DAMOCLES

DEBRISFALL ASSESSMENT IN MOUNTAIN CATCHMENTS FOR LOCAL END-USERS

Contract No EVG1 - CT-1999-00007

DETAILED REPORT OF CONTRACTOR FOR THIRD ANNUAL REPORT (March 2002-February 2003)

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UNIVERSITY OF PADOVA

DETAILED REPORT OF CONTRACTOR
FOR THIRD ANNUAL REPORT
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CONTRACTOR: UNIVERSITY OF PADOVA, DEPARTMENT OF LAND AND AGRO-FOREST ENVIRONMENT – WATER RESOURCES DIVISION

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Section 2.

Summary

The integration of MODDS (1-D) and DDPM (2-D) models within the Arcwiew GIS framework was improved. Such integration enable the one-dimensional channel model (based on vector elements) to be linked with the two-dimensional fan model (based on raster cells). The component model can be run independently or integrated together. The overall Debris Flow Impact Model, DEFLIMO, was tested at sites in the Italian Alps (Rio Lenzi and Rio Rudan basins) and in the Spanish Pyrenees (Rio Sahun).
A demonstration linking of the Workpackage 2 (WP2) and Workpackage 3 (WP3), as an integrate approach for debris flow hazard assessment on alluvial fan has been carried out in collaboration with the University of Milano Bicocca. In the regional scale analysis, the discriminant function model for landslide susceptibility is used in order to indicates the extent to witch an area is at risk for debris flows. The quantification of the effect that a debris flow would have if it occurred, can be done applying (as second step), the local debris flow impact model (DEFLIMO) as a function of debris flow characteristics.

Familiarity with use of DEFLIMO was achieved thought the participation of the End-users at the Padova training course, in September 2002. The practical technical session developed on the GIS laboratory was a great success and particularly appreciated from End-users.
The assistances of the Padova team to own End-users thought frequent meeting and support in critical phases of applicability that they carried out by themselves, after the Training Course, have guaranteed a real and efficient transfer of the DAMOCLES technology.

Section 3.

Section 3.1: Objectives of the reporting period (01/03/2002 - 28/02/2003)

According to the proposed work programme for DAMOCLES project the research team of the University of Padova (Mario A. Lenzi, Vincenzo D'Agostino, Carlo Gregoretti, Diego Sonda, Alberto Guarnieri, Francesco Comiti and Luca Mao) had the following objectives included in the workpackge WP3 "*Development of a small basin debris flow impact model*" and WP5 "*Dissemination of the project deliverables*" :

- **Task 1:** Improvement of user-friendly graphics and data input-output of the Debris Flow Impact Model;
- **Task 2:** Final simulations of the Debris Flow Impact Model on the Rio Lenzi catchment;
- **Task 3:** Demonstration linking of WP2 and WP3 workpackages;
- **Task 4:** Organisation of the Damocles Training Course (Padova, 10-11, September 2002);
- **Task 5:** Application of the Debris Flow Impact Model to the Rio Rudan catchment;
- **Task 6:** Calibration, validation and application of the Debris Flow Impact Model to the Sahùn Catchment (Spain);
- **Task 7:** Preparation of papers and oral presentations, for the Milan Final Workshop and Milan GISIG meeting (Milan, 21, November 2002).
- **Task 8:** Preparation of Technical Report, Scientific and Final Report, T.I.P. and Cost Statement.

Section 3.2: Methodology and Scientific Achievements Related to Work Packages

3.2.1 WP3 "Development of a small basin debris flow impact model"

In the previous report (second year) the general setting out of the 1-D and 2-D sub-model for debris flow routing has been described. The work carried out during the reporting period 01/03/2002 – 28/02/2003 has dealt with the following topics:

- Improvement of user-friendly graphics and data input-output of the Debris Flow Impact Model;
- Final simulations of the Debris Flow Impact Model on the Rio Lenzi catchment;
- Application of the Debris Flow Impact Model to the Rio Rudan catchment;
- Calibration, validation and application of the Debris Flow Impact Model to the Sahùn Catchment (Spain).

In order to facilitate the use of DEFLIMO model, a user-friendly graphic interface for data input and results output was developed.
The integration of 1-D and 2-D sub-models within a GIS system was improved. The DEbris FLow Impact Model (DEFLIMO) was checked by applying it to two different torrents of the Italian Alps: Rio Lenzi and Rio Rudan, both located in the Trento Province, and to the alluvial fan of the Rio Sahùn catchment, Benasque Valley (Spanish Pyrenees), (Fig. 1a and b).

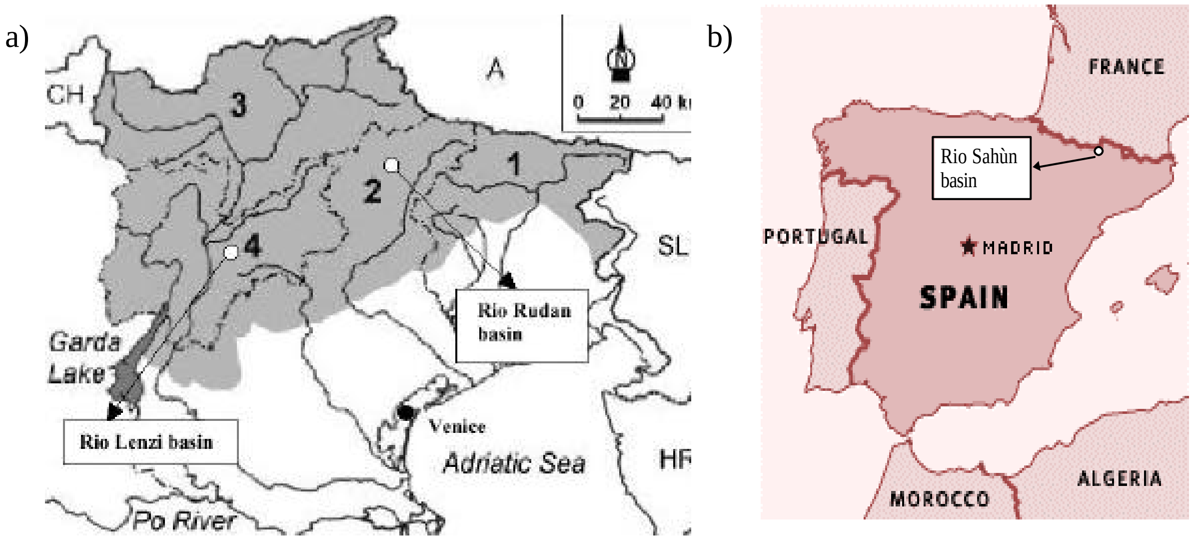

Figure 1. a) Location of Rio Lazer and Rio Lenzi in the northeastern italian Alps; b) Location of the Rio Sahùn in spanish Pyrenees.

The Lenzi torrent is a tributary of the Fersina River in the Adige valley (near Trento city). Its basin drain an area of 2.43 km^2 and ranges in elevation from 1407 m (fan apex) to 2409 m. The geology of the catchment features an igneous upper part, whilst the middle and the lower ones are characterized by quaternary morainic deposits. The basin has a typical Alpine climate with annual precipitation ranging from 930 to 1100 mm. Precipitation occurs mainly as snowfall from November to April. Runoff is usually dominated by snowmelt in May and June whilst summer and early autumn floods represent an important contribution to the flow regime (Lenzi *et al.*, 2003).
The basin is prone to generate granular debris flows as it results from many documented historical events. In the 1882 an extraordinary precipitation event occurred all around the Province of Trento, triggering a massive debris flows along the Rio Lenzi stream. Several deep erosion (still active) were incised in the upper part, delivering huge amounts of sediment to the main channel which built many lateral deposits downstream. Boulder up 2-3 m^3 in size were eroded and transported during past events (Sonda, 2001). The urbanised fan was flooded with severe damages. In 1917 and 1951 other smaller debris flow events affected the catchment fan. In the 1966 other extraordinary rainfalls produced a debris flow which flooded the lower part of the fan (Lenzi *et al.*, 2003).The field evidences of such events allow the application of the Aulitzky (1994) method for mapping debris flow hazard areas on the fan (Fig. 2). However, the hydraulic torrent control works constructed after 1966 flood should induce some modification to this mapping based on “silent witnesses” (Aulitzky, 1994).

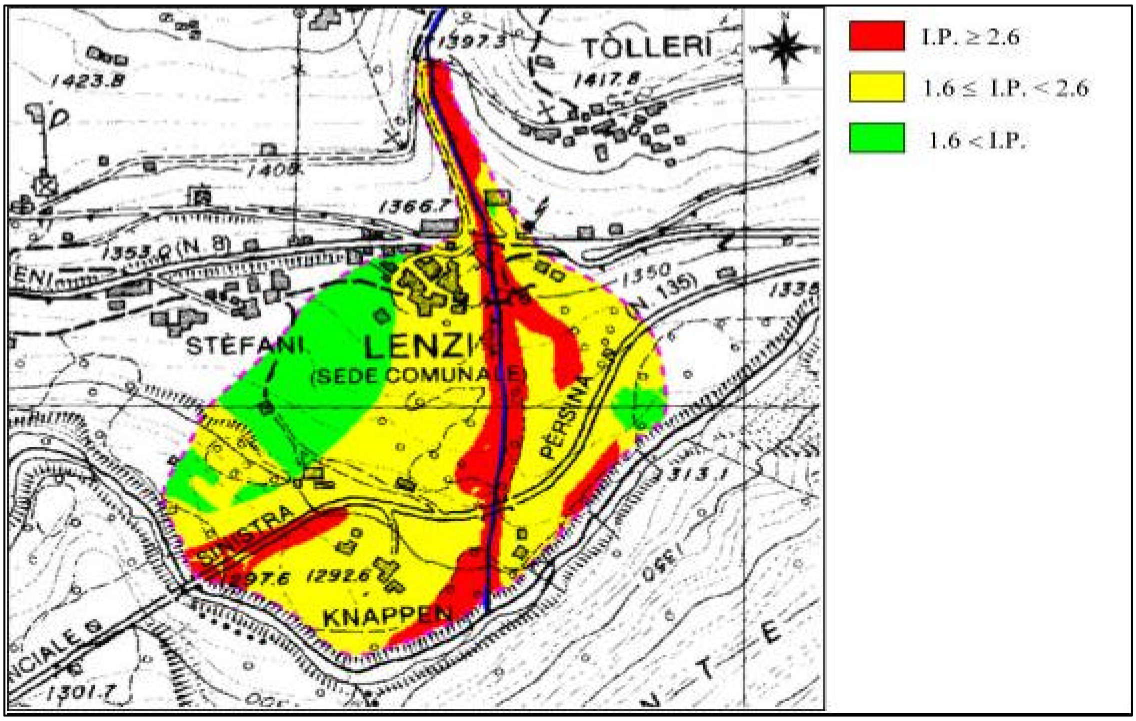

Figure 2. Map of debris flow hazard areas for the Rio Lenzi fan according to the Aulitzky (1994) method (Source Lenzi *et al.*, 2003).

DEFLIMO model was applied for assessing a more current hazard map scenario and for comparing it with the Aulitzky approach. Existing topographic maps do not offer the proper accuracy (i.e. at scale of 1:500 or 1:1000), therefore a high-precision topographic survey was carried out for the fan area and for the lower 600 m reach of the stream. Constructed DEM of the fan has 1×1 m size; average distance between two consecutive channel cross-sections resulted at about 20 m (Sonda, 2001). The simulated debris-flow surge entering at the upstream channel cross-section has a total volume of 30000 m^3 (D'Agostino & Marchi, 2001) and a peak value equal to 120 m^3/s. Assumed roughness coefficients are coincident for channel and fan cells: $C_f^* = C_c^* = 2$. Results given by the MODDS 1-D application can be alone deemed as representative of a first level hazard mapping. In fact, when the overflowing discharges versus time has been assessed by the model, a realistic high-hazard zone can be inferred trough the run-out distance computation. By applying to the whole outflow volume (11000 m^3) a run-out formula (Ikeya, 1981) and directing its flow path according to the steepest terrain slope, hazard map reported in Figure 3b has been obtained. The exhaustive simulation deals with the DEFLIMO application (Fig. 3a): no substantial differences exist respect to the first level estimation (Fig. 3b), even if the complete simulation is able to asses the sediment distribution in terms of the flow levels at a selected time of computation (Lenzi *et al.*, 2002, 2003).

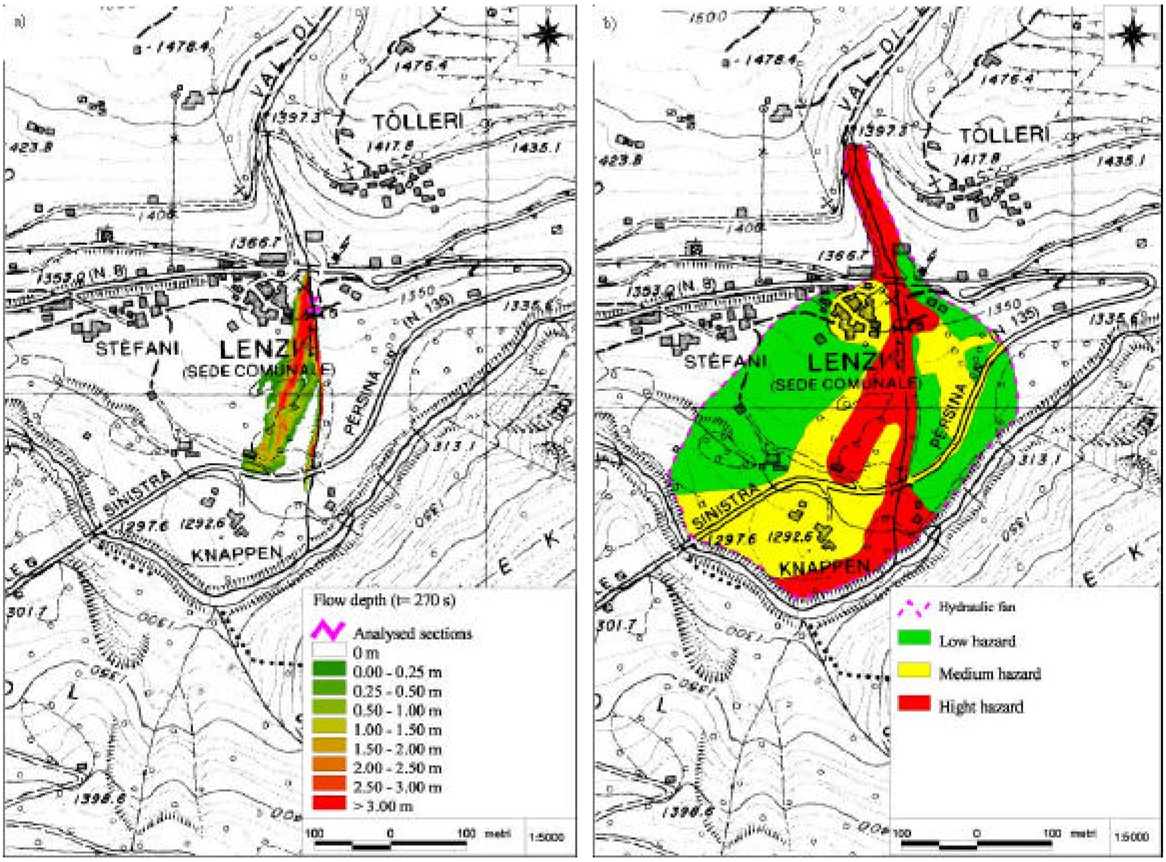

Figure 3. Rio Lenzi fan: a)DEFLIMO application: debris flow depths (m) on the fan area represented at the time 270 s; b) Hazard map obtained by means of the MODDS-1-D model linked to the run-out distance computation

The second basin in witch there was implemented the DEFLIMO model is the Rio Rudan watershed, a small catchment located in the Province of Belluno (Veneto Region). Its main morphometric characteristics are summarised in Table 1. The Rio Rudan basin is characterised by a dolomitic nature: high-sloped (subvertical) rocky cliffs make up the upper part along with a narrow, steep valley covered with talus deposit. Fluvial deposits cover most of the lower part, with a minor percentage of morainic, alluvial and fluvio-glacial materials. The basins have a typical Alpine climate with annual precipitation ranging from 950 to 1300 mm, mainly occurs as snowfall from November to April. Runoff is usually dominated by snowmelt in May and June whilst summer and early autumn floods represent an important contribution to the flow regime.
The Rio Rudan stream take origins at 1900 m.s.m. at the foot of a fall, 15 m high, downstream a scree placed under the southern rock faces of Monte Antelao (3264 m.s.m.).

Catchment area	km^2	3.003
Average elevation	m.a.s.l.	1689
Minimum elevation	m.a.s.l.	801
Maximum elevation	m.a.s.l.	3264
Mean catchment gradient	%	98
Length of the main channel	km	4.02
Main channel mean gradient	%	34

Table 1. Main morphometric characteristic of Rio Rudan catchment.

In the lower part of the watershed the forest stands are made up by broadleaves such as beech (*Fagus sylvatica* L.) and ash (*Fraxinus excelsior* L.) mixed with spruce. Upslope, due to the high soil permeability, gradient and general slope instability, the Scotch Pine (*Pinus sylvestris* L.) predominates, blending with increasing patches of shrubs (*Pinus mugo* Turra, *Salix* spp.) moving toward the upper part of the basin (above 1800 m a.s.l.) where *Pinus mugo* forms a continuos belt under the dolomitic cliffs.
The upper part of this basin is characterized by the steep cliffs of the Antelao peak (3264 m.) and by a large scree slope. At this important accumulation of talus material triggering of debris flow usually occurs; debris-flow deposits located downstream of this zone indicate that debris flows are a recurring geomorphic process in this area. The upper watershed portion also shows the presence of vast sediment sources areas, and the supply of mobilizable sediment is rarely a limiting condition for debris flow occurrence. The Rio Rudan flows past a deep alluvial channel with high and steep banks (Fig. 4), which are continuously eroded by mass transport phenomena except in the middle part of the basin, where the torrent flows over rock (Fig. 5).

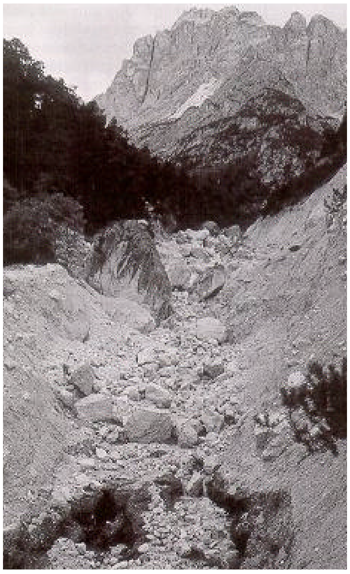


Figure 4 and 5. The Rio Rudan main stream: upper and medium reaches.

The average slope of the Rio Rudan between the waterfall and the National Road is 24%. The torrent is channelized 50 m upstream of the National Road n. 51; the banks here are concrete walls (2 m) and the cross section is rectangular. The average width of the cross section is 10 m and downstream of the bridge some transversal drop are present built to avoid bed erosion. The channelized reach of the torrent passes through the hamlet of Peaio (860 m.s.l.) before flowing into the Boite River at 800 m.s.l.m. The Melton index analysis shows that Rio Rudan can be considered a debris flow-generated fan.
The assessment of the liquid discharge was performed by using the S.C.S. method giving a value of 7.5 m^3/s for a 50-years return interval. Potential debris flow volume was evaluated by using several equations, and the most verisimilar value is considered to be 64,400 m^3. The routing of a debris flow down the channelized reach was simulated using the 1-D MODDS model; its peak solid discharge was evaluated from the peak liquid discharge (Hashimoto *et al.*, 1978). Considering the activity and the location of sediment sources, the peak discharge of the debris flow for the considered return time turns out to be around 112.5 m^3/s.
The simulation carried out with the 1-D MODDS model (Fig. 6) shows that the channelized final reach have three critical sections: a) near the second bridge – section 30 – and b) on the left side of two sections, section 41 and 42. The total overflow volume is about 300 m^3.

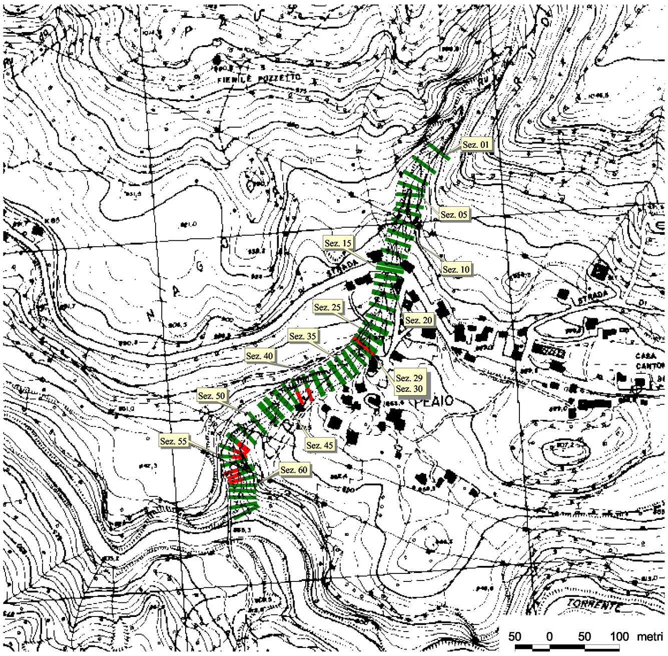

Figure 6. 1-D MODDS output map. Red colour individualize overflow sections.

The thirty model application has been carried out for the Sahùn River. The catchment of the Sahùn stream (3,26 km^2) takes origin from the Oriental south slopes of the Tuca Cambra mountains in the Benasque Valley (Spanish Pyrenees). Sahùn reach length within the alluvial fan is 830 meters, average slope of the fan is 13%. In the higher part of the analyzed area, where the morphological and climatic condition become severe, pastures areas are alternated with unproductive land; in the lower part, shrubby and forest type (52% of the basin) are dominant. The morphology of Sahun watershed is due to the quaternary glaciers action and, recently, to fluvial activity.

The Sahùn main channel do not present transversal or lateral consolidation handwork. The abundance of vegetation in river bed, particularly in correspondence of sediment fan, could constitute a problem during floods. The basin doesn't show conditions of elevated instability; however, all the possible sediment sources areas were recognized. The application of Melton index (0,74) and the analysis of the critical cross sections (bridges and bends) and debris flow magnitude, associated to extraordinary floods, underline the possibility of considering potential overflow and debris flow hazard areas on the fan. The application of the 1-D MODDS model to Sahùn torrent benefits of field activities, detailed topographic survey, thematic maps and hydrological data supplyed by IGME of Zaragoza.

The quantification of the potential debris flow volume was evaluated with several equations; the simulated debris flow surge entering at the upstream channel cross-section on the fan apex was estimated in 40000 m^3. Peak flood discharge was estimated using the Rational Method and performed 24.60 m^3/s for 50 years return time; peak solid discharge was evaluated by using volumetric method from liquid discharge data (Hashimoto *et al*., 1978), and pointed out a value of 197,00 m^3/s.

The bridges are the most critical cross sections in the analyzed area, the first located at the top, and the second one in the medium part of the fan. Simulations of two possible scenarios (with and without re-entering solid material leaked out from first bridge at the top of the fan) underlined the insufficiently of the first bridge (section 15), while the second bridge is able to conduce higher discharges (up to 586 m^3/s) without lateral overflow. The simulations conducted with MODDS model emphasized the insufficient conveyance of any intermediate section too, particularly section 16. Figure 7 shows graphical result of the simulation, hypothesizing debris flow with 197,00 m^3/s peak discharge and the re-entering of overflow solid material. Beginning from these results, a primary hazard map was elaborated using Ikeya (1981) method for the evaluations of debris flow runoff (Fig. 8).

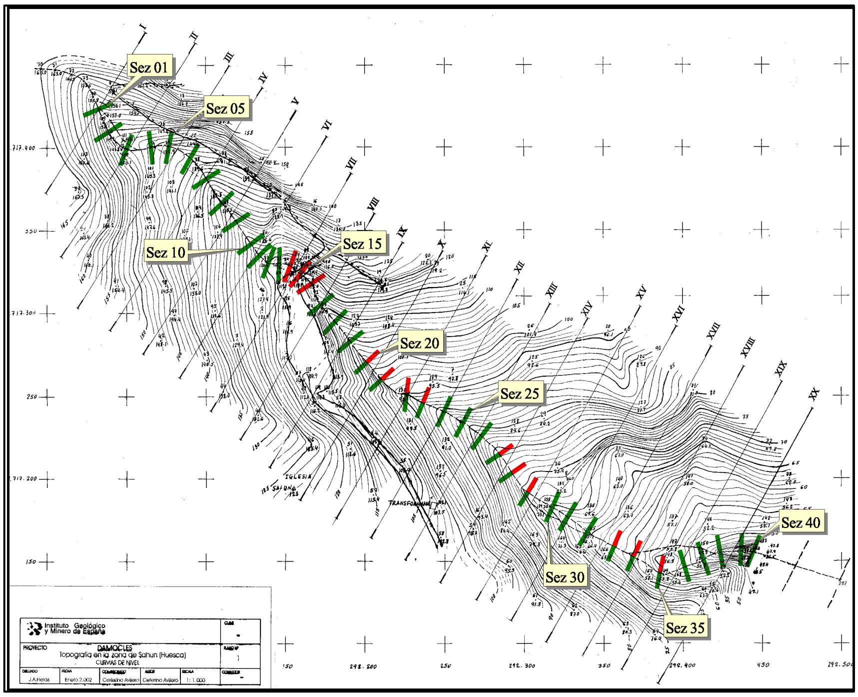

Figure 7. 1-D MODDS output simulation hypothesizing 197,00 m3/s of debris flow discharge and re-entering solid material overflow from first bridge. Red color individualize overflow section.

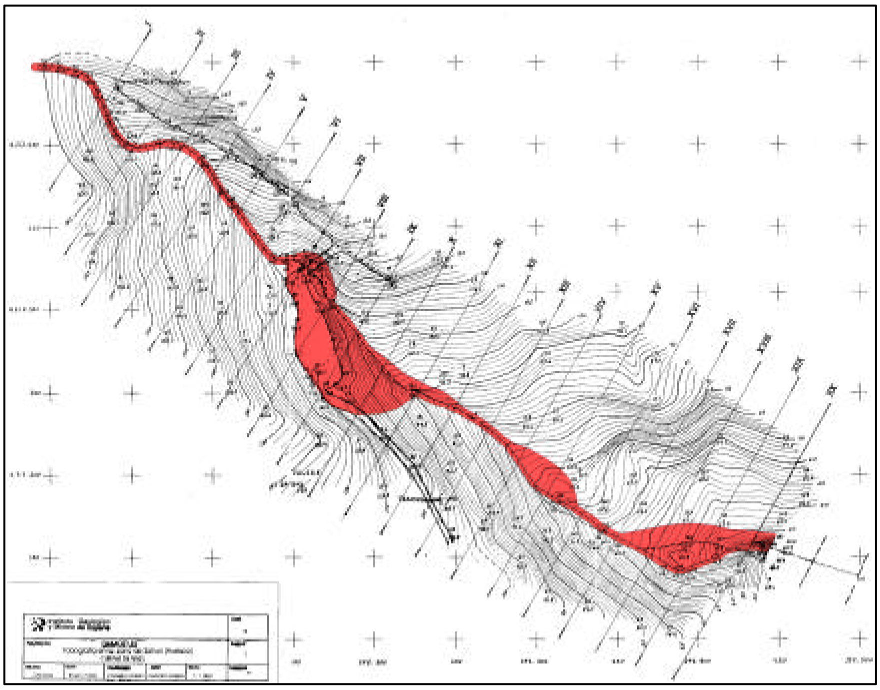

Figure 8. Hazard map of the Sahùn fan area.

3.2.2 WP5 "Dissemination of project deliverables"

Training course related with the application and implementation of the Work Package 3 (*Small Basin Debris Flow Impact Model*) was hold on the campus of the Agricultural Faculty of the University of Padova (Agripolis) at Legnaro (PD). Sessions were organized in two days; Tuesday 10, 2002, was dedicated to the presentation of the 1-D and 2-D Models and also to discuss the different types and characteristics of gully-channelised debris flow, limits of the two models, field of applications and data set inputs requirements. A video showing triggering, propagation and sedimentation of a debris flow was used to facilitate the exchange of ideas between end-users (geologists, practicing engineers, forestry managers, technicians). A typical practical-individual technical session using 10 dedicated-PC was carried out on the GIS laboratory, Wednesday 11, 2002.
A report titled *Methodological guide: case studies and applications* was prepared and given to all participants. The PDF file of this document is available on the DAMOCLES Project website (http://damocles.irpi.pg.cnr.it/). The participant list includes 4 persons coming from the Torrent Control Agency of the Autonomous Province of Trento; 2 from regional planning authorities of the Veneto Region; 1 from the *Struttura Rischi Idrogeologici* of the Lombardia Region and 2 participants of the University of Milano Bicocca; 1 participant coming from a Spain End-user (Instituto Geològico y Minero of Zaragoza). Other participants as geologists, consultants, junior geologist working in private companies. Ph.D students also attended the course.

3.2.3 WP2-WP3 "Demonstration linking of WP2 and WP3 workpackages"

The linking of WP2 and WP3 as an integrated approach for the debris flow hazard assessment on alluvial fan has been carried out in collaboration with the University of Milano Bicocca. The methodological approach is based on two subsequent analysis:

- Regional scale analysis: This first step permit the identification both of the debris flow susceptibility of the slope terrain unit and the hazardous basins.
- Small basin scale analysis: Permit to simulate the propagation of the debris flow on the fan area.

In the regional scale analysis, the discriminant function model for landslide susceptibility was used to product a map of relative occurrence probability of debris flow. The identification of an hazardous small basin (high probability of debris flow occurrence), leads to the next step of applying of the debris flow modelling on the alluvial fan (DEFLIMO).
The sequence of the operation that describe the linking between WP2 and WP3 approaches is concisely schematised in Figures 9-13.

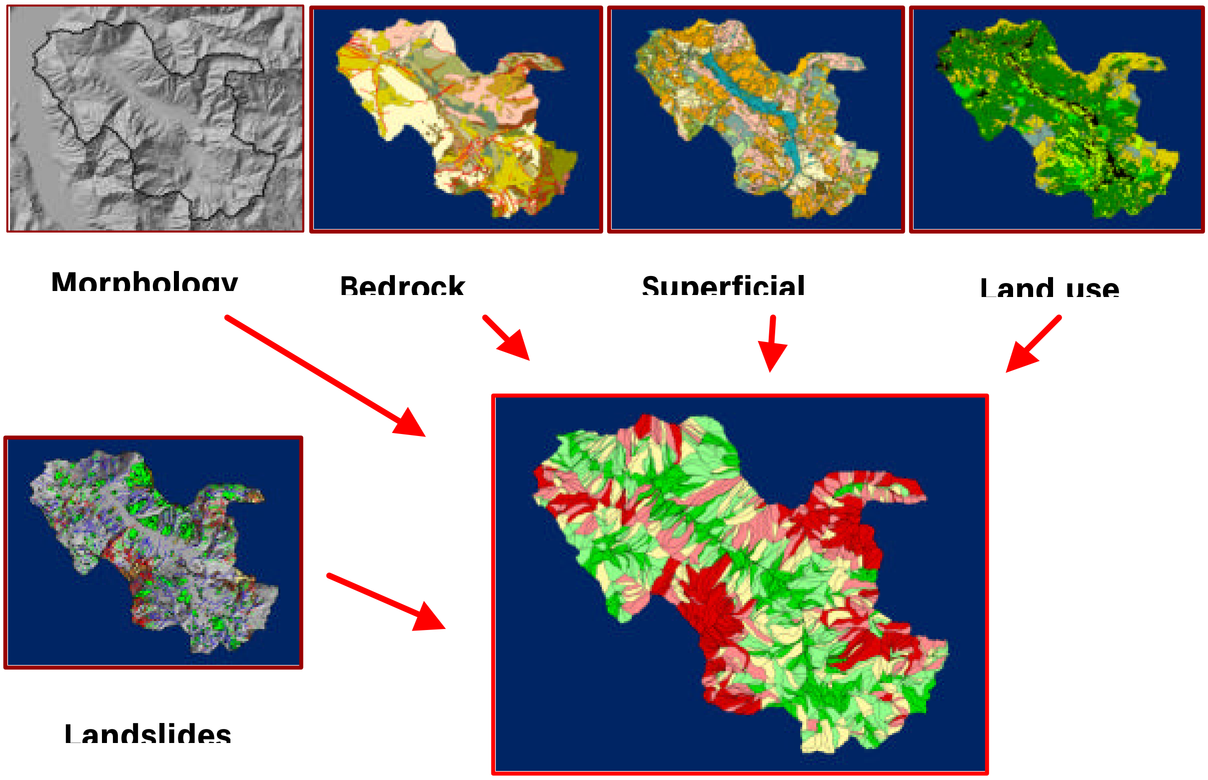

Figure 9. Regional scale analysis step 1: Discriminator model of debris flow probability (sources: G.B. Crosta, University of Milano Bicocca).

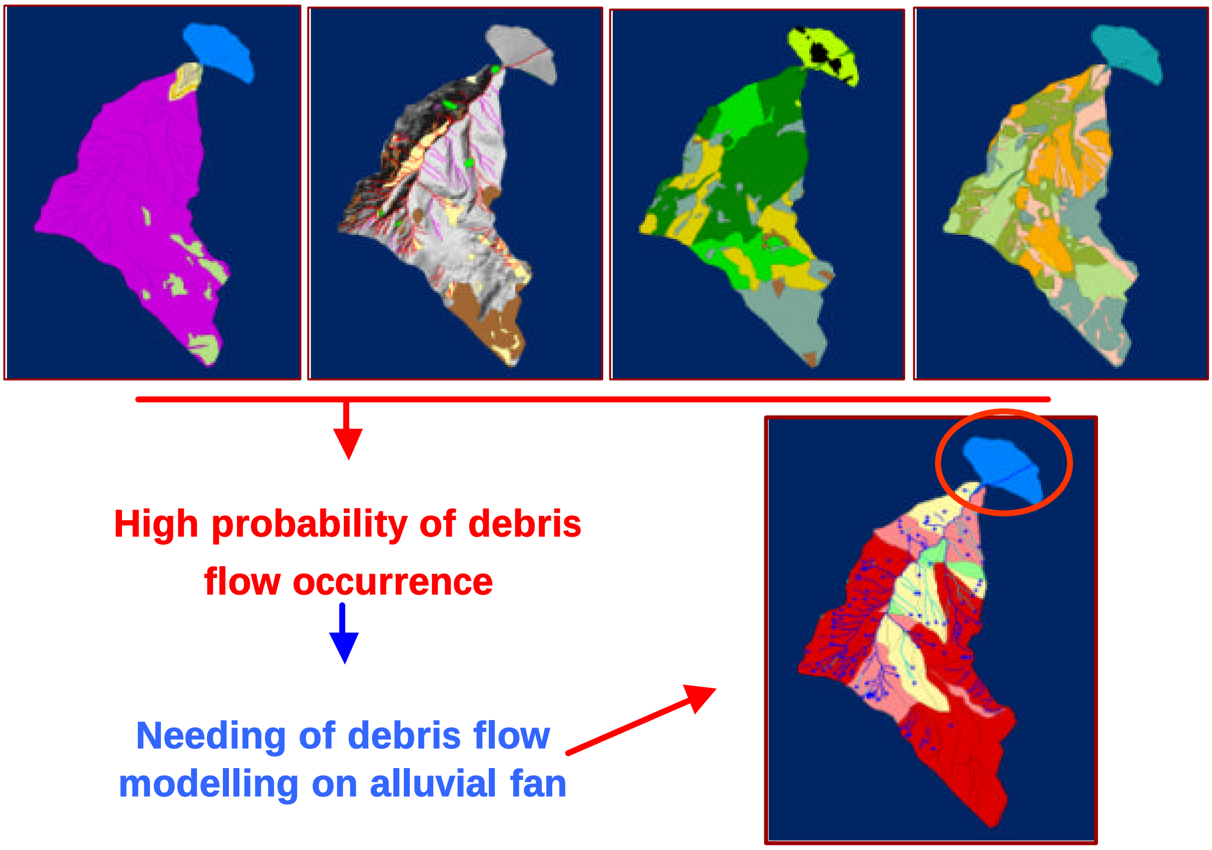

Figure 10. Regional scale analysis step 2: Identification of the alluvial fans needing of debris flow propagation modelling (sources: G.B. Crosta, University of Milano Bicocca).

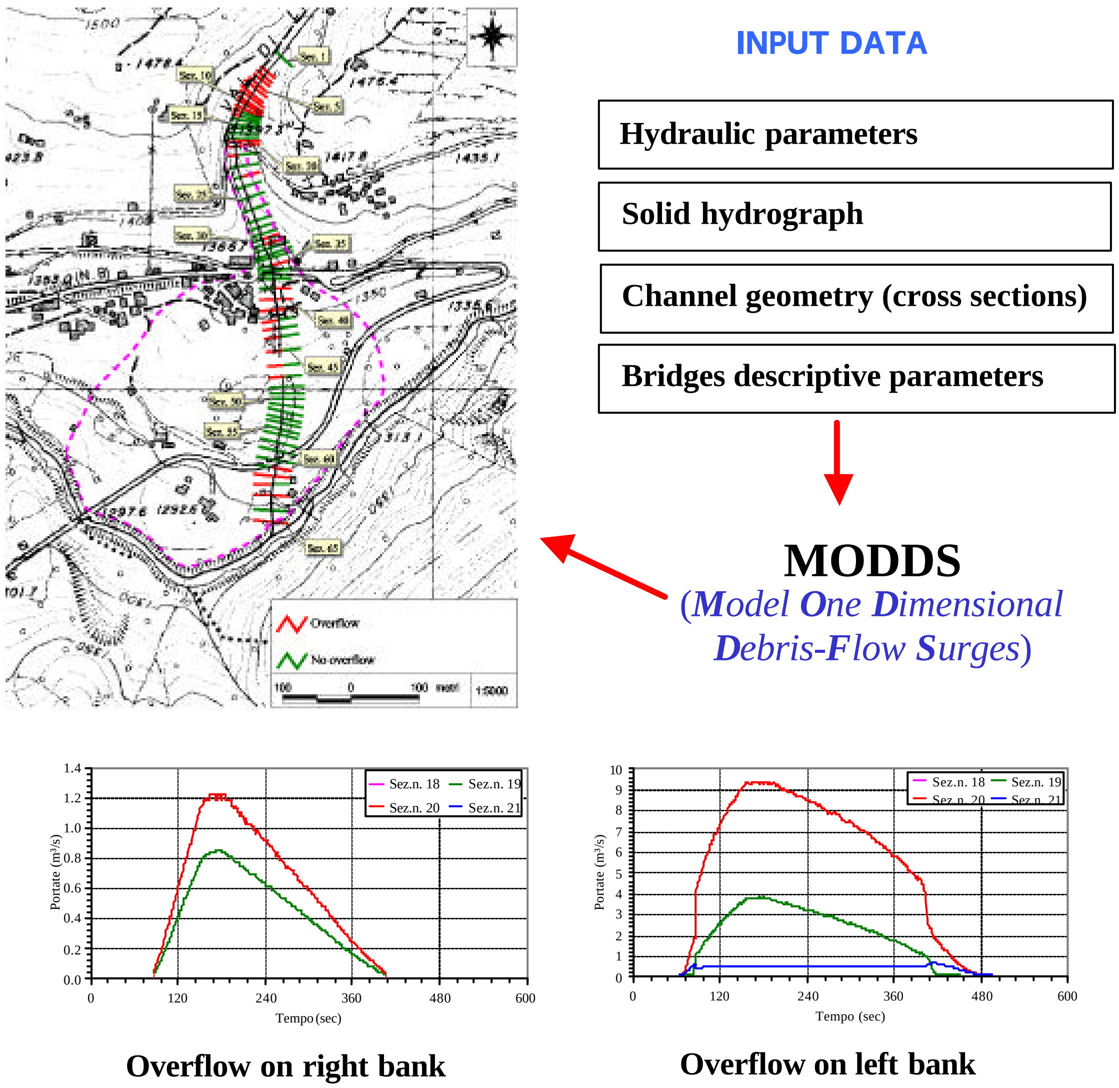

Figure 11. Basin scale analysis conducted with 1-D submodel in order to modeling the channeled debris flow propagation on alluvial fans

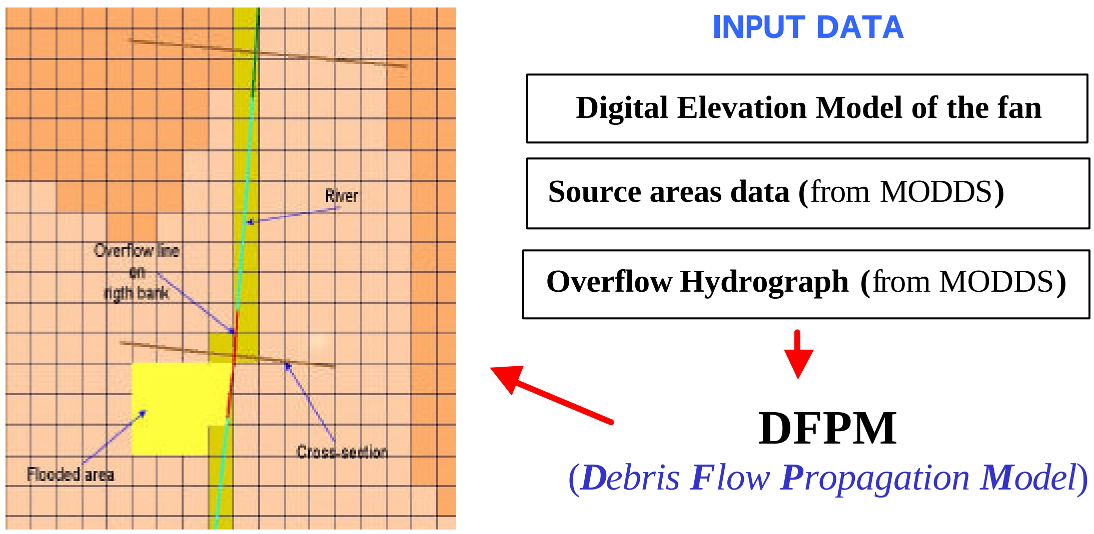

Figure 12. Basin scale analysis conducted with 2-D submodel in order to identificated the debris flow inundation on the fan

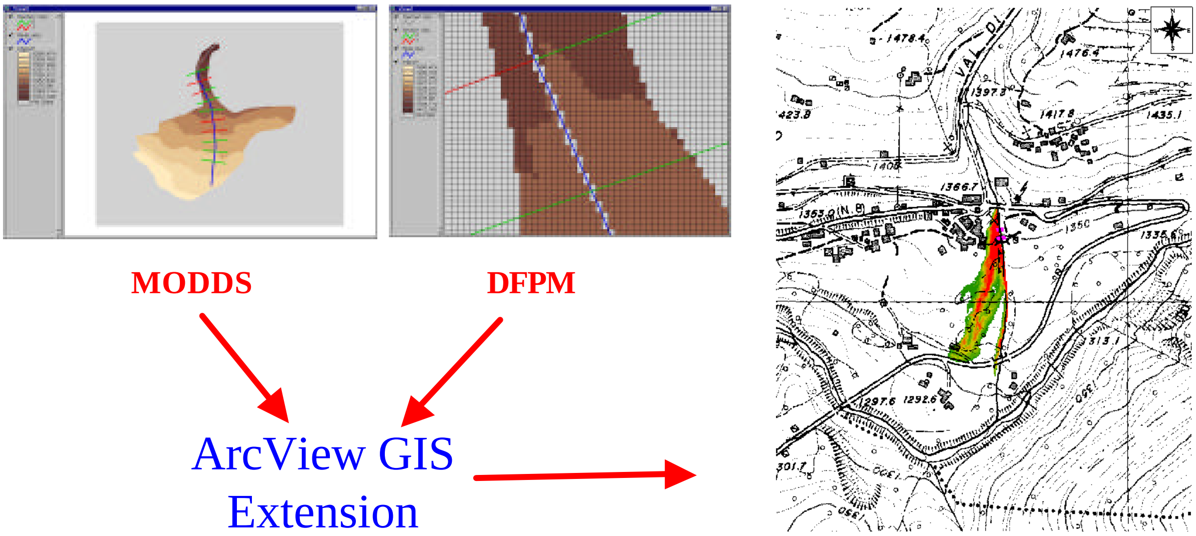

Figure 13. DEFLIMO integration of the 1-D and 2-D sub-models within a ARC-VIEW GIS framework

Section 3.3: Socio-economic Relevance and Policy Implication

In order to clarify with an actual example the socio-economic relevance of the project advances, consider that the annual budget of the Autunomous Province of Trento for torrent control works and debris flow management is around 20 millions euros, whereas damages caused by debris flow events can reach tens of millions euros, with hundreds of deaths, since many towns are present on the alluvial fans. Another concern are the road closures, for example recently the important motorway connecting Verona with Innsbruck has remained blocked for two days because of a debris flow.
Before Damocles Project the end-users (i.e. the Torrent Control and Protection Agencies) has been using the Aulitzky methodology both to evaluate whether debris flows can occur along a stream and to produce maps with three different levels of hazards on the alluvial fan. This qualitative approach does not allow to assess how critical structures along the channel (i.e. bridges, check-dams, ripraps) affect the debris flow route along the channel, particularly where flooding is likely to occur and the volume of the overflowed material. The developed 1-D submodel permits to simulate such dynamics and the 2-D fan propagation submodel produce detailed hazard mapping with valuable information about deposition patterns, which can lead to both an efficient land-use planning and a better design of torrent control works.

Section 3.4: Discussion and Conclusions

Debris flows is a familiar hazard in European mountain areas and regularly cause loss of life, livelihood and property and disruption of communications. The potential for such loss is increasing as the mountain areas are increasingly developed and insurance claims as a result of this threat are steadily rising. In some European countries hazard debris flow mapping combines information on past events with geomorphological surveys (Aulitzky, 1994). Other available techniques are still approximate and give qualitative or relative estimates of hazard.
A one-dimensional sub-model for debris flow routing along the channel (MODDS) has been developed and calibrated. MOODS was tested and validated in the Test Area C (Rio Lenzi channel).

The estimation of the fan areas subjected to debris flow deposition is approached by using a 1-D routing model (MODDS) linked to a 2-D scheme for prediction of runout areas (DDPM). Both models originates from exemplificative hypotheses descending from the high slopes which characterize debris flow fans located in the north-eastern italian Alps. Such hypotheses allow to couple a practical employ of the model (end-users oriented) with the physical basis maintenance of the debris phenomenon. Application facilities of the debris flow impact model (DEFLIMO) also come from its integration with the ArcView GIS framework. Exemplificative study cases of DEFLIMO for three debris fan (Rio Lenzi and Rio Rudan, Trento Province, Italy, and Sahùn River, Benasque Valley, Spain) offer reliable mapping of hazard areas, if compared to historical observed events.

The linking of WP2 and WP3 as an integrated approach for the debris flow mapping risk on alluvial fan was carried out in collaboration with The University of Milano Bicocca DAMOCLES team. The methodology benefits from the linking between a regional and a subsequent basin scale analysis. The first one permit to identify the debris flow susceptibility of the slope and the hazardous basin; the second one allow to simulate the propagation of the debris flow event on the fan area.

Section 3.5: Recommendations Arising from the Project

End-users familiarity with use of the small basin Debris Flow Impact Model was achieved through his participation at the Padova training course (September, 10-11, 2002). The practical technical session developed on the GIS laboratory with the constant support of four assistants of our research team was a great success and particularly appreciated from the End-users.

The Torrent Control Agency of the Autonomous Province of Trento and the Soil Defence Agency of the Veneto Region have started to apply the MODDS model for their own works to two different basins. There was an interesting exchange of ideas between End-users, practicing engineers and our research team in relation with data requirements and field surveys. Special suggestions for the main channel topographic survey were given in relation with the application of MODDS to the two new catchments.

It was commented that the cost of the topographic survey necessary for the implementation of the 2-D DDPM model could be so high to discourage a wide dissemination (to many fan areas, i.e.: 25-30) of the technology. Our opinion is that it is necessary to analyze each case and final decision should be related to a preliminary evaluation of the entity and magnitude of hazards, damages and risks and to the presumable cost of the investments (structural and/or non-structural measures) needed for the risk mitigation. Some “alternative” new technologies, as the use of “laser scan” or high resolution remote sensing techniques, should also be tested in the future and compared with both resolutions and costs of traditional topographic survey.

The assistance of our research team to our End-users through frequent meetings and our support in critical phases of the applications they are actually carrying out by themselves in some basins guarantee a real and efficient transfer of the DAMOCLES technology.

Section 3.6: References

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Lenzi, M.A., 2002. Debrisfall Assessment in Mountain Catchments for local End-Users: Detailed Report of Contractor for Second Annual Report. DAMOCLES Project, Contract EVG1-1999-00007. University of Padova, Padova, Italy, pp.21.

Lenzi, M.A., D'Agostino, V., Gregoretti, C., Sonda, D., Guarnieri, A., Comiti F. & Mao, L. 2002. *Modellistica della propagazione delle colate dedritiche e della sedimentazione nei conoidi alluvionali: guida metodologica, casi di studio ed applicazioni*. DAMOCLES Training Activities, September 10-11, 2002, University of Padova: pp. 74.

Lenzi, M.A., D'Agostino, V., Gregoretti, C. & Sonda, D. 2003. A simplified numerical model for debris flow hazard assessment: DEFLIMO. In *Proceedings 3° International Conference Debris-Flow Hazards, Mitigation*, Davos, Switzerland, September 10-12: pp. 12.

Sonda, D. 2001. Valutazione della pericolosità idrogeologica sui conoidi alpini. Ph.D Thesis, Department of Land and Agroforest Environment, University of Padova: pp. 256.

3.6.1 List of publications in the reporting period.

Peer Reviewed Articles:

Authors	**Date**	**Title**	**Journal**	**Reference**
Lenzi M.A. & Mao L.	2003	Analisi del contributo del trasporto solido in sospensione alla produzione di sedimento del bacino del Rio Cordon nel periodo 1986-2001.	Quaderni di Idronomia Montana	Vol. N. 21 (in press)
Lenzi M.A.	2002	Stream bed stabilization using boulder check dams that mimic step-pool morphology features in Northern Italy.	Geomorphology	Vol n. 45, 243-260.
Lenzi M.A.	2002	Debris-flow hazard assessment using numerical models and GIS: case studies in central Italian Alps and Spanish Pyrenees	Environmental Science and Environmental Computing	Submitted
Lenzi M.A., Mao L. & Comiti F.	2003	Inter-annual variation of suspended sediment load and total sediment yield in an instrumented alpine catchment over 16 years	Hydrological Science **Journal** des Sciences hydrologiques	Submitted

Non refereed literature:

Authors / Editors	**Date**	**Title**	**Event**	**Reference**	**Type[1]**
Lenzi M.A., D'Agostino V. Gregoretti C. & Sonda D.	2003	A simplified numerical model for debris flow hazard assessment: DEFLIMO.	3° International Conference Debris-flow Hazards, Mitigation; Davos, Switzerland, September 110-12, 2003	Accepted for publication; 13 pp.	Proceedings
Lenzi M.A., D'Agostino V. Gregoretti C. , Sonda D. , Guarnirei A., Comiti F. & Mao L.	2002	Modellistica della propagazione delle colate detritiche e della sedimentazione nei conoidi alluvionali: guida metodologica, casi di studio ed	DAMOCLES Training Activities, September 10-11, 2002, University of Padova.	University of Padova, 74 pp.	Report

[1] Type: Abstract, Newsletter, Oral Presentation, Paper, Poster, Proceedings, Report, Thesis

		applicazioni.			
Sonda D.	2002	Valutazione della pericolosità idrogeologica sui conoidi alpini	University of Padova	University of Padova, PhD "in Idronomia", 256 pp.	PhD. thesis
Lenzi M.A.	2002	Nuevos modelos para la predicción de riesgos geomorfológicos en abanicos aluviales; un ejemplo de los Alpes Dolomíticos	Workshop "Métodos para la predicción de riesgos de movimientos de ladera en áreas de montaña » ; Zaragoza, May 14-15 2002.		Oral presentation
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