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DISASTER AND SOCIOSYSTEMIC VULNERABILITY*

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ABSTRACT

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The aims of this paper are to suggest a preliminary sociological definition of vulnerability to disasters, to discuss this notion in relation to different levels of sociosystemic complexity and, only for heuristic purposes, to present a tentative and synthetic conceptual schema for the assessment of the overall vulnerability of a social (sub)system.

Disaster is defined as "the actualization of the sociosystemic vulnerability." The term "vulnerability" refers to the structural state of a social (sub)system.

Three levels of social vulnerability are identified: typological, specific and general. The discussion suggests that only a simultaneous and combined assessment of these three levels, at least, can allow reliable predictions/explanations of the overall degree of vulnerability of the social subsystem that is of interest. The analysis of the social response to the Friuli earthquake is used as a rough example for the matter under discussion.

The last section of this paper deals with the hypothetical relationship between the degree of structural (in)determinacy and the degree of social vulnerability. The main goal is to identify only one indicator, or dimension of vulnerability which could fit any structurally relevant component along the axis of the sociosystemic complexity.

DISASTER AND SOCIOSYSTEMIC VULNERABILITY

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The aims of this paper are to suggest a preliminary sociological definition of vulnerability to disasters, to discuss this notion in relation to different levels of sociosystemic complexity and, only for heuristic purposes, to present a tentative and synthetic conceptual scheme for the assessment of the overall vulnerability of a social (sub)system.

If one seeks an understanding of what happens at the interface between extreme physical phenomena and social systems, it is necessary to look at the relationship between the context of "normality" and the processes of disaster. From the point of view of disaster research, the pre-impact type of social organization could be considered in terms of its degree of vulnerability, in relation to different types and intensitites of potentially destructive events. In conceptual terms, it would be relatively simple to assume a direct linkage between the pre- and post-disaster structural state, and the behavior of a social (sub)system. But very little is known about the quality, the quantity and the type of this relationship. In other words, we could state that pre-disaster social vulnerability plays a crucial role in determining the range of destruction and the aftermath of social dynamics, but we do not know, or we know only roughly, what type of vulnerability plays what role.

Current social science does not have manageable models of societal dynamics. In particular, there is a lack of knowledge about the critical thresholds which determine the loss of the system's structural stability. Even though we must accept temporarily the general state of the art, in disaster research, we cannot maintain too high an indeterminacy in understanding and defining what is the sociosystemic vulnerability to disaster. This is particularly crucial when we advance the hypothesis that the post-disaster society is an extension of the pre-disaster one.

In the following sections of this paper we will try to give some starting points for the matter under discussion. In section 1 we will present a new synthetic definition of both disaster and sociosystemic vulnerability. In sections 2,3, and 4 we will identify three levels -- the typological, specific and general -- of social vulnerability to disasters. In section 5 we will propose a hypothetical and tentative scheme in which the degree of structural indeterminacy predicts the overall degree of vulnerability to disasters of a social (sub)system. The discussion will be at a relatively abstract level. But we believe that our point of view can be a heuristic and preliminary tool for finding the most powerful and simplest indicator of social vulnerability, for later application in disaster minimization strategies.

1. DEFINITIONS OF DISASTER AND VULNERABILITY FROM A SOCIOLOGICAL POINT OF VIEW

The conceptual need to define vulnerability depends on whether or not one believes in the utility of a synthetic concept for assessing the social (sub) systems probability of losing viability under given conditions, and/or the probability of generating these conditions. For the purposes of this paper we need to give some consideration to the definition of disaster before dealing with the conceptual and terminological identification of the notion of social vulnerability.

In the literature, definitions of disaster of a "social nature have clearly

and fortunately replaced the very early referents in almost solely physical terms" (Quarantelli and Dynes, 1977: 24). Nevertheless, the major part of the sociological definitions of disaster focus only on the description of social and environmental effects of an impact, i.e., when disaster strikes. In these definitions, disaster is viewed as an event concentrated in time and space in which the normal structural arrangements of a social (sub)system are suddenly destroyed, and the fullfillment of all or some of the essential social functions are prevented (see: Endelmann, 1952; Form and Nosow, 1958; Fritz, 1961; Cisin and Clark, 1962; Skeet, 1977). Other authors define disasters as collective stress situations which render expected conditions and goals unattainable to the degree customarily considered essentail by the social units (see: Killian, 1954; Loomis, 1962; Gillin, 1962; Barton, 1970). Only a few definitions try to relate the notion of disaster to the collapse of the already existent capacity of the routine social structures. In other words, a disaster is defined as a situation in which the social demands exceed the organizational capabilities and precautions which had hitherto been culturally accepted as adequate (see: Dynes, Quarantelli and Kreps, 1972; Turner, 1978; see also Sjoberg, 1962; Western, 1972).

In spite of many variations in the existent sociological definitions of disaster, the causes which generate disasters, i.e., the reasons why disaster occurs, are commonly left undetermined. In other words, the disaster social situation is arbitrarily separated from, or not explicitly connected to, the pre-disaster one. This could mean that a certain degree of "neutrality" of the pre-disaster type of normality is assumed.

In the last two decades disaster researchers have produced many findings stressing the relevance of pre-disaster social conditions on post-disaster effects. On the other hand, the causes of a disaster have been considered partially external to the "normal" structural state of a social (sub)system. This view could be summarized as the "principle of limited responsibility" of the social structure in generating disaster situations. On the contrary we believe in the principle of the "total responsibility" of the sociostructural organization in generating the pre-conditions of every type of disaster, even when a natural agent is involved. In human systems there is always a social or a sociotechnological cause for every sort of destruction and the effectiveness of the response to it (see Battisti, 1980; Disopra, 1980). When, for example, a large scale earthquake occurs, the level of destruction depends on the capacity of the physical structures to absorb the massive release of energy. But his capacity is totally socially, economically and technologically pre-determined.

In the case of technological disaster-agents, it has been shown that "the community preparedness necessitates social change, not mere technological upgrading" (Quarantelli and Tierney, 1979: 10). We could generalize this to all types of disaster, that is, a "technical investigation alone is insufficient to provide a full understanding of the origins of disasters and that a socio-technical approach must be employed" (Turner, 1979: 57). Similarly, in the case of natural disasters we could also apply the principle that disasters always arise from an absence of some kind of knowledge at some point (Turner, 1978). From this perspective we could interpret all disasters as acts of ignorance or situations which depend on a lack of rationality. On the other hand this lack of rationality is a constant in social systems. It is well described in Simon's principle of "bounded rationality" which asserts that there is always a state of potential ignorance that prevents the maximization of any human goal (Simon, 1957).

We must temporarily accept as a constant the incapability to perfectly control and understand the dynamics which lead to a disaster situation. But we cannot tolerate a conceptual ambiguity about the context in which a disaster arises. Any sort of disaster, natural or man-made, dissensus or consensus type etc., totally depends on social causes. If we accept this principle of "total responsibility" then the simplest and most general definition should state that disaster is the actualization of social vulnerability.

In the disaster literature there is a lack of clarity about the interpretation of the term "vulnerability." In many studies, the notion of vulnerability is implicitly defined as proneness, risk hazard; or lack of preparedness, readiness, organization, experience, viability, or low capability for absorption, normalization; or low elasticity, flexibility, stability; or high susceptibility, fragility, penetrability, exposure, etc. Only a few authors try to define explicitly the notion of social vulnerability. Here we can mention a representative sample of their writings.

"In some sense vulnerability is a concept which stands in a reciprocal relation to viability. Studies of social vulnerability should identify those key structures and processes which, when broken under assumed or actual stress will decrease the general and specific viability of society and its institutions" (Vestermark, 1968: 14). The following definition is relatively similar: "vulnerability defines the susceptibility of population-at-risk to loss when an event of given intensity occurs" (Friedman, 1975: 2).

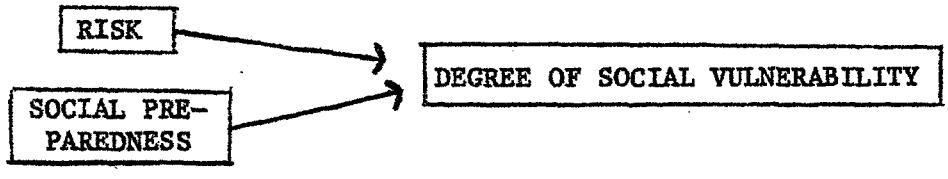
Disagreement is explicitly present in the distinctions among "vulnerability," "proneness" and "risk." Lewis, for example, trying to distinguish between proneness and vulnerability states that "the former concept refers to the frequency and magnitude of the physical events; the latter describes and measures the impact of disasters by means of statistical and other methods" (Lewis, 1979: 104). For other authors the term "proneness" describes the degree of social capacity to absorb or minimize disasters, while "vulnerability" refers to the degree in which a social (sub)system is at risk to extreme phenomena (see for example: Burton, Kates and White, 1977). Westgate and O'Keefe, criticizing the above point of view, assert that the notion of social vulnerability is a combination of both of the concepts of proneness and risk, as follows: "vulnerability is the degree to which a community is at risk from the occurrence of extreme physical or natural phenomena where risk refers to the pejorative probability of occurrence, and the degree to which socio-economic and socio-political factors affect the community's capacity to absorb and recover from extreme phenomena" (1976: 65). A recent work in the area of chemical disasters amplifies the latter approach, asserting that vulnerability is a characteristic of a community as a totality and that it is a complex function of both risk and preparedness (Gabor and Griffith, 1979).

Even though many of these definitions stress the socio-ecological quality of the term vulnerability, they assume a relative independence between the probability of occurrence of a destructive event and the sociological context. From this point of view one could derive by logical implication that a low or high probability of occurrence of an extreme phenomenon reduces or increases the level of social vulnerability. This, in operational terms, could be expressed, for example, with the formula: VULNERABILITY (disaster risk) = NATURAL HAZARD RISK x DAMAGE PROBABILITY (U.N.D.R.O., 1977). In spite of the conceptual evidence that the degree of risk cannot be viewed as a factor which is independent from the sociostructural context, a distinction is made "as it serves to illustrate the different strategies community planners can pursue according to the relative importance of the two sets of factors in a

given situation" (Gabor and Griffith, 1979: 325; Gabor and Pelanda, 1981). In fact there is a level of applied knowledge in which, for practical purposes of contingent assessment, the separation of the notions of risk and the structural state of a social (sub)system could be justified in building both a working definition and combined indicators of social vulnerability.

Here, for our purposes, the problem is that this latter approach stays at the level of "functional rationality." That is, it is a series of actions organized in such a way that they lead to a previously defined goal with every element in these series of actions receiving a functional position and role (Mannheim, 1940). But for a better understanding of what social vulnerability and disaster are, we need to operate at a level of "substantial rationality" i.e., acts of thought from which arises an intelligent insight into the interrelations of events in a given situation (Mannheim, 1940).

In other words, even though at a practical level we could separate the notions of risk and the social structural state, this point of view, assuming the relative independence between the pejorative probability of occurrence of an extreme phenomenon and the sociological context, is ambiguous for purposes of a substantial understanding of the concept of social vulnerability against disasters. As previously stated, we believe in the principle of "total responsibility" of the social organization in creating the pre-conditions of all the types of social destruction. This means that the approach in which risk and type of sociological context are both separate and independent factors (predictors) on the dependent variable "social vulnerability," i.e.,:



does not satisfy our principle. On the contrary, we interpret the notion of social vulnerability as an independent factor (predictor) on risk, i.e.,:

where risk is defined as the probability of an event occurring multiplied by the magnitude of the loss.

The latter causal relation satisfies the principle that the type of organizational state of a (sub)system generates the pre-conditions for any sort of destruction, natural or man-made. It also implies that the sociological notion of vulnerability refers to the structural situation of a social system. The common sense preliminary assumption is that the notion of the probability of occurrence of an extreme environmental event is relevant from the sociological point of view only when it is an extreme social phenomenon i.e., when a "barrier of indifference" does not exist. This means that risk depends on a factor of sociotechnological capacity which is a subcomponent of the degree of social vulnerability inside a given societal and/or community system.

From this perspective we need a "pure" sociological concept for defining the term "social vulnerability." The simplest notion could be the quantity of sociostructural "domain" (e.g., control) that a social system (or subsystem or component) has over its internal and external processes. At an abstract level, the condition of perfect domain is constituted by the fullfillment of

two prerequisites: a) substantial knowledge of all the events which are possible given the structural state of the system of interest and b) related successful construction of sociotechnological barriers of indifference in opposition to the subset of possible events whose actualization would directly or indirectly lead the system below the threshold of minimum viability. At this level of generality we could assert that the degree of social vulnerability of a (sub)system is the quantity of sociostructural "non-domain" (e.g., non-control) over its internal and external processes. The notion of vulnerability is a relativistic concept based on the interests of an observer. This definition could be applied to the point of view of all the components placed along the continuum of sociosystemic complexity.

The actualization of any event socially defined as disaster is a specific property of the sociosystemic non-domain (Pelanda, 1981, A). This approach implies that both man-made and natural disasters simply assume the same quality of outcomes of "sociotechnological options," which are not sufficient to dominate the environmental variability. Furthermore, one of the implications related to the above definition of social vulnerability is that no extreme physical phenomenon, relevant from the point of view of human systems, can be considered independent from the involved sociological context. Or, better stated, any physical event characterized by a social impact is directly "generated" by causes inside the structural organization of a social (sub)system. Sudden, rare, random, unexpected, destructive events are only synonyms of what we do not know or of what we are not able, or we do not want to organize.

In the last section of this paper we will tentatively identify the main structural determinant of the quantity of social vulnerability as defined above. In the following pages we will discuss the problem of how many types of social vulnerability play what role in localized disasters.

2. PRELIMINARY IDENTIFICATION OF THREE LEVELS OF SOCIAL VULNERABILITY

To observe whether or not localized disasters have relevant long-term socio-economic and psychological effects, could be a preliminary way of finding some empirical evidence about what and how many types of social vulnerability play a role in disaster situations. In the social science disaster literature, at the socioeconomic level, American studies have produced two recurrent findings.

(1) The first finding is that localized natural disasters do not generate significant long-term changes in the demographic, economic and urban dynamics of impacted communities when compared with the pre-disaster ones (Wright et al, 1979; Friesema et al, 1979; Aguirre, 1981). If small changes occur, they tend to be positive in economic terms and more relevant at a regional level rather than for single communities inside the geographical area of the disaster (see: Dacy and Kunreuther, 1969).

(2) The second finding is that localized natural disasters tend to produce an accelaration of the already pre-existing developed and underdeveloped trends (Bates et al, 1963; Haas et al, 1977).

At the psycho-social and epidemiological levels, there is a basic conflict between two subsets of survey findings relating to the long-term individual effects of natural disasters (for a general discussion see: Mileti et al, 1975; Perry and Lindell, 1978). The first set asserts that a natural disaster might produce short-term psychological disturbances, but does not generate significant long-term individual consequences (see Drayer, 1957; Dohrenwend, 1973; Hall and Landreth, 1975; Taylor et al, 1976; Omaha Tornado Project, 1976; Western and Milne, 1976; Sterling et al, 1977; Melick, 1978). Moreover,

disasters do not necessarily produce negative individual effects, but they can have many positive effects on some characteristics of the involved social units (see Barton, 1970; Turner, 1966; Drabek, 1976). In contrast, the second set suggests that relevant psychological consequences can appear after a considerable period subsequent to the impact (see Killian, 1954; Demerath and Wallace, 1957; Form and Rosow, 1958) and can persist in the long-run among significant number of the disaster victims (see Wilson, 1962; Erikson, 1976; Titchener and Knapp, 1976; Logue et al, 1978; see also Ahearn, 1979). A variation of this latter finding, based on community studies focused on the long-term social consequences of the 1976 Friuli (Italy) earthquake, proposes that both the destruction and the type of reconstruction tend to produce significant negative effects only, or mainly, on those victims already characterized by high pre-disaster psychological and/or socioeconomic vulnerability (Tessarin, 1980; Pelanda, 1981; Pascolini, 1981).

From a societal point of view, and on the basis of the literature we reviewed, we could hypothesize that in developed western societies, local natural disasters do not produce any long-term relevant structural effects. In other words, these types of social systems maintain their structural stability under localized destruction.

If one is interested in a more formal description of this observation we could use (only as a parenthetical note in the context of this paper) the mathematical concept of topological isomorphism related to the preservation of a system's structure over time (see Gottinger, 1975; Williqan, n.d.). If we identify (S,X) as a differential dynamic system, where S is the system's phase space, with some assumed appropriate topological structure, and X is a vector field made up of a set of differential equations specified in S, we could define the system (S,X) to be structurally stable if for some perturbation δX on X the system (S, $X + \delta X$) is topologically isomorphic to (S,X). This is simply a description of a system which maintains its qualitative dynamics under perturbation.

From a macroscopic point of view this should be the situation of the developed western societies in relation to localized disasters. On the other hand we do not know anything, or little, about the threshold of intensity beyond which a local crisis becomes a societal disaster, and about the permanent effects of localized disasters in both non-western and non-developed societies. Therefore, we can only assume that in western developed societies there is a general factor of sufficiently low social vulnerability, which maintains the structural stability of the system when the typological vulnerability, (i.e., the quantity of "non-control" over a particular sort of environmental variation) of a subsystem actualizes into a local disaster.

Further problems arise when we have to assess the disaster effects at the involved subsystem (regional area or community) level. In spite of many systematic observations which suggest that local natural disasters do not produce permanent changes on the characteristics of both the structural dynamics and the social units of the involved subsystem, we have good reasons to believe that this finding is more appropriate for low-range disasters, which are easily counterbalanced by the average capacity of institutional rehabilitation existent in developed western societies.

On the basis of the above reductively summarized findings, and assuming a relevant level of destruction, we could hypothesize that there are differential disaster effects among communities inside the same societal system, and among social units inside the same community. These differential effects

are mainly based upon the subsystem's social units level of pre-disaster specific vulnerability, i.e., a pre-disaster capacity factor related to the involved social units' probability of maximizing adaptive behavior under stress. This means that the differential distribution of the specific pre-disaster social, economic, cultural, organizational, vulnerabilities in the components inside the sociosystemic level of interest, creates the pre-conditions of differential adaptive or maladaptive post-disaster social dynamics.

But neither these factors of specific vulnerability nor those of typological vulnerability, which determines the post-impact degree of environmental alteration, are sufficient for exhaustively predicting/explaining the type of disaster response of the involved social units. In fact, in modern societies, no social subsystem is left alone to cope with mass emergencies (Quarantelli and Tierney, 1979; Strassoldo and Pelanda, 1981). Further, the degree of institutional rehabilitation (i.e., the level of actualization of a societal factor of general vulnerability), can totally modify the only apparent linear relationship between the particular vulnerabilities inside the involved subsystem, and its overall degree of adaptive response to the disaster.

A unifying general notion for understanding this complex matter is the principle of continuity (Quarantelli and Dynes, 1977) which asserts that the pre-disaster behavior (or state) is the best predictor of the post-disaster dynamics. This principle fits our point of view. But for our purposes, which are focused on how the social vulnerability at different levels of the sociosystemic continuum plays its role in disaster situations, we have to elaborate this point. Until now we have identified the notion of total sociosystemic vulnerability (i.e., the quantity of "non-domain" of a social system over its internal and external processes) as a conceptual leitmotif. This implies at least three sublevels of social vulnerability: general, at a societal level, and specific and typological, at the involved subsystem level. The hypothesis is that if we know only one of these levels, or we assess them separately, we cannot measure the overall vulnerability of a social subsystem of interest nor predict/explain its post-disaster behavior. We need a simultaneous assessment of at least all these three types of social vulnerability. In other words, the fact of knowing each type of vulnerability alone does not allow us to predict/explain the subsystems post-disaster social dynamics. Only a threefold simultaneous assessment could at least have this property at an acceptable level of reliability.

Before trying to better define these three levels of social vulnerability and their interrelationship, it will be useful to give a brief concrete empirical example of the matter under discussion.

3. AN EXAMPLE: THE FRIULI EARTHQUAKE CASE

We undertook a questionnaire survey focused on the 1976 Friuli earthquake[2] and obtained a sample of 896 dwellers from 16 damaged and destroyed communities. We gathered data organized in a (recursive) causal scheme (see fig. 1) in which the rough determinants of the long-term individual (mal)adaptivity to the disaster are represented and measured (see Pelanda and Cattarinussi, 1980; Cattarinussi, Moretti and Pelanda, 1980; Strassoldo and Pelanda, 1981). Here, because of space limitation, we can only briefly mention those findings most directly relevant to the topic of this paper.

In this research, we used reliable indexes of the disaster-victim's pre-impact socioeconomic (X_1) and psychological (X_{11}) vulnerabilities. In the

causal scheme (fig. 1), the degree of pre-disaster psychological (in) stability is the best direct linear predictor of the long-term psychological state of the disaster involved subjects (X_2). The degree of pre-impact socioeconomic vulnerability (X_1) is not directly related to the latter index (X_2). But, the socioeconomic vulnerability strongly influences other direct predictors of the dependent index (X_2), that is, the degree of loss of cultural identification (X_7), the degree of post-disaster family economic change (X_5) and the degree of "individual disaster frustration" (based on a measure of self-esteem change) (X_8). Therefore, this type of vulnerability is one of the most crucial determinants of the long-term level of individual (mal)adaptivity to the disaster (X_2).

Compared with the pre-disaster overall personal state, the relative majority of the sample does not show changes four years after the impact. But relevant numbers of individuals, about 20%, show significant symptoms of maladaptivity. A similar number of disaster victims as well exhibit a general improvement in their socioeconomic and psychological conditions when compared with their pre-disaster state. Both changes tend to be linearly predicted by the degree of pre-disaster socioeconomic and psychological vulnerability.

In some of the findings derived from the causal schema (fig. 1) we can see that the levels of pre-disaster economic and psychological vulnerability are the best linear predictors of the long-term degree of individual (mal) adaptivity to the disaster. Even though this relationship is true in the statistical model we built, it does not imply, on the other hand, that we can exhaustively predict/explain the individuals post-disaster situation only knowing their pre-disaster degrees of specific vulnerability. The statistical significance only means that there is a particular tendency in the data. Many exceptions suggest that the continuity between the overall pre- and post-disaster personal state of individuals is obviously affected by many other factors.

Before exploring these factors, we need a synthetic and manageable concept to identify the key dimension of the social units' capability for absorbing environmental crises. This crucial notion is the individual capability to maintain a sense of predictability and cultural coherence in spite of both the "disorder" produced by the destruction and the uncertainty related to the reconstruction process (this general factor is roughly captured and measured by the variables X_7 and X_8 in fig. 1). While this crucial notion is suggested in the model presented in fig. 1, it is clearly evident in the context of other parallel qualitative analyses of the sociological dynamics related to the Friuli earthquake. The degree of this cultural mediation capability weakens, for example, the linear relationship between the material objective disaster-situation (see the weak relation between X_6 and X_2 in fig. 1) and the psychological state of the disaster victim.

In synthesis, the general pre-disaster social state of individuals is not alone sufficient to explain exhaustively the probability of maintaining predictability under perturbation, and adaptivity to the disaster situation. Hundreds of intervening variables are relevant for the remaining quantity of this type of prediction/explanation. But we could state that all of them depend on the degree of actualization of both the typological (i.e., all the factors which determine the degree of environmental alteration) and the general (i.e., all the factors which determine the level of institutional rehabilitation) vulnerability.

In the Friuli earthquake case, the actualization of the typological vulnerability (1000 casualties, 2800 injured, 70,000 homeless) was bounded inside the housing system, leaving whole the productive structure. Moreover, the presence in Friuli of 2/3 of the Italian Army substituted and counter-balanced the total lack of community preparedness for emergency management. The general vulnerability, at a societal level, actualized mostly in some intervention delays, but not in the amount and quality of the financial and organizational resources which converged into the disaster area. The bounded actualization of both the typological and general vulnerability, generated a similarly bounded actualization of the specific vulnerability of the social units inside the involved subsystem.

From a general point of view, this means that the overall post-disaster organizational environment remained below the threshold, beyond which the average capability of the disaster-area social units for maintaining a sense of cultural coherence and predictability, collapses. On the other hand, and at another level of observation, the partial actualization of these vulnerabilities was high enough to create a relevant quantity of randomness in the individual adaptive success. The quantity of post-disaster environmental indeterminancy was, and is, high enough to make unpredictable the degree of adaptation of many social units if we know only their own degree of pre-disaster social vulnerability. For our immediate purposes, this set of necessarily reductive considerations, is sufficient to make reasonable the hypothesis that the simultaneous assessment of at least three levels of vulnerability along the continuum of sociosystemic complexity, is the minimum pre-condition for getting an acceptable prediction/explanation of the social dynamics inside a post-disaster subsystem.

Now let us go back again to the general discussion we interrupted to present some rough empirically-based illustrations.

4. ROLE AND INTERACTION OF THREE LEVELS OF SOCIOSYSTEMIC VULNERABILITY IN DETERMINING THE OVERALL SUBSYSTEM'S VULNERABILITY AND DISASTER RESPONSE

When disaster strikes modern societies, the involved social subsystem is not left alone, but it is "rehabilitated" by the (over)system. When we have to deal with the problem of the assessment of disaster minimization in communities or regional areas, we cannot simply use measures of local exposure or of social vulnerability inside the area of interest. We have to identify as many levels of vulnerability as there are functional connections among components, subsystems and system. For minimum acceptable predictions/explanations at least a simultaneous assessment of three levels of social vulnerability, defined as follows, is required.

A. Subsystem of Interest Level.

(1) TYPOLOGICAL VULNERABILITY: refers to all the local sociotechnological pre-conditions whose resultant defines the degree of the social subsystem's indifference to a given intensity of a possible type of environmental perturbation. In other words, this term includes both the technological and social factors which directly define the probability of avoiding or minimizing a specific type, or a set, of potentially destructive events. The level of emergency planning preparedness, the degree of resilience of the physical structures, the technological capability to locally assess the degree of exposure, the sociopolitical awareness about risk, etc., are examples of some of the required indicators for assessing the typological vul-

nerability. Its degree of actualization directly determines the subsystem's post-impact degree of environmental alteration.

(2) SPECIFIC VULNERABILITY: is the combined resultant of the distribution of the cultural, organizational, technological and economic resources of the subsystem's social units (individuals, families and organizations). In other words, this is a complex measure of the local levels of both socioeconomic development and cultural stability. The degree of specific vulnerability directly influences both the degree of pre-disaster typological vulnerability and the social units' type of response when the typological vulnerability actualizes.

B. Society System Level.

(1) GENERAL VULNERABILITY: is the societal degree of socioeconomic, organizational and technological development. The national society vulnerability indicators refer to: 1) the quantitative and qualitative availability of economic, organizational, cultural, normative and technological resources; 2) the degree of functional connection between the societal system and its subsystems; 3) the degree of functional linkage with the international oversystem (see DelliZotti, 1981; Strassoldo, 1979). The degree of general vulnerability directly influences both the pre-disaster levels of typological and specific vulnerability and the degree of after-impact institutional rehabilitation.

As shown in figure 2, these types of preliminary analyses imply both a causal relationship among the three levels of social vulnerability and their different direct roles after the impact of a localized disaster. In the disaster situation, the degree of societal general vulnerability directly influences the subsystem's vulnerabilities. The degree of specific vulnerability amplifies or reduces that quantity of typological vulnerability which directly depends on the general state of the societal system. After impact, the three types of vulnerability play a combined but differential role in determining the subsystem's overall social response. Its level of success directly depends on the degrees of: a) environmental alteration (the actualization of the typological vulnerability), b) pre-disaster specific vulnerability of the involved social units and c) institutional rehabilitation (the actualization of the general vulnerability).

The representation in figure 2 is made from the point of view of the involved social subsystem. This approach means that for assessing its overall vulnerability against possible disasters, we have to simultaneously use reliable indicators related to at least all three levels of the social vulnerability identified above. If we know only one or two levels or if we are not able to combine all of them, the failure to predict/explain the involved subsystem's disaster related dynamics is more likely to occur.

The required social science assessment, as shown in figure 3, could be described as a three-step process: 1) reduction of the complexity of the reality by the identification and measurement of a satisfying number of indicators related to all three levels of sociosystemic vulnerability; 2) employment of multivariate techniques (e.g., factor analysis) for reducing the complexity of the indicators and finding the latent dimensions which synthesize them; 3) combined assessment of the factor analysis derived indexes, and their causal relationship, to obtain the degree of overall social vulnerability of a societal subsystem for any chosen set of unwanted possible

events.

This is the minimum we believe that is required. But obviously, after accepting the idea of the simultaneous employment of indicators related to all the relevant levels of sociosystemic functional interconnections, we could use many other techniques. For example, to perform risk analysis, we could employ the Monte Carlo Method and the related Network Analysis or the Delphi procedure or the Event Tree Analysis and so forth. We think that the problem of choosing the technique which better fits the researcher's goal follows, and does not preceed, the problem of being able to pursue a holistic approach.

The point of view expressed here might satisfy a preliminary introduction to the problem of assessing the degree of the social subsystem's vulnerability for every given set of perturbing events, but it is only a rough idea of what is necessary. Among the many difficulties, one is particularly crucial. In fact, if we could operationalize our approach, we would find not only difficulties in dealing with the large number of required indicators, but, above all, the crucial problem of having to use different criteria of vulnerability per any chosen level of the socio-systemic complexity.

Employing only one common criterion for assessing the vulnerability related-state of all the sociosystemic components of interest would be a better strategy. But we have to find something which could fit this goal. In this perspective, our preliminary working hypothesis is that the degree of (in)determinacy of the structural state of a social (sub)system could be functionally related to its overall degree of social vulnerability (Pelanda, 1980).

In the following and final section, we will try to suggest some tentative considerations about the hypothetical possibility of employing an indicator of the degree of sociostructural (in)determinacy, for assessing the overall level of vulnerability of a social (sub)system. The discussion will be necessarily short and incomplete because of the tentative and preliminary nature of our untested hypothesis.

5. SOCIOSYSTEMIC VULNERABILITY AND BOUNDED INDETERMINACY: A TENTATIVE AND PRELIMINARY APPROACH

The problem is to find only one indicator of vulnerability which can be compatable with any structurally relevant component and/or level, placed along the continuum of sociosystemic complexity. If one believes in the possible existence of such an indicator, then the preliminary methodological step is to identify the simplest, theoretically acceptable dimension which could fit any element of the system(s) under analysis. Our point of view is that the degree of (in)determinacy in the structural relations among social system, subsystems and components could be functionally related to their degree of sociologically relevant vulnerability. A necessarily short general discussion justifying this tentative approach is required.

We define a social system as a particular type of cybernetic system in which all the components are interconnected and have a certain degree of autonomy (for a general discussion see Buckley, 1968; Katz, 1981). By logic, the behavior of any component could be viewed as totally determined or relatively undetermined or totally undetermined.

If the behavior of all or many of these components is highly undetermined, we could say that the structural state of the system is characterized by high levels of disorder and unpredictability in its functional connections. The opposite situation could be viewed as a state in which the behavior of any component is highly determined and therefore the structure is extremely rigid. A great amount of structural rigidity implies that there is not sufficient elasticity for absorbing some possible unexpected event.

Let us assume two systems whose structure is characterized by, in the first, extreme indeterminacy, and, in the second, extreme determinacy. In both cases we could predict that, for different reasons, there is a similar high level of vulnerability. In the first case, because there is a lack of structural control over those social and environmental processes which potentially can lead the system to a disaster situation. In the second case, because the structural organization has not sufficient variety (e.g., alternatives) for adaptively reacting to an unpredicted event.

This abstract consideration implies that there is an optimal level of indeterminacy in the structure of a system, where a sufficient degree of variety combined with a high but not extreme level of order (determinacy), maximizes the probability of reacting to the actualization of an unpredicted event, by adopting the required elasticity. We define this optimal level of indeterminacy as "bounded indeterminacy" (see: Katz, 1974; Pelanda, 1980). We can measure the degree of indeterminacy of the structure of a given system along a continuum of indeterminacy - determinacy (i.e., 0 = MAX. indeterminacy; 1 = max. determinacy). We assume that there exists an interval along this continuum called "bounded indeterminacy", in which the system's structure maximizes the required levels of both variety and organization for minimizing or avoiding all types of potentially destructive events. If the system's structural state goes beyond the limits of bounded indeterminacy towards the extremes of both determinacy (rigidity) or indeterminacy (disorder) then its degree of vulnerability raises.

Let us give some conceptual examples for clarifying the latter statement. One of the smallest units of social structure are roles. They could be viewed as packages of expected and socially enforceable behavior. Their interaction makes up role systems (see: Katz, 1974). If we observe some individuals who are playing social roles, we could find that the interaction is functional or possible as long as the role-playing remains within the socially defined limits. If the role-playing goes beyond these limits in the direction of both extreme indeterminacy and determinacy, a dysfunction in the involved social interaction is more likely to occur.

Let us change the level of observation and let us assume, from a macroscopic point of view, that a social system reproduces its structure over time. If there is a rigid (i.e., highly determined) reproduction of the original matrix we could say that such a social system is at a steady state, and it does not increase its levels of variety, organization, development. If the process of reproduction generates a new structure which is highly different from the former one we could say, roughly speaking, that the social system has lost its structural stability at a certain point over time. In both cases, we could predict an extremely high level of social vulnerability. In the first case, this could be because of the rigidity in the structural dynamics. In the second case, this would be because of too high an uncertainty in the social processes. Only a bounded change from the former structural state makes a social system able to increase its levels of organi-

zation and variety maintaining, at the same time, its already established structural stability. In other words if a structural change occurs within the limits of bounded indeterminacy we assume that it maximizes the organizational resources for coping with all the events which could lead the system below the threshold of minimum viability.

In general terms, if we observe the behavior of an organization we could find that both extreme determinacy (e.g., centralization, rigid hierarchy) and indeterminacy in the structural connections among components produce some dysfunction. The situation in which any component has a relatively high, but structurally bounded degree of freedom, maximizes the probability of avoiding or minimizing the organizational collapse under unexpected tasks.

The function of a limited degree of indeterminacy in the structure of systems is well known in both the daily experience of engineers and planners and in the scientific work undertaken with systems. In the latter sector, particularly, the recent evolution of all the scientific disciplines shows a great interest about the role of indeterminacy in the life of both man-made and natural systems. We can only mention some examples incidentally in the context of this paper.

How a system maintains or increases order in its interaction with environmental variations is an important question in many disciplines. Von Foerster (1960), criticizing the Schrödinger's (1945) principle of the "order based on order" observed that a self-organizing system does not feed only upon order and formulated the principle of "order based on disorder" (i.e., noise, indeterminacy). One of the basic findings in the first developments in the science of cybernetics, was an assertion, that as an automaton increases its complexity, a certain quantity of indeterminacy (e.g., redundance and delocalization of both the functions and the components) is required for maximizing its probability of adaptation to a perturbation (see: Von Nuemann, 1956; Winograd, 1963; Cowan, 1965). This latter consideration is at a certain degree related to the Ashby's (1958) law of "requisite variety." Atlan (1972), generalizing a finding which Eigen (1972) obtained in biochemistry, formulates the principle of "noise (i.e., indeterminacy) as a principle of self-organization." It states that a certain degree of indeterminacy in the structural processes of a self-organizing system is a required pre-condition for transforming a perturbing event by generating an increasing level of organization, complexity and variety. Closer to our purposes, a sociological hypothesis suggests that "...indeterminacy needs to be, and can be, explicitly incorporated into theories that describe the structure of systems. (We do it) by proposing that there exists a phenomenon of bounded indeterminacy within many systems. The boundedness, i.e., the limits within which there exists indeterminacy, can be specified precisely while at the same time, accepting the unspecifiability of what lies within these limits" (Katz, 1979: 394).

Going back to the specific topic of this paper, from our point of view the probability that a perturbing event (i.e., disaster, threat) will activate a process of increasing organization in the involved social (sub)system is the key dimension which defines its overall degree of social vulnerability. Our hypothesis is that a social (sub)system's state, in which all the structurally relevant components are operating within the limits of bounded indeterminacy, maximizes this probability.

The main assumption of this approach is that such a structural state is the

optimal pre-condition for having the maximum availability of the required organizational resources for coping with all the potentially destructive events.

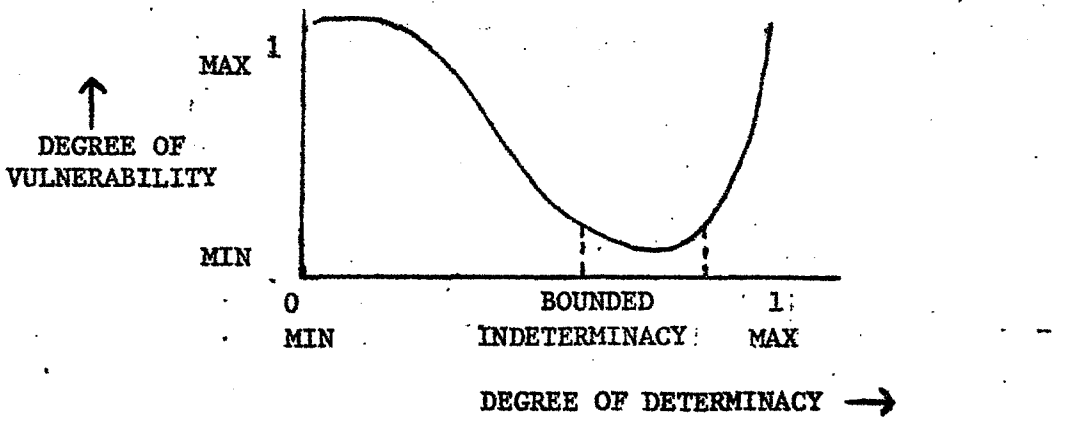
To synthesize we believe that:

A) There is a theoretically justifiable possibility for measuring the degree of (in)determinacy of all the chosen structurally relevant components of a social (sub)system.

B) The probability of both maintaining order and increasing organization inside a social (sub)system under perturbation, could be seen as a function of the degree of (in)determinacy in which it and its components operate during the "normality" phase.

If we assume a continuum 0 → 1 along which we can measure the degrees of both social vulnerability and structural (in)determinacy, then our hypothesis could be represented as follows:

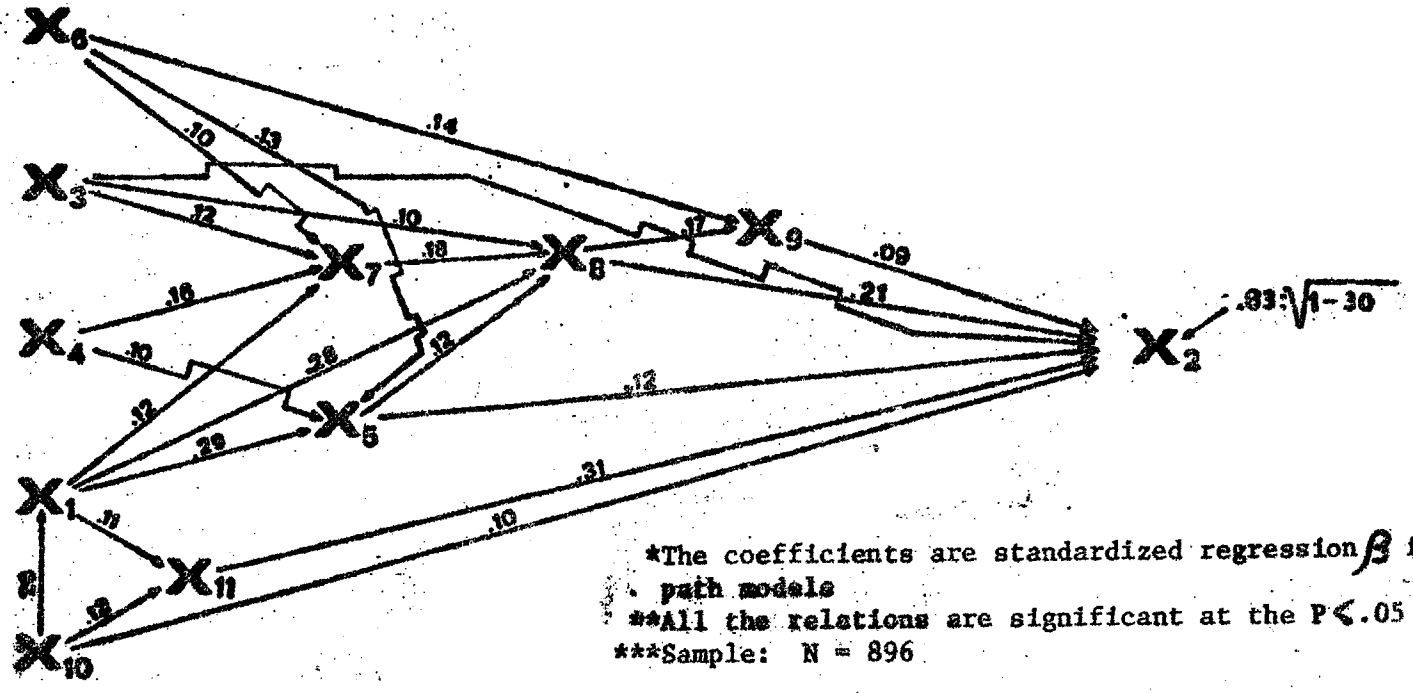
Fig. 4 HYPOTHETICAL RELATIONSHIP BETWEEN VULNERABILITY AND INDETERMINACY



According to our preliminary and rough conceptualization, we assume that the overall vulnerability of a social (sub)system and its components is at a relative minimum when their structural dynamics operate within the limits of bounded indetermanacy (see fig. 4). Such a structural state maximizes the (sub)system's and components' probability of absorbing a perturbation (or threat) by generating positive social change and increasing organization variety. The related statement we propose to subject to falsification asserts that: if the dynamics of all the structurally relevant sociosystemic components operate within the limits of "bounded indeterminacy," then the overall degree of social vulnerability is at a relative minimum.

Going back to the starting point of this section, we believe that the degree of sociosystemic (in)determinacy could be the best single dimension or indicator of upper level, for assessing the overall structural vulnerability of a social (sub)system, for any type of possible disaster. This is a tentative and only a conceptually based approach. In future work we will try to falsify/verify this preliminary hypothesis. Meanwhile, we believe that it might serve as a heuristic tool for developing holistic and concretely manageable methodologies of sociostructural vulnerability analysis. To find the most powerful and simplest indicator of social vulnerability is one of the main preliminary goals for applying disaster minimization strategies.

Figure 1. CAUSAL SCHEMA OF THE DETERMINANTS OF THE LONG-TERM INDIVIDUAL (MAL)ADAPTIVITY TO THE 1976 FRIULI EARTHQUAKE



X_1 Degree of pre-disaster socioeconomic vulnerability (min - max: high)

X_2 Degree of long-term individual maladaptivity (min - max: high)

X_3 Degree of perceived social climate change as compared with the pre-disaster one (min - max: deterioration)

X_4 Degree of "kin embedness" (min - max: low)

X_5 Degree of family economic change as compared with the pre-disaster one (min - max: pejorative change)

X_6 Degree of damage and its persistence over time (min - max: still living in a barracks)

X_7 Degree of loss of cultural identification (min - max: high)

X_8 Degree of disaster frustration (min - max: high)

X_9 Degree of change in the family climate as compared with the pre-disaster one (min - max: deterioration)

X_{10} Sex (max: female)

X_{11} Degree of pre-disaster psychological unstability (min - max: high)

Figure 2. ROLE AND INTERACTION OF THREE LEVELS OF SOCIOSYSTEMIC VULNERABILITY IN DETERMINING THE OVERALL SUBSYSTEM'S VULNERABILITY AND DISASTER RESPONSE.

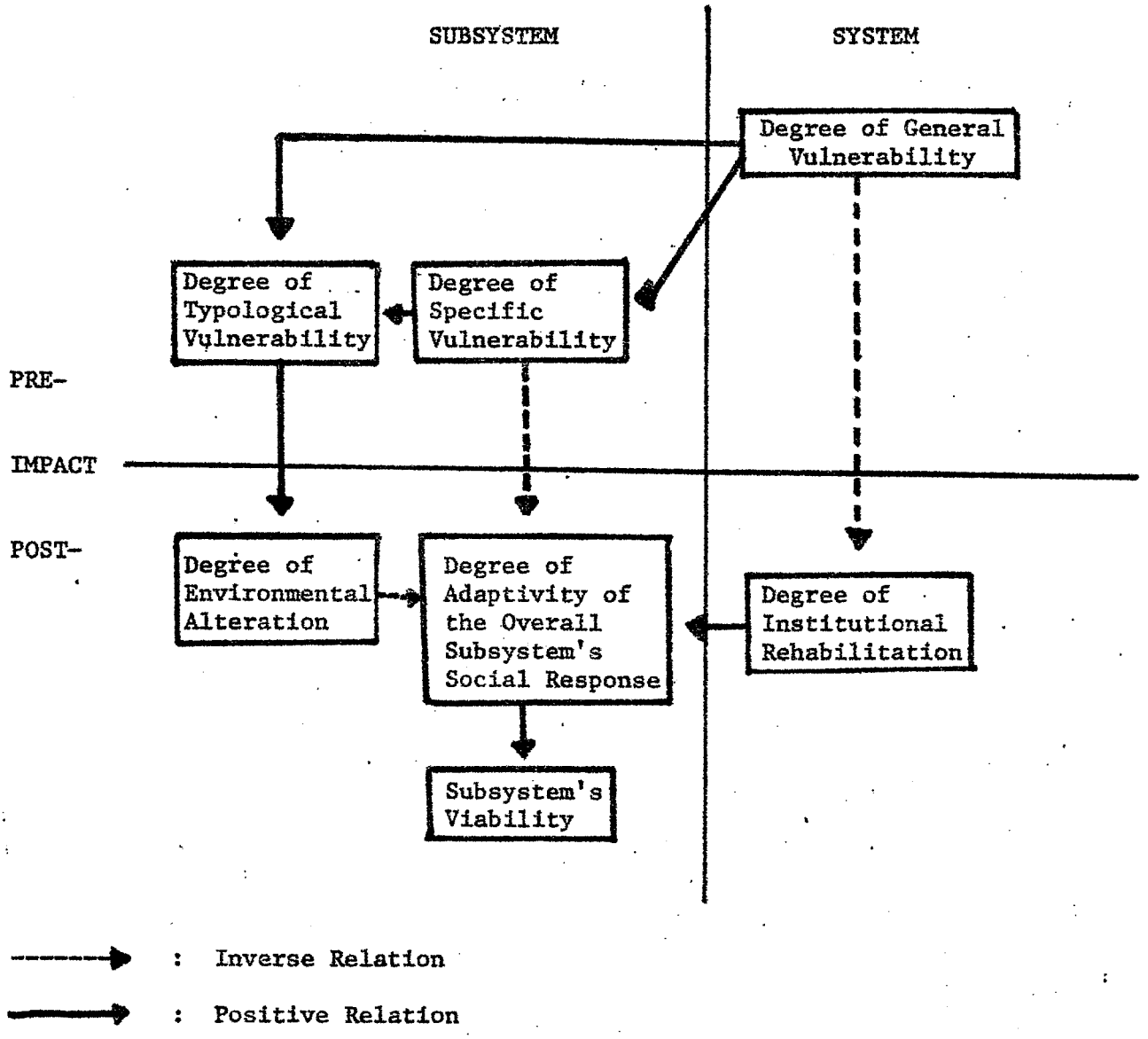
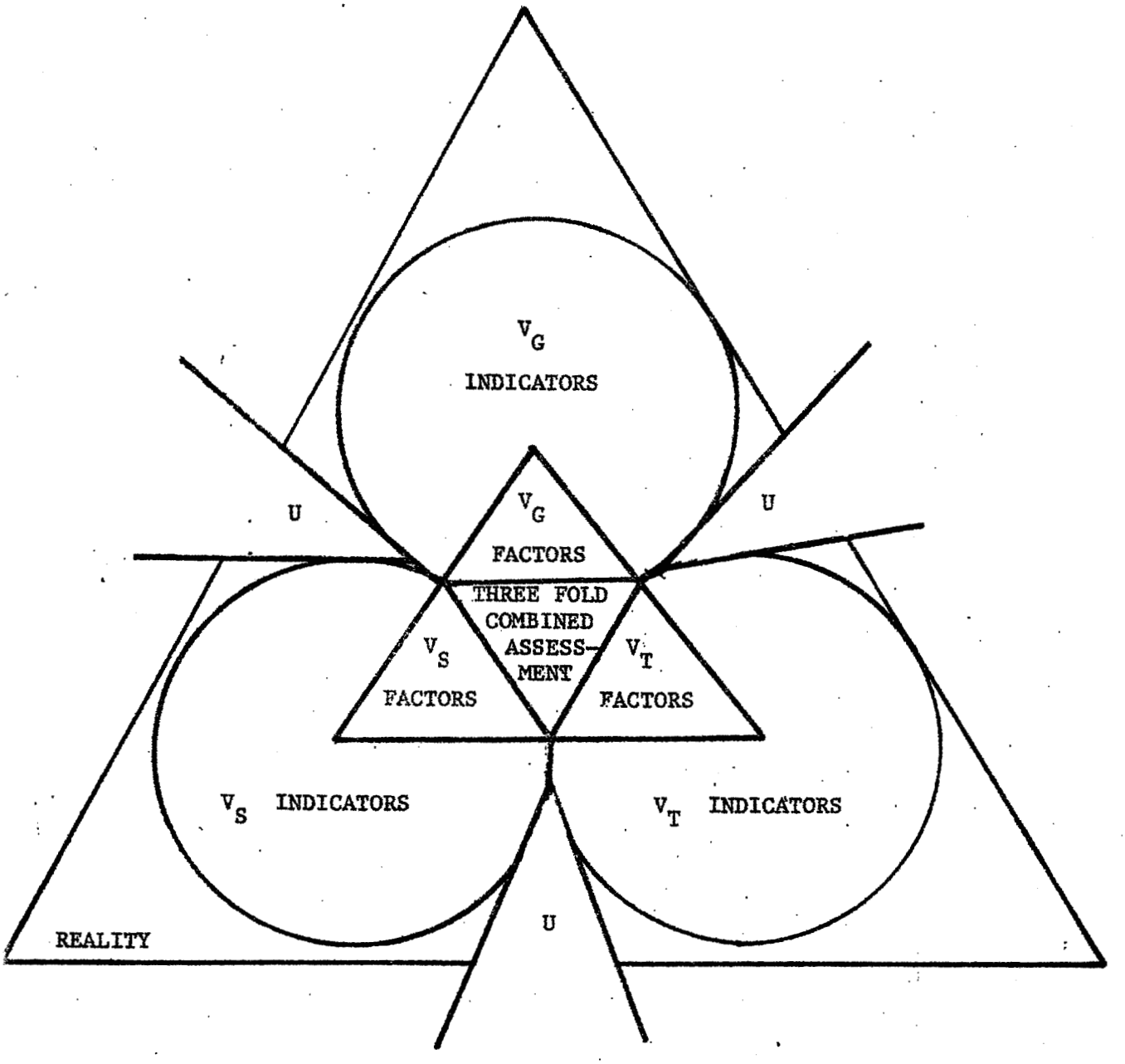


Figure 3. REPRESENTATION OF A THREE-STEP MEASUREMENT PROCESS FOR THE ASSESSMENT OF THE OVERALL SUBSYSTEM'S SOCIOSYSTEMIC VULNERABILITY.



V_G : General Vulnerability

V_S : Specific Vulnerability

V_T : Typological Vulnerability

U : Unknown Processes and Relations

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FOOTNOTE

1. Four years after the impact, less than 50% of the houses have been rebuilt, while about 40,000 disaster victims still live in a temporary housing system. The disaster area communities show differential trends. Those already developing in the pre-impact period have had an acceleration of their economic and urban improvement dynamics, while those already marginalized (e.g., mountain communities) have tended to increase their degeneration or to have maintain a steady under developed state. For the sociologically relevant history of the Friuli earthquake, see Geipel, 1977; Strassoldo and Cattarinussi, 1979; M. Strassoldo, 1979; Tellia, 1979).