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Complexity, Vulnerability Processes and Environmental Justice: An Essay in Political Epistemology*

This paper, in the form of an essay, discusses the potentialities and limits of the concept of vulnerability concerning the integrated analysis of social and environmental problems. It focuses on two perspectives. The first one derives from *post-normal science*, considered as a new epistemological and methodological basis for the analysis and management of complex environmental problems. For this purpose, the author analyses the concept of vulnerability within the context of four phenomenal worlds, each with increasing levels of complexity: the world of the physicalist sciences, the world of biological life, the world of life from the perspective of biomedicine and public health, and finally, the emergent and reflexive human world. The second perspective includes contributions by authors involved in both theoretical discussion and activism related to environmental justice movements, especially within the Brazilian Network for Environmental Justice.

Keywords: post-normal science; complexity; epistemology; environmental justice; risk; social vulnerability.

Introduction: Vulnerability, post-normal science, environmental (in)justice and the challenge of change

As a reflective and critical essay, this article proposes to contribute towards analysing the potential of the concept of vulnerability from two perspectives. The first is epistemological in nature and has its origins in the work developed by Funtowicz and Ravetz (1994) in their proposal for *post-normal science*, understood as a new epistemological and methodological basis for analysing and confronting complex socio-environmental problems. The second, which is social and political in nature, draws on contributions from authors who are, in the main, Brazilian and have been active in the theoretical debate on environmental conflicts and environmental justice movements. Whilst discussing environmental, health and human rights issues, these authors have also deepened what are, in my opinion, two key debates on the potential, limits and paradoxes of the concept of vulnerability: on the one hand, the dialectical relationship between this and the historical context of the environmental conflicts underlying social and environmental vulnerability in specific territories and, on the other hand, the importance of so-called vulnerable populations assuming their role as collective subjects actively working towards changing their vulnerable status.

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The underlying proposal of this article, entitled *political epistemology*, implies a connection between these two perspectives: (i) the *epistemological* perspective, via the notion of complexity or, in other words, recognition of the limits of the various areas of knowledge associated with specific phenomena which, in complex problems, cannot be analysed separately; a further contribution is associated with making the uncertainties and values in question explicit, as well as the role of the production of knowledge in shaping decision-making processes and public policies; (ii) the *socio-political* perspective, through reference to environmental justice, which involves recognising environmental conflicts in vulnerable contexts in which territories are in dispute over resources, values and development models. This perspective also identifies strategies for revealing the hidden voices of populations affected as human beings by environmental conflicts which make them vulnerable. I believe that by integrating these two perspectives the notion of vulnerability is able to meet the challenge of producing approaches that combine academic work with more effective social processes for changing society in the face of the most pressing environmental problems of today.

The polysemic concept of vulnerability has been used in different disciplines and areas of knowledge to study themes such as development and sustainability, poverty and food security, natural and technological disasters, global climate change and public health problems, amongst others. Its use is linked to the application of systemic approaches, given the complexity of these themes, which involve separate perspectives, dynamics or subsystems originating from different academic fields, and therefore demanding inter- or transdisciplinary analyses (Porto, 2007; Turner II *et al.*, 2003; Cutter *et al.*, 2003; Füssel, 2007).

For Füssel (2007), vulnerability represents a kind of conceptual *cluster* for investigating problems involving human and environmental systems. However, the use of distinct conceptualisations and terminologies for vulnerability may make dialogue between research communities with different traditions difficult, given that the outlines of the theoretical model tend to be shaped by the hegemonic paradigms in the academic fields from which the approach originates. For example, natural scientists and engineers tend to apply the term in a more descriptive, functional and quantitative way, whereas social scientists tend to use it in a more qualitative and contextualised explanatory model. Still according to Füssel (2007), the various approaches and types of integration are differentiated basically in terms of the

way in which the analytical model that is constructed links aspects such as socio-economic and biophysical factors, spatial scales (internal and external to the “system”) and time scales, as well as, I would add, the ways in which it incorporates the relationships and voices of the social subjects involved, in particular the affected, vulnerable populations very often made invisible, even by social science approaches (Mendes, 2010).

In its turn, the environmental justice movement (EJ) fundamentally seeks to integrate the environmental dimension with the dimensions of law and democracy through transformative action. The movement has developed over the last two or three decades out of the struggle against discriminatory dynamics that are burdening particular groups of people with the harmful effects of economic and industrial development. For Martinez-Alier (2002), EJ stands as an alternative to the two other strands of international environmentalism, namely (i) preservationism, centring on the “cult of the wilderness,” which aims to preserve fragile wildlife from human actions and systematically enters into conflict with traditional populations and farmers living in what are considered priority conservation areas; (ii) eco-efficiency, which aims to link the notion of sustainable development to market mechanisms based on the valuation of externalities and efficient environmental management of the natural resources and production-consumption cycles that sustain the economy. For Martinez-Alier (2002: 5), the latter has become “a religion of utility and technical efficiency without a notion of the sacred” under the hegemony of economists and engineers, though linked to the social and human sciences through the development of participatory methodologies and vulnerability studies based on notions of consensus and governance, which disregard the dynamic and transformative potential of conflicts. EJ therefore has a critical stance towards the systemist and functionalist views of vulnerability contained in what Füssel (2007) identifies as a branch of the natural sciences and engineering.

In Brazil, the EJ approach has been developed through the critical contributions of authors working in the fields of political ecology (Martinez-Alier, 1992), the social sciences (Acseirad, 1992) and public health (Porto, 2007), amongst others, who have extended the debate on the invisibility of certain social groups, not only in terms of their social and economically vulnerable status, but as the expression of social, economic and political processes involving disputes and conflicts over resources and ways of life in certain territories. For Martinez-Alier (2002), EJ, which she also terms popular environmentalism or

the environmentalism of the poor, emerges from conflicts involving the distribution of the costs and benefits of the use or preservation of natural resources and, in a broader sense, economic processes overall. These conflicts are exacerbated in regions that export raw materials and agricultural or metal commodities, such as Africa, Latin America and Asia, characterised by unfair trade based on a social metabolism in which the risks and benefits of production and consumption are unequally concentrated within the international division of labour, which is also a division of risks and vulnerabilities.

Following a similar line of analysis, authors such as Acselrad (2004) and Porto (2007) consider that, in linking environmentalism with social justice, EJ represents an important example of resistance to the harmful effects of globalised capitalism, which uses its growing freedom to base investments in different regions of the planet – whether continents, countries or even areas within the same country – to prevent the construction of social, environmental, health and cultural parameters in order to direct economic and technological development towards market interests. By imposing the economic principles and interests of countries and elites outside the territory on local populations, the subsequent *detritorialisation* processes produce situations of *environmental injustice* which make the populations affected *vulnerable*, not only by loading them with various risks and burdens, but also by failing to recognise their rights in essential areas such as health, land, natural resources and local culture, as expressed in their material and immaterial relations with such resources.

According to EJ, populations affected by certain economic development projects and worldviews reduce their vulnerability as they establish themselves and assume their role as collective subjects, allowing for the public and political expression of voices that are systematically absent from the decision-making processes that define the main development projects in territories. To this end, it is necessary to “denaturalise” and politicise vulnerability through the concept of justice, adopted not as a technical legal term but as a broad notion that calls into question the ethical, moral, political and distribution issues associated with the economic operations, public policies and institutional practices that lie behind countless environmental problems. These may be associated with the use of land and natural resources, the occurrence of technological and natural disasters, the introduction of hazardous industries or even infrastructure projects potentially affecting the environmental,

social, economic and cultural characteristics that shape the living conditions and ways of life of certain populations in the territories in question.

These ideas are present in the original 2001 manifesto of the Brazilian Network for Environmental Justice, in which the concept of environmental injustice is defined as

the mechanism by which unequal societies, from an economic and social point of view, direct the main burden of environmental damage from development towards low income populations, social groups facing discrimination, traditional ethnic populations, working class neighbourhoods, and marginalised and vulnerable populations.

The concept of environmental justice, in its turn, is understood as the set of principles and practices which ensure that no social group, whether based on ethnicity, race, class or gender, “shoulders a disproportionate burden of the negative environmental consequences of economic operations, policy decisions and federal, state and local programmes, as well as the lack or omission of such policies” (*idem*).

In what follows, this article will present and discuss the contributions of post-normal science to understanding the concept of vulnerability with regard to certain phenomena that shape different fields of knowledge, such as engineering, the life sciences and the social and human sciences. The intention is to reveal the increasing complexity that characterises the transition through the physicalist, biological and social worlds on the basis of the concept of vulnerability itself. Environmental problems are always, in some way, social and environmental, and therefore simultaneously encompass all the different levels of complexity. As will be demonstrated, the risk of reductionism lies in failing to consider this increasing complexity and in treating social and human phenomena in a functionalist and qualitative way only – or, alternatively, in using the metaphor of “natural” and “social” systems indiscriminately, thus ignoring the dimensions of consciousness, history and conflict that underlie human vulnerability. In addition to acknowledging this, a political epistemology is proposed which favours combining contributions on complexity with environmental justice movements and principles, involving transformations based on supportive recognition of the vulnerable populations as bearers of rights and as political subjects. One clear assumption is that the emergence of these voices, sometimes in contexts that radicalise conflicts, is an important condition for ensuring that any future dialogue involving broader communities of peers and decision-making processes becomes genuinely legitimate and democratic.

Post-normal science: Vulnerability, complexity and meaning in terms of phenomenal worlds

The concept of post-normal science (Funtowicz and Ravetz, 1994) emerged out of the debate on contemporary environmental problems and is based on four strategic pillars:

- (i) Notions of complexity and of simple, ordinary and emergent complex systems as the basis for understanding the kinds of phenomena present in environmental problems, serving as a conceptual toolkit for transdisciplinary work which seeks to integrate separate fields of knowledge.
- (ii) The recognition of uncertainties relating, in increasing order of complexity, to three major factors: probabilistic risks pertaining to theoretically well defined problems and coherent databases; indeterminacies typical of more complex problems which, even when well defined, involve nonlinear phenomena with high unpredictability; and, finally, the gaps in scientific knowledge itself, termed epistemological uncertainty, in the face of problems involving major theoretical disparities and levels of incomprehension (Van der Sluis, 2006).
- (iii) Complementing the two previous points, the critique of normal science, in the sense provided by Kuhn (1962), due to its apparent “neutrality” and “objectivity,” which makes hard facts explicit whilst concealing both the values and the uncertainties in question and is reproduced through quality standards maintained by specialist peer communities working within hegemonic paradigms. It is argued, therefore, that it is not the specialist model of science that has been involved in creating the major modern environmental risks that will resolve the situation.
- (iv) Finally, the active search for dialogue, not only between the various scientific fields but also between these fields and other legitimate forms of knowledge that include the values, experiences and needs of people and communities who are involved in the problem. The argument is that progress can be achieved by constructing extended peer communities centred on the problems in question, dedicated both to producing knowledge and establishing decision-making processes with a better ethical and epistemological quality, including the adoption of new forms of language, expression and communication to bridge the various legitimate types of knowledge and interests concerned.

With regard to the subject of complexity, according to Funtowicz and Ravetz (1994) there are two main classes of systems or problem-objects: *simple or complicated systems*, studied by the *physicalist natural sciences*, in particular physics and chemistry and their applications within engineering, and *complex systems*, studied by both the biological sciences, including ecology, and by the social and human sciences. The main difference between the two groups of systems – simple and complex – is the impossibility of understanding the latter from a single perspective without losing sight of essential aspects of the system in relation to the problems being analysed. In other words, the complexity of a system or problem-object increases in relation to the dimensions required to understand it and search for solutions, expressed by the various forms of knowledge.

Complex systems contain two levels or orders of complexity: (i) *ordinary complexity*, characteristic of biological and ecological systems in which there is a lack of self-awareness and more complete purposes and a more natural pattern of organisation and balance geared towards complementary competences and cooperation, such as the predatory behaviour, parasitism and symbiosis existing in ecosystems; (ii) *emergent or reflexive complexity*, characteristic of social, technical or mixed systems which include human beings. The latter cannot be explained in mechanistic and functionalist terms and contains characteristics such as “individuality, along with some degree of intentionality, consciousness, foresight, purpose, symbolic representations and morality” (Funtowicz and De Marchi, 2000: 64).

One conclusion that may be drawn from this classification is the following: the greater the level of complexity, the more important the qualitative, as opposed to quantitative, aspects will be (even though the latter are always present), and the greater the level of uncertainty, the less capacity there will be for control and prediction. Emergent or reflexive complexity in the human world is essentially qualitative, dialectic, historical, autopoietic and plural, and laws which are atemporal or independent of the context that governs physicalist, and in part biological, phenomena do not apply in the same way to social and human phenomena. The complexity of human experience maximises the qualitative dimension, since it contains core teleological and ethical questions relating to human consciousness, values, meanings and dilemmas in the existence of human beings within their cultures and organisations. This recognition makes the limits of science, in particular normal science, clear in terms of the understanding and management of more complex problems in the living world, in particular the human world.

Emergent complexity materialises both on an individual-existential and a social-collective level, and is marked by a plurality of perspectives, singularities, unpredictabilities and often by conflicts resulting from power relationships, confrontations of interests and the ensuing disputes, especially in historical periods and territorial, economic, cultural and political contexts in which conflicts escalate. This appears to be the case in our present-day industrial civilisation within the context of intensive globalisation. The analysis of emergent complexity therefore requires multiple combinations of qualitative and participatory approaches in addition to quantitative approaches, which can incorporate the aspects most relevant to the understanding of a given problem, as well as paying attention to the legitimate needs of the human beings concerned.

This epistemological discussion, which Funtowicz and Ravetz (1993) also call “political epistemology: science with people,” may help us to understand the potential of the concept of vulnerability in analysing socio-environmental problems. For example, it clarifies the distinction between social and human systems and systems originating in non-human nature relating to ecosystems, geophysical or climate-related phenomena such as earthquakes, hurricanes, or phenomena that are technological in origin, such as chemical contamination and industrial disasters. The clarity of this distinction allows a plurality of perspectives and methodologies to be accepted as legitimate, acknowledging that systemic thinking formulated exclusively on the basis of energy, material and thermodynamic flows is appropriate for various kinds of environmental problems but may conceal or dilute the relevance of ethical and cultural questions, or even historical or social dimensions of a dialectical nature, including conflicts and disputed values (Loureiro, 2006). Another central contribution of political epistemology is to bring the issue of uncertainty and ignorance to the forefront of the debate on the environment and risk. This subject has been systematically concealed by the theoretical and practical formulations of experts in normal science, although it is central to confronting problems for which the wisest answers involve adopting precautionary principles.

The following sections will describe how the various fields of knowledge dedicated to systems proposed by post-normal science approach the concept of vulnerability, taking certain environmental problems as examples. Each type of system corresponds to what may be termed a specific phenomenal world, namely the physicalist world, the living world and the human world, in rising order of complexity. Drawing on previous work (Porto, 2007), the

aim will be to describe how vulnerability is understood in each, adding in a transitional approach between the living world and the specifically human world that is represented by biomedicine, given that one relevant application of vulnerability is related to human health problems, whether in individual or collective terms.

Vulnerability and functionality in the physicalist world and in technical systems

Vulnerability in the physicalist world is analysed by the natural sciences of physics and chemistry, as well as by engineering which applies it to the field of technology when, for example, analysing safety and reliability problems and failures in technical systems. Here the notions of resilience and vulnerability adopted involve the adaptive dynamics associated with changes in bodies – or technical systems – in the face of some external impact or environment variability. Whereas resilience refers to the adaptive processes that preserve the basic properties of a system in the face of impacts and variations in the environment, vulnerability is defined as a loss of resilience or, in other words, the inability of a system to preserve certain properties during or after the period of the impact. This perspective is substantially influenced by the mechanistic paradigm of the physicalist sciences and engineering, the latter of which is concerned with the functionality of technical systems.

A more restricted set of variables and interactions between components vis-à-vis certain environmental impacts predominates in the simpler technical systems, involving linear cause and effect relations even though a certain environmental variability may make quality control and predictability difficult. Examples of simple technical systems include mechanical tools and machines, which become more complicated when modified by computerised and digital technology in integrated production systems.

There has been an increase in the quality control and predictability problems of various processes in technical systems, including failures and accidents involving more sophisticated technologies such as those of the aerospace, chemical processing and nuclear industries. In these technical systems the number of variables and types of relationships are greater, and may include feedback, nonlinear relations and abrupt transitions between states or phases characterising what Perrow (1984) has termed “normal accidents” in highly interconnected complex systems that are typical of the chemical processing and nuclear industries which have led to the main technological disasters in industrial societies.

It is necessary at this point to identify an important paradox that restricts the approach used by engineers in analysing dangerous technical systems: in these cases, a significant portion of their complexity may be attributed precisely to the interaction between strictly technical factors and human and organisational factors. Every technical system, even of the simplest kind, is of a mixed nature, since it is always planned and operated, albeit indirectly, by humans and their organisations and may be simultaneously considered a complex system. Therefore, by disregarding or restricting their understanding of the human, organisational and social aspects concerned, the technicist approaches of the physicalist sciences and engineering to the study, planning and management of technical systems become reductionist; it was within this context that technical and organisational systems such as Taylorist production and the Ford assembly line were developed. The scope for understanding and designing technical systems has been extended principally since the second half of the 20th century with the development of new interdisciplinary and systemic approaches dedicated to increasing the security and reliability of systems. Two examples of this are safety engineering, dedicated to increasing reliability (Lewis, 1987), and ergonomics, especially as it developed in France during the post-war period, which extended the human and organisational aspects of the analysis of human labour and their implications in terms of accidents and health problems (Leplat, 1985; Wisner, 1994; Dejours, 1991). The transformation of technical systems into sociotechnical systems through interdisciplinary approaches such as ergonomics implies that all technical reliability is related to human and organisational reliability and involves higher levels of complexity by incorporating approaches derived from psychology and the sociology of work, for example. This explains why the possibility of predicting scenarios and designing more reliable technical/production systems in preventive terms depends on risk and environmental management recognising and understanding the people, organisations and uncertainties at stake.

Vulnerability, vitality and continuity in the living world and in ecosystems

Vulnerability in the living world, in the restricted sense of the non-human world, is used by the biological sciences, particularly ecology. The subject is approached as an attribute of ecosystems and their components when confronted by certain impacts. Vulnerability may be associated with an ecosystem as a whole or with plant and animal species, with

environmental systems and their various divisions – soil, water and air. The biotic and abiotic systems that shape ecosystems are related to the previously discussed notion of ordinary complex systems. It may be said, for example, that certain ecosystems, species or communities may be more vulnerable to certain “disturbances” or risks, such as climate change due to greenhouse gases, land clearance for expanding monocultures or chemical contamination. In this case, the concept of vulnerability is biological in nature, governed by the biological paradigm of ecology, whose opposite may be understood, in a broad sense, not only as resilience but also as the integrity or health of ecosystems.

For Constanza *et al.* (1992), working on an operational definition of the health of ecosystems, sustainability represents the expression of three basic components: (i) *vigor*, relating to metabolism and primary productivity; (ii) *organisation*, relating to biodiversity and connectivity between living species; (iii) ecosystem *resilience*, a product of the two previous components and the expression of the ability of an ecosystem to confront disturbances without loss of integrity. The vulnerability of an ecosystem represents a loss of resilience, whether due to declining vigor and biodiversity, or due to the intensity of an environmental impact caused, for example, by climate change, loss of biodiversity or environmental pollution.

It is interesting to observe that the ecosystemic biological focus does not value the life of isolated individuals or even certain communities. As the focus of the analysis is spatially and temporally broad and the life-death cycle tacitly recognised in the continuation of life, the meaning of resilience or health is revealed through global cycles and relationships that form a given whole, whether this is a community, species, group of species, environmental sediment or complete ecosystem. What might be considered vulnerable in isolation may represent the healthy functioning of a greater whole. This is the case, for example, with the food cycle that defines the relationship between predators and their prey, or even the individual cycle of birth, life and death. Even certain natural phenomena that lead to tragedy for individuals and species in a particular region, such as forest fires, may form part of the environmental characteristics of the area and favour cyclical processes that enhance the vigor of the ecosystem, improving the quality of the nutrients in the soil and renewing deteriorating plant species. Thus, the apparent tragedy that is full of vulnerabilities in the short term may mark the beginning of the renewal of a healthy and virtuous destruction-production cycle in the medium and long term. However, in complex human systems, the

finite nature of life represents a phenomenon of enormous complexity for which the scientific approach can never equal the existential, mysterious, tragic and even liberating plenitude of other narratives from the arts – such as novels, poetry, theatre and cinema – and from philosophy, metaphysics and religion.

Vulnerability, individuality and “vulnerabilisation” contexts from the perspective of public health

As it relates to health and the biomedical paradigm, vulnerability represents an interface between the biological living world and the specifically human world, since it entails ethical and cultural issues that bring a new dimension to bear on the understanding of complexity. In the strict biomedical paradigm the notion of vulnerability is related to the existence of individuals or groups who are particularly susceptible to developing infirmities in risk situations, such as air pollution, heat waves or cold spells. The classic cases are associated with specific age groups (children and the elderly), those with a genetic predisposition to certain illnesses, those with handicaps or specific pathologies or even certain “natural” situations, such as pregnancy or breastfeeding (Ayres *et al.*, 2003).

The strict biomedical paradigm particularly values the biological dimension in the analysis of health problems, which may provide scope for reductionist and discriminatory views that dangerously overrate biological or genetic questions to the detriment of a socio-political, economic and cultural contextualisation of the problem, as well as fundamental questions and ethical dilemmas. This danger was present in the formulation and political use of eugenics in the early decades of the 20th century, reaching its peak in the Nazi ideal and currently featuring in the apologia for biotechnological and genetic engineering solutions in medicine and agriculture (Ho, 1998).

As in other fields, especially since the 1990s, the term vulnerability has been used in public health not only in the restricted biological sense, but also as a conceptual and methodological strategy for analysing various health and sickness processes. It thus seeks to incorporate social, economic and cultural elements into the analysis of certain complex health problems such as AIDS, mental health, drug use, cardiovascular diseases, external causes/violence and environmental health issues. The concept has been developed principally in studies of AIDS and mental health, where the approaches seek to incorporate the dimension of the subject and autonomy (Porto, 2007). Another area that has been

incorporating the theme of vulnerability involves exploring the so-called social determinants of sickness and health, including communicable diseases, within a historical perspective that also includes social and spatial dynamics originating in political geography (Barcellos and Sabroza, 2000).

The modern public health view of complex subjects has broadened the restricted view of biomedicine not only by considering individuals with organic predispositions belonging to certain socioeconomic sectors or age groups to be vulnerable, but also the context and the processes of “vulnerabilisation” in the light of resources and ways of life that restrict or make the virtuous life cycles of individuals and communities viable. Therefore, as with the previous perspectives for physicalist and biological systems, when we refer to vulnerability from the point of view of health what is at stake is an aprioristic definition of functions or properties that may be affected or lost in the face of certain changes caused by time and the environment. From the point of view of biomedicine and public health this can be expressed as a loss of vitality, the emergence of diseases and premature or avoidable death among individuals or groups exposed to situations of risk. All three possibilities inevitably form part of the life cycle of any individual, but it is the context of these episodes, their meanings and the alternatives for reorienting the course of events, i.e., the levels of autonomy and liberty, that provide the human meaning when the concept of vulnerability is incorporated into the field of health. In addition, the specific case of environmental health brings to light an ethical question essential to sustainability and democracy: what are the avoidable risks propagated as part of the development process in a given territory, and which groups are more exposed and vulnerable?

Therefore, the actual concept of vulnerability becomes more complex and is humanised when related to the issue of health. As Mendes points out (2010), citing the work of Patricia Paperman, the recognition of our own vulnerabilities and dependencies – the fact that “we are all vulnerable” in a certain sense – makes the ethic of care central to our understanding of the human condition in the face of suffering, illness and death. Consequently, it should be incorporated into the production of knowledge in a wide range of areas and issues, such as disasters, climate change and hunger. In this sense, in a previous work (Porto, 2007) it was suggested that health should be understood in a less functional way, not merely as absence of disease, suffering and the maximum postponement of death itself, but as a more

dynamic, multidimensional, qualitative and evolving concept, encompassing the limits and potential of human realisation in its physiological, psychological, social and spiritual spheres.

This understanding implies recognising the processes and conditions that favour human beings, in their various levels of existence and organisation (personal, family and community), achieving certain objectives, forms of fulfilment or virtuous life cycles that are rooted in the culture and values of societies and their various social groups. In addition to its biomedical dimensions, health should therefore be considered in its irreducible ethical, social and cultural dimensions, and an object of ongoing negotiation and possible conflicts within society, depending on how values and interests are related within structures of power and distribution of existing resources. (Porto, 2007: 82)

Vulnerability, ethics and tragedy in the human world: Beyond the determinism of “everyday” disasters

From the viewpoint of post-normal science, the study of vulnerability in the human world of emergent or reflexive complex systems involves the incorporation of perspectives from the social and human sciences, including philosophy, to deal with complex themes, making fundamental qualitative and ethical dimensions explicit.

As we have seen, important qualitative advances have resulted from bringing those perspectives to bear on the analysis of sociotechnical systems and health problems. Another issue of particular interest to the application of the concept of vulnerability is the study of disasters, whether technological or natural, since in both cases vulnerability sheds light on the social processes that increase or reduce the potential impact of events such as hurricanes, earthquakes, global climate change or major industrial accidents. All types of disasters involve social and anthropocentric processes that are important in explaining different impacts in events of a similar magnitude affecting different territories and populations, thus blurring the dividing line between the “natural” and the “technological” in disaster analysis (Funtowicz and De Marchi, 2000).

The incorporation of the concept of vulnerability into the field of disaster studies is illustrative of the development of integrated approaches that combine more operational and quantitative dimensions with those that are more qualitative and contextual, associated with emergent or reflexive complexity. Fuster (2007), in his classification of vulnerability studies, terms integrated approaches those which combine contributions from risk sciences and political economy, such as the “hazard-of-place model” (Cutter *et al.*, 2003) and the “coupled vulnerability framework” (Turner II *et al.*, 2003). Whereas in the approach of Cutter

et al. (2003) the concept of social vulnerability is central to explaining the differences in exposure and the effects of disasters, for Turner II *et al.* (2003) vulnerability is the expression of three linked components – exposure, sensitivity and resilience – each interacting with biophysical and social components.

It is interesting to note that the authors cited in the previous paragraph make no reference to authors whose work focuses on Latin America and who have developed integrated approaches influenced by political economy and critiques of the natural and environmental determinism prevailing in the region in the 1970s and 80s. For Blaikie *et al.* (1996: 9-11), within the naturalistic paradigm natural disasters were seen as expressions of the “violent forces of nature” for which only mitigation responses were required, whereas in the more wide-ranging view of environmental determinism the most serious consequences of disasters were the expression of an underdeveloped stage in non-industrial societies, to be overcome through economic development. In the decades that followed, these concepts were increasingly criticised by authors influenced by political economy and political ecology. One important example of this is the authors linked to La Red (Red de Estudios Sociales em Prevención de Desastres em América Latina), such as Lavell (1996) and Cardona (1996). Another example is the work of the Argentinean geographer Claudia Natenzon (2003) who, influenced by post-normal science, combines four dimensions in her analysis of problems such as catastrophic floods in Argentina: hazardousness, exposure, social vulnerability and the uncertainties involved, the latter relating to limits both in the state of knowledge of the problem and difficulties regarding institutional powers and normative aspects. It is not by chance that all these authors, in their own separate ways, have developed integrated approaches that extend the social dimension of vulnerability: they are all confronted with the stark reality of the region, given that excluded populations in countries with a history of social inequality live in a state of “everyday disaster” in terms of their survival strategies in the face of precarious living and working conditions, which may severely intensify when natural or technological disasters occur.

The limits of vulnerability: Historical processes of “vulnerabilisation” and the concealment of conflicts and subjects

The approaches that have been cited and which deal with disasters recognise the central dimension of vulnerability resulting from social iniquities aggravated by economic processes

and public policies that disregard care for the populations most affected. However, in my view, despite all their advances there are three significant gaps in the theoretical matrix and methodological proposals of these approaches.

The first becomes evident when the theoretical framework does not explain the historical reasons for a certain social group becoming vulnerable or, in other words, the processes of “vulnerabilisation” in a particular territory and its population. The condition of being made vulnerable, rather than being vulnerable, in populations and communities is important if we are to redeem the history of processes which affect social groups and places in this way, and also to attribute to social groups the status of subjects who have rights that have been, or are being, taken from them (Acseirad, 2010). This gap may emerge, for example, when referring to the vulnerability of black people during Hurricane Katrina without referring to both the history of racism in the USA and urban planning in New Orleans, or also the unequal access to the most important resources needed to mitigate damage amongst the various social and ethnic groups (Bullard, 2005). Similar examples may be cited in relation to the vulnerability of traditional peoples (Indians, *quilombolas*¹ or traditional extractivist communities) affected by the construction of large hydroelectric plants in Amazonia, the urban populations affected by flooding in the Latin American metropolises, or even workers and residents living next to dangerous industrial zones, principally in emerging or peripheral countries (Porto, 2007).

The second gap is associated with the absence or lack of explicit reference to socio-environmental conflicts that define vulnerable contexts. In failing to acknowledge or make this explicit, these approaches to vulnerability tend to depoliticise the debate and emphasise the passive nature of populations facing “systemic,” unquestioned social characteristics (Loureiro, 2006) – or, as happens with certain relatively naive views, to assume that accepting the most appropriate logical arguments (since they recognise the emerging and reflexive complexity of humans) is sufficient to create the participatory processes and dialogue required to form extended peer communities. This is, in fact, one of the problems of a certain systemism which relates physicalist and ecosystemic phenomena to human and social issues that are typical of reflexive complexity with no historical or critical vision.

¹ *Quilombolas*: residents of communities (*quilombos*) founded by slaves who managed to escape from plantations [T.N.].

Normally environmental problems and vulnerable populations are submersed in a set of power relations involving political and economic interests that reflect disputes between different meanings and values that are related, for example, to the meaning of nature, life and death, to the access, use and distribution of natural resources, to economic investments and ways of distributing the benefits and damage resulting from these investments, to public policies and institutional practices – in sum, to the model and meaning of human and social development. Failing to recognise the existence of conflicts that emerge in territories, whether related to disasters or public health problems, may lead analyses of vulnerability to ignore the dialectical dimension of history and its “vulnerabilisation” processes, and to accept a disregard for vulnerable people and their status as subjects as “natural.” The problem with this is that the most substantive proposals for change are defined only in terms of the arguments and good will of decision-makers or leaders within the context of governments and public or private organisations in “collaborative” and depoliticised contexts that are blind to conflict or dissent, even when this is central to an understanding of the problem. In other words, confronting vulnerability essentially results from good governance and possible conflict resolution without discussing the grounds for such conflicts, rather than from the ability to mobilise, confront and gain ground on the part of those faced with disrespect or injustice as vulnerabilised people.

Finally, the third gap concerns the concealment or invisibility of vulnerable populations, or rather populations made vulnerable, and how they can be recognised and strengthened in their role as collective subjects with rights. One of the key elements of vulnerability, and also a dilemma and a contradiction within the concept itself, is that vulnerable populations frequently find themselves absent from the formal political arena and public debate within the hegemonic media. Alternatively, even if they are present, in contexts of extremely unequal power balance they remain absent in terms of real participation as political subjects who express opinions, denounce illegitimate practices and interests, demand solutions to their problems and propose alternatives. This is further compounded when the territory in question is a space that belongs to *nobody*, a non-subject not recognised as possessing rights, such as forests, mango groves and rivers where hydroelectric plants, mining and agribusiness monocultures are expanding, as can be seen in the Map of Environmental and Health Injustice in Brazil [Mapa da Injustiça Ambiental e Saúde no Brasil] (Porto and Pacheco, 2009). This invisibility can be understood more easily when vulnerability is

associated with specific conditions that prevent or make expression and political organisation exceptionally difficult, as may be the case with children, for instance. Nevertheless, they may be transformed into collective subjects through the intervention of women and mothers, as in certain paradigmatic cases of environmental justice movements such as Love Canal (Brulle and Pellow, 2006).

However, in the case of many environmental problems the populations involved consist of adults who have been discriminated against, excluded or disregarded as subjects. This often happens when their condition intensifies the socio-environmental conflicts resulting from power games by questioning the legitimacy of the means of appropriating resources and wealth, or the distribution of risks and environmental burdens in a particular territory and context. In these cases, the concealment or invisibility of such populations is deliberate, given that the inclusion of certain interests or values in the political arena may make it difficult for other hegemonic interests to flourish.

In other words, classifying certain populations as “vulnerable” may, in a paradoxical and ambiguous sense, represent a kind of consolidation of their status as non-subjects with no rights, whether they are exploited workers, ethnic groups who are the victims of racism, traditional populations such as Indians, extractivist communities or *quilombolas*, poor people living in urban peripheries facing multiple risks or, as Bullard calls them (2005), “environmental sacrifice zones,” amongst other population groups.

Environmental justice movements and their development in Brazil

Although the concept of environmental justice was originally formulated in the USA, it is important to note some aspects which differentiate its appropriation in other countries such as Brazil. According to Mitchell *et al.* (1992), three tactical options were pursued by environmental movements in the USA between the 1960s and 1990s, namely education, direct action and policy reform, and it was precisely through direct action in conjunction with the civil rights movements that expressions such as environmental racism and, later, environmental justice were coined. In addition, Cole and Foster (2001) observe how environmentalism in the USA is being reinvented on the basis of EJ movements organised by specific local and ethnic communities – “people of color,” as Bullard argues (2000: 101), who are particularly affected by the current environmental model – in the fight against the so-

called environmental racism. These movements recover and re-channel issues that are strategic to environmentalism, such as the development of technical expertise, the simultaneous capacity for coalitions and litigation and direct participatory democracy, characteristics that had already featured in the civil rights movements and other social struggles.

In Brazil and other Latin American countries, in contrast, discussions have from the outset placed a greater conceptual and political emphasis on the capitalist “model of development” and the region’s role in unsustainable and unjust international trade involving the appropriation of natural resources, as well as on the traditional and farming communities living on the borders of capitalist expansion using natural resources. This reinforces an important historical characteristic of the region: the historical pattern of social inequality and ethnic discrimination that creates environmental conflicts in Latin America is closely related to its involvement in the international economy as an exporter of raw materials and rural and metal commodities (Porto and Milanez, 2009). However, in both Brazil and the United States, environmental justice movements and theories give emphasis to a central dimension of the concept of social vulnerability and its reversal: the role of community-based organisation and political movements led by populations made vulnerable by economic projects or state measures.

In Brazil, one important landmark in the environmental justice movement was the launch, in 2002, of the Brazilian Network for Environmental Justice (RBJA) – information on its origins, goals and actions is available on the Internet at www.justicaambiental.org.br. This network is composed of representatives of various social movements, non-governmental organisations (NGOs), environmental bodies, trade unions, militant researchers, organisations of people of African descent and indigenous populations from throughout Brazil. The main task of the RBJA has been to bring together different social movements active in environmental justice, even though the majority had not adopted this expression until joining the network. Despite being initially formulated in the USA, the environmental justice movement has enormous political potential in countries throughout Latin America, in that it makes it possible to bring together campaigns for social justice and care of the environment. The main objectives of the RBJA include:

- Promoting exchanges and the sharing of experiences, theoretical reflections, contextual analyses and the planning of strategies for action amongst multiple actors

involved in environmental struggles, including consultancy work for affected groups by environmental, social science and healthcare professionals working with the network;

- Bringing together Brazilian researchers and social activists, and encouraging them to form partnerships for joint work;
- Creating national and regional agendas for research and action with the aim of confronting concrete cases of environmental injustice and drawing up political proposals and demands directed towards the state authorities;
- Linking human rights with socio-environmental conflicts resulting from new economic investment cycles and the appropriation by private enterprise of natural resources, leading to exclusion and expropriation.

The RBJA has mobilised numerous bodies, social movements and environmentalists to confront the pursuit of economic investments that are potentially destructive in various territories and workplaces. Amongst other investments, the following have been highlighted: the exploration and production of oil; mining and the iron and steel industry; the construction of hydroelectric plants; economic sectors producing and using highly dangerous chemical substances such as asbestos and POPs (persistent organic pollutants); the expansion of intensive monocultures such as soy and eucalyptus plantations, as well as the intensive use of pesticides, of which Brazil has become the main world consumer since 2009; and, more recently, the nuclear issue in relation to uranium mining and the plan for new atomic power stations. In all cases working parties have been formed to unite social movements, the populations affected, and environmental and human rights NGOs, as well as activist researchers who share their role in producing knowledge and new arguments for the political debate.

Vulnerability and environmental justice: From vulnerabilised to collective subjects in the struggle for justice

It is precisely because the contributions made by environmental justice offer the possibility of filling the previously identified gaps in the concept of vulnerability that I consider them to be important. They give a central place to the voices of the affected populations whilst also making explicit what and who loses or gains in terms of economic and social processes in

territories in which “vulnerable” populations live, particularly in the light of environmental degradation and the creation of hazards, including more severe crises such as disasters.

According to Acselrad (2004), one of the main principles of environmental justice can be found in its critique of the depoliticising concept which affirms that the causes and consequences of environmental problems affect everyone indiscriminately, regardless of social class, gender, ethnicity, colour or the area in which they live. As already stated in the introduction, EJ works with the idea that inequalities and discrimination in society are essential to understanding and confronting environmental problems. Without denying the importance of the contemporary environmental crisis, the contributions of ecology and the occasional progress offered by certain technological, organisational and economic proposals, EJ stands out as a counterweight and an alternative to the disrespect for human rights shown by some conservationist trends, as well the technocratic position and acritical faith in the solutions offered by eco-efficiency and the green economy (Martinez-Alier, 2002).

With regard to the first of the gaps identified, concerning the limits of the concept of vulnerability, various authors who study and cooperate with the EJ movements have analysed the historical nature of environmental problems through the principles of dispute and distribution in territories, in terms of both natural resources and the burdens of a social, industrial and commercial metabolism resulting from hegemonic models of production and consumption governed by market principles and unfair international trade practices (Acselrad, 2004 and 2010; Bullard, 2000; Martinez-Alier, 2002; Porto, 2007). In this context, the contributions of the critical social sciences, political geography, political ecology and economic ecology have been important both for building theoretical foundations and revealing historical and ongoing processes. One relevant example of the work of the environmental justice movements in Brazil which incorporate the historical element can be found in the disputes over natural resources, such as the use of water from hydrographic basins to construct dams for the big hydroelectric plants, as well as the land used for expanding agribusinesses. In the case of the former, the arguments presented by the movements and partner organisations have revived, amongst other aspects, the history of the exploitation and dispossession of traditional peoples such as indigenous populations and communities of African descent, and the material and symbolic dependence of these populations on nature, which is being rapidly destroyed by business ventures. They have produced a critique of the aims of electricity generation, which is heavily committed to

serving the extraterritorial economic interests of groups associated with agribusiness, the iron and steel and bauxite and aluminium industries, or even contractors involved in building infrastructures (Porto and Milanez, 2009).

In relation to the second gap, and as a consequence of the previous dialectical perspective, it is recognised that many environmental problems are marked by conflicts associated with such disputes, as well as by the suffering and fears of the populations affected. In other words, the conflicts created by the appropriation of natural resources and public space for specific purposes which generate exclusion, expropriation and injustices produce reactions from the social movements, groups and populations whose fundamental rights are affected, involving issues such as health, work, culture and preservation of the environment. Furthermore, environmental conflicts tend to become radicalised in societies marked by strong social inequalities and ethnic and racial discrimination, in addition to the imbalances in terms of information and power that characterise decision-making processes and institutional practices (Porto and Pacheco, 2009). In practice, these conflicts are expressed both in direct actions, such as those carried out by the movement known as *Justiça nos Trilhos* which, amongst other campaigns, has interrupted the passage of certain trains transporting minerals in the northern region of the country, and in the denunciation of decision-making processes in institutional arenas seen as invalid for not acknowledging and discussing of problems raised by vulnerable groups facing the most serious injustices. This may include both public hearings on the awarding of licences for activities which create impacts, such as forums, committees and conferences organised by government departments concerned with issues such as health and the environment. In theory these arenas should be democratically open to wider participation by members of society and dedicated to defining public policies, regulatory standards and guidelines for institutional practices. However, since they were created, the environmental justice movements in Brazil have faced the dilemma of whether to participate critically in these committees and conferences and institute change from within, or withdraw from them and present their criticisms from the outside without direct participation, due to the corruption, imbalances, and forms of co-optation that legitimise decisions counter to the EJ movements, or because of the excessive drain on political and personal resources resulting from participation (Porto and Pacheco, 2009).

Finally, the third gap, namely the invisibility and concealment of the populations affected and their interests, is considered a central issue by EJ, and therefore its most important concern is to organise the affected communities and groups with the aim of making them political subjects, as well as direct actions taken by them in the defence of their interests. In addition to actual political organisation, which may unfold on more local levels or in conjunction with national and international movements and networks, the development of new arguments and symbolic struggles has become strategic, in partnership with academics, militants, organisations and research groups. The actions and counter-arguments produced seek to delegitimise the discourses, practices and public policies deployed to defend hegemonic development models which overvalue the benefits of large-scale enterprises and the market economy, and conceal or make the environmental risks and vulnerabilisation of the affected populations invisible (Porto 2007). Countless examples may be cited of actions over the past ten years in Brazil that reflect the transformation of vulnerable groups into collective subjects with rights, given that EJ, by definition, materialises in practical terms essentially through the political organisation of the affected groups. One important example in recent years has been the campaigns against uranium mining in Brazil. The small town of Caetité, in the interior of the State of Bahia, has been the stage for numerous local movements organised into a network by the RBJA which have reverberated nationally, whether due to the reports that have been produced, such as the one recently written by the Environmental Law reporting coordinators at DHESCA Brazil (Brazilian Platform of Economic, Social, Cultural and Environmental Human Rights), or the direct action campaigns, such as the recent road block carried out by thousands of residents to prevent the passage of lorries bringing radioactive waste from the State of São Paulo to be deposited in Caetité. In addition to the as yet unclear issue of the impact of radioactivity on the water supply, the case also involves the work of farmers, the population's health and quality of life, and confronting the attitude of the public regulatory bodies and the company responsible for the mining, the state-run Indústrias Nucleares Brasileiras (INB).² The conflict has been aggravated by the fact that the main regulatory and supervisory body of nuclear activities in the country is an INB shareholder, and by the increasing mobilisation against the Brazilian

² See <http://www.oeco.com.br/noticias/25049-populacao-de-caetite-reclama-de-uranio>, consulted 14.03.2011.

nuclear programme, which envisages building numerous plants in the coming decades and is being questioned more intensively in the wake of the Fukushima tragedy in Japan.

Final considerations

The concept of vulnerability, since it is approached from different perspectives by specialists from various phenomenal “worlds,” may be considered strategic to the development of integrated analyses of complex problems that involve different dimensions – social, economic, environmental, cultural or health. Integrated and trans- or interdisciplinary approaches have been particularly influenced by political economy, the social sciences and ecology in terms of environmental and health problems and disasters. Some key questions may be raised when the concept of vulnerability is considered in relation to certain environmental problems and their consequences for the health of populations, including workers. In addition to operationalizing the concept by producing socio-economic indicators designed to aid our understanding of which population groups are most vulnerable in the face of certain dangers or situations, the discussion on vulnerability also introduces ethical and political questions into the debate. On the one hand, vulnerability must be recognised as part of the human condition, as should our capacity to confront it, thus highlighting certain essential questions that have pervaded the history of civilizations and cannot be answered adequately by modern science. A significant portion of the cultural, artistic, philosophical and religious production of humanity since time immemorial, ranging from the mythological Greek tragedies and mystical orders of the Middle Ages to the science fiction films and literature of the present day, is dedicated to the mysteries and existential dilemmas that in some way permeate the theme of human vulnerability.

However, in addition to this existential dimension, the concept helps to make explicit that what is at stake is not only the predictive and operational aspects relating to such groups, but the substantive and political nature of the actual risks and vulnerabilities – in other words, whether they are morally acceptable or not, how history has produced such conditions, and the social, political, cultural, economic, scientific and technological processes, amongst others, that may alter the dynamics of producing vulnerability.

In analysing certain environmental and social problems, it is possible to see vulnerability as the simultaneous expression and abuse of human freedom. In addition to being an

expression of the finite nature of the human being in the face of natural forces and life-death cycles, it derives from economic and technological development options and the power exercised by some human beings over others, or over nature. The affected populations resist and mobilise to defend their interests, and nature reacts and reinvades, as Bruno Latour put it, the closed and allegedly controlled world of science and laboratories, intervening in human and non-human life cycles. Unrestricted freedom, power, uncertainties and ignorance combine to increase vulnerability in modern societies, which, by developing their science and technologies, explain certain mysteries and bring many comforts. But opening up Pandora's box in situations of injustice and arrogance releases forces that prevent the exercise of this freedom and the creation of virtuous life cycles, particularly in territories, countries and regions with a lack of democracy, whose economic operations and decision-making processes in an era of globalisation do not acknowledge the interests, values and culture of local populations.

The perspective of political epistemology developed in this article enables the contributions of environmental justice to be understood in various ways. Making the issue of risk and the uncertainties of knowledge explicit removes the legitimacy of a specialist peer community defining, in isolation, the parameters of the problem and the arguments most relevant to decision-making. The link between this issue and justice allows for discussion of risks and dangerous situations that are morally unacceptable because they are avoidable, but are still imposed on groups which are socially more discriminated against and vulnerable. The notion of justice also encourages the development of joint supportive action involving various individuals and organisations that aim to transform this reality by recognising the role of conflict and the actions of vulnerabilised groups as collective subjects working for change. When a socio-environmental problem is analysed in a context of vulnerability, it is important to know that we are not alone: normally other people, organisations and social movements have already developed, are developing, or intend to develop knowledge and actions in relation to similar issues. In the academic field, supportive action highlights the relevance of engaged science and researchers who combine activism and knowledge production.

Another important current strategy for analysing and confronting more complex environmental problems, whether on a local, regional or global level, is organising social and intersectoral networks. These networks make it possible to share both the production and

dissemination of knowledge and joint actions in a collaborative and supportive way. Social networks may be understood as flexible structures which enable the construction of communities of practice by integrating channels of communication and strategies for action, establishing broader and more supportive commitments between individuals, social movements, institutions, and government and non-governmental organisations, organised around common causes. Networking helps us to think in a systemic, supportive and responsible way about responding to problems, whilst it also expresses more adequately the integral functioning of biological and human life, bridging ecological, social and ethical dimensions. The case of the Brazilian Network for Environmental Justice is a concrete example of this kind of production and action to reduce the enormous socio-environmental vulnerabilities that characterise contemporary societies, particularly those suffering from a serious lack of democracy and social inequality.

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