 27.8 ; 28.25
B.C. 140	B.C. 138, Silifke region in Turkey was affected by the tsunami .Tsunami between Acre and Sur	33.0	35.0
B.C. 26	B.C. 23, Sea-waves at Pelusium-Egypt	34.75	32.4
46	South coast of Crete . Eruption of Santorini Volcano	36.5, 36.4	25.5 , 25.4
53/62/66	62, Southern coasts of Crete ; 62, at noon ; 66	36.0, 34.8	25.5, 25.0
115/12/13	Tsuanami at Caesaria, the Lebanese coast and Yavne	36.25	36.10
120/123/128	Occurred in 123, November 10	40.40, 40.7	29.7, 29.1
142	148; Rhodes, Kos, Seriphos, Syme; destructive sea inundation	36.3 , 36.4	28.6 , 28.33
261–262	262; western Anatolia ; sea inundation	36.5	27.8
342	Paphos, Famagusta-Cyprus	34.75	32.40
348-349	Beirut-Leban	33.80	35.50
358/8/24	Izmit Gulf, Iznik, Istanbul	40.75 , 40.8	29.90, 29.7
365	Eastern MediterraneanTsunami	23.45	35.3
368/10/11	Iznik, The sea rose up	40.40, 40.5	29.70, 29.6
407/4/1	Istanbul, Many ships were wrecked and many corpses carried out to the coast of Hebdoman (Bakirkoy-Istanbul)	41.0	29.0
447/11/8	447.11., 447.01.26 night , 447.12.08 . The sea cast up	40.7, 40.9	28.2, 28.5

	dead fish, many islands were submerged and ships were stranded by the retreat of waters		
450/1/26	450.01	41.0	29.0
478/9/25	Yalova, Izmit, Istanbul	40.8, 40.3	29.0, 26.6
488/9/26	Izmit Gulf	40.8	29.6
542	Western coasts of Thrace, Bandirma Gulf	41.0	29.1
551/7/9	Tsunami along Lebanase coast ; in Botrys Mt. Lithoprosopon broke off and fell in to the sea, and formed a new harbour	33.80	35.10
553-554/8/15	Istanbul, Izmit Gulf	40.75, 40.9	29.10, 29.4
554/8/15	The sea rose up to a fantastic height and engulfed all the buildings near shore	36.8	27.3
557/12/14	Iznik Izmit, Istanbul	40.9	28.8
715	Istanbul, Izmit Gulf	40.4	29.7
740/10/26	In some places, the sea retreated behind its usual boudries and was intense enough to change the frontiers of some cities	40.7	28.7
859/11	Syrian coasts, near Samandag	36.25	36.10
989/10/25	Istanbul, Marmara coasts	40.8	28.7
991/4/5	Damascus, Baalbek	33.45	36.30
1033/12/5	The water in the port of Acre receeded	32.0	35.2
1064/9/23	Iznik, Bandirma, Murefte, Istanbul	40.8	27.4
1068/5/29	The sea retreated from the coast of Palestine, and then flowed back, engulfing many people. The river Euphrates owerflow its banks	32.57	35.28
1114/8/10	Ceyhan,Antakya, Maras, Samandag	36.50	35.50
1157/7/15	Hama-Homs, Syria	35.0	36.6
1170/6/29 03:45	Damascus region	34.40	35.80
1202/5/20 02:40	Damaging sea wave in Levantine coast	33.5, 33.43	36.0; 35.72
1222/5/11 06:15	Tsunami flooding in Paphos and Limasol ; The horbour at Paphos was left completely without water	34.5, 37.45, 34.7	32.5, 32.40 32.8
1265/8/10-11-12	A big piece of mountain breaks off and thumbles into the sea, creating huge waves that hit the shore and swallow up the area.	40.7	27.4
1303/8/8 3:30	Destructive inundation, The sea wave drowned many people and threw European ships on land ;tsunami	35.0, 36.1 ,35.18	27.0, 29.0 , 25.63

	flood;		
1343/10/18	The sea rushed on land and in plain areas reached upto 2000 m. In some places it took off some ships which were in the harbours and crushed them.	40.9, 41.05	28.0, 29.06
1389/3/20 12:30	A sea wave penetrated as far as the market place in Chios	38.4 ,38.27	26.3 ,26.52
1404/2/20	Aloppo-Tripoli	35.15	35.95
1408/12/29	Tsunami in Lattakia and landslide in Sfuhen ,Tsunami threw the boats onto the shore	35.67	36.17
1419	The sea became very rough and flooded the land, which was unusual	40.4 , 40.9	29.3 , 28.9
1481/5/3	At the night of 3 may the largest shock occurred which was associated by a sea wave of 3 m height in the coast	36.43	28.22
1494/7/1	In the harbour, large waves caused so vilent collisions of anchored ships. A withdraw of the sea was observed in Israel .Local tsunami at Kandiye Harbour	35.5,35.2	25.5, 24.92
1509/9/10	Waves overtopped the walls in Galata, Yenikapi and Aksaray was flooded. The Izmit shipyard collapsed and waves flooded the dockyard.	40.9	28.7
1609/4	Over 10000 people were drowned by the waves. Very strong wave in Rhodes and Dalaman	36.4	28.3 ,28.4
1612/8/12	Northern Crete	35.5	25.5
1650/9/29	A strong underground volcanic eruption	36.4, 36.5	25.4, 25.5
1667/11/30	Izmir Gulf	38.4	27.2
1672/1673	Santorini and Cyclades, Bozcada, Kos Isl.	36.5	25.5
1688/7/10 11:45	Izmir Gulf	38.38 , 38.4	27.17 , 27.20
1741/1/31	The sea retreated then flooded the coast 12 times	36.2	28.5
1752/7/21	Tsunami at Syrian coasts	35.6	35.75
1754	In places the receeded from the shore, presumably of Istanbul	40.8 , 40.6	29.2 , 29.4, 30.0
1759/10/30 03:45	Tsunami at Acre and Tripoli	33.1 ,33.0	35.6 ,35.5
1759/11/25 19:23	Tsunami in Acre	33.7	35.9
1772/11/24	The gates of Foca Castle which were on the edge of the sea, were completely destroyed by an earthquake and sea wave	38.8	26.7

1822/8/13 21:50	Antakya, Iskenderun, Kilis, Latakiye (Latakia)	36.4	36.2
1829/5/23	Istanbul, Gelibolu	41.1	24.5
1837/1/1	Tsunami in coasts of Israel and Syria; tsunami at the lake of Tabariya	32.9	35.4
1843/10/18	Dodecanese	36.3 , 36.25	27.6 , 27.7 , 27.5
1851/2/28	Sea wave in Fethiye .The sea in Fethiye rose approximately 34 cm. The shore in Fethiye sunk 0.5 m	35.5 ,36.5 , 36.4	28.7 ,29.1 29.0, 28.7
1855/2/13	Sea wave in Fethiye.	36.6	29.10
1856/10/12	Rhodes, Crete, Chios	36.25, 35.6	28.0 ,26.0
1856/11/13	Chios	38.25 , 38.4	26.25 , 26.1
1863/3/22	Rhodes	36.5	28.0
1866/1/31	Santorini Isl.	36.4, 36.4	25.3 , 25.4
1866/2/2	Chios	38.25	26.25
1867/3/7	Lesvos	39.1 , 39.1 , 39.25	26.5, 26.6 , 26.21
1872/4/3 07:45	Antakya, Samandag	36.25	36.10
1878/4/19	Izmit	40.7	29.3, 29.7
1881/4/3	On 5 April at 03:10 AM a strong vertilcal effective earthquake demolished some city walls. The sea became wavy right away and a mass of smoke was seen rising from sea surface	38.3	26.2
1886/8/27	Southern Peloponnesus, Pylos, Izmir	38.25, 37.1	26.10 , 21.5
1893/2/9	40.49N-25.52E Samothrace D=30m , Alexandroupolis D=40m	40.5 , 40.3 , 40.59	25.5 ,25.53 , 26.2
1894/7/10	D=200m at some place between 41.02N-28.58E Buyukcekmece and 40.89N-29.19E Kartal	40.7	29.6
8/9/1982	A high water occurred in the Bosphorus and demolished a yatch named "Mahrussa" achored at Pasabahce . The sea receeded along the Tekirdag shores .	40.7 ,40.62	27.2, 26.88
3/31/1928	Izmir	38.1	27.1
4/23/1933	Kos Island	36.8	27.3
1935-01-04	Generated sea waves locally at Hayirsiz Island.	40.64	27.51
2/9/1948	Damaging waves in Karpathos. A destructive tsunami originated and rolled along the eastern shore of the	35.5	27.2

	Island of Karpathos . Sea waves caused damage in the southwest coast of Rhodes .		
9/10/1953	Series of tidal waves were noted on the Island of Cyprus	35.00, 34.8	32.00, 32.5
7/9/1956 3:11	Huge waves flooded fields in the islands. The sea rose up in Fethiye	36.64	25.96
5/23/1961	A weak wave. The color of the water in the Gulf of Izmir changed after the earthquake	36.7	28.5
1/4/1991	Possibly meteorological origin, a weak local sea wave	37.42	26.18
7/5/1991	Possibly meteorological origin, an intense rise of of the sea level by 0.5m occurred suddenly	37.06	26.48

4. Collection of necessary data for the selected sites & Processing of data and database development for use in the computational tools

Most of the tasks of the first year were focused on data collection and developing the framework for the modeling studies. Databases for tsunami and sea level rise vulnerability studies are being prepared in GIS environment. Although most of the data necessary for the model studies are collected, local high resolution data for some of the parameters are still being collected or at acquisition stage from relevant institutions/persons. Data from different databases are inspected according to projections, resolutions and coverage area. All the data layers are transformed to same projection which is chosen as WGS84.

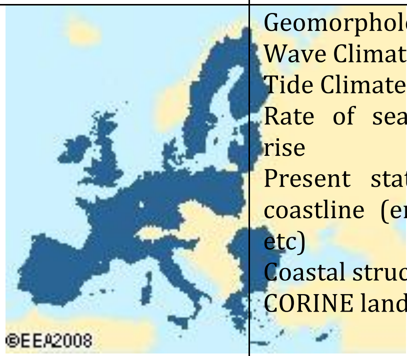
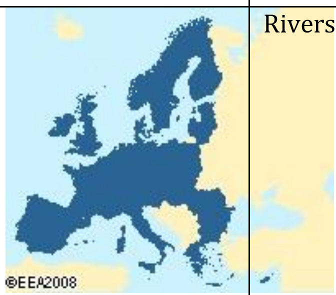
4.1. Database for Vulnerability Studies

The database for the vulnerability study is aimed to include information on physical characteristics of the shorelines and information related to human activities along the shorelines. For the Maltese islands, some of the data collected cover the whole shoreline at a coarser resolution. Higher resolution data are being collected for some of the parameters for the selected sites. For Turkey, again two types of data are collected; a coarser resolution data covering a larger region and including information for many parameters and high resolution data for selected sites for some of the parameters. Local high resolution data is taken from different national institutes such as Environmental Protection Agency for Special Areas of Turkey, local municipalities and research reports of local universities.

The coarse resolution data is collected from a variety of available databases. Some of the databases used are themselves collection of other databases that are either publicly or commercially available. However, all the data collected from these databases are available for free for research. The sources of these databases and information available are presented in Table 4.1.

Table 4.1. Database sources and properties

Database	Developing Group/Project	Spatial Coverage	Parameters	Properties
DIVA (Dynamic Interactive Vulnerability Assessment)	DINAS-COAST (Dynamic and Interactive Assessment of National, Regional and Global Vulnerability of Coastal Zones to Climate Change and Sea Level Rise) www.dinas-coast.net/	Global	Area Geomorphology Bruun factor(possibility of erosion) River Storm surge height Coastal slope Tidal range Wave climate Uplift/ subsidence River depth River discharge	Attributes of each parameter is integrated to coastal segments of shoreline divided due to morphological and social characteristics. Given in digital format in GIS environment.

EUROSION database	EUROSION project: www.eurosion.org/project/ The main objective of this project is to provide a comprehensive description of the calculation of the EUROSION Indicators (technical and conceptual) which will support the rating of European regions in terms of exposure to coastal erosion.	 %20 of coastal areas of Romania, Bulgaria and Cyprus are included	Geomorphology Wave Climate Tide Climate Rate of sea level rise Present status of coastline (erosion, etc) Coastal structures CORINE land cover	Coastal areas are defined as the land between shoreline and 10 km distance from shore. Data is given in digital format in GIS environment.
WISE database	WISE (Water Information System for EU) http://water.europa.eu/	 Scale: 1:1 000 000	Rivers and lakes	Rivers having basins larger than 50000km2 are given in digital format in GIS environment
Waterbase database	EUROWATERNET http://water.europa.eu/		Surface and groundwater quality parameters, stations, land use, water demand	Given as digital table.
WWDII database	World Water Development Assessment http://www.unesco.org/water/wwap/wwdr/	Global	River discharge, dams and reservoirs water use for irrigation, river flow regulation and fragmentation, sediment trapping efficiency of dams	Given as table, printed map and some layer are digitized in GIS environment
GEMS/GLORI database		Global	River discharge, sediment load, water quality	Printed data digitized
RivDIS database	River Discharge Database, Version 1.1 (RivDIS v1.0	Europe	River discharge (monthly and annually)	Printed data digitized for rivers of Europe

	supplement) 1998			
GISCO administrative boundaries (NUTS) v9	***Administrative land accounting units (Land analytical and reporting units, LARU, used in LEAC), zipped shape file format, raster http://www.eea.europa.eu/***	Europe	NUTS 3 (province level) to NUTS 0 (country level)	Digitized in GIS environment

Table 4.2 shows parameters used for the vulnerability study [14, 15], corresponding database used to extract information at coarser resolution for this project and the properties of the data available.

Table 4.2. Coastal vulnerability study parameters

Parameters	**Database**	**Properties**
PHYSICAL PARAMETERS		
Rate of sea level rise	EUROSION database PSMSL observations	Predicted sea level rise at the location centers mm/year Rate of relative sea level data from PSMSL stations worldwide
Geomorphology	EUROSION database DIVA database	Morphological coding related to coastal erosion McGill(1958)
Coastal Slope	DIVA database	Degrees
Wave climate	EUROSION database DIVA database	17 year data (m) According to LOICZ classification
Sediment budget	EUROSION database DIVA database	Evolution trend of shoreline Bruun rule factor (possibility of coastal erosion)
Tide range	EUROSION database DIVA database	17 year data (m) According to LOICZ classification
Proximity to coast (groundwater)	Local data is needed!	
Type of aquifer		
Hydraulic Conductivity		
Depth to water table above sea		
River depth at downstream	DIVA database WWDII database Waterbase database	Water depth (m)
Discharge	DIVA database WWDII database Gems-GLORI database RivDIS database	Annual or mean (m3/s)
Storm surge height	DIVA database	Return periods of 1,10,100 ve 1000 years Calculated storm surge height above Mean Sea Level
HUMAN INFLUENCE PARAMETERS		
Reduction of sediment	WWDII database	Sediment yield (before and after dams)

supply	EUROSION database GLORI database	
River flow regulation	WWDII database EUROSION database GLORI database Rivers of Europe (**Klement Tockner** et al., 2009)	Discharge, river fragmentation and regulation index
Engineered frontage	EUROSION database	Harbors, marinas, other coastal structures in terms of coastal segment length
Natural Protection Degradation	EUROSION database	CORINE land cover 1990, 2000 and 2006 comparison of dunes, wetlands and land use changes
Coastal protection structures	EUROSION database	Parallel and perpendicular to shoreline
Land use	CORINE land cover database DIVA database	Land use in raster format
Groundwater Resource Abstraction	Local data is needed.	

Different layers are being prepared in GIS environment for different impacts of sea level rise and for each selected site. These databases are a combination of spatial data and tables where spatial data is not available for a particular parameter. For the latter case, the available data (or data points) will be used to interpolate the information for the selected site areas. Although the initial layers are prepared as feature layers on GIS platform, eventually, all the information will be transformed to raster format for the spatial vulnerability assessment. If available data in high resolution does not exist, then the assessment will be performed using the available data and the result will be assumed to represent the vulnerability of the whole selected site. Data processing for the vulnerability studies is in progress since data for some sites are still being acquired.

4.2 Database for Tsunami Studies

Tsunami modeling studies need proper and accurate bathymetry and topography database, and reliable information about historical events. In this study the bathymetry and topography is developed for selected areas of Malta and Turkey.

4.2.1. Malta

Maltese Islands are located at the south of Sicily Island in the Mediterranean Sea. Location of Malta in the big study domain is shown with red square in Figure 4.1. The smaller selected area for Malta region covers 14.10E – 14.65E latitudes and 35.75N – 36.15N longitudes. The rough data is taken from Gridview software and the resolution is 900 meters. By using the image from Google Earth the selected area is digitized and 135 m resolution grid is obtained.

4.2.2. Turkey

Three regions are selected in Turkey which are Bodrum, Fethiye and Kas.

4.2.2.1 Bodrum

The selected area for Bodrum region covers 27.2E – 27.6E latitudes and 36.95N – 37.175N longitudes. The rough data is taken from Gridview software and the resolution is 900 meters. By using the image from Google Earth the selected area is digitized and 135 m resolution grid is obtained.

4.2.2.2 Fethiye

METU has collected and purchased available bathymetric data for these areas, as well as collected shoreline data for the area by the measurements. Bathymetry/topography data with 1 min resolution from GEBCO are collected. Bathymetric data at Fethiye Bay/surrounding bays with 50 m and 100 m horizontal resolution are measured directly. Shoreline data at settlement regions of Fethiye towns are measured directly with 2 m horizontal resolution. Hard copy of 50 m horizontal resolution bathymetric data is

obtained from Fethiye Municipality for Fethiye Bay only. New collected data is compared with the existing METU Civil Engineering Department, Ocean Engineering Research Center archived data which is formerly developed for the previously completed projects, using nautical charts with various scales and resolutions. High accuracy topography data is needed for the Master case of Fethiye area. For this purpose, METU has collected and purchased available topography data and new DEMs and orthorectified (in progress) products are produced from these data. The Landsat image of Bodrum, Fethiye and Kas and Quickbird image of Fethiye area are shown in Figure 4.7.a and Figure 4.7.b, respectively.
Bathymetry/topography data of 1 min resolution from GEBCO are collected. QuickBird (2005) satellite images of Fethiye are purchased. Combination of Differential Global Positioning System (DGPS) data (sum-meter accuracy) and General Command of Mapping 1/25000 contoured digital-heighted vector data are used to construct DEM for Fethiye region with accuracy of ± 5 m. Separate sheets Quickbird 4 band satellite images are mosaiced to generate final Fethiye image.
LANDSTAT satellite images are obtained from free sources for South Western region and offshore area of Turkey including Fethiye area. DEM for Fethiye and nearby area is purchased with scale 1/25 000 from Turkish Mapping Command. Direct measurement of topography is performed for verification and upgrading the digital data in Fethiye town especially in the probable tsunami inundation zone by METU GGIT Division and Ocean Engineering Research Center.

There are three major domains studied in Fethiye region, which are called B, C and D.

4.2.2.3. Kas

There are three major domains studied in Fethiye region, which are called B, C and D. The biggest domain B covers coordinates 27.5E 30E 34.0N 36.8N with resolution 450 m. Domain C covers coordinates 29.07E-29.95E and 36.1N-36.4N with 150 m resolution. Domain D covers coordinates 29.2E-29.46E and 36.16N-36.33N with resolution 45 m. Smallest domain E covers coordinates 29.23E-29.33E and 36.23N-36.3N with 15m resolution.

4.2.2.4. Goksu

Satellite image for Goksu Delta is taken from Environmental Protection Agency for Special Areas of Turkey. The domain covers coordinates 33.89E-34.06E and 36.21N-36.36N with resolution 45 m.

5. Surveys for vulnerability assessment

To prioritize coastal areas according to their vulnerability to sea level rise is one of the objectives of the vulnerability assessment which requires ranking of coastal areas. In addition, comparison of individual impacts of sea level rise according to vulnerability as well as selecting the governing parameters for site specific vulnerability requires ranking of impacts and parameters relatively. On the other hand, the physical impacts are complex and continuous processes, which different set of criteria and sub-criteria are necessary to be defined. Not all the parameters have equal influence on the physical process assessed by the model. In some cases, such as salt water intrusion to groundwater resources, one set of criteria (human parameters) are more dominant. To be able to derive most realistic results using different sets of criteria requires assignment of weights to different parameters and criteria with respect to their influence on the impact vulnerability.
To determine the weights of the parameters and the perception of the experts regarding the urgency and level of threat sea level rise present to the coastal areas, a survey was prepared and sent to experts from Turkey and Malta. Some of the experts were chosen from academia, some from government agencies and some from NGO's. The survey asks the experts to rank the parameters from the highest to lowest in terms of level of influence on the physical processes. These physical processes are coastal erosion, inundation, flooding due to storm surges, salt water intrusion to groundwater resources and salt water intrusion to river/estuaries. Each participant was asked to compare the impacts of sea level rise and rank them according to risk these impacts present at their regions.
The results are analyzed according to the country to determine differences in perception of the two countries and to understand the reasons for these differences. Additionally, these weights will be integrated to the coastal vulnerability model for site specific assessments.
The results from Turkey are presented in Table 5.1.
Table 5.1. Parameter weights according to survey results from Turkey

Inundation					
Physical	**Weights**	**Human**	**Weights**		**Weights**
Rate of sea level rise	**0.350**	Natural Protection Degradation	**0.67**	Physical Parameters	**0.67**
Beach Slope	**0.370**	Coastal Protection Structures	**0.33**	Human Influence Parameters	**0.33**
Tidal Range	**0.280**				
Flooding due to Storm Surge					
Physical	**Weights**	**Human**	**Weights**		**Weights**
Rate of sea level rise	**0.10**	Engineered Frontage	**0.32**	Physical Parameters	**0.62**
Beach Slope	**0.26**	Natural Protection Degradation	**0.37**	Human Influence Parameters	**0.38**
Surge Height	**0.42**	Coastal Protection Structures	**0.31**		
Tidal Range	**0.22**				
Coastal Erosion					
Physical	**Weights**	**Human**	**Weights**		**Weights**
Rate of sea level rise	**0.15**	Reduction of sediment supply	**0.40**	Physical Parameters	**0.43**
Geomorphology	**0.19**	River flow regulation	**0.13**	Human Influence Parameters	**0.57**
Beach Slope	**0.17**	Engineered Frontage	**0.20**		
Significant Wave Height	**0.20**	Natural Protection Degradation	**0.12**		
Sediment Budget	**0.26**	Coastal Protection Structures	**0.15**		
Tidal Range	**0.13**				
Groundwater					
Physical	**Weights**	**Human**	**Weights**		**Weights**
Rate of sea level rise	**0.04**	Groundwater Abtraction	**0.55**	Physical Parameters	**0.43**
Proximity to coast	**0.09**	Landuse	**0.45**	Human Influence Parameters	**0.57**
Aquifer type	**0.60**				
Hydraulic Conductivity	**0.08**				
Depth to water table from sea	**0.19**				
River					
Physical	**Weights**	**Human**	**Weights**		**Weights**
Rate of sea level rise	**0.16**	River flow regulation	**0.42**	Physical Parameters	**0.48**
Tidal Range	**0.21**	Engineered Frontage	**0.28**	Human Influence Parameters	**0.52**
Depth at downstream	**0.28**	Landuse	**0.30**		
Discharge	**0.35**				

These relative weights show that only for inundation process, rate of sea level rise is the major parameter to be considered. Although it is seen that rate of sea level rise is thought as one of the contributors to these impacts, it is not taken as the driving force by the experts. This also underlines the general perception on sea level rise of the decision makers who believe that sea level rise is not an urgent threat when present problems are considered. However it should be noted that although sea level rise would not trigger any of the impacts within a short frame of time, it will exacerbate the present coastal problems of erosion, groundwater usage, etc. (Harvey et al., 1999). Thus any coastal zone management plans and implementations should consider the effect of sea level rise on these impacts for the near future and keep in mind that new impacts could be triggered as longer time scales are considered.

In addition to the perception of sea level rise as a minor component in the physical process along coastal areas, the results of the AHP analysis highlighted the fact that for some of the impact processes, anthropogenic parameters are much more dominant. Although the interaction between human and physical parameters is not a simple problem, human activities are easier to control and regulate than the physical properties of a coastal region. Thus when adaptation planning is considered, understanding the influence of human activities on the impact processes as well as the overall vulnerability of a region would increase the options for future implementations. Especially for salt water intrusion to groundwater and rivers, the perception of experts is that human activities are the primary controlling parameters that need to be addressed. On the other hand, flooding due to storm surges and inundation primarily depend on the physical characteristics of the coastal area. Coastal erosion is the most complex process of these impacts where many physical and human parameters need to be considered. Although both parameters contribute to the coastal erosion process, human activities especially any anthropogenic activity leading to reduction of sediment supply significantly state the outcome vulnerability.

In addition, the relative weights calculated from the surveys for the overall vulnerability are also given. These results (Table 5.2) should be considered as the general perception of the experts participated in the survey on which impacts will be more profound due to sea level rise, thus will be more important in the upcoming future for Turkey and Malta.

Table 5.2 Weights of impacts of sea level rise (expert opinion for Turkey)

Impacts	
	Weights
Coastal Erosion	**0.25**
Inundation	**0.15**
Flooding due to Storm Surge Height	**0.20**
Salt water intrusion to Groundwater	**0.22**
Salt water intrusion to River/Estuary	**0.18**

From the results, it is seen that major concern for the upcoming future is coastal erosion as is the present problem of many coastal areas. Although flooding due to storm surges is a problem that could be significantly exacerbated in the near future, it is considered as a secondary impact along with salt water intrusion to groundwater and rivers. Inundation is the least important impact which is an expected outcome due to the time scale it is expected to occur.

The results for Malta are still being analyzed. However preliminary results indicate that similar perceptions regarding the influence of sea level rise on physical coastal processes hold true. Sea level rise is considered as a parameter influencing the physical processes however; it is not given much importance when the overall results are considered. In general, experts from Malta consider human activities especially coastal protection structures (structural protection/adaptation) as the major parameter that influences the outcome of the physical processes. This indicates a general tendency to plan structural adaptation options for impacts of sea level rise. It is an expected tendency due to the limiting physical availability of being an island nation. The final results of the surveys from Malta will be presented in the 2nd year report. The weights of the parameters will be integrated to the fuzzy coastal vulnerability assessment model as calculated from the survey results for Malta as well.

6. Tsunami Source Maps

Possible tsunami sources in Eastern Mediterranean and their rupture parameters are given in Table 6.1.

Table 6.1 Fault and Rupture Parameters of Tsunami Sources

Source	Epicenter	Lenght of Fault (km)	Strike angle (° W)	Width of fault (km)	Focal Depth (km)	Dip angle (°)	Slip angle (°)	Displacement (km)	Height of initial wave (m)	Max. positive amp. (m)	Min. negative amp. (m)
01-365	23.45E 35.3N	100	315	90	25	30	90	20	9.07	8.15	-0.92
02-Z13-2	23.5E 35.2N	140	100	35	40	30	90	6	1.48	1.26	-0.22
03-z13-1	25.1E 35.05N	140	80	35	40	30	90	6	1.48	1.26	-0.22
04-z26-1	26.6E 35.2N	120	50	35	40	30	90	6	1.43	1.23	-0.21
04-Z26-1b	26.6E 34.9N	60	80	30	3	25	90	9	5.40	4.52	-0.88

05	27.5E 35.8N	140	40	40	50	30	90	6	1.31	1.12	-0.19
06	27.78E 34.2N	136	60	40	40	45	45	6	1.20	1.05	-0.15
07-Z26-1	28.48E 35.16N	121.5	60	40	40	45	45	6	1.18	1.03	-0.15
08	28.462E 36.447N	126	294	63	7.5	27	99	3.65	1.96	1.82	-0.14
09	28.434E 36.077N	100	184	50	7.5	47	262	2.9	1.66	0.16	-1.50
10	28.393E 35.821N	91	303	45	7.5	25	90	2.7	1.54	1.28	-0.26
11	28.4E 35.5N	190	55	90	7.5	20	90	5	3.06	2.40	-0.66
12	34.41E 36.13N	106	45	40	40	45	45	6	1.14	1.00	-0.14
13-z32	32.1E 35.4N	156	305	40	20	45	45	6	1.84	1.61	-0.23
14-z30	32.98E 33.83N	149	330	40	40	45	45	6	1.21	1.06	-0.15
15-z31-2	33.09E 34.33N	73	60	40	40	45	45	6	1.00	0.88	-0.12
16-z31-1	33.79E 34.68N	137	60	40	40	45	45	6	1.20	1.05	-0.15
17-z41	35.7E 35.07N	175	60	40	40	45	45	6	1.06	1.00	-0.06

7. Planned Activities for 2nd Year

Following tasks are planned for the 2nd year of the project.

- Development of regional / local scenarios (e.g. forecasted climate change impact on Sea Level Rise and possible tsunami events, downscaling from global to regional to local scenarios);
- Correlation of Mediterranean regional history of tsunamis to local vulnerability.
- Wind and wave climate studies & wave transformation studies for selected sites.
- Tsunami simulations and computations of the near shore tsunami parameters at selected sites.
- Development of database for the vulnerability risk maps.

Some of the tasks mentioned in the 2nd year activity plan are linked with the ongoing tasks of the 1st year such as development of database for the vulnerability risk maps. Wind and wave climate studies including wave transformation studies will be undertaken for some of the selected sites since METU OERC already have research material regarding wave and wind climate of some of the selected sites especially for Turkish sites.

Necessary data for development of regional/local scenarios will be used when in-situ data is not available especially for sea level rise measurements. For this task, sea level rise projections for Mediterranean will be used and interpolation of different measurements taken from Mediterranean will be interpolated when applicable.

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METHODIC FOR DISTANCE AUTOMATIC ON-LINE MONITORING OF BUILDINGS ENGINEERING CONSTRUCTION FRAMES (ECNTRM - EUROPEAN CENTER FOR NEW TECHNOLOGIES OF RISKS MANAGEMENT, MOSCOW)

In 2010 the Methodic for Distance Automatic on-line Monitoring of Buildings Engineering Construction Frames successfully went through the expertise of the Interagency Coordination Scientific Council on the Problems of Civil Defense and Emergency Situations and was certified by the Government Commission on prevention and elimination of emergency situations and providing fire safety It was recommended to implement the methodic and provide the buildings and constructions with the on-line monitoring systems.
The number of buildings is growing and today we have the tendency of constructing skyscrapers, huge trade, entertaining and business centers. Speed of construction leaves behind the quality control. It is also known that during the exploitation buildings wear out and lose their strength. The most vulnerable the buildings are to seismic and vibration pressure. It is understood that the source of seismic pressure is not only the earthquake but industrial explosions (during the mining works). The sources of vibration are huge industrial machines, ground and underground transport. Because of constant or periodical influence of such pressure construction may accumulate this destructive force and it can result in strong and disastrous destructions.
Existing approach to the periodical diagnostics of buildings and constructions is based on the local principal of visual stability and is connected with the examination of samples of material and foundation research. It is clear that being concentrated on details it is impossible to realize the main mechanism and reasons of object vulnerability to the mechanical pressure. Presented **Hard warily bundled software complex** allows in real time to monitor and estimate technical condition of different types of constructions and materials – simple one-story buildings, multistoried buildings and constructions of difficult configuration both civil and industrial.
The Methodic was developed for the unified scientific approach to creating and providing activity of automatic on-line monitoring of buildings engineering construction frames, for the purpose of hazards elimination.
The Methodic defines general regulations and contents of scientific provision of creating and operating automatic on-line monitoring of buildings engineering construction frames.
Presented technology of distance automatic on-line monitoring of buildings engineering construction frames allows to predict sudden destruction of objects under control and thus save lives of people and radically reduce material damage. Suggested model of on-line estimation of conformity of evaluated criteria of changes in engineering construction frames with those received in the process of monitoring can be used for taking decision on:

- people security;
- transfer of buildings and constructions in accident type of exploitation;
- taking anti hazard measures to minimize possible consequences;
- strengthening buildings engineering construction frames.

There was developed hard ware and soft ware complex aimed at estimation of buildings and constructions seism stability on the basis of constant analyses of spring constant and geometrical parameters of ground-building system.

Before setting up the complex, technical observation of the object should be completed to define original parameters of the building. Complex is a multi channel system and measurements could be done through 32 channels at a time. Dynamic parameters are taken by means of dynamic energizing of ground with massive impulse device.

In order to get required data, cable is to be put between the indicators and controller. In case of emergency information is transferred both to the operator on duty and rescue service of the city for preventing emergency situation and taking measures for saving people.
The soft ware dialogue with the user is providing very low rate of mistaken actions. Dialogue is done in interactive mode by means of working with screen forms with the CAS usage. Figure 3 shows the main working window of the program, which reflects on the left two columns of the list of installed sensors with the graphic reflection of their condition. At the bottom of the screen there is a status line reflecting time of the last request of the construction state. By mouseclick to the status line the user gets the system operation protocol. Basic field of the program form shows the graphic description of the object with the sensors location. Image is interactive thus by clicking to the sensor the user can get the current status (Fig. 4,5). Developed data goes both to the operator

terminal and special internet site. Thanks to this the owner of the object can control the technical condition of the building being at any place of the world. In case of emergency information is transferred to the operator of the object and emergency services of the city for immediate response.
Hard warily bundled software complex has already been implemented in the Russian Federation during the construction of Ice Palace in Moscow
Operation and maintenance of the complex is done by the supervisory service
personal of the Palace.
Mode of the dialogue with the user embodied in the hard warily bundled software complex provides low probability of accidental false actions of the operator on duty.
Complex provides twenty-four-hour functioning with the necessary reliability behavior (availability rate, average renewal time). It has means of reserve information copy, data restoration and software.
Complex allows monitoring of various constructions: skyscrapers, ground deepened constructions, trunk lines, waterworks etc.
For today about 100 projects already applied for the Methodic.

DEVELOPMENT OF THE EURO-MEDITERRANEAN COMMUNITIES NETWORK FOR NUCLEAR SAFETY (TESEC - EUROPEAN CENTRE OF TECHNOLOGICAL SAFETY, KYIV)

1. INTRODUCTION

Energy is an essential part of our life; we need safe, clean and sufficient sources of energy for the future.
Nuclear power has some advantages compared to fossil fuels, like low-carbon emissions – helping to minimise climate change, also increasing diversity and reducing our dependence on any one technology or country for energy or fuel supplies.
However, nuclear power also has disadvantages. Each NPP is an accumulator of huge amounts of radioactivity and thus is a source of risk. Although construction and operation of nuclear power plants are closely monitored and regulated, an accident, though unlikely, is possible.
For any incidents that do occur, the practical measures to minimize the consequences on human life and health and on the environment have to be ready at all times for rapid and effective implementation, prepared on the basis of best international experience. The Chernobyl disaster stands as a testimony that a nuclear accident has no respect for local, national or international boundaries. Nuclear safety cannot be confined to a single country's political and administrative boundaries. It demands effective neighbourhood solidarity and trans-frontier co-operation to ensure that each area concerned, irrespective of the country to which it is attached, is ready to respond. In this respect, it is important that authorities which have already experienced accidents, or which live under their threat, improve population safety through exchange of experiences.
Council of Europe EUR-OPA Major Hazard Agreement is starting the project with the main aim to foster better radiological protection and information for populations living in areas that might be affected in the case of an accident at a Nuclear Power Plant or any other nuclear facilities through dissemination of best European experience on emergency planning, early warning procedures, iodine prophylaxis and other elements of radiological protection.
The international workshop ***"Public authorities and civil society together for a safe European nuclear future"*** was held in Kiev, Ukraine 22-23 September, 2008. The participants of the workshop – representatives of international organizations: European and Mediterranean Major Hazards Agreement of the Council of Europe (EUR-OPA), Congress of Local and Regional Authorities of the Council of Europe, International Atomic Energy Agency (IAEA), national, regional and local authorities and communities' representatives, mayors of cities from 15 countries: Armenia, Belgium, France, Italy, Spain, Sweden and others – discussed and adopted conclusions of the workshop. They defined the priority activities:

1. develop "Iodine Prophylaxis Administration Guidance" for local authorities;
2. develop and deploy a multi-level website "Radiological Hazard, what we must do in the case of an accident at a nuclear facility" for the benefit of people living in areas that might be affected in the case of an accident at such facilities;
3. organize training courses for local doctors on "Emergency medicine in the case of a radiological accident";
4. organize the development of modern teaching materials for schools and organize training courses for teachers on "Radiological Hazard";
5. organize training courses for journalists on "Communications with the public in the case of a radiological accident";
6. identify opportunities to support bilateral exchange study visits of local authorities and key community stakeholders (teachers, medical doctors);
7. examine insurance aspects of rehabilitation in the case of nuclear accident;
8. elaborate benchmark legal approaches for better co-operation between local communities and nuclear facility authorities.

During the meetings in 2008 and 2009 we deployed the network of end users- representatives of communities of people, living in areas that might be affected in the case of an accident at a Nuclear Power Plant or any other nuclear facilities, and also representatives of EUR-OPA member-states willing to co-operate on that subject. The main aim of our activity in 2010 was implementation of the conclusions of the 2008 workshop and of the 2009 Task Force Group meeting.

2. IMPLEMENTATION OF THE CONCLUSIONS OF THE 2008 WORKSHOP AND OF THE 2009 TASK FORCE GROUP MEETING.

The meeting of EUR-OPA and ASN, have been organized in Paris, Council of Europe Office February 3, 2010.

Subject: Improvement of the radiation protection of the population by strengthening the co-operation between International organizations, National authorities and communities and by deploying a network for a wide exchange of best international experiences and practices

Participants:
Mr. Jean-Luc LACHAUME,
Deputy General Director of the French authority for nuclear safety (ASN)
Mr. Eladio FERNANDEZ-GALIANO,
Executive Secretary, European and Mediterranean Major Hazards Agreement (EUR-OPA), Council of Europe, Strasbourg
Mr. Francesc PLA
Deputy to the Executive Secretary, European and Mediterranean Major Hazards Agreement, Council of Europe, Strasbourg
Mr. Stepan BADALYAN
Permanent Correspondent of Armenia to EUR-OPA
Mme Monique BERNAERTS
Permanent Correspondent of Belgium to EUR-OPA
Mr. Michel FEIDER
Permanent Correspondent of Luxembourg to EUR-OPA
Mr. Victor POYARKOV,
Executive Director of European Centre of Technological Safety, EUR-OPA/Ukraine

Presentations and discussion:
Mr. Eladio FERNANDEZ-GALIANO opened the meeting and informed about EUR-OPA's activity on better radiological protection and information for populations living in areas that might be affected in the case of an accident at a Nuclear Power Plant or any other nuclear facilities through dissemination of best European experience on emergency planning, public awareness, iodine prophylaxis and other elements of radiological protection.

Mr. Victor POYARKOV informed about the **international workshop** "***Public authorities and civil society together for a safe European nuclear future:*** *learning from the Chernobyl legacy to make European nuclear energy safer: the role of local communities, authorities and central governments in emergency preparedness and management*" held in Kiev, Ukraine **22-23 September, 2008**.

Workshop participants :

- representatives of international organizations: the European and Mediterranean Major Hazards Agreement (EUR-OPA) of the Council of Europe, the Congress of Local and Regional Authorities of the Council of Europe, International Atomic Energy Agency (IAEA).

- representatives of national, regional and local authorities and communities: Mayors of cities from 14 countries - Armenia, Belgium, France, Italy, Spain, Sweden and others.

The participants discussed and adopted the conclusions of the workshop and expressed their willingness to collaborate for better radiological protection of the population. (http://tesec-int.org/ConclusionKIEVworkhop2008_EN.pdf).
Mr. Poyarkov also informed about the **Task Force Group Meeting** "To foster better radiological protection and information for populations living in areas that might be affected in the case of a nuclear or radiation accident" which was held in Kiev, Ukraine on **2-4 September, 2009.** The purpose of this Task Force Group (TFG) meeting was to develop the basis for co-operation with the Group of Local Authorities with Nuclear Facilities in Europe (GMF), the Spanish Group of Mayors in Municipalities with Nuclear Facilities (AMAC) and the Association of Swedish Local Authorities with Nuclear Facilities (KSO).
The participant of the TFG meeting recommended (http://tesec-int.org/concl%2002-04%20SEPT%202009.pdf):

1. There is a problem – necessity of better awareness and information of the population on radiological risk.
2. National, international organizations and the local community have to join efforts to use best international experience on this aim in the EU and in neighbouring countries. EUR-OPA, UNDP, GMF, KSO and AMAC are privileged partners for such collaboration; they could be the basis for a network for better awareness and information of the population on radiological risk.
3. The realization of priorities defined in the 2008 Workshop in Kiev could be a first step towards such collaboration. It is necessary to study the different opportunities for funding this activity.
4. We foresee the need to spread the positive experiences of Local Information Committees and Local Stake Holders Groups in the work of communication of radiological risks to citizens living near NPP's in Europe.
5. The organisations participating in the conference underline the need for a transnational European programme for information and experience exchange to learn the lessons of the Chernobyl disaster.

Mr. Jean-Luc LACHAUME informed about nuclear emergency preparedness and response in France. The **Nuclear Safety Authority (ASN)** is a state organization independent from the Government; its main aim is **to protect workers, the public and the environment from nuclear risks**, and to contribute to the information of the public. In the case of nuclear emergency situations, ASN responsibilities are the following:

- To ensure that the measures taken by the licensee are adequate
  - for managing the accident and reducing its consequences
  - to ensure on-site staff protection
  - to inform the authorities rapidly
- To advise the Prefect on the protective actions to be taken, based on
  - the diagnosis made by IRSN and the expected consequences of the accident
  - the real or potential consequences
- To contribute to informing
  - the public and media
  - French institutions (Prime Minister, other ministries,…)
- To inform safety authorities abroad and international institutions (IAEA, EU), to request or give assistance if requested, in application of international, European and bilateral agreements with neighboring countries.

Mr. Michel FEIDER informed about a common document of Belgium, France, Germany, Luxembourg and Switzerland: "**Trans-border harmonization of iodine prophylaxis and other linked protective actions in the first hours of an accident in Belgium, France, Germany Luxembourg and Switzerland"**. This is a very good example of a fruitful collaboration between States for a better understanding and improving the protection of the population in the case of nuclear accident. This document should be made available to other countries having similar problems, using that best international experience and encourage the implementation in their region.
All participants took a part in the discussion to identify the way for a better collaboration on radiological rotection of the population and improve the co-operation of national and regional authorities.
Conclusion:
The participants agreed upon the necessity for joint activity to promote better radiation protection of the population by strengthening co-operation between international organizations, national authorities and communities, deploying the network for wide distribution of the best international experience.
As first step, **it was decided to organize a training course for state authorities and representatives of communities of populations living in the areas that might be affected by an accident at a Nuclear Power Plant (NPP) in June 2011 (location to be defined (either Kiev or elsewhere) .**
The training materials for this course will be developed by an international team of experts and will be based upon best national and international experience. The training materials for the course will be published on the Internet in French, English and Russian.
As implementation of that agreement, the content of training course have been developed, training materials "Emergency planning and response" have been prepared, the protocol of EUR-OPA and ASN meeting have been distributed to Ministry of Emergency Management of Ukraine and Ukrainian Nuclear Regulatory Commission. They expressed willing to collaborate in organizing such training course.

REPORT OF THE "FLOOD AND LANDSLIDE ISSUES IN THE BLACK SEA REGION" MEETING (AFEM - EUROPAN DISASTER TRAINING CENTER, ANKARA)

Date: 26-27 October 2010
Venue: Novo Hotel, Trabzon TURKEY
General Overview
Disaster and Emergency Management Presidency, Europan Disaster Training Center (AFEM) with support of EUR-OPA organized a seminary to take up flood and landslide issues in the Black Sea Region. Two keynote speech and 17 presentations made during two days programme. More than 60 experts, academicians and local administrators, NGOs, Chamber of Geological Engineers attended to the seminary. EUR-OPA Secretariat and the "European Training Information Center" in Baku also represented in the seminary.
Seminary included 3 sections called; *"Climate Change, Floods And Early Warning Systems"*, *"Landslides Case Studies In The Black Sea Region"* and *"Solutions To Flood And Landslide Problems"*.
Discussions and Outputs of the Sessions
- Session 1: "*Climate Change, Floods And Early Warning Systems*"

The session started with a keynote speech given by Prof. Dr. Miktad KADIOGLU from Istanbul Technical University and continued with six presentations. Prof. KADIOGLU discussed the terms of flood, flash flood, and gave information about the flood risk management and examples from Turkey and the world. At the end of the session following outputs were uttered by the participants;

- There is a gap between scientific community and practitioners (especially the central and local authorities). There are also lack of team work between different stakeholders working in the field of floods and early warning.
- Technical capacity of the local authorities are also discussed as one of the main problem for the region. Especially for the Black Sea Region, there is a strong need for flood, landslide and avalanche expert to contribute to the local authorities' studies.
- Participants underlined the need for effective early warning systems in the region, especially for floods and landslides. The need for more detailed flood risk maps for the Black Sea Region was also stated as one of the priority areas with respect to flood risk reduction.

- Session 2: "*Landslides Case Studies In The Black Sea Region*"

The session started with a keynote speech given by Prof. Dr. Candan GOKCEOGLU from Hacettepe University and continued with five presentations from the representatives of universities and governmental organizations. Prof. Gokceoglu informed participants about the terminology on landslides, hazard, risk and susceptibility concepts and gave examples from landslides in Turkey and other countries. In the Questions&Comments sessison participants discussed the following issues;

- There is an urgent need for landslide inventories and related documents to be compiled systematically. There is also a need for those databases to be shared for public use. Goverment units must play a crucial role for creating and managing such databases,
- Studies on landslide mapping and susceptibility are limited with the academic studies with some exceptions at governmental level exists. Local authorities and public units must be more involved at these studies.
- There is no specific information about landslides in school curricula. In order to create public awareness information especially for children, landslides must be included at school curricula.
- This meeting once again showed that databases and historical information about past events are very important. There is a strong need to harmonise those data and must be reached through single one source.

- Session 3: "*Solutions To Flood And Landslide Problems*"

Last session of the seminary included six presentations from different organizations. In the Questions&Comments sessison participants discussed the following issues;

- In the last session participants called attention to the mainly organisational and administrative matters of the govermental units. Participants suggested that there is a need to coordinate hydrological and meteorological services by establishing or restructuring existing organizations.
- Participants underlined the importance of local authorities and uttered the decentralisation at disaster management.

- As offerred by several international policies and strategies, the new disaster management structure must pay more attention to the risk reduction issues rather than response and emergency management.
- Participants offered that preparation of flood master plans and strategy document in order to use water sources effectively both for the Black Sea Region and whole country is very important.
- Participants also took attention to the need for a common terminology at disaster management is very crucial for Turkey and need to be established and distributed to all stakeholders.

RAPPORT DU COURS "MANAGEMENT AND PROTECTION OF CULTURAL HERITAGE FACING CLIMATE CHANGE "(CUEBC – Centre Universitaire Europeen pour les Biens Culturels, Ravello)

Ce Cours de Master-Doctorat, organisé du 4 au 9 octobre 2010 au Centre Universitaire Européen pour les Biens Culturels (CUEBC) de Ravello, Italie sous la direction de R.-A. Lefevre, Professeur émérite à l'Université Paris Est Créteil (UPEC) et C. Sabbioni, Directrice de Recherche au CNR de Bologne, était le 18eme d'une longue série initiée en 1993 au CUEBC et intitulée « Sciences et Matériaux du Patrimoine Culturel » .
Il faisait suite à deux autres cours exposant eux-aussi les problèmes posés au patrimoine culturel par le changement climatique global actuellement observé : le premier organisé en 2007 à Ravello, le second en 2009 à Strasbourg. Sur cette même problématique, un Colloque international avait eu lieu à Ravello en 2009. Les étudiants ont bénéficié de la parution en octobre 2010 du volume intitulé « Climate Change and CuJtural Héritage» (201 p., Edipuglia, édit.), rassemblant les Actes du Colloque de 2009 et les textes des Cours de 2007 et 2009.
Le cours d'octobre 2010 a réuni 22 étudiants de 7 pays (Italie, Suisse, France, République Tchèque, Royaume-Uni, Etats-Unis et Azebaïdjan) et 16 professeurs de 8 pays (Italie, France, Suède, Norvège, République Tchèque, Pologne, Royaume-Uni et Espagne), les meilleurs spécialistes européens de cette problématique. Le Conseil de l'Europe a attribué des bourses aux étudiants sur demande appuyée par un dossier.
Le programme du cours a largement fait appel aux chercheurs et aux résultats du projet de recherche « Noah's Ark » financé par la Commission Européenne, auxquels se sont joints des spécialistes des matériaux (la pierre, les bétons, le verre et les vitraux, en particulier), de la climatologie actuelle et future, du climat du passé, de l'océanographie et des paysages culturels. Un accent particulier a été mis sur les notions de vulnérabilité, d'atténuation et d'adaptation du patrimoine culturel au changement climatique.
Deux demies journées ont été consacrées à des travaux dirigés ayant donné lieu à des présentations orales par les étudiants : la première a concerné les effets prévisibles du changement climatique sur 4 villes mythiques, la seconde les valeurs culturelles attribuées à des objets ex-aussi susceptibles de subir les conséquences de ce changement de climat. Une visite de terrain sur la côte amaliitaine a occupé l'avant - dernière demi-journée du cours.
Le secrétariat du CUEBC a assuré l'organisation matérielle et le bon déroulement de ce cours, ainsi que la fourniture à chacun des participants d'une disquette contenant les présentations faites par les professeurs.
Il est certain qu'en plus de l'intérêt, de l'actualité du thème et de la qualité de ce cours, i l'attribution de bourses par le Conseil de l'Europe, jointe à la contribution financière du CUEBC, a été pour beaucoup dans le succès rencontré auprès des jeunes étudiants de nationalités très diverses. C'est là évidemment une incitation à poursuivre ce cycle dans l'avenir avec les mêmes soutiens.

TRAINING COURSE ON SEISMIC RISK ASSESSMENT IN SPECIFIC AREAS WITH MONUMENTAL STRUCTURES (ECPFE - EUROPEAN CENTRE OF PREVENTION AND FORECASTING OF EARTHQUAKES, ATHENS)

OBJECTIVE OF THE PROJECT

Global objectives

The ECPFE with the contribution of other Institutions organized a training course in the Province of Greece and especially in Sites of great archaeological interest. Summer Schools is a unique opportunity offered to professionals or post-graduate students to enrich their background in the areas of Seismic Risk Assessment through the development of Seismic Scenarios. The program included visits to Sites of great importance like Monuments and nearby Faults. The topic of the lessons included the basics of Seismic Hazard Studies as well as a development of an Earthquake Scenario on a specific Fault that lies near Monuments of Great Interest. The Vulnerability assessment of Monuments can operate as a valuable tool for the seismic risk management and thus the development of efficient mitigation plans .

RESULTS OBTAINED IN 2010

The goal of this event (held in Athens from the 6th to the 10th December) was to educate young scientists and to transfer knowledge and experience on this very important matter.
The themes of the training course comprised :

- Seismic Hazard assessment
- Vulnerability assessment of monuments (a valuable tool for seismic risk management and the development of efficient mitigation)
- Risk assessment for monumental structures
- Case studies.

The programme included a field trip on 8 December 2010 to the archaeological site of Delphi and to the Monastery of Osios Loucas.