Geo-engineering research and teaching experiences

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The LARAM School: teaching "LAndslide Risk Assessment and Mitigation" to PhD students

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ABSTRACT: The paper deals with the ongoing 6-year long experience (2006–2011) of the International School on "LAndslide Risk Assessment and Mitigation" (LARAM), which was founded by the University of Salerno (Italy) on April, 12th 2005 with the aim of offering a systematic and continuous forum among young researchers and renowned experts in the field of landslide risk. The main focus of LARAM has been a yearly residential Doctoral School, held in Italy and more recently in China, for PhD students working in the field of civil engineering, environmental engineering, engineering geology or related fields.

1 INTRODUCTION

Landslides are among the most destructive natural hazards, causing every year significant economic losses and casualties all over the world, as shown by the map of avalanches/landslides disasters (Figure 1) derived from the OFDA/CRED Disaster Database (EM-DAT).

This worldwide problem is regularly addressed by the scientific and technical community by means of a large number of regional and international initiatives (e.g., Symposia, Conferences, Projects) in which high level researchers and professionals exchange their experiences on many issues related to landslides. However, typical teaching programmes on this topic for young researchers (Table 1) are not as common and, when they are offered, they mostly occur as project-based short-term initiatives within projects (e.g., SAFELAND, MOUNTAIN RISKS, CHANGES) or thematic research networks and centres (e.g., ALERT, CISM). Furthermore, considering that these initiatives are essentially monodisciplinary, they are mostly aimed at participants coming from a specific field of expertise, and they do not offer a systematic and continuous forum on landslide risk to which young researchers can usefully refer.

The International School on "LAndslide Risk Assessment and Mitigation" (LARAM), founded by the University of Salerno on 12 April 2005, was envisioned to overcome the above limitations by offering a permanent venue for students having different backgrounds, young researchers and renowned experts to interact and exchange ideas in the field of landslide risk. The main objectives of LARAM are: to develop high educational interdisciplinary programs for assessing, forecasting and mitigating landslide risk over large areas; to promote the creation of vocational training programs "on the job" aimed at solving real landslide risk problems using the most advanced theories and methodologies in the fields of geotechnical engineering, geomechanics, geology, mathematical modelling, monitoring, GIS techniques, etc. These aims are achieved by means of yearly cycles of lectures, seminars, workshops and conferences.

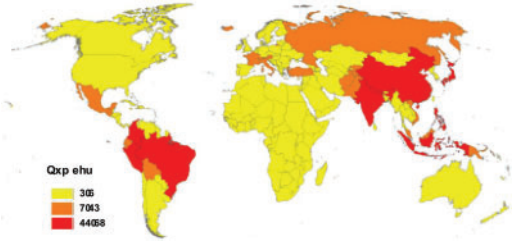

Figure 1. Number of Avalanches/Landslides disasters by Country 1974–2003 (modified from http://www.emdat.be/maps-disaster-types.

Table 1. Typical features of educational initiatives for young researchers on landslides.

	Offer	Duration	Recurrent	Reach	Disciplines
Project	W, S	1–2 days	no	nat/int	mono/multi
Network	W, S, C	1–3 days	no	int	mono
Centre	S, C	3–5 days	no	nat/int	mono
University	S, C	3–6 months	yes	nat	mono
LARAM	C	1–2 weeks	yes	int	multi

W = Workshop, S = Seminar, C = Course
nat = National, int = International
mono = monodisciplinary, multi = multidisciplinary

2 TEACHING LANDSLIDE RISK

The most general formula which can be used to identify the risk associated to a natural phenomenon, R_t, was proposed by Varnes (1984):

$$R_t = ER_s = EHV \quad (1)$$

where: R_t (Total risk) is defined as the expected number of lives lost, persons injured, damage to property, or disruption of economic activity due to a particular natural phenomenon; E (Elements at risk) means the population, properties, economic activities in a given area; R_s (Specific risk) is the expected degree of loss due to a particular natural phenomenon; H (Natural hazard) means the probability of occurrence within a specified period of time and within a given area of a potentially damaging phenomenon; V (Vulnerability) means the degree of loss to a given element or set of elements at risk resulting from the occurrence of a natural phenomenon of a given magnitude.

Despite the apparently simple formulation, this definition of risk has proved to be very useful and efficient since it clearly identifies the three components of the risk related to landslides. Of course, the adequate application of this formula requires at the same time the capacity to have a global perspective of the problem and several specific expertises in different fields, which range from geology to civil engineering, from social sciences to economics, among others. To this aim, it is necessary to have a clear procedure to follow in which both the aims and the most adequate methods to adopt are specified.

Once risk is estimated, further steps are necessary as the computed risk must be evaluated and, when necessary, risk mitigation options must be put in place. Recently, a comprehensive framework for landslide risk management has been proposed by Fell et al. (2005). The Authors define a process comprising three sequential and interrelated phases: risk analysis, risk assessment and risk management (Fig. 2). Within this framework, risk assessment takes the output from risk analysis and assesses these against judgements and risk acceptance criteria. The output from the assessment is then used to develop risk mitigation options, including accepting the risk, reducing the hazard or reducing the consequences. This last phase necessarily involves a number of different stakeholders including owners, residents, the affected public, regulatory authorities, geotechnical professionals and risk analysts.

It is clear that the global efficacy of the obtained results is strictly related to the effectiveness of each step and, above all, to the reliability of landslide risk analysis and zoning. This aspect is well addressed within the recent "Guidelines for landslide susceptibility, hazard and risk zoning for land use planning" (Fell et al. 2008). For instance, the purpose of the study (e.g. information, advisory, statutory, design) determines both the scale of the analysis (e.g. regional, local, site-specific) and the methods to be used for susceptibility, hazard and risk analysis and zoning.

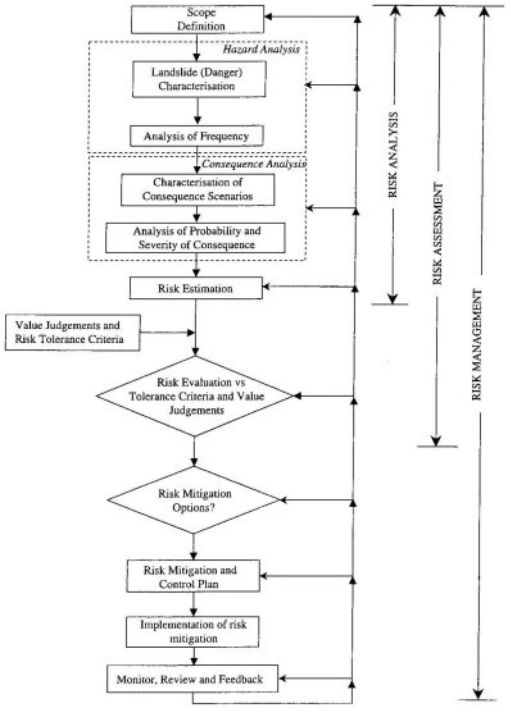

Figure 2. Flow chart for landslide risk management (from Fell et al. 2005).

On the basis of the previous considerations, it can be concluded that teaching the landslide formula, the landslide management framework and the methods for landslide zoning are not challenging tasks, in principle. However, it is not straightforward to find a small number of lecturers who are experts on so many wide-ranging technical areas. To overcome this difficulty and to effectively teach the concepts related to landslide risk, the LARAM School involved, since its beginning, a large group of outstanding international experts in many different fields. Thanks to this choice, the LARAM School is designed to transfer to selected students both a global overview of the risk management process and the most advanced and up-to-date topics and methods to be used for the evaluation of the factors defining landslide risk. Moreover, for every course, a strongly international and multidisciplinary class of PhD students has always been selected. This encourages the mutual exchange of different experiences and backgrounds, thus promoting a multidisciplinary teamwork approach to the study of landslide related problems.

3 THE LARAM SCHOOL EDUCATIONAL CASE STUDY

3.1 *Structure of the School*

The LARAM School's administrative bodies, which are appointed for three years at a time, are: the Director,

the Board of Directors, the Scientific Committee, the Technical Committee and the Administrative Unit. The Director of the School is, since the foundation of the School, Prof. Leonardo Cascini, full Professor of Geotechnical Engineering at the Department of Civil Engineering of the University of Salerno. The Director presides over a Scientific Committee composed of about 20 experts in the field of Landslide Risk Management. Every year the Committee sets the criteria for the students' selection, defines the contents of the courses, chooses the lecturers, and evaluates the results of the School's programme. The Scientific Committee has always been very international (Tab. 2) with a majority of members having an engineering expertise. As for the Technical Committee, it is in charge of implementing the programme planned by the Scientific Committee, supervising the organisation and evaluation of the courses, defining and collecting the School's teaching material and managing the School's information system. The Authors of this paper have served as the Technical Committee's members since the foundation of the School.

The main yearly initiative of LARAM is the Doctoral School, which is held in Italy in the month of September. Every year 40 PhD students are selected to attend the School's residential courses, with 10 places reserved to Italian PhD students. The courses include formal lessons, tutorials and field training. Over the six years, the LARAM School's lectures have been attended by 238 students belonging to over 150 different European and extra-European Universities from many different Countries (Fig. 3).

Other significant initiatives organized by LARAM in these years were: a yearly Workshop, held in Italy in the same period as the School, dealing with specific landslide risk issues attended by researchers, professionals and authorities in charge of the territory governance in Italy and Europe; the participation in the SAFELAND project "Living with landslide risk in Europe", a European funded 3-year long cooperative project among researchers from 25 different Institutions, with the main task of disseminating the project results; the launch of a first LARAM-Asia Course in 2011, a teaching initiative outside Europe planned to extend the reach of the LARAM teaching approach to a continent heavily affected by landslides; a constantly updated web portal (http://www.laram.unisa.it), aimed at presenting information on the LARAM initiative as well as becoming a virtual community among LARAM alumni and lecturers.

Table 2. Members of the LARAM Scientific Committee.

Year	Italy	Europe	World	TOT
2006–2008	4	10	7	21
2008–2011	4	9	5	18

As for the SAFELAND initiative, it must be stressed that LARAM, besides being a key partner of the research Consortium, contributed significantly, through a strongly positive evaluation of its dissemination capabilities, to the winning bid of the Consortium to the FP7 research call of the European Union. This may be seen as an indirect confirmation of the potential of the LARAM educational initiative in this field. As for the LARAM-Asia initiative, this course is not meant to remain a solitary experience but rather a first step towards the diffusion of the LARAM teaching format in regions of the world where the risk related to landslides and its management are important.

Finally, the financial support to the LARAM School was provided, over the years, by different sources of funding. The main financial sponsors of the School have been, in order of importance: the local Authority in charge of the governance of the territory of the Amalfi coast "Comunità Montana Penisola Amalfitana," without which the LARAM School activities, probably, would not have started (about 67% of budget); the Campania Region (about 10% of budget); the SAFELAND project (about 10% of budget); the research network between the Universities of Salerno and Naples dealing with natural risks "CUGRI" (about 7% of budget); the University of Salerno (about 3%

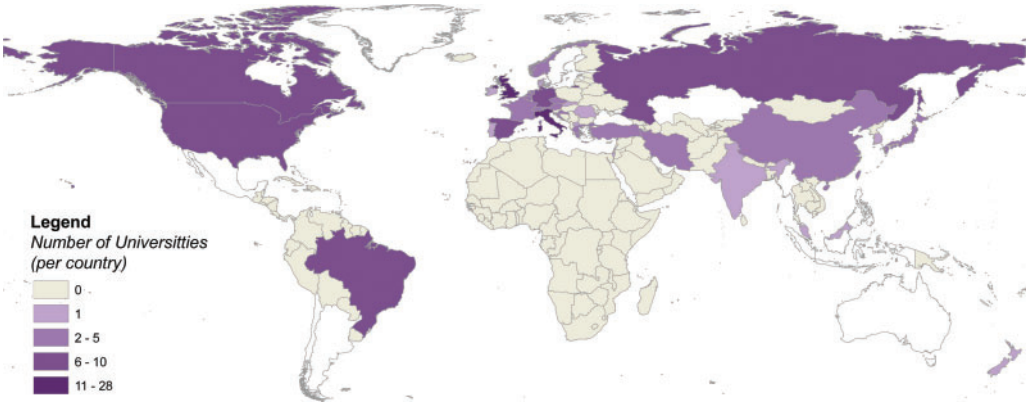

Figure 3. Number of Universities per country providing PhD students participating to one of School's classes from 2006 to 2011.

Table 3. Number of lecturers at the LARAM School and the LARAM-Asia Course, by year and location.

Year	Italy	Europe	World
LARAM School 2006	3	8	3
LARAM School 2007	8	9	2
LARAM School 2008	4	7	3
LARAM School 2009	6	8	3
LARAM School 2010	7	8	4
LARAM School 2011	6	8	0
LARA-Asia Course	2	4	9

of budget); other sources (about 3% of budget). As for the LARAM expenses, they are related to: accommodation and lodging for the selected students, who enrol to the School at no cost (about 55% of budget); travel, accommodation and lodging for the lecturers, who do not get otherwise paid for their teaching activity (about 35% of budget); logistical and administrative costs (about 10% of budget).

3.2 *The programme of the School*

The LARAM course is structured to follow, as much as possible, the landslide risk framework presented by Fell et al. (2005). Therefore, every year the lecturers are chosen and the programme is set by paying a great attention to address both the most advanced theoretical issues as well as to present and discuss relevant landslide case studies coming from many different Countries. To this aim, the list of lecturers has always been strongly international (Tab. 3) and the different topics are organized in sessions reflecting the structure of the landslide risk management framework (Fig. 4).

As Fig. 4 shows, in the first 5 years the structure of the programme remained almost constant, i.e. two weeks of classes (75–80 hours among lectures, tutorials and technical visits) and the majority of lectures offered within the same main sessions. In this period, the only few fine-tuning improvements occurring were: the introduction, since the second year, of a short introductory session specifically devoted to outline the role of geology and geotechnics within landslide analysis; the discussion, since 2009, of the results of the cooperative European-wide project SAFELAND. The year 2011 differs significantly from the previous years because two LARAM teaching initiatives were offered: i) a one-week special edition of the LARAM School, mainly aimed at disseminating the results of the European project SAFELAND; ii) a new two-week course, held in China, which included a 3-day field trip. Globally, this means that the amount of lecture hours devoted to three important sessions of the programme (Intro to landslides, Safeland project, Field trip) significantly increased.

As it concerns the interdisciplinarity of the programme, all the topics of the landslide risk management framework are purposefully addressed through many short lectures delivered by many different lecturers (on average 16 lecturers per edition with 4 hours

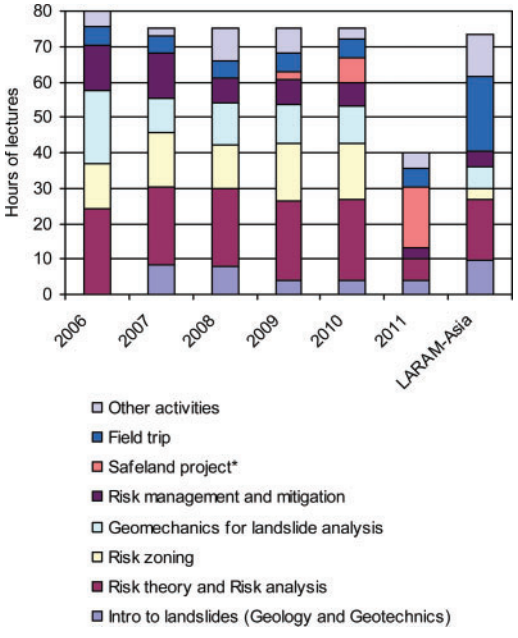

Figure 4. Topics addressed in the LARAM School lectures from 2006 to 2011 and in the LARAM-Asia Course.

of lessons, including tutorials, per lecturer). In such a way, each student, irrespective of his/her background and previous knowledge, gets "exposed" to state-of-the-art methods of analysis, experience and developments in all the areas of the landslide risk management framework, with lectures delivered by recognised experts in the fields. Another important benefit offered by such a programme is that it allows significant networking opportunities to the students at a very early stage of their career among themselves (i.e. the future landslide experts), as well as with the lecturers (i.e. the experts). In order to illustrate the LARAM programmes better, the following section provides details on contents and organisation of a typical LARAM course.

3.3 *An example: LARAM School 2008*

The LARAM School 2008 was held in Ravello, Italy, from 8th to 20th September. The LARAM class of 2008 was composed of 40 students enrolled in PhD programmes of 36 different European and non-European Universities, selected from a pool of 101 applications sent by PhD students coming from all over the World. The teaching group comprised 14 lecturers, coming from 11 different countries, for the most part also belonging to the LARAM School Scientific Committee. The programme of the School consisted of 60 hours of lectures, 10 hours of tutorials and 5 hours of field training. Particularly, the detailed programme of the Course (and hours of lectures) was:

INTRODUCTION. [1] Introduction to LARAM 2008 (0.5 h); [2] Introduction to landslides. (1 h).

SESSION I "Landslide analysis using approaches based on: Geology, Geotechnics and Geomechanics." [1] Landslide identification. Key geological, geomorphological and hydrogeological features of: landslides in soils, large landslides and rock slides (2 h); [2] The geotechnical slope model (1.5 h); [3] Basic geomechanics of landslides (3 h); [4] Tutorial (1.5 h).

SESSION II "Risk Theory and Risk Analysis for Landslides." [1] Landslide Risk Management concepts and framework and examples (2.5 h); [2] Deterministic and Probabilistic models for slope stability evaluation (2 h); [3] Introduction to modelling of catastrophic landslide events (2 h); [4] Empirical models for travel distance (1.5 h); [5] Application examples of probabilistic methods and semi quantitative methods for landslide hazard zonation (2 h); [6] Landslide Frequency Assessment (1.5 h); [7] Different components of vulnerability to landslides. Prevention and long term management of landslides (3.5 h); [8] Case Studies: coal waste dump risk assessment, example from motorway in La Reunion Island, Aknes Rock slope in Norway (2 h); [9] Application of QRA to other geotechnical problems – Internal erosion of dams, crater lake hazard (1.5 h); [10] Advanced numerical models: initiation of landslides, propagation of sediments/climate change effects (3.5 h).

FIELD TRIP "Technical visit." Field trip to an area affected by catastrophic landslides in 1998 and to the geotechnical laboratory facilities of the University of Salerno (5 h).

SESSION IV "Landslide susceptibility, hazard and risk zoning at different scales." [1] Input elements to zoning maps. Zoning scales, levels and methods. Basic methods and procedures for zoning at small and medium scales (<1:100,000–1:25,000). Tutorial on susceptibility, hazard and risk zoning at 1:25,000 scale. Statistical methods for susceptibility and hazard analyses (6 h). [2] Natural terrain zoning and management criteria – Hong Kong practice and experience. Qualitative risk rating for individual slopes/hillsides and global quantitative risk assessment. Site-specific quantitative risk assess-ment and risk management. Tutorial on quantitative risk assessment (6 h).

SESSION V "The role of sophisticated methods in landslide Risk analysis." [1] Introduction to advanced slope stability characterization (1 h); [2] Analysis of the stability of soil slopes with low slope angles as a result of latent instability (3 h); [3] Finite element modelling of landslides by taking into account an hydromechanical coupling and an instability criterion (3 h); [4] Flow-like mass movements in pyroclastic soils: triggering mechanisms and some remarks on propagation stage (1 h); [5] Thermo-hydro-mechanical couplings in slope stability: the case of rapid drawdown, thermal effects in landslides. Tutorial on rapid slides (4 h).

SESSION VI "Landslide risk management and mitigation." [1] Risk management on la Désirade Island and Pointe-Noire in Guadeloupe (3 h); [2] The role of control works in the risk mitigation framework (0.5 h); [3] Site investigation and field monitoring in the research of sliding mechanisms of residual and colluvial slopes in tropical areas. Principles of prevention and long-term management of landslides, efficiency of drainage works (1 h); [4] Remarks on Control works for Landslide Risk Reduction and some Case Histories (1 h); [5] Principles and design of control works against rockfalls and shallow slides: solution in urban areas – the example of Rio de Janeiro (1.5 h).

CONCLUDING SESSION (1 h).

Finally, in order to have significant feedback on the learning level of the students, the programme included tutorial activities and an end-of-course exam.

Example of tutorial activity

One of the tutorials offered in SESSION IV was aimed at addressing the issues related to landslide risk zoning at medium scale. The problem statement was the following: "A Regional Authority needs to set up a procedure for landslide hazard and risk zoning of its territory of about 12,000 km^2, based on maps available at 1:25,000 scale. The mapping must be completed within a few months using qualitative risk assessment criteria. An engineering consultant company will be hired to help define the zoning procedure. Four companies (i.e. 4 groups of 10 students) expressed an interested in performing this job. The competitive evaluation of the 4 companies (i.e. today's tutorial) consists in defining an adequate zoning method with reference to a sample area of about 18 km^2."

Each group of students (i.e. each virtual Company) was provided with the following maps of the sample area at 1:25,000 scale: i) topographic map; ii) landslide inventory map, including a 2-class descriptor of the state of activity of the phenomenon; iii) urban areas and infrastructure map; iv) elements at risk map; v) damage map; vi) consequences map. The students were also provided with the procedure used to define a "Consequence model" producing a 4-class qualitative consequence map on the basis of available thematic information. Each group was asked to work for 60' to define either a Susceptibility, or a Hazard or a Risk Model, following the example of the Consequence model provided. At the end of that time, a 30' plenary session was scheduled for 5' short presentations by the leaders of the 4 groups and a 10' final discussion on the criteria on which the models proposed by the different groups were based.

End-of-course exam

The end-of-course exam was offered, upon request, to students interested in being evaluated for accreditation purposes. To this aim, during the last days of the School, the interested students were asked to answer three out of five questions within a take-home style 48-hour long examination.

The questions on the LARAM 2008 exam were the following: [1] Using a summary of your PhD thesis, indicate how the lessons at LARAM School will improve the work that you are doing. [2] The frequency of debris flow in a site is about one event every four years. A city of 10,000 inhabitants is located in the deposition area. a) What kind of data would you look for in both hazard and risk analysis assessment? b) What kind of measures would you suggest to reduce the risk? [3] What are the advantages and disadvantages of assessing the performance and reliability of protection measures by drainage and anchors? [4] What is a suitable scale for assessing risk at the level of a commune or region? Which parameters or components should be taken into account and how do they influence the choice of the scale? [5] What does "landslides characterisation" mean? Why is it important for risk assessment?

Three students asked to take the facultative exam. The evaluation of the exam was in charge of the six members of the Scientific Committee involved as lectures in LARAM School 2008. After the end of the School, each exam was sent to the lecturers who were asked to review the students' answers and to evaluate them. Each exam was considered as passed if it received sufficient marks from at least 51% of the evaluators. All three students passed the exam. As for the marks, a scale expressing a percentage with respect to a 'full mark evaluation' (i.e. from 0 to 100%) was initially used and then converted into different nominal scales following the specific needs expressed by the different students. In particular: an "A to E scale" was used for a Norwegian student; a "1 to 5 scale" – being 1 the best grade and 5 the worst – was used for an Austrian student.

4 THE SCHOOL: SIX YEARS OF EXPERIENCE

A total of 238 PhD students attended the LARAM School in Italy from 2006 to 2011 (Fig. 3). As expected, most of the students were enrolled in PhD programmes offered by Italian and other European Universities. Yet a significant number of students coming from Canada, USA, Brazil, China and Russia was also observed.

The first LARAM-Asia course was attended by 37 students mostly coming from China or other Asian Countries, thus highlighting the strong regional attractiveness of this initiative, which reaches out to students unwilling or unable to apply to the Italian LARAM School.

The main statistics on the LARAM School Alumni, i.e. PhD students selected to participate to one of School's classes from 2006 to 2011, are reported in Figure 5. They indicate a clear majority of male over female students (140 vs 98), engineers over geologists or engineering geologists (131 vs 83), first and second year students over students approaching the end of their PhD programme (180 vs 68) and students younger than 30 years old over "older" students (172 vs 76). The comparison among these data and the corresponding statistics for the first LARAM-Asia Course (Fig. 6) shows, beside the already mentioned issue on the country of origin of the students, the following main differences: more geologists or engineering geologists than engineers (17 vs 12) and a more even distribution with respect to the PhD year.

To investigate how the students valued their LARAM experience, since the first year of the School, a questionnaire was set up with reference to both the didactic and logistic aspects of the School and handed out to the students at the end of each year's course. Figure 7 shows the results of questionnaires

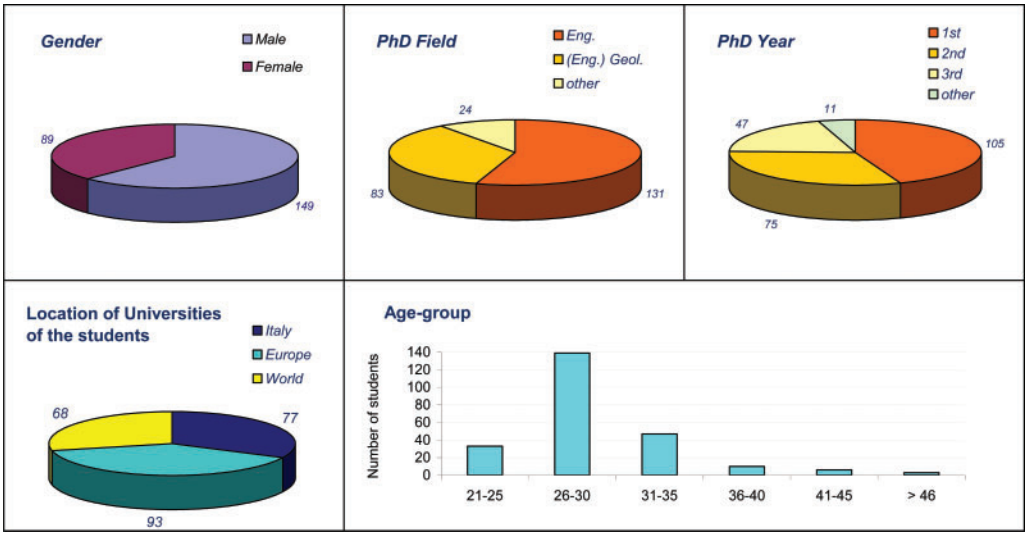

Figure 5. Statistics of the LARAM School Alumni, distribution by: (a) gender, (b) PhD Field, (c) PhD Year, (d) location of University, (e) age.

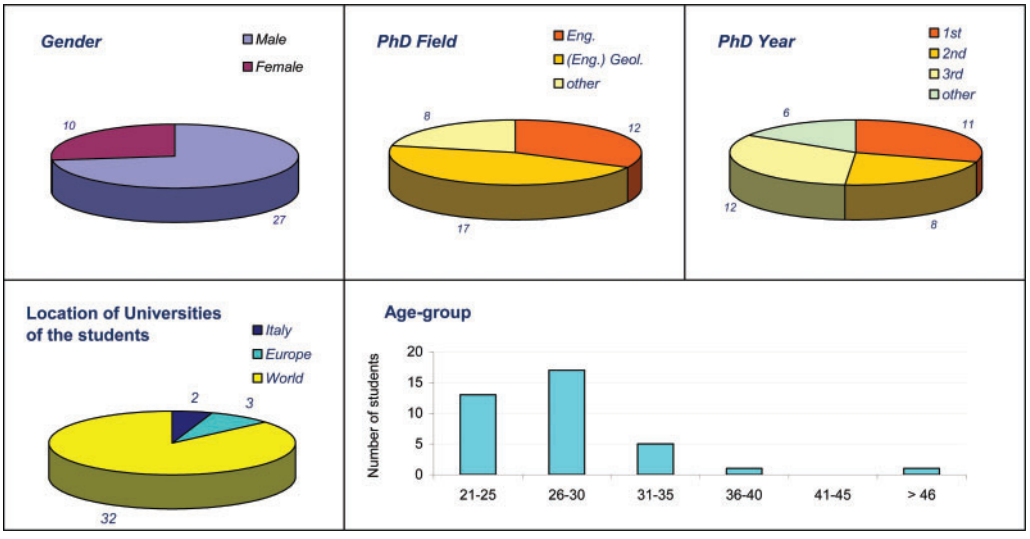

Figure 6. Statistics of the LARAM-Asia students, distribution by: (a) gender, (b) PhD Field, (c) PhD Year, (d) location of University, (e) age.

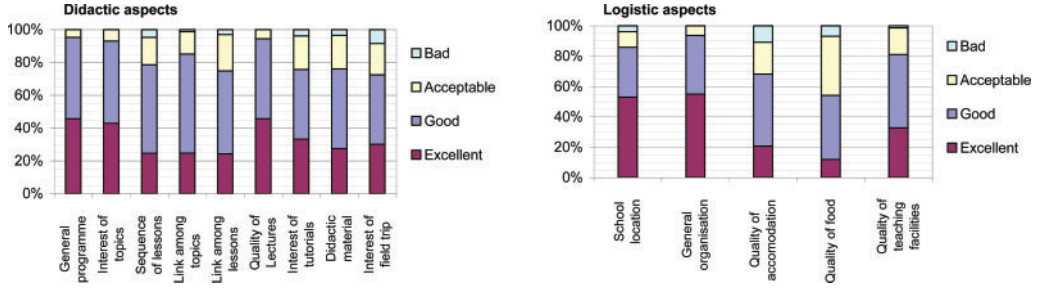

Figure 7. Results from questionnaires filled by the LARAM School students (2006–2011) at the end of each year.

filled by the all the 238 LARAM School Alumni. An extremely positive feedback was provided for the interest of topics and the general programme (about 95% of excellent/good answers), thus highlighting the seeking of knowledge on the part of PhD students in this field interest and the adequateness of the School programme for this purpose. Also the link among topics was judged positively (85% of excellent/good answers), which means that the basic goal of the LARAM mission, i.e. bridging the current gap between geotechnical engineering, geology and other fields in landslide risk theory, was achieved. However, an improvement on this issue is still desirable and possible, as the high quality of teachers is also recognised by the students (95% of excellent/good answers). A positive judgement (average of 75% of excellent/good answers) was given to other teaching issues: tutorials, field trip, didactic material and teaching facilities. Of course, the success of the School as a didactic experience also depends on logistic aspects. As for these issues, while School location and the general organization reached outstanding reviews (average of 90% of excellent/good answers), the quality of accommodation only reached 70% of positive answers and the "world-famous Italian food" ranked as the very last added value of the School (only 55% of excellent/good answers).

As for the effectiveness of the education provided by LARAM for the students attending the School and its relevance for the pursuit of their PhD degree, the Authors had positive feedback only from few of the 238 LARAM Alumni who passed an optional post-course exam. Regardless, the Authors believe that the real benefits of the participation of the PhD students to such an initiative will appear "more effective" to them only at later stage of their career, when they will be able to value the LARAM experience with respect to their research standing and other educational experiences.

5 CONCLUDING REMARKS

Landslide risk is becoming more and more a worldwide problem that requires adequate actions to be

taken from both Authorities in charge of territory governance and the scientific community. The latter, in particularly, is called to give scientifically-based answers to the analysis, assessment and, more in general, management of landslide risk. This must be performed taking into account both the large variability of geo-environmental contexts as well as the different social expectations related to different socio-economical conditions. A particularly important issue in this process is the dissemination of proper procedures and methodologies, which need to be shared and validated by the international scientific community. To this aim, the LARAM School is working to become a permanent didactic institution through which young researchers meet and interact with renowned experts in the field of landslide risk.

The first six years of experience of the LARAM School seem to demonstrate that the path towards that challenging goal is promising. Over the years, the LARAM community has grown significantly both among students and landslide experts, thus underlining the effectiveness of the initiative. Such success is also demonstrated by the fact that other Countries, for instance China, have expressed the need to have residential courses within their Institutions. Of course, future developments of LARAM will depend on many other factors, such as, for instance, the demand of such expertise, the amount of PhD candidates working in the field of landslide risk and, of course, on the related actions promoted by LARAM.

ACKNOWLEDGEMENTS

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Moreover, the Authors wish to thank all the members of the Scientific Committee, who surely provided an outstanding contribution to the success of the School. The Authors also thank all the students that attended the School and, more in general, all the applicants, because they are the main reason why such an initiative exists.

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CISM. International Centre For Mechanical Sciences. http://www.cism.it/

CUGRI. Consorzio Interuniversitario denominato Centro Universitario per la Previsione e Prevenzione Grandi Rischi. http://www.cugri.it/

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