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The Hazard Assessment in a Terraced Landscape: Preliminary Result of the Liguria (Italy) Case Study in the Interreg III Alpter Project

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Abstract

In steep areas the lack of terrain suitable to farming has induced man to modify the slopes with terraces. In the ligurian territory (northern Italy) above the twenty per cent of the total surface area have been changed by means of terraces. Terraces may be regarded as a human interference with the geomorphic system, which drives the evolution of the terrestrial surface. This interference actually causes the increase of the hazard particularly in those areas where the morphology hardly constrains the urbanisation. The preliminary results here presented are part of the hazard assessment task of the EU Interreg III Alpter project, which was born to contrast the abandonment of terraced agricultural areas in the alpine region. After checking the real extension of terraces and collecting data, will be performed a MS (multivariate statistic) analysis to get to a decision tree model of the hazard connected with terraces. The preliminary results make focus attention mainly on aspect and gradient slope more than on other features.

The hazard assessment in a terraced landscape: preliminary result of the Liguria (Italy) case study in the Interreg III Alpter project

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Abstract

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Introduction

Along the past centuries man has induced deep changes in the landscape of wide areas with the aim to obtain terrain suitable to farming. This modification has been done varying the profile of the terrain to gain sub horizontal surfaces and managing the flow of the rainfall runoff. Depending on different parameters like the original slope, the lithology, the soil type and others, different kind of techniques have been applied: some of them make use of series of little stone wall alternated to horizontal surfaces and some others use soil and vegetation to produce the same effect (Fig.1).

Actually, in Italy, most of the managed terraces are used as vineyard as it is the more profitable cultivation practice. This is the case of Cinque Terre (Liguria region), which is famous as a terraced landscape.

As Shresta et al. (2004) state, one of the causes of land degradation in steep areas is related to cultivation practise and to the collapse of man-made terraces. In fact the processes of changing the slope of the surface, the flow of the rainfall runoff and of immobilising soil are, from a geomorphologic point of view, an interference with the geomorphic system that rules the dynamics of the earth's changing surface.

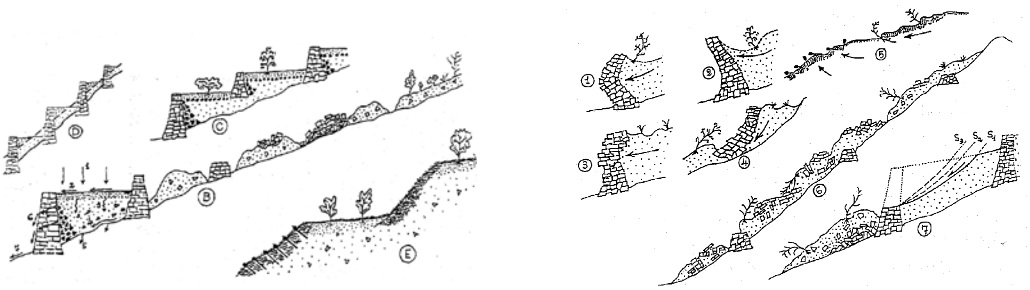


Figure 1 B to E: different kind of terraces. 1 to 7: different kind of disorders in terraces. 1, 3: bulge; 2; upsetting; 4: collapse. (after Brancucci et al., 2005)

The abandonment of terraced agricultural areas results in a new interference with the geomorphic system: the lack of maintenance of a man-altered landscape implies the geomorphic system to gain the control back by means of erosion processes that cause land degradation. The final result is the increase of the geomorphic hazard with diffuse problems of instability and the raise of the solid transport in the rivers (fig. 2).

In areas like Liguria territory this problem assumes a particular importance because of the strong and direct linkage between the hinterland and the coastline that is hardly urbanised. This strong linkage is caused by the peculiar morphology and by the climatic situation of the region .

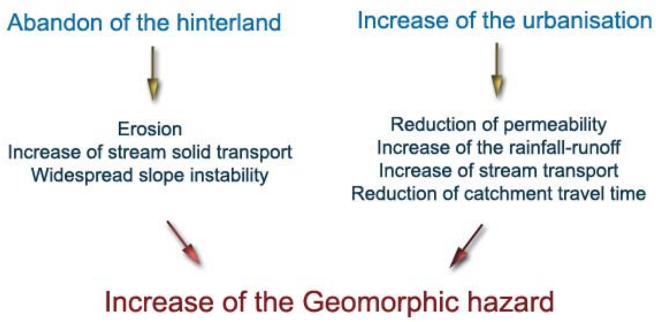


Figure 2 The abandon of the hinterland and the increase of urbanisation cause the raise of the geomorphic hazard in Liguria region.

The Alpter project. The EU Interreg III Alpter project was born to contrast the abandonment of terraced agricultural areas in the alpine region, a problem that only during the last years has raised the attention of both institutions and population. Loss of productive land, increase of natural hazard, loss of biodiversity and disappearance of a rich cultural heritage are all consequences of the decay of terraced structures.

The project is working in areas spread all over the alpine region, to collect data, develop specific technologies and realise examples of productive recovery. The final aim is to promote a large-scale transformation.

Among the Alpter project the Laboratory of Applied Geomorphology is developing a model to monitor, survey and assess the geomorphic hazard in the terraced landscape. The model makes use of GIS, DEM, field survey and MS analysis to take into account the tendency to instability induced by the human modification of the slopes. This approach will allow including terraces in the risk assessment procedures and strategies.

As underlined by Shrestha et al. (2004), many authors have studied techniques to assess land degradation and hazard prediction but with results often difficult to interpret. For this reason we decided to follow an approach based on the evidences given by field survey data; these data will be analysed with the MS technique and the results will be used to build an hazard assessment model based on the decision tree technique (Murthy et al., 1994; Rossiter, 1990). The object is to give a choice instrument to planners to decide where it is more important to operate on the abandoned terraces with the aim to reduce the hazard, as it is impossible to recover all the terraces over the ligurian territory.

On this basis the first phase of the project regards the terraces census all over the Liguria region, making use of aerial photographs and thematic cartography. Then the second phase keeps on with the field survey in the three sample areas of figure 3. The survey allows to control the real extension of the terraces acquired in the phase one and then to collect data about terraces conditions. In this paper are presented the preliminary results of the first sample area, the Bisagno basin.

Study area

Liguria (figs. 3, 4) is a mountainous region close to the sea that covers a surface area of about 4800 km^2. The main geologic features are a substratum composed by a great variety of lithotype and a complex structural asset that derives from the orogenesis of the Alps and northern Appenino. The lithology, that is strongly folded, ranges from metamorphic to sedimentary, while the fragile deformations are dominated by two main systems set W-E and N-S.

The main geomorphic features of the territory are the closeness to the sea of the main watershed, that ranges from an altitude of 500 m a.s.l to 2000 m a.s.l., and the strong steepness of the slopes facing the Tirrenian Sea. The many short basins in the region are interested by strong erosion with a high level of flood risk along the coastline that is intensively urbanised.

The Bisagno basin, which covers a surface area of about 96 km^2, is one of the two of Genova's hinterland. The substratum is composed by marly mudstone, mudstone, shale, clayschist, and alluvium deposits only in the lower part of the basin; in a short distance from the sea, the mountains get to a maximum altitude of 1000 m a.s.l.. The climate is typically Mediterranean along the coastline but in the hinterland the winter is cold; the mean annual precipitation is between 1600 and 1800 mm (Brancucci, 1994). At lower elevations the basin is totally urbanised, while at higher elevations the land cover is mainly forest with some grassland in the slopes facing south. The analysis of the surface hydrography of the basin shows a fair degree of network organisation (Brancucci and Paliaga, 2004) that may be related to a standing out natural tendency to erosion. The main degradation features in the basin are debris flow and rotational and complex landslides; some large historical landslides are present in the basin together with some deep gravitate deformations in the eastern part. The lower part of the basin presents a high flood risk level: many events in the last forty years have produced damages and victims. Man-made terraces cover more than the 15% of the surface area of the entire basin; actually most of them are in abandonment (fig. 5).

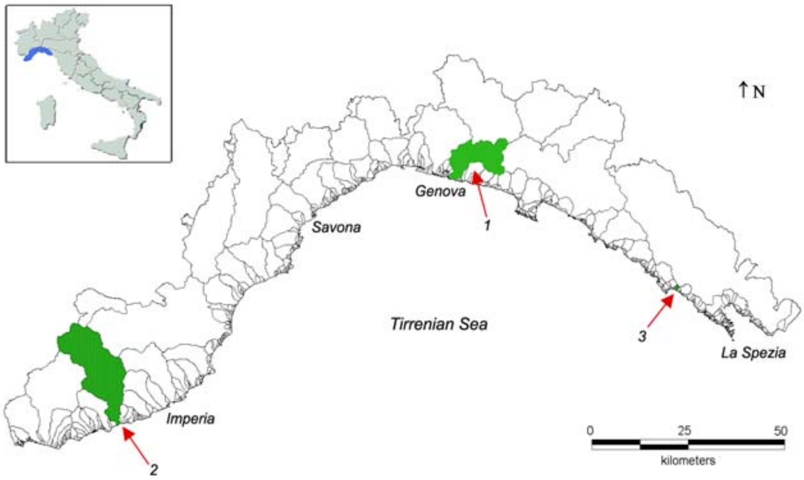


Figure 3 The ligurian territory and the three sample area of the ALPTER project.

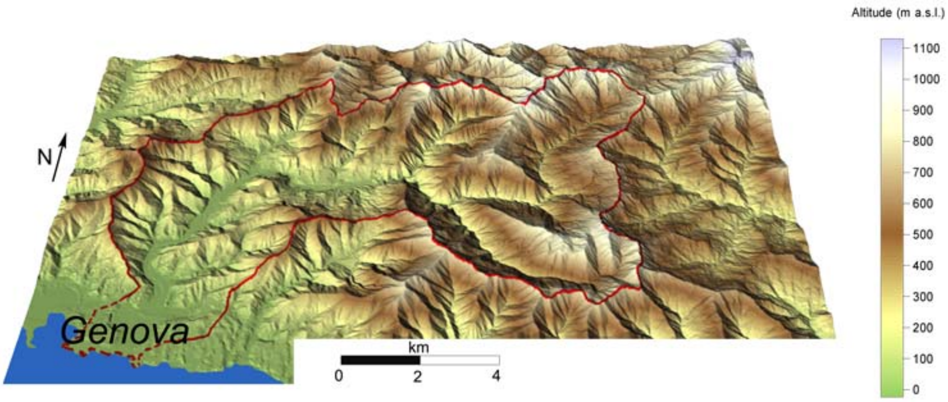


Figure 4 DEM model of the sample area number 1: the Bisagno basin (the red line shows the main watershed).

Methods

Many authors have approached the problem of hazard assessment by land degradation processes: some of them estimate soil losses (Nearing et al., 1989; Morgan et al., 1998), others model the slope stability and landslide susceptibility through validation procedures on surveyed areas (Rowbotham and Dudycha, 1998). These methods are essentially based upon the multivariate statistical analysis of landscape features associated with past landsliding (Lieneback Gritzner et al. 2000; Carrara et al. 1991).

Following this approach we decided to collect data about terraces in the studied area with two methods: a quickly survey to be performed on large areas of the region and a more detailed survey for restricted areas. All the data have been collected in a GIS to perform an integrated analysis with aerial photography and

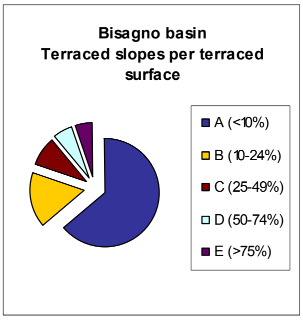
DEM. Actually the Bisagno basin survey is almost completed; once all the data will be available we will elaborate the final model that will make use of MS analysis to get to the decision tree procedure, which validity in land degradation modelling has been underlined by Shresta et al. (2004).

The survey: following Carrara et al. (1991, 1995) approach we decided to perform the analysis of the territory on the basis of the slope unit. This methodology seems to be the more appropriate because of the particular evolution followed by the abandoned terraces: terraces in a slope must be regarded as a system because of the strong linkage among the whole structure. In fact the lack in managing the rainfall runoff processes implies that the degradation of terraces moves like an avalanche process: a disease in a terrace quickly extends to the close ones in the slope.

The data collected per slope unit in the quick survey regards: the kind of terraces, the percentage of the slope surface modified by terraces, the number of disorder evidences in terraces (upsetting, bulge and collapse), the land use and the maintenance conditions. The detailed survey includes also: the mean height of the terraces and a parameter that measures the fragmentation of the stones in the wall obtained through the digitalisation of a photo of a square metre of the vertical surface.

Preliminary data analysis

Figures from 4 to 10 show the preliminary result obtained from the survey on a surface area of 90 % of the Bisagno basin. The quick survey has allowed collecting data of more than 300 terraced slopes, which have been analysed in a GIS environment with the lithology and the main morphometric features.



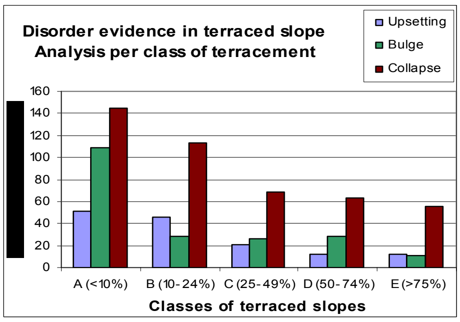


Figure 4 Left: frequency of surveyed slopes per range of terraced surface. Right: different kind of disorder evidences per range of terraced surface.

The diagrams show that the disorder evidences in terraces are primarily concentrated in the slopes facing south and north and with a high slope gradient. Lithology doesn’t seem to affect particularly the disorder. At the same time, figs. 4 and 5 put in evidence how disordering is almost equally present in abandoned and in cultivated terraces, while the more frequent evidences are present in little slopes rather than in large ones.

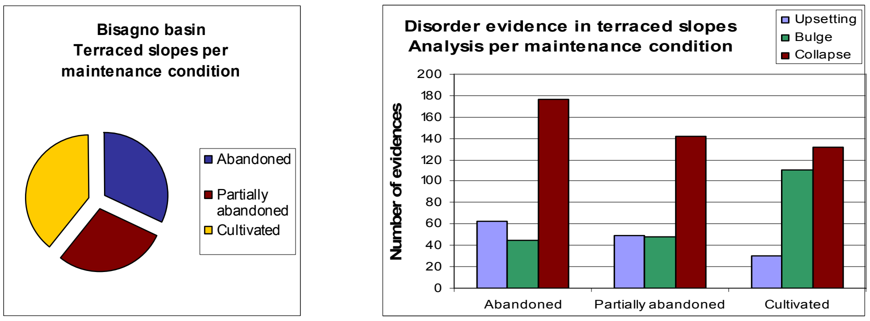


Figure 5 Left: maintenance condition of the surveyed terraces.
Right: different kind of disorder evidences per maintenance conditions.

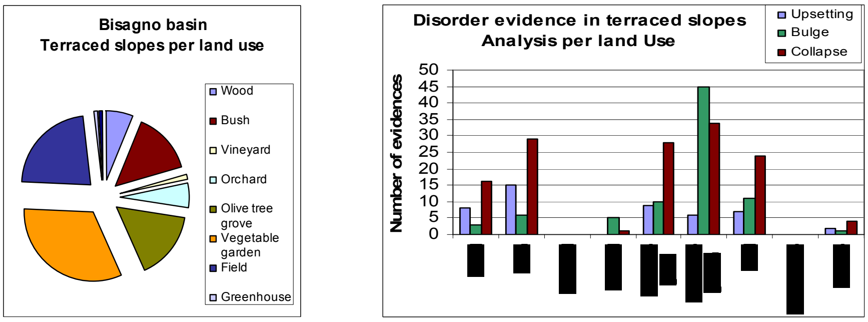


Figure 6 Left: land use in terraced slopes.
Right: different kind of disorder evidences per land use.

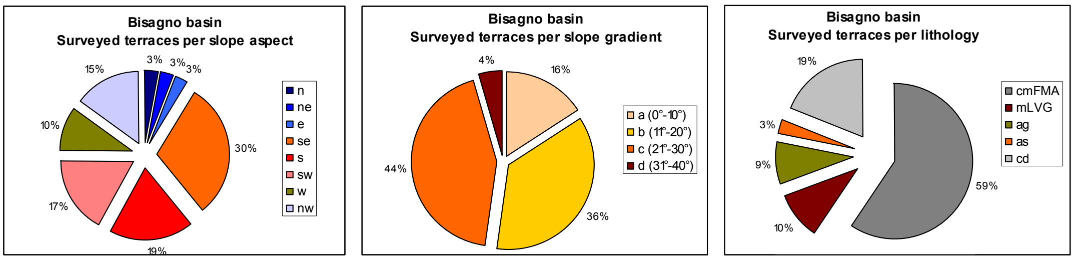


Figure 7 Percentage of surveyed slopes per morphomentric features (centre and left) and lithology (right); cmFMA: marly mudstone; mLVG: mudstone; ag: shale; as: clayschist; cd: surface deposits.

Conclusions

The many terraces in the studied area are largely abandoned; often is hard to precisely assess the conditions of stonewalls because of the spreading of vegetation and difficulty in access.

Despite of this problem the collected data allows to perform a preliminary basic statistical analysis that gets to some early results. The lithology of the substratum, which is in part responsible of the drainage, seems not to significantly influence the stability of terraces. This result, which may look in contrast with the erosion models, may be interpreted with a stronger effect on stability caused by others parameters. At the actual phase of the analysis these may be identified mainly in the slope gradient and aspect; the first is related to the intensity of the erosive processes and the second to weathering that in the studied area is influenced by strong rainfall that often are related with southern wind. The high number of disorders in terraced structures facing north (fig. 10a) may be related with the tendency of retaining moisture.

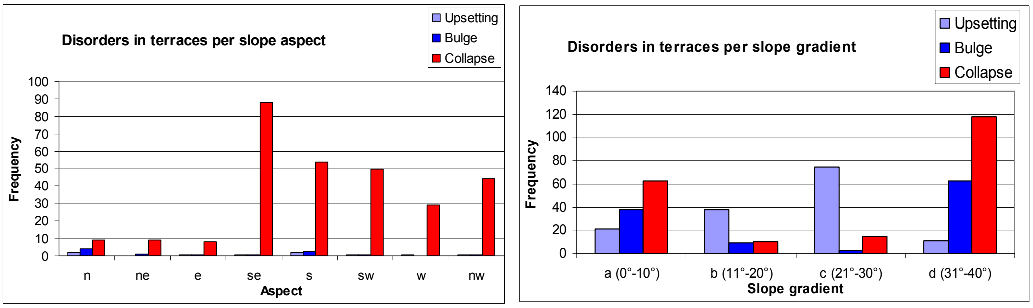


Figure 8 Disorders evidences per slope aspect (left) and gradient (right).

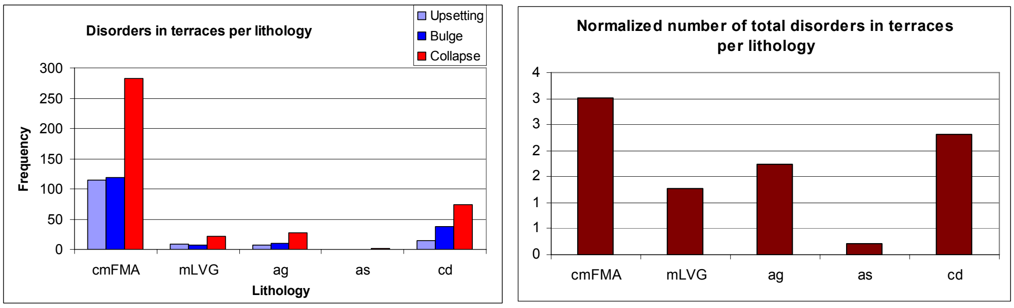


Figure 9 Left: disorders evidences per lithology (see fig. 7).
Right: total number of disorders normalized for slope lithology.

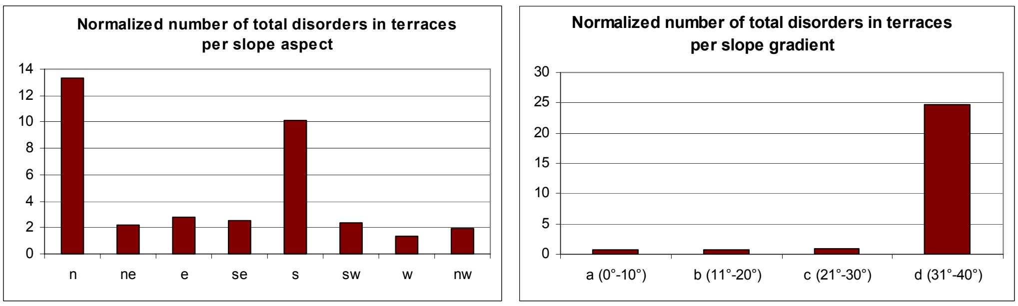


Figure 10 Total number of disorders normalized for slope aspect (left) and for slope gradient (right).

These preliminary remarks will be better defined once the data survey will come to end in the other two sample areas which present some differences (lithology, altitude, climate etc.): the MS analysis will avoid to identify the parameters probably are responsible of terraces disorders and to classify the threshold levels that will be used in the decision tree model. The final results will allow associating to every terraced slope a hazard value that will allow planning the recovery politics.

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