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Natural disaster reduction in Europe: a Don Quixotic project in the face of a changing world?

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Abstract

The interrelations between the physical environment systems, human systems, and man-made environment are unstable and constantly changing. However, traditional hazard mitigation policy considers natural hazards as isolated, static processes and not as a product of these three components. Therefore, mitigation is a linear trend and response an event-focused reaction, both rarely viewed as an integral part of a much larger context. Consequently, disaster reduction measures are often like Don Quixote fighting against wind mills. In order to shape disaster mitigation actions just as dynamic as the ever-changing processes which are responsible for natural disasters, changes in the social relation to natural hazards are needed.

This paper outlines the shifts necessary for a holistic sustainable hazard mitigation from a scientific perspective. It is argued that the concept of vulnerability is an adequate technique for disaster reduction strategies which permits socialising spatial-temporal characteristics and pixelising actual-objective parameters. A first approach is presented which is applied in northern Spain to assess susceptibility of given spatial unit to flood and landslide hazard. It is presumed that the constant assessment of vulnerability is more capable to seize the variable factors which are responsible for disaster losses than traditional strategies. Furthermore, the results provide a useful tool for decision-makers in disaster mitigation policy.

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Rationale

Neither natural disasters nor researcher's calls for a broader view of both disaster issues and theoretical approaches are novelties of modernity. In contrast to pre-modern times, both are embedded in contexts which are characterised today by changing environmental parameters, growing human population and urbanisation rates, and a higher complexity of natural, human, and human-built circumstances. Year after year society has become more vulnerable to both natural and man-made hazards which explains the increasing disaster losses.

Since natural hazards are the result of interacting natural and social forces, disaster losses are the product of the interaction of, first, the characteristics of the physical environment systems that produce extreme natural events, second, the characteristics of the society, communities and people that experience those events, and third, the characteristics of the constructed environment that is affected. The roots of the disaster problem lie in the complexity and diversity of these factors.

The earth's physical systems (atmosphere, biosphere, cryosphere, hydrosphere, and lithosphere) are constantly changing. Natural processes do not operate uniformly at the same time and space scales, and, therefore, ecosystems are not uniform or continuous in space or time; they are patchy and heterogeneous in space and discontinuous in time. The non-linear structure of natural systems contributes greatly to uncertainty and its extremes pose natural hazards and, in the worst case, disasters when they affect factor two and three.

Not only the physical systems are complex and non-linear, but also the human systems (economics, science, politics, education, justice, religion) change continuously, both as individuals and as groups. Several other disaster-significant shifts, such as, demographics, technology, perception, social and cultural characteristics, interact with the physical systems, resulting in a network of dynamic relationships. They all influence the exposure to natural hazards.

The third component – the man-made environment with its housing, communications, public infrastructure and utilities – is subject to the same temporal and spatial changes. Furthermore, the ability of the constructed environment to withstand the impacts of extreme natural hazards plays an important role in determining human and financial losses.

Consequently, the interrelations between these three factors are unstable and, therefore, the human and scientific perception and assessment of involved processes are constantly changing. In order to harmonise human actions with the dynamics of the ever-changing processes which are responsible for natural disasters, changes in the social relation to natural hazards are needed.

Focusing Don Quixote: reframing disaster reduction strategies

Viewed historically, the interpretation of natural disasters has shifted from 'acts of God' to 'technical problems' and 'human failure' [1]; observed scientifically, a move from isolated discipline-bounded to integrated holistic approaches has become evident [2; 3]. Viewed globally, the international community has reacted

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upon the changing conditions by funding a special resource window and establishing an Emergency Response Division [4], by setting out a new strategy framework for disaster reduction [5], and profiling especially least developed countries and specifying more concrete actions [6]. However, these shifts, although necessary and important, are obviously not sufficient. Science and research, especially in Europe, must consider the social production of vulnerability with at least the same degree of importance that is devoted to understanding and addressing natural hazards.

In view of the growing amount of disaster losses traditional approaches and models have failed to mitigate adequately natural hazards. Too often, the double connection between disaster mitigation and sustainable development has been disregarded. On the one hand, natural disasters are more likely to occur where unsustainable development has taken place, and, on the other hand, the occurrence of disasters itself hinders sustainable development because of it's negative impacts on ecology, economy, and quality of life. Habitually, many efforts have been undertaken to calculate statistical likelihood, frequency, and magnitude of natural hazards while social factors have been not taken into consideration. Although positive examples exist in Europe (e.g., the 'make way for rivers' policy in the Netherlands [7] or the ARCHAEOMEDES project [8]), research findings need to be practically applied and operatively realised. In brief: while in the United States after two assessments of hazard research in 1975 [9] and more recently [2] and the development of general principles to guide disaster reduction [3] sustainable hazard mitigation has already become concrete, in Europe the gap between theory and practice, between research findings and operative application, between words and deeds still has to be reduced.

Lately, a World Vulnerability Report (WVR) has been edited by UNDP-ERD in which relevant information and data is conducted, best practice case studies on disaster mitigation are outlined, and a Global Risk-Vulnerability Index (GRVI) is presented which should facilitate comparing countries according to their relative risk levels over time. This confirms the authors' key assumptions made in the last issue of Risk Analysis [10] and elsewhere [11] that, first, the concept of vulnerability is of high practical utility because it provides a vehicle to assess the interacting factors which determine potential losses: the social can be pixelised, the pixel can be socialised. On the other hand, however, the low contributions from Europe to the WVR reflect adequately the position of EU hazard research on international level.

Concerning natural hazards the physical process, exposure, prevention, and preparedness are the key factors which have to be assessed (obviously, each factor is of different importance with regard to the type of hazard and other factors such as socio-economic and political resources and demographic aspects are also significant). Only if these factors are unfavourably superimposed the harmful consequences occur, what we then call natural disaster (Fig. 1). Therefore, vulnerability is a measure of the capacity of this set of elements to withstand events of a certain physical character.

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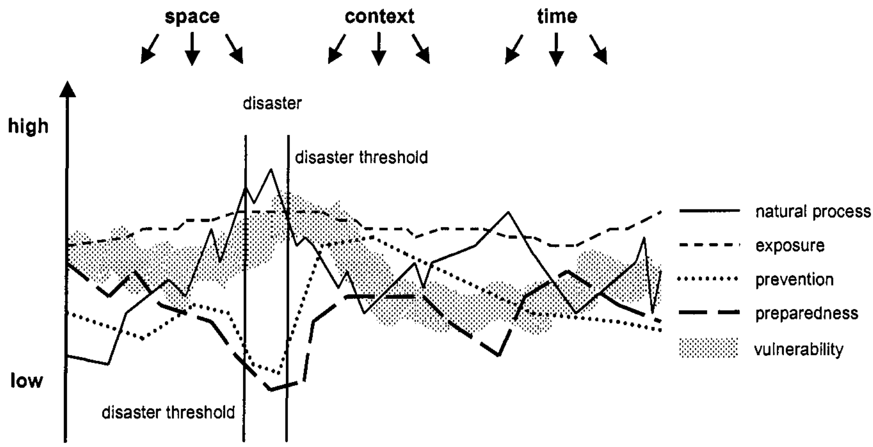

Figure 1: Vulnerability to natural hazards

Traditional disaster reduction strategies are not capable of integrating hazard assessment, socio-economic factors, and learning and decision processes into a more holistic dynamic concept. Some key aspects concerning mitigation and response which need to be focused by European disaster research to capture the described complexity are suggested below:

1. Societal context: Political, legislative, historical, and socio-economic circumstances have to be increasingly integrated in hazard research. Hence, data must be collected and useful indicators identified to measure or assess these external driving forces.

2. Hazard: With respect to physical hazard assessment a shift may be needed from data quantity to quality. This includes collection, analysis, storage, and publication of standardised hazard-related data.

3. Exposure: The issue of vulnerability has to be taken into account because its assessment can improve predictions of spatial distribution of potential losses, in comparison to predictions based on the product of hazard and exposure only. The improvement of availability of spatial data is another focal point.

4. Prevention: Prevention measures must be planned and integrated in the broader context of sustainable development. The focus on short-term thinking (e.g., local structural flood control measures based on cost-benefit analyses only) has to be replaced by long-term activities (e.g., water management aspects concerning the whole river basin). Research is needed with regard to impact assessment and strategy design.

5. Preparedness: Research has illuminated factors that influence preparedness, but more attention should be given to societal participation and decision-making processes in the field of disaster experience, governmental context, and the progress in professionalisation of disaster management. Approaches are needed

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which raise awareness of disaster mitigation in local everyday life.

6. *Rescue and relief*: The principles of sustainable development have to be moved from a philosophical perspective towards a scientific concept. Research is needed on how these factors can be implemented in both local and larger-scale relief structures and measures.

7. *Humanitarian assistance*: One key aspect is improvement of efficiency of external assistance. Focal points are the inclusion of local involvement in outside donor programmes, the co-ordination of different governmental-administrational levels, the education of staff, and the reorganisation of top-down, inflexible, standardised approaches which often do not meet the needs of the needy.

8. *Recovery and reconstruction*: Both are most effective when community-based organisations assume principal responsibility, supplemented by external financial and technical assistance. Therefore, more attention should be given to decision-making and participation processes and how local organisational and decision-making capacity should be strengthened.

Focusing the wind mills: a methodological proposal for the assessment of vulnerability

Study site and methodology

The area used for application of the methodology consists of 13 municipalities situated along the coastal strip of Cantabria (northern Spain). The area is densely populated (850 habitants per km^2 against 79, the average for all Spain) and is affected above all by two types of hazards: slope instability and floods and the examples given below refer to vulnerability to these hazards.

The methodology is composed of three different steps: 1) individual assessment of vulnerability factors (hazard, exposure, prevention, and preparedness), 2) integration of these factors, and 3) repetition of previous steps when contributing factors change over time.

In the first step, indicators are identified for each of the four factors. Here, for explanatory purposes, only one factor (preparedness) and corresponding indicators are discussed (for a complete description of method see [1]).

Preparedness represents all precautionary activities and measures in a given area, which enable society to respond rapidly and effectively to disaster situations and can be described with the following characteristics: time elapsed since the last catastrophic event; education and information about the hazards provided to the population; presence of warning systems; existence of emergency plans; existence of official bodies that respond to emergencies; and presence of facilities for accommodation of victims. The corresponding indicators are formulated as questions (resulting in a binary scale; yes or no): Has the municipality suffered a damaging hazard event in the last 20 years?; Are there education or information programmes to raise awareness among the public?; Are there evacuation plans?; Are there operative warning systems?; Is there a fire

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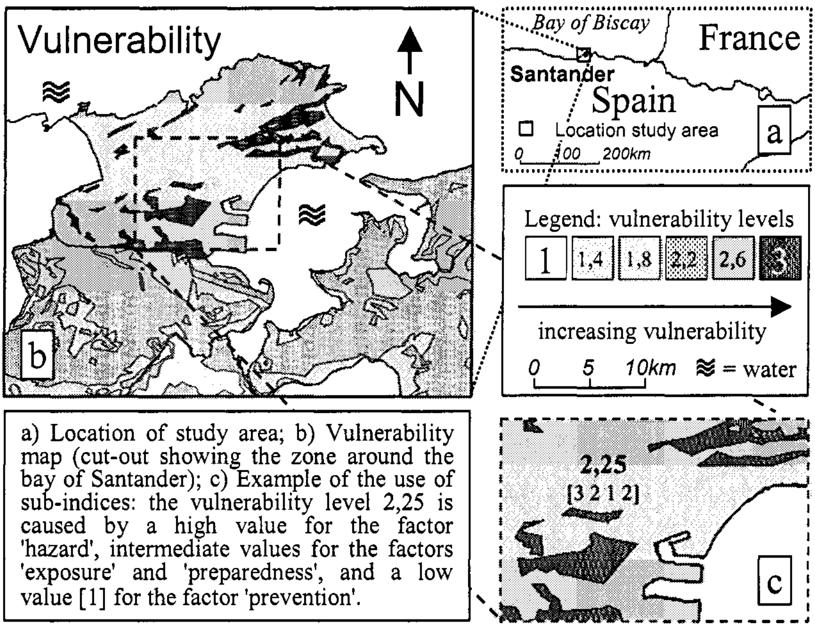
station?; Is there a hospital within a range of 30 km?.

This first step leads to a qualitative assessment of the four factors, which can be visualised as four maps that depict the spatial distribution of these factors in qualitative terms.

The second step is the integration of the factors to obtain a vulnerability map (Figure 2). This is achieved by combining the four maps. Here, in a first approximation, the weights of the factors are considered equal and their combination is a linear one.

The third step consists of updating the state of vulnerability as contributing factors change in time, i.e. repeating the first two steps. A change in any one of the four factors will be reflected in a change in vulnerability. Therefore the assessment of vulnerability must be repeated as changes occur in the physical environment systems, the human systems and the human-made environment.



a) Location of study area; b) Vulnerability map (cut-out showing the zone around the bay of Santander); c) Example of the use of sub-indices: the vulnerability level 2,25 is caused by a high value for the factor 'hazard', intermediate values for the factors 'exposure' and 'preparedness', and a low value [1] for the factor 'prevention'.

Figure 2: Process of vulnerability mapping

Results and discussion

The resulting vulnerability map has an ordinal scale: low to high vulnerability. Each homogeneous unit is described by a 'vulnerability level', which represents the degree of susceptibility to losses. Corresponding values for hazard, exposure, prevention, and preparedness can be presented as sub-indices (Figure 2), where each of these four indices refers to the state of a specific factor. If one wishes to

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reduce vulnerability in a particular area, the vulnerability map shows which factors cause that high vulnerability in a spatial unit. For instance, if a unit is defined as highly vulnerable and sub-indices indicate that low preparedness and high exposure cause that vulnerability, one can focus on these two in order to reduce vulnerability.

The application illustrates that the methodology is workable and gives an example of integrating societal context into hazard assessment. However, the methodology remains untested. Validation on the basis of independent observations is needed to assess the soundness of the approach. These observations would be actual losses due to catastrophic events: 'vulnerability levels' can then be compared to actual losses. A practical problem is the availability of such data at municipal level. Efforts are being made to obtain data from local insurance agents at the desired scale. A very coarse initial assessment of soundness was performed by subjective, qualitative evaluation of the vulnerability map by local experts familiar with the natural hazards in the region. Also, the statistical distribution of vulnerability levels was considered. The frequency distribution of vulnerability levels is more or less normal, skewed slightly towards the higher values. This makes sense considering the high population density of the area and may serve as an additional indicator of the logic of the results.

An obvious advantage of the approach is its applicability. The indicators, mostly binary, are combined in a simple way through a series of clearly defined steps. If more detailed data is available, indicators can be adjusted to the desired level of detail. The indicators are processed using a GIS, in a manner comparable to procedures used for hazard assessment, where a series of entities in a map that are described with the attributes of that map. Integrating the analyses of physical and social factors is thus facilitated since the attributes of a map can include both. Also, the approach can easily be coupled to a variety of SDA techniques.

Although ideally indicators relate directly to the characteristic they should describe, in some cases less obvious indicators can or have to be used (e.g., here, the indicator used to assess exposed farm production was the number of cattle per km^2, since dairy farming accounts for more than eighty percent of all farming activities and no exact figures of farm production were available).

A possible drawback is the availability of sufficiently disaggregated data on societal factors (as is the case with validation data). Whereas physical factors can, theoretically, be measured at practically any desired level of detail, for many socio-economic factors this is not the case. Data concerning such factors is often collected at municipal or even higher levels (province, country etc.) and does not contain the spatial distribution within the unit for which the information was collected. In such cases, the smallest unit for which that data can be obtained determines the spatial framework of the assessment.

Another advantage is the transparency of the procedure: no expert knowledge is needed for its comprehension. Consequently, linkage of theory to concrete policy actions is facilitated. Additionally, after the identification of vulnerable areas, adequate prevention measures can be found more easily since not only the degree of vulnerability is obtained, but also the cause of vulnerability by

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means of a sub-index. Afterwards, combining the results with other mitigation tools, such as, DSSs, loss estimate modelling, and cost-benefit-analysis, can support more adequately the search for appropriate measures.

The approach presented is also relevant for other purposes such as reconnaissance studies or EIA. In these studies hazard and risk are generally approached from a physical point of view, while social factors are largely ignored. In mentioned studies data availability usually imposes major restrictions, but by using straightforward indicators as presented here, social context can be incorporated.

Aspects that need further elaboration include the integration of the individual indicators. In this case equal weights were assigned to all four vulnerability factors and to all indicators that were used to assess those factors. However, the nature of individual weights is not clear. This is illustrated by the following example: what is the relative importance of high preparedness compared to high exposure? Favourability functions provide a means to assess the contribution of each factor considered to the final values obtained and may provide a way to deal with this problem.

The authors are also aware of the lack of assessment of (the access to) social, economic, and material resources which need to be integrated in the approach proposed. Another critical point is the lack of proper validation. A possible alternative would be to perform the analysis in an area where hazard events are frequent and data on damages for one or more past occurrences can be obtained. Therefore, the methodology must be considered as a first approximation. Nevertheless, initial results are promising and suggest that it is worthwhile to further improve and test the procedure.

Conclusion and recommendations

Traditional hazard mitigation policy – study the problem, implement one solution, and move on to the next problem – considers natural hazards as isolated, static processes and not as a product of the natural, human, and human-made system. Therefore, mitigation is an upward, positive, linear trend and rarely viewed as an integral part of a much larger context. Not surprisingly, nature frequently provides a hazardous event more extreme than that anticipated in local mitigation plans and structures. Moreover, many mitigation efforts themselves degrade the natural environment, reduce preparedness and resilience, and thus contribute to the next disaster because vulnerability was increased.

Traditional scientific approaches are typically linear, assume only one causal factor, overemphasise stability and objectivity, focus on risk as a product of probability and potential damage, and end up labelling change as negative. However, natural hazards must be studied holistically and dynamically: multiple and interrelated causal factors must be recognised and the range of factors examined simultaneously; space, time, subjects, feedback loops, and uncertainty need to be integrated; interactions among the elements of each system and the effects of its interactions must be focused.

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Aggressive mitigative bottom-up actions linking short- and long-run changes are needed to break down the interactive structure of natural hazards. The actions should be tested and only carried out if they do not have negative effects on vulnerability and sustainability. However, natural hazard mitigation will not be successful until it is integrated into the considerations of the population's daily activities. This, in turn, requires a societal shift from reaction to precaution, from response to mitigation, from objects to subjects, from wind mills to Don Quixote. Some key aspects to implement that shift in European disaster culture are listed below:

Technologies and approaches:
GISs and remote sensing are fundamental elements of both mitigation and response actions and, therefore, must be related and applied more directly to disaster management; DSSs must be integrated more firmly in disaster planning tying together spatial/temporal information with simulation models that depict spatial/temporal reactions, preferable in real time; internet technology must be further improved to create a virtual library and database, and computer-mediated communications need to be used more frequently to rapidly obtain and exchange information; risk analysis has to move from technical-engineering single cost-benefit analysis to social-political multiple risk-benefit strategies incorporating local stakeholder values, loss estimate modelling, and vulnerability mapping; finally, a common tool must be developed that integrates control systems (historical data, e.g., losses, hazard events, trends), database systems (current data, e.g., demographics, weather, socio-economic and political-legislative information), modelling systems (simulation tools, such as, HAZUS, TAOS, or IRAS, to model environmental *and* social conditions), and report systems (e.g., maps, statistical analyses, and hazard mitigation teams).

Research infrastructure and education:
A centralised archive is needed to collect, store, and deliver all kind of disaster-relevant information and data in standardised measures; government and private-sector support must be increased and better co-ordinated to hit knowledge needs and practical demands; transdisciplinary research groups must be further established and funded to work problem-focused and to produce more directly useful findings; universities without walls offering cross-disciplinary disaster-based programmes and degrees, international exchanges and comparisons (concerning research, data, and persons), and close co-operation with practitioners from local communities should be implemented.

Operative and public policies:
The gap between research and operative practice must be filled, efficiently, by broader joint programmes, flat-hierarchical networks, and co-operative actions; example communities in terms of disaster mitigation should be elected, supported, observed, and evaluated; national forums on disaster mitigation must be conducted and a holistic European policy constituted.

Some of the recommended steps seem like old news, some seem redundant because they have been already introduced, but as long as they have not been met

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and realised entirely we will continue fighting like Don Quixote against wind mills. Since significant future scientific progress in the field of disaster reduction, under conditions of global change, is unlikely in the absence of greater conceptual and applied progress, the approach proposed may help to make the concept of vulnerability an operational tool and, therefore, it can be seen as at least a first step towards a European culture of prevention.

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