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Gert Spaargaren, Arthur P.J.Mol
and Frederick H. Buttel

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Self-organizing Complexity, Conscious Purpose and 'Sustainable Development'

Ernest Garcia

> Now, all right, let us say we are now paleontologists and we are studying fossil Bread-and-butter-flies and we wonder why they became extinct. The answer is not that they became extinct because their heads were made of sugar. The answer is not that they became extinct because they couldn't find their food. The answer is that they became extinct because they were caught in a dilemma; and the world is made that way, and is not made the linear single-purpose way. (Bateson, 1991: 279)

> Progress and Doom are two sides of the same medal (...) both are articles of superstition, not of faith. (Arendt, 1967: xxix)

> I expanded without time for proper planning, without any pauses to learn from my experiences or my mistakes or my contemporaries, without time for reflection. How then could I have turned out to be anything but a mess? (Rushdie, 1996: 161-62)

'Development', as this word is used in current social thought, connotes a handled process of change. 'Sustainability' refers to the maintenance of social life within the Earth's supporting capacity. 'Sustainable development', then, suggests an intentional and conscious control of the relationship between society and nature. This relationship consists of historical systems embedded in evolving environments. Conscious purposive behavior therefore implies adaptation and learning under conditions of constant change and unpredictability. There are then some conditions – of time and space – which shall be eroded if social interventions in the environment accelerate their pace and globalize their scale.

Connecting the idea of environmental viability to the general conditions of societal learning opens a way to delimit the scene where sociological analysis has a role to play in the debate about social progress and the continuity of life. Along this way, the question is to avoid reductionist, naturalistic lines of reasoning, without dissolving the ecological predicament in a more or less fashionable cultural mood.

Introduction: value assumptions and metaphors

I have never liked the term 'development'. It is too reductionist. It excessively simplifies things. Mechanical engines have been developed. Organisms 'have' a development too, but in a different sense. On the contrary, societies have a history, which is something rather different. In our *historic* epoch, distinctions in this regard are not frequently made, and something which, in politics and sociology, is also designated with the word 'development' seems to be a fundamental matter; on many occasions, it even seems *the* fundamental matter. However, I feel that human collectives do not have a development problem; their problem is to improve life, to get people to live with enough dignity and freedom. At most, what we call development may be a means to achieve this objective, a means which has turned out to be hypostatic. The era of development as a universal objective, with a planetary scope, is already five decades old. During that time, one out of five human beings has reached a material wealth unheard of. On the other hand, inequality and the number of victims of hunger has increased immensely to levels never known before and, in addition, the natural bases for the subsistence of the species have been damaged, maybe irreversibly. The presumed solution to the dilemmas of social evolution led to 'forms of "improvement" that impoverish and dis-empower' (Seabrook, 1993: 250) more and more people in more and more places. We should at least wonder if, after all, the means was not adequate.

I am not very keen on the word 'sustainability' either, as it replaces the eventual commitment with the beauty and diversity of life – and the beauty and diversity of the exchanges between societies and their ecosystems – by an abstraction which vaguely suggests the possibility of ruling these exchanges in a way unknown to us until today. It is acknowledged, at last, that some natural limits do exist. It is now accepted that – by ignoring those limits – we can jeopardize the material supply which permits the expansion of the industrial civilization. Then the question arises: how to sustain all that, both the supply and the expansion? The answer which seems to be succeeding first states that ignorance can be overcome through new 'sciences of the Earth', supported by artificial satellites and computers. The next step is to postulate that the exchange can be controlled even in extreme situations by means of sophisticated 'geo-engineering' formulas and 'eco-sphere management' techniques. Finally, the opportunity to engage in 'a battle to save the planet' is proclaimed. Such a battle, naturally, requires the urgent constitution of suitable major states which will soon demand full power. This looks more and more like a new cold war, inspired – like the previous one – by the principle of 'keeping at bay'. Keeping at bay nature and society, on the more or less blurred boundaries of the carrying capacity of the planet.

The combination of both terms ('sustainable development') is even more unpleasant to me. My feelings are obviously related to the suspicion that in this apparently promising concept the priority lies on the noun and not on the search for a true balance. The years of unstoppable rise of this expression, since the Brundtland Commission consecrated it up to the éclat provoking its current omnipresence at the Rio Summit, coincided with the initial stage of environmentalism as 'the highest state of developmentalism' (Sachs, 1993: 3). I believe this is not just an ideological and political contingency but something inherent to the concept itself, as I will argue in what follows.

In its contemporary use in social sciences, the term 'development' suggests a managed and controlled process of change. It usually includes the determination of the objectives of the process and also of the means considered adequate to achieve them. The word 'sustainability' refers to the maintenance of the economy within the limits of the carrying capacity of the ecosystems on which it depends. The 'sustainable development' notion therefore suggests an intentional and conscious control of the relationship between society and nature.

The attempt to adapt human beings to their environment by means of consciousness can be represented in several ways. However, there are two metaphors whose comparison is especially instructive. The first of them refers to the well-known image of the 'spaceship Earth', proposed by Boulding (1966). The spaceship has a crew and specific amounts of supplies and fuel. The crew member in command can – more or less – manage everything in an efficient manner. Indeed, a spaceship is a mechanism, that is to say, a system of linear relations which can be controlled if its structure and the laws which rule its dynamics are studied in detail. The second metaphor (not so well-known) was proposed by Bateson (1987: 449-50) and refers to one of the situations in which Carroll's Alice was involved: a croquet game in which a flamingo is used as a mallet and a hedgehog as the ball. Bateson described such a situation as a meta-random sequence of events subject to a second order indeterminacy. In this case, conscious control is impossible, and the finalist interventions, id est linear, are similar to trying to fix a clock by randomly nailing a pencil on its mechanism (Commoner, 1978: 40-41).

Both metaphors illustrate, in a sense, the basic difference between mechanics and life. In my opinion, the relationship between society and nature – two complex self-organizing systems – is better described by the second metaphor. The idea of a sustainable development suggests that it is reasonable for somebody to risk his or her neck in a game like the one described above as far as his or her pulse is firm and his or her will is not fickle. In other words, it tries to match the relationship of human beings to the rest of the living creatures in an essentially mechanistic epistemological framework, this being a systemic mistake.

Complexity, change, and social theory

Societies surely possess the basic properties of complex, self-organizing, and reflexive systems. Unlike a simple or mechanical system (for instance, a rocket or the solar system), a complex system (for instance, an organism, an ecosystem, or a city) cannot be described comprehensively by only considering its integrating parts or elements and the linear relationships among them. Self-organizing systems normally evolve into more complex states by increasing the information they contain. This evolution is possible because they are open systems, able to absorb low entropy (free energy and concentrated materials) from their environment or ecosystem, which – on the contrary – they simplify (or degrade). Human beings and societies are also flexible systems capable of learning, or of learning to learn. Societies can condensate nuclei (institutions) which accumulate information and a decision capacity (power) with a view to acting in a conscious, purposeful way.

The fact that living systems can only evolve by increasing the entropy in their environment has been widely known ever since Schrödinger's (1992: 62-75)

famous paper on the physical aspect of the cell was first published in 1944. Organizing systems are disorganizing systems too; that is to say, the term 'self-organizing' has no sense unless the system is in close contact and permanent interaction with an environment possessing available order and energy, so that it can manage to 'live' – somehow – at the expense of that environment. The other aspect of self-organizing systems is their high order and mysterious stability, which cannot be explained by the interchange of energy with the environment. Von Foerster (1991) maintained that autonomy, order, and stability can only be tackled if a separation between the flow of 'foods' and the flow of signs is established. This leads up to new distinctions: all living systems are organized in such a way that internal regularities and stabilization are produced; but societies, unlike organisms, organize themselves on the basis of language and individual autonomy. We experience this new dimension of operating coherence as consciousness, as 'our' mind (Maturana and Varela, 1988: 153). Organisms and societies are, then, opposite cases in the series of those meta-systems that are shaped by cell-system aggregation. Different positions in this series can be ordered according to the degree in which the components, in their existence as autonomous units, depend on their participation in the meta-system they compose. Organisms would be meta-systems with scarcely autonomous components, id est, with components having very few or no dimensions of independent existence. On the other hand, human societies would be meta-systems with highly autonomous components, i.e. with components having many dimensions of independent existence (Maturana and Varela, 1988: 132).

Language radically modifies human behavior because who operates in it can describe him- or herself and his or her circumstance, and then reflection and consciousness become possible (Maturana and Varela, 1988: 139-142). This fact is related to some social theory features, for instance: the impossibility to neatly separate objective from subjective dimensions; the fact that the way in which societies build up their own perceptions – and thus their own visions of social change – modifies the conditions in which the change occurs; the need not to consider only cause-effect relationships but also motivations and purposive orientations of the social action, etc.

The above mentioned distinction between second order couplings (organisms) and third order couplings (societies) leads up to some corollaries having a pure sociological content. The organism restricts individual creativity of its integrating units, as these exist for it; the human social system expands the individual creativity of its components, as it exists for these. As a consequence, those societies that stabilize all their members' behavior in a coercive way spoil themselves shifting to the form of organism (Maturana and Varela, 1988: 132).

Following the above sketched perspective leads to realize that only the recovery of random-ness, indeterminacy, plurality of responses, diversity, and history, makes possible a system with a survival value. In an isolated system, survival value depends on all the holes being closed, on the absence of questions; in an open system, on their being open, on the absence of answers (absolute answers obturating questions) (Ibáñez, 1992). 'Competition, exploitation and accumulation – contrary to cooperation, use and storage – have no survival value' (Ibáñez, 1990: 64).[1]

I would like to clarify what exactly is my point now. I do not think that current attempts to create a new science of complexity starting from building models which simulate the behavior of non-linear dynamic systems have a social theory as one of their outcomes. Indeed the constitution of such a general theory is rather doubtful and the present possibilities of applying it to social sciences are minimum (see Lewin, 1994; Waldrop, 1994). Instead of it, I am thinking about empirical features of reflective systems, and some of their negative, impossible implications, which impose limits to all conceivable descriptions of social change (and so to any concept of sustainable development). The dynamics of reflective systems are irreversible or asymmetric as far as time is concerned (societies never go back to a previous state). Then, they have a history, that is, the activity of the elements constrains the number of possible future states although they do not determine them. The future states are unpredictable in an inherent way, and there is a continuous emergence of novelties as a consequence of the indeterminist dynamics which combines gradual organizational changes with changes (which may be intense) due to disturbances. Finally, as information grows in the systems, the possibility of describing them by means of theories (id est a few basic laws) is reduced and, therefore, their comprehensive description is longer and longer (and may be exclusive to each society and non-applicable to others). As a consequence, theories of social change, rather than instruments for the accumulative production of facts or for the control of future events, are means through which the reflexive agents become more aware of their circumstances (Bohman, 1991: 234). The sustainable development debate cannot escape from these limits. The very notion of 'unsustainability' can provide a starting point in laying the foundations of this point of view.

Several meanings of 'unsustainability'

Concern about a development being sustainable has arisen because, in one way or another, people perceive the current trends of industrial civilization as unsustainable. However, 'unsustainability' means different things. This section considers four different meanings of 'unsustainability' (hence, of sustainability as well), from the nearest to the mechanistic paradigm to the more 'holistic' one. They are to some extent alternative, but my proposal is to consider them as being complementary, as different ways of referring to the same set of facts from different perspectives.

1. The meaning which is nearest to the mechanistic paradigm refers to the *exceeding of the carrying capacity.* Unsustainability, then, is the tendency to collapse caused by surpassing limits. This meaning is implicit in the usual environmentalist advice that nothing can indefinitely grow in a finite environment. In this context, sustainability implies that the physical scale of the social system, namely the totality of human bodies and their associated artifacts, and the metabolic flow of energy and materials needed to reproduce them, should be maintained under the natural capacity for supplying resources. Resources are sources of free energy and concentrated materials, and sinks for bound energy and sparse matter.

This point of view can be seen in the well known reports on the limits to growth (see Meadows et al., 1992). In this last book we find, on the one hand, calculations

related to the carrying capacity. The models worked up to accomplish these calculations are highly sophisticated, of course, and they illuminate substantial aspects of the human predicament. They do not need sociological inputs to be built. Population, capital growth and natural environment data are all that is required. On the other hand, moral and political recommendations are proposed, in an openly normative way. They are like commandments: develop visions!, build networks!, tell the truth!, learn!, love! (see Meadows et al., 1992: Chapter 8).

Malthus, whose legacy has been uncomfortable for so many sociologists, is the inescapable reference here. Reasons for discomfort are partly ideological. Malthus was a gloomy thinker, indeed. His work is full of symptoms of that cultural climate which has been described as a 'Western philosophy love affair with death' (Benhabib, 1996: 135). However, there are theoretical reasons too. A careful re-reading would possibly uncover forgotten dimensions of his work. But his recognized inheritance, alive in sociological tradition, has in essence only two aspects. First of all, calculations about the relationship between population growth and food production. Secondly, moral advises. Little room for social theory between these two pieces. Present-day followers of Malthusian tradition, including the most enlightened ones, derive socio-political rules from biological models.[2]

2. Unsustainability as the outcome of a catastrophic *imbalance in the co-evolutive process*. If one of the species 'at stake' receives a much too high energy subsidy, then that species imposes upon the ecosystem a radical simplification, a drastic bio-diversity loss. This has happened ever since the human species developed its special ability to oxide the 'necrosphere' (Margalef, 1991: 250) and to appropriate primary photosynthetic production on a large scale. Then, sustainability implies leaving enough 'room and food' for the creatures remaining.

This meaning is implicit in an article, widely quoted, by Vitousek and colleagues (1986). Its starting point is remembering that we need to take into account that human beings are not the only terrestrial consumers of solar energy captured through photosynthesis. It includes a calculation according to which almost 40% of the potential net primary production[3] over land is directly used, co-opted or lost due to human activities. It is directly used by the human beings and their domestic animals as food, fibers, or wood; it is co-opted in order to use the land for farming or grass for the cattle; it is lost as a result of urbanization, clearing up of forests, desertification, or over-exploitation. The population and economic growth demands an even greater appropriation of the products of photosynthesis.

The above mentioned article falls upon the debate about carrying capacity for human beings, of course.[4] But the point here is that it does not only warn about human beings, but also about the effects on other species (Vitousek et al., 1986: 368), outlining in its conclusions the possibility of 'extinctions that could cause a greater reduction in organic diversity than occurred at the Cretaceous-Tertiary boundary 65 million years ago' (Vitousek et al., 1986: 372). The subsequent loss of options for humanity would entail unpredictability and indeterminacy both in specific signs and in the time of appearance. The limits depending on the drastic reduction in the biological diversity which will take place – if the space is too crowded and the food scarce for the other species – are previous to those of the carrying capacity calculated only for human beings and 'their animals and vegetables'.

The co-evolutive approach allows a special kind of integrated social-natural theory, in which knowledge, organization, technology and values co-evolve with nature (see Norgaard, 1994: 27). However, Norgaard's view seems to imply a common framework of concepts for cultural and biological evolution: '...the well-being of people can improve to the extent that their ways of knowing, social organization, and technologies select for an evolutionary course of the biosphere which complements their values' (Norgaard, 1994: 39). Today this common framework does not exist. May be it cannot exist, as far as linguistic couplings and organic couplings are of a different order. In this sense, the co-evolutive approach can reduce sociology to a rather misty expanded ecology.[5]

3. Unsustainability as acceleration of *entropic degradation* as a consequence of too large or too intense production processes. This meaning is implicit in the proposition that nothing lasts forever, that no process can indefinitely endure in a finite environment. This perspective stresses the fact that industrial civilization has been possible thanks to an uncommon mineral bonanza not easy to repeat. It perceives, as fundamental limits, the extreme uncertainty surrounding the replacement of fossil fuels with more plentiful and less polluting new energy sources as well as the fact that materials cannot be indefinitely recycled. Then, sustainability tends to identify with conservation.

Georgescu-Roegen is the conspicuous representative of this perspective. Despite the fact that it is grounded in thermodynamic laws, it only can be developed by focusing on the social world. The point was introduced by this author stating that it would be absurd to think that the economic process exists only for producing waste; instead, the true product of this process is the *enjoyment of life*: '... the entropy reversal as seen in every line of production bears the indelible hallmark of purposive activity. And the way this activity is planned and performed certainly *depends upon the cultural matrix of the society in question*' (Georgescu-Roegen, 1971: 18-19, emphasis added). Georgescu-Roegen's 'sociological' contributions were rather scarce (1971: 292-316; 1977; 1984). This notwithstanding, it is easy to see that the 'cultural matrix' is not a mere corollary of the physical analysis in the debate on sustainability which can be derived from his approach.

4. Unsustainability as a *blockade of the societal learning devices*, as a consequence of an excessive acceleration and a much too high connectance. If the debate on the environmental crisis is more than a melancholic contemplative exercise it is because human beings are supposed to be able to learn and therefore modify their behavior by causes other than direct physical constriction. Now then, conscious learning has some conditions. Two of these conditions, which are very important, are time and availability of error margins. Learning requires time to select viable adaptations. It also requires places untouched by the effects of error, from where it can be corrected. Both conditions emanate from the basic fact that error is unavoidable. If the system accelerates too much, decision centers begin to make bigger and more frequent mistakes. If the system globalizes too much, if all of its elements are strongly connected, mistakes spread everywhere, and there will not be any alternative spaces open to eventually successful essays. In acceptance of this, sustainability is in maintaining flexibility, avoiding boundless acceleration and globalization in the system.[6]

Some features of the environmental impact of man-made chemicals are strongly related to the pace of their introduction and the time scale of their length in the

natural world. It is the case, for instance, of hormone-disrupting chemicals. Many of them resist normal breakdown and accumulate in the body. 'This pattern of chronic hormone exposure is unprecedented in our evolutionary experience, and adapting to this new hazard is a matter of millennia not decades' (C. Hugues, cited in Colborn et al., 1997: 81-82).

Similar concerns are often expressed when the possible effects of biotechnologies are estimated. For instance, one of these effects is the destruction of centuries-old, proved and viable local traditions of agricultural knowledge (Shiva, 1995). They are suddenly replaced by worldwide experiments whose effects, in evolution and history, in biology and culture, are mostly unpredictable. In these conditions, some worrying questions arise: how many experiments? at what pace? how global should they be?

The fourth of the above discussed meanings clearly allows for many relevant sociological contributions, because societal learning is always embedded in culture, organizations, and institutions. It is not so clearly the case for the other three. For instance, the 'limits-to-growth' meaning of sustainability requires two main elements to be established. On the one hand, calculations about carrying capacity (about maximum or optimum physical scale). On the other hand, ethical – perhaps religious – rules. No (or very little) social theory is needed. The 'co-evolutive balance' approach seems to require a unified framework for biological and cultural evolution, and then the basic distinction between societies and populations of organisms fades away. The analysis starting from the entropy law needs to take in the enjoyment of life – its unavoidable counterpart. Social construction of needs and other cultural processes should then be introduced. This is to say, if sustainability analyses carried out on the basis of the approaches which are closest to the mechanistic paradigm were able to solve all the problems in the environmental debate, then social theory would not have a distinct role in that debate .

I don't think this is the case. Substituting mono-cultures of timber for genuine forests could be perceived as being sustainable under the first approach, but not so under the second one. Combining intensive recycling with vast nature reserves could be sustainable from the point of view of biological balance, but unsustainable from the point of view of entropic degradation. Accelerated replacement of entropy by information could make some parts of the world sustainable under the general conditions of the third approach, but does not fulfil the learning requirements of the last. Through the following pages these shifts are developed in a more detailed way.

Beyond reductionism

The 'limits-to-growth' approach depends on the idea of sustaining or carrying capacity. The sustainability condition of the social evolution would then be that the physical dimension of the economy (including the 'sociomass', as Boulding (1995: 29) called the total mass of human beings and their associated artifacts, as well as the periodical throughput of energy and matter required for its reproduction) remained within the carrying capacity of the planet. For this perspective, the sustainable development notion is meaningful, although – once the maximum (or

optimum) physical scale is reached – reference could only be made to qualitative aspects (procuring more service from constant or decreasing energy and material inputs). In this context, the distinction made between growth as 'something getting bigger' and development as 'something getting better' (Boulding, 1995: 30) is relevant.

We will now take a respite. The idea that a material system can undergo important qualitative changes without altering its physical dimension seems rather bizarre to me. It may be backed, but it is certainly less obvious than what some of its defenders argue. As defended by many biologists, it may be true that the total mass of the biosphere has not been substantially altered during its evolutionary course, but to me it does not seem so easy to say that about any particular species. In general, in the living world, the notion of development seems to be extremely close to the ideas of growth and form, that is, to quantitative and qualitative variations (Tyler Bonner, 1992: xviii). I do think this requires further analysis with a view to discarding what cannot be maintained in the proposals of 'zero-growth' or 'steady state', due to an excessively idealistic vision. I shall not focus on this for the time being, though.

Apart from what has been said, there are two reasons for which the carrying capacity approach seems insufficient in my opinion. Firstly, the maximum scale cannot be determined (there is no way we can know when the flamingo's neck will bump into the hedgehog nor the direction which the latter will follow). Secondly, this approach does not resolve the problem of human needs (or in other words, although it permits to deal with sustainability to a certain extent, it does not say anything about society). Table 1 shows such an appreciation.

The left column is a combination of the sustainable development operational rules proposed by Kerry Turner (1988: 12-20) and Herman Daly (1991: 256).[7] The column on the right indicates what happens with such rules if applied in the only context where they are meaningful, as they are anthropocentric, id est a society where people believe it is worth living (why should it be sustained otherwise?). If we were to delete the terms 'desirable', 'needs', or 'equity', then both columns would be equivalent. However, we cannot rule them out, which implies the inevitable disappearance of the straightforward advantages of the environmental sustainability rules.

Maybe the core of the subject could be explained by stating that sustainability has to do not only with ecology but also with ethics, aesthetics, and politics, or – optionally – with a single word: mind, that annoying form of complexity.

Whoever may find so much concision extreme, may now be able to pay attention to a somehow more extensive argument. If we ask about the limits of the relationship between humanity and nature, we would start with the biological level, in terms of population and carrying capacity of the environment (as in numerous approaches which associate environmental problems to the population boom). The most serious defenders of this point of view do know that any calculations taking into account only the number of human beings have no meaning, and then they tackle the issue by saying that the impact caused by a human group on the environment results from three factors. The first one is the number of people, the second one is the amount of resources consumed by the average individual, and the third one is the environmental destruction rate caused by the technologies

which supply us with commodities. That is to say, Impact = Population x Wealth x Technology (Ehrlich and Ehrlich, 1993: 52).

Table 1 *Notions of sustainability*

Environmental sustainability	Environmental and social sustainability
1. Renewable resources harvesting rates must be equal or inferior to the capacity of natural regeneration of the ecosystems, and waste emissions must remain within the natural assimilative capacity.	1. The desirable level of exploitation of the renewable resources is equal or inferior to the capacity of regeneration/assimilation of the ecosystems, provided this permits the satisfaction considered sufficient of the needs and an acceptable equity level.
2. The exploitation of non-renewable resources must be as slow as possible, preferably using renewable substitutes and exhausting the most abundant non-renewable resources before their more scarce substitutes; the emission of pollutants must remain within the natural assimilative capacity.	2. Adoption of a desirable pace for the exhaustion of non-renewable natural resources, that is, the slowest pace compatible with a sufficient level of satisfaction of the needs of the human beings and an acceptable equity level in their distribution.
3. Technological change should increase the service derived from each natural resource unit consumed and should promote the substitution of non-renewable resources by renewable ones.	3. The technological change needs to increase the service derived from each natural resource unit consumed and to promote the substitution of non-renewable resources by renewable ones, within the framework of acceptable levels of consumption and equity.
4. The physical scale of economy must remain within the carrying capacity of the ecosphere.	4. The physical scale of economy must remain well under the carrying capacity of the ecosphere, in order to provide the necessary flexibility for the unpredictable social evolution.

As a matter of fact, it is not very practical to be aware of this if wealth and technology are afterwards considered as mere external variables. However, if both factors are internalized, the result is a debate which never comes to satisfactory conclusions (Tabah, 1995: 75-76) about the relative influence of population growth, technology, and consumption on the environmental deterioration. As a consequence of different technologies and levels of wealth, the inter-individual variability in energy consumption is so great that it is radically different from any other species. Hunters/harvesters need from 2,500 to 3,000 calories a day, north-American urbanites need at present 200,000 (Catton, in Jensen, 1995: 135). Should we conclude that they belong to different species?

In fact, depending on different hypotheses about technology and consumption, the estimations made on the carrying capacity of the Earth range from 1-2 (Pimentel et al., 1994) to 50 (Revelle, 1974) billion people, this being a conclusion which – as has been said – 'inspires little confidence' (Clarke, 1995: 42).

There is still a relevant human peculiarity. As long as non-renewable resources are extensively exploited, the question to be answered is not 'how much population?', but 'how much population and for how long?'. Additional annoying difficulties join the game, linked to the duration of a process which changes.

To sum up, if the population variable is analyzed in an isolated way, we will not get anywhere. And if we only introduce in the analysis a small portion of the real connections, then the apparent empirical advantage of the carrying capacity concept vanishes (Livi-Bacci, 1997: 224). This result has been acknowledged by many experts, who frequently say that the environmental problems are related to the growth of the human population in an indirect way and through various intermediate factors of a social, economic, and political nature.

The immediate step is to admit that the limits of the society/nature relationship depends on technological change (which may find a way to use materials or energy sources not exploited previously, that is, make them into resources). In human societies, biology is not independent from technology. A consequence of the latter – the proliferation of artifacts irrevocably associated to the human body – entails a considerable implication: some people can have exo-somatic extensions enormously bigger than others. Social inequality is now included in the analysis, or – in other words – there is no way to detach biology from technology nor sociology, nor politics. On the other hand, in the framework of the debate on conscious purpose and sustainability, the arguments about the carrying capacity are only interesting if – unlike any other species – human beings are described as being able to find, in their environment, a 'feeding' source and not exploit it until exhaustion. That is, if they are able to alter their structure of needs for reasons other than the existence or lack of means to meet these needs. We have now added the culture (values and myths also), without eliminating the previous levels. This is enough for now. I have just stopped at one particular point in my route (population) and I have gone through others very quickly, but it does not really matter where we start, as none of these interrelations can be avoided.

In Table 2 the column in the middle refers to the different mind/nature social mediations which should be taken into account. They are demographic, technologic, economic, organizational, political, cultural and symbolic. They are only *relatively dependent* on each other. *Dependent* because the starting point, wherever it can be located, is connected by multiple yarns to all the remaining levels. For instance, the notion of 'limit' that appears in the population-resources debate, built upon feelings of excess and guilt, belongs to the vast off-spring of the *hubris/némesis* dialectics, a mythical narrative which is omnipresent in Western culture (see Zoja, 1993). *Relatively* because each level is autonomous and can not be reduced to any other level. There is no way of deducing the symbolic world of *némesis* from any concrete historical experience of overloading natural environments. There is no way of forecasting the technical novelties which a social group will be able to produce by studying the endowment of natural resources within that group's reach.

Table 2 *Mind-nature social mediations*

	Nature		
S	compatible with biosphere	carrying capacity	tends to be unlimited
o	solar energy	energy supply	nuclear fusion
c	limited	substitution of production factors	very high
i	egalitarian	social structure	polarized
e	pluriversalist	political order	globalizing
t	orientated to sufficiency	structure of needs	orientated to affluence
y	harmony myths	constituting narratives	dominance myths
	Mind		

Source: Garcia, 1995b: 51

Each term from the columns on the left and right side represents a pole or extreme position in the autonomous field of problems arising at the corresponding level. For instance, the energetic alternatives to the fossil fuels issue has its own entity, it is not a mere corollary of positions chosen at the other levels, whatever they can be. The grouping of terms on the right or left side is significant only as a limit trend. From a theoretical point of view, a lot of different groupings could be conceived. In practice there are many 'bridges' and 'crossed paths'. For example, there are people who consider that population growth should be stopped, but not so economic growth. It is possible to imagine a solar *and* global age. Or anything else.

Sometimes a sharp edged alternative between eco-centric and anthropocentric visions is set up. This alternative is to some extent positional. It has something to do with the possibility of circulating through that complex semantic field. When the attention is centered upon human appropriation of photosynthesis, the adoption of an eco-centric point of view is not so difficult. To the contrary, if social perception of risk is focused on, such an association hardly could be spontaneous. Because of these positional shifts, anthropocentrism and eco-centrism are equivocal poles for the environmental dilemma. Neither outside nature nor completely inside it there is a place for civilization.[8] Civilization is rather eccentric. As much as social theory, of course.

The semantic field of 'sustainable development'

How does all this relate to sustainable development? Thinking about this also means taking into account specific forms of the above mentioned interrelations (Garcia, 1995a). Table 3 (p. 243) summarizes the issues at stake.

This table is in itself a drastic simplification. In despite of it, possible combinations of the varied items it contains would generate hundreds of meanings of

'sustainable development'. Sure, making sense of many of them would be a task doomed to failure. A fair amount, however, would conserve a reasonable look. Here they have been reduced to three, striving after minimum losses.

1. Sustainable development as sustained growth. Expansion of production and consumption should then be maintained, together with the consolidation of affluent culture and lifestyles. Reduction of inequality tends to be delayed until a wealthier future (only the growth permits redistribution). Global scale dependence tends to be strengthened. Technological innovation should assure solutions to eventual scarcities or pollution crises.
2. Sustainable development as qualitative improvement without increase in the physical scale, that is to say, as evolution of a homeostatic, steady-state or zero-growth economy. In most of its versions, state intervention should guarantee the generalized satisfaction of basic needs in a context of global interdependence. Transition to a solar age would drastically reduce the consumption of non-renewable resources, thus allowing many inter-resource substitutions.
3. Sustainability is always uncertain, submitted to the permanent necessity of adapting in random conditions. In order to gain flexibility, societies should liberate themselves from considering development as an objective instead of a means (in some versions, development is seen as being the cause of both poverty and environmental degradation). More integration of the economy into natural cycles should permit a fair satisfaction of basic needs. Sufficiency as a cultural regulator, and egalitarian community institutions interconnected by middle intensity relations complete the picture.

Columns on the table are ideal constructions, like sort of attractors in the abstract space of possibilities. Some current proposals coincide almost completely with one of these constructions, but most of them do not. There is nothing surprising about it: the different levels are only relatively dependent on each other; then, there are lots of cross-links between them.

Is there any way of reducing all that to a clear-cut programmatic rule? I do not think this is the case. Let us consider, for instance, the proposal which identifies sustainable development with using energy and raw materials in a more efficient way. The usual discourse says that sustainable development should improve the ecological compatibility, equity, and the satisfaction of needs. Nevertheless, the term 'improvement' refers to some assessment criterion which ultimately can only be the people's feeling that the society or the world in which they live is better than it was the previous year or whenever, and different groups can have different valuations, and so on. Fair enough, let us assume now that the historically dominant needs structure is such that people only feel improvement if their material wealth increases, as seems to be happening with most of the billion people who benefit from industrial civilization. Then sustainable development is an impossible dream and can only be summoned in the magical world of *abracadabra*.

The magic word already exists and – as it is the case with magic words – it belongs to a different language: *prodequisus!* (productivity, equity, sustainability) (Altvater, 1994: 220). Or, as the politicians – who should not utter abracadabras if they want to keep their serious appearance – are used to saying, the 'solution' is the simultaneous promotion of economic growth, social justice, and the protection of the environment. In this context, understanding that a reduced energy and

materials consumption is an improvement could mean – at least by now – eco-efficiency, the new motto by Schmidheiny (1992: 62-63) and his greenish executives. But it only makes sense in the short term (Von Weizsäcker et al., 1997: 357), because an indefinite path of increasingly immaterial economy is impossible. For instance, reducing by half the energy and materials per unit of output is difficult, but it seems plausible (and adequate, of course). However, a 'sustainable' growth on that basis would have to reduce also the material intensity in a sustainable way: a fifth, a tenth, a hundredth? I do not need to go on.

To sum up: the approach which argues that growth means increasing and development means improving will only be meaningful in the long term if the current idea of 'improvement' changes, that is, if we accept that a different cultural notion of 'meeting the needs' would be required. Basically it is a historic-cultural question. To the greater efficiency, we need to add an idea of sufficiency, because without it there is no way to round up the figures.

The story would not be very different if sufficiency, or population control, or solar power, or whatever, had been taken as reference points instead of efficiency. The analysis always stumble over a bundle of social mediations. There lies the task for a critical environmental social theory.[9]

Entropy, acceleration and instability

Let us comment on the last problem for the approach of the limits to growth (development without growth, in its latest versions). Despite all the reservations about it in previous pages, many of its warnings are – in my opinion – basically reasonable and realistic. However, there will always be people willing to remember that the Earth is not an isolated system but a closed system which exchanges energy, although not materials, with the external world; so that an abundant energy source could permit a reiterated recycling of materials and the development of costly engineering systems for the terrestrial confinement of material waste and the expulsion of energy waste (heat) into outer space.[10] Or in other words, there will always be people willing to renew – now under the sustainable development flag – the old idea that for a 'technological species' there is no limit to the economic growth related with the carrying capacity of the Earth.

In order to theoretically discuss the last point of view, we must appeal to a more refined and deeper version of the limits dilemma, like the one proposed and defended by Georgescu-Roegen. I cannot go into detail here, so I should just summarize it in the two following laws: no material process can last indefinitely in a finite environment, and no material can be recycled in an indefinite way.[11] The thesis derived from this (social life can only be maintained by reducing the capacity of the environment to sustain it in the long term) depends on the Entropy Law. From this perspective, the notion of sustainable development is essentially contradictory. It belongs to the same class as other useless old myths (the perpetual mobile or the immortal organism, for instance).

Table 3 *Semantic field of the debate on development and sustainability*

	Sustainable growth	Development without growth	Bioeconomic conservationism
Population	limited by the opportunities of the output growth	limited by the carrying capacity of the biosphere	limited by the carrying capacity of the biosphere
Energy supply	replacement of fossil fuels by more abundant and concentrated sources (nuclear fusion?)	replacement of fossil fuels by renewable energies, solar era	more participation of renewable energies, high uncertainty about substitution
Technology	high replaceability of natural resources by man-made capital	low replaceability of natural resources by capital; high replaceability of non-renewable by renewable	heterogeneity and, therefore, limited replaceability of natural resources by natural resources
Economy	monetary calculation of environmental externalities, integrated accounting	accountancy of the natural heritage in physical magnitudes, optimum scale calculations	political ecology, valuation of resources through social conflict
Social structure	only the growth permits some redistribution and reduction of poverty	equity by redistribution (centralized)	different forms of communitarian egalitarism
Political order	globalizing, liberal	globalizing, technocratic, centralizing	'pluriversalist', community-based, decentralizing
Structure of needs	affluence, mass consumption culture, regulation by momentary calming of the anxiety	sufficiency, austerity, moral regulation	sufficiency, rejection of extravagance, aesthetic and political regulation
Constituting narratives	myths of dominance, hubris (Prometheus, Faust, 'multiply yourselves and rule the world!')	myths of limits, (Icarus, Cassandra, aurea mediocritas)	myths of harmony (Goddess, Mother Earth, Prakriti)
Sustainability criterion	weak sustainability (intergenerational transmission of a constant or growing amount of natural 'capital' plus man-made capital)	strong sustainability (intergenerational transmission of a constant amount of natural resources)	quasi-sustainability as slowing down and deglobalization (parsimonious use of the resources with a view not to speeding up the unavoidable entropic degradation)
Vision of sustainable development	sustainable development as a new ('environmentally aware') expansive phase of the present industrial era	sustainable development as a new historic era of qualitative improvement without increasing the physical dimension	sustainable development as a self-contradictory concept (similar to the perpetual mobile and the immortal organism)

In my account, the bio-economic approach encompasses a pretty precise generalization of the material conditions of all social changes. The fact that society, like any other living system, can only evolve by increasing the entropy in its environment is now widely known. If the disorder introduced in the environment is very big, the system may enter a new adaptation form, consuming more energy (but also increasing the degradation of the environment even further). When this is applied to the contemporary debate on development and sustainability, we need to remember – at least – that there is no guarantee that an alternative power source will be found more abundant and less polluting than fossil fuel. In addition, we need to keep in mind that materials also run out irrevocably.[12] The conclusion drawn by this Romanian economist and mathematician is most reasonable: the only valid law in tackling the environmental crisis is conservation (and so it makes sense speaking of 'bio-economic conservationism').

The problem with the analysis starting from the second law is that it does not allow the making of sophisticated calculations nor brilliant formal models. On the basis of the entropy law, there is no technical way to decide whether a particular production rate is sustainable or not. Georgescu-Roegen was aware of that. He said, in a rather abrupt way, that the entropy law 'does not help an economist to say what precisely will happen tomorrow, next year, or a few years hence'. We only can be sure – he added – that 'any use of the natural resources for the satisfaction of non-vital needs means a smaller quantity of life in the future' (Georgescu-Roegen, 1971: 19-21). Doubtless, the application of this criterion on specific and immediate contexts inevitably leads to an undefended direct exposure to abstruse and intricated moral dilemmas.

There is, however, an aspect related with all this which permits us to take a step further. A system depending on growing energy inputs becomes more unstable. Anybody could now adduce that this situation is creative. As it is indeed, but nothing allows us to say that frantically emerging novelties are really what we are interested in from the particular perspective of the human species. We can now approach the subject from a somehow different point of view formulated by the astro-physician Peter Kafka (1993: 346), who has suggested that the environmental crisis is basically a matter of speed and globalization. This point of view assumes that access to low entropy sources and sinks for high entropy waste are essential prerequisites for social life. It accepts that unsustainability has to do with entropic degradation as a destructive consequence of current practices in using raw materials. That is to say, it does not deny the conclusions of bio-economic analysis; it simply adds a dose of space-time concretion to this analysis (although it does not transform it into a *calculable*). More necessary conditions have to be taken into account: 'The time-scales and the degree of diversity in the process of trial and error are decisive for the probability of "success"' (Kafka, 1993: 346). And so, a new notion of 'limits' arise. According to this new notion, a system turns unsustainable if (a) it accelerates excessively, having no time to select the most feasible adaptations; if (b) it is too global, that is, it is unable to fail in some of its parts surviving in others, and so it risks everything at the turn of a card. A conscious control or management device in such a context is doomed to act tentatively, to make bigger and more frequent mistakes. If – in addition – the control center is connected to the most remote parts of the system and if it even has a powerful

technology (Bateson, 1987: 440) capable of intensely or deeply altering the ecosystem, then we have all the ingredients for a major disaster.

Let us consider acceleration. A society becomes unsustainable when it has more and more new options at shorter and shorter intervals. When – for instance – it introduces thousands of new chemical substances into the natural environment every year, or when the same begins to be done with thousands of genetically modified organisms. This is not exactly the same excess as that in the physical scale, and it is not even equivalent to entropic increasing, although the similarity here is important. We are instead dealing with an essential failure of the information system, with a powerful error-amplifying device.

The preceding comment suggests that sustainability would be, if anything, slowing down, parsimony (or in cruder terms, less development). A seemingly paradoxical conclusion, as far as many reports on the environment indicate that there is little time before the environmental balance is damaged dramatically. In other words, the reports describe a situation which apparently demands urgent and quick actions. The answer to the dilemma is that there is not such an urgency to do things, but to leave them undone, or – as Walter Benjamin put in his metaphor – to press the emergency brakes.[13] There are two conceivable social answers to the over-heating of the Earth, for instance. The first one is to drastically reduce energy consumption. The second one is putting into orbit gigantic mirrors to reflect a part of the incoming solar radiation, inserting aluminium balls in the stratosphere (for critical remarks, see Rosenberg and Scott, 1994: 59-60), injecting carbon dioxide in the oceans and geological containers (Dessus and Claverie, 1995), or to keep it frozen in hyper-fridges (Fritsch et al., 1994: 108-121). Only the first answer (non-action route) allows for a reasonable hope in at least not generating more problems than solutions.

In contemporary sociology, it is constantly said that we are living a time of intense and fast changes. But there is a lot of confusion in this perception. Instead, we should say that this era prevents social change, as changing takes time for detecting and correcting the mistakes. As pointed out by philosophy of science, the mind can discover error, but not truth. An excessively accelerated system loses this quality and becomes rigid, unable to develop the flexibility which is needed for selecting viable novelties.

Naturally, the previous observation is also anthropocentric. Something will always happen. Something will also happen to an accelerated system, even many things. The thing is we were talking about intentional and conscious answers, and if the speed is too fast, answers can be intentional (and in fact they probably are because they are human) but – let us put it this way – they are less and less 'conscious'.

Globalization and diversity

I would like to propose a reflection about a shrewd comment on his own astronaut metaphor which Boulding made years after he first formulated it. We quote: 'The most worrying thing about the Earth is that there seems to be no way of preventing it from becoming one world. If there is only one world, then if anything goes wrong, everything goes wrong. Also by the generalized Murphy's Law, every

system has some positive probability, however low, of irretrievable catastrophe' (Boulding, 1993: 312-313).

Boulding said this keeping the analogy, that is, applied to an 'Earth-Machine'. But this is even more worrying if we take into account that the Earth is not a machine. He felt this as well but did not draw all the consequences:

> Perhaps the greatest weakness of the metaphor is that the spaceship presumably has a clear destination and a mission to accomplish. It is essentially a planned economy. The evolutionary process, however, is not a significant planned economy any more than an ecosystem. The biological ecosystem is not even a community, in spite of the fact that biologists sometimes call it that, it is the wildest example of free private enterprise and does not even have a mayor. (Boulding, 1993: 313)

It is striking that – in our time, when nobody dares defend the planning of the economy and when it is a commonplace that planning replaces random by error – there are so many people willing to support an idea of sustainability which implies the planning of nature, let alone, a global planning. After all, plans made for society – despite not having been very bright until now – can be conceived in theory. The mind, the system which has turned reflexive, can aim at a certain level of self-regulation (provided not too many new options are imposed at the same time). But it cannot aim at regulating life, upon which it is dependant, since the part cannot entail the whole.

In nature, reduction of diversity takes place in accelerated renewal processes, which does not fit too well with the parsimony co-substantial to sustainability. On the contrary, a very large diversity is found in systems which preserve little energy for the changes and which – despite their stable outlook – are highly vulnerable to external impulses. Therefore an intermediate level of diversity seems appropriate in front of evolutive errors. The idea arises that globalization of economy, centralization of power, and cultural unification, are inherently anti-environmental and consequently not recommendable as suitable structures for environmental performance. In line with this, the 1970s environmentalism did defend decentralization to a great extent. Nowadays, the climate is changing – excuse the joke! – and the tendency seems to be rather different. Some arguments are usually accepted without much discussion, for instance: '...many environmental problems transcend the local level, and some of the more intractable ones are global in scope. Institutions of scale appropriate to deal with such issues are necessary' (Dryzek, 1992: 37). Even Arne Naess (1995: 404) is riding the wave, and defends the adoption of a new motto: 'Think globally, act globally'.

The environmental motto used to go: 'think globally, act locally'. Today, we frequently hear about 'global government' or 'global control'. But both government and control are relative to action, not to thought. In the really existing globalism, the usual trend is to invert – and pervert – the old motto, transforming it into 'local thought and global action'.

Somehow, this discussion has always been confusing. The expression 'think globally' referred mainly to a certain capacity to see beyond immediate interests, to consider oneself a part of a whole with the people of the future, and with the rest of the living beings. I will mention here a passage by Naess himself, as an example. When he wanted to illustrate what global thought actually meant, he wrote

down an answer given by a member from an indigenous community to somebody who asked about his opposition to the construction of a dam in the land which traditionally had belonged to his people: 'This place is part of myself' (Naess, 1995: 404). Note he said 'this place' and not 'this world', which – by the way – is very reasonable, as semi-gods capable of having the world in their heads are rarely found.

The advice to act locally was also quite sensible, if we take into account the possibilities of the average people to whom it was addressed. Of course, one could allege that all actions affect the Earth and therefore everybody always acts globally. Although this statement cannot be sustained (the systemic principle that everything is related to everything else must not be interpreted too literally, as in the world only a part of the possible relationships actually become effective), we can admit it in the discussion. Then some individuals are more global than others: they hold more power or they have longer arms; the relations are asymmetric.[14] They are asymmetric in their material dimension: some populations depend almost exclusively on local resources and therefore degrade the local environment, whereas others are nearly exclusively based on external resources, causing degradation everywhere. They are also asymmetric as to information: there are no Latin American networks advising, for instance, on how to deal with the Canadian forests (Gudynas, 1993: 173). As a result, the truly existing globalization tends to discriminate the perspectives and interests of those who have less power (this was, for instance, the general feeling of the women who attended the Rio Summit) (Venkateswaran, 1995: 219).

The so-called 'global environmental change' is – to a great extent – an ideological construction, at least as far as the problems and the institutions which deal with them are concerned.

The way in which problems are presented sometimes results from an 'arbitrary pattern of global labeling' (Buttel and Taylor, 1994: 237). A simple look at the usual lists is enough to realize that reality is much less schematic than suggested by the summary 'environmental problems are global'. Climatic change has to do with 'global commons' – greenhouse gas sinks – but in its predictable effects there is a great geographical diversity, and even the appraised temperature rise is just an average value. And of course, if we were to consider the causes instead of the effects, the diversification is even more obvious. Indeed, large oil or automobile companies have a global reach, but this globality has very little to do with the diffuse responsibility patterns which are normally associated with the sentence 'this problem is global'. The same could be applied to the hole in the ozone layer. In fact, if any progress has been made at all in this field, it is because there were just a few large producers of CFCs. The most pugnacious global element in the bio-diversity debate is the bio-tech companies' wish to have free access to the genetic reserves all around the world. Similarly, there is not a lot of globality, except for the fact that they spread everywhere, in industrial pollution, desertification, soil erosion, scarcity and loss of quality of fresh water, etc. The 'globalizing' presentation of the environmental crisis has more to do with other things: it permits to concentrate on the symptoms instead of the causes (which favors the apparent consensus and makes the political 'management' less conflicting); it permits to simplify and gives a somehow controllable outlook to the agenda (something convenient for all the participants in the 'global environmental com-

plex', from governments to news super-agencies, or different international organisms, corporations and large NGOs). All this involves a shifting of the gravity center which is not only ideological: in Rio, a meeting was held on the climatic change but not on the automotive industry; desertization was discussed but not beef farm-factories, etc.

Similar things could be said about the suitable institutions. The management of commons (even if they are global, as the atmospheric carbon dioxide sink) leads to a debate on hierarchy and mutual support. Theoretically, this management could be approached from a center with separate power or by means of a set of reciprocity rules (like those which permit the sustainable use of resources in numerous small communities which elude the tragedy of the commons through a communal management, without having to delegate on any eco-Leviathan). I do not think there is a clear way-out to this dilemma (and basically, I do not think there is just one way-out). In any case, it may be worth remembering this diversity of options (Keohane and Ostrom, 1995: 21) in order to try to move the debate away from the polarization 'world state or uncooperative anarchy', which excludes many intermediate possibilities for a more or less institutionalized cooperation.

The results of taking into account these dimensions of the subject would blend some of the sociological attempts which, by accepting the ideological framework of globalism, reduce the social content of the environmental crisis to a conflict in which the global capitalist system (made up with transnational companies, the transnational capitalist class, and the consumption culture-ideology) is threatened by an enemy who, being weaker though not less ambitious, turns into a 'global environmentalist system' (Sklair, 1994: 207) (with the corresponding elements: transnational environmentalist organizations, transnational environmentalist elites, and an environmentalist culture-ideology). The excessive schematism of this giants-fight should be sufficient by now, at least, to moderate its ambitions.

Ending remarks

In the previous comments, there is plenty of political and cultural critique. I do not think this polemic impulse should be repressed, not because a more abstract and 'neutral' formulation is not possible. In fact, all which has been previously said could be summarized by saying that a system depending on growing energy inputs tends to extreme instability forms and, if it only contains one evolutive line then the instability will be fatal. However, if the analysis outlined in the first part of this paper is right, the specific system I am talking about is a very particular one which cannot detach its energy consumption from its ghosts. What we could call the 'emerging paradigm of sustainable development' – greenish version of the end of history – seems to be prisoner to the basic myths of the European patriarchy, of a pact with the devil in return of knowledge and dominance over the world. A transaction, as everybody knows, whose payment cannot be deferred in a 'sustainable' way.

The beneficial effects that could perhaps be derived from following the old environmentalist advice (scale down, slow down, democratize, decentralize (Roszak, 1993: 312)) are undoubtedly excluded, despite its promises, from the new program which announces the sustainability of development by means of more

energy, more megatechnics, and more concentration of power. Combining social betterment and the continuity of life is not exactly a problem, it is rather a dilemma proposed by a sphinx. Let us put it in a different way: it is the re-establishment of history.

Notes

1. The Spanish sociologist Jesús Ibáñez did a creative profound work on this line, mainly on epistemology, research techniques and sociology of consumption. In the last years of his life, he had an interest in environmental matters and he proposed a sociological framework defined by three characteristics: a) it is *ecological*, i.e. because of the fact that every open system exists in an ecosystem, the survival unit (as well as the object of knowledge) is not the system but the circuit between system and ecosystem; b) it is *global*, with this word meaning 'a system cannot survive if all its related ecosystems do not survive'; c) it is *complex*, i.e. it goes from elements to the whole, it integrates randomness (dis-order, noise), it informs of singularities, and it includes the observer into observations – since the object is a product of a subject's objectifying action (Ibáñez, 1992).
2. See, for instance, Hardin (1993). There is, in Hardin's book, an important exception to his overall reductionist drive. Although commons must be managed, different schemes to manage them (market, state, community) can be socially established. His theory has no answer to the query about the best system of distribution (Hardin, 1993: 218-220).
3. The net primary production is the amount of energy which remains after having subtracted the respiration of primary producers (mainly plants) from the total amount of energy (most of it being solar) which is fixed biologically, and it 'provides the basis for maintenance, growth, and reproduction of all heterotrophies' (Vitousek et al., 1986: 368).
4. Although the authors display the usual reservation and clarify that the information they supply cannot be used directly for the calculation of the long-term carrying capacity for human beings (as it also depends on consumption and technology (Vitousek et al., 1986: 372-373)), it is obvious that they provide a powerful argument in favor of the less expansive forecasts and therefore in favor of population control: a society with a low consumption and not a very sophisticated technology but very dense would not be sustainable either.
5. However, it also has to be said that other aspects of Norgaard's book hint at combining several approaches in 'a co-evolving patchwork quilt of discursive communities' (Norgaard, 1994: 172).
6. In my opinion, the best formulation of the theoretical bases of this point of view can be found in Kafka (1993). With other grounds, many members of the so called 'culturalist school' work on lines which refer to the learning approach.
7. There is a remarkable difference between both sources: Daly proposes a rule for the use of nonrenewable resources according to which their consumption should be established by the pace set by the development of renewable substitutes. On the limit, only a strictly solar civilization would be sustainable, that is, a civilization using exclusively solar power and biospheric materials. I think this is too extreme a proposal. There has never been (and there will probably never be) a solar civilization in this sense. Civilization is near synonymous to nonrenewable resource consumption. Therefore, a parsimony rule – like the one proposed in the table – seems more plausible. A second difference is that Daly insists more on a rule with global scope, according to which sustainability means to remain within the carrying capacity of the biosphere. Simplifications embodied in operational rules for environmental sustainability are surely the outcome of a

conscious purpose in their proposers' mind, motivated by polemic and pedagogic reasons, and cannot be found in other arguments by the same authors. In fact, I totally agree with the latest Daly's programme: 'the most pressing need is to stop the exponential expansion of this subsystem boundary under the current regime of economic imperialism – but without falling prey to the seductions of ecological reductionism' (Daly, 1996: 12).

8. Some of the texts of Hannah Arendt contain valuable insights into this question. She turned down the idea of finding a place totally outside the natural world (1977: 280). On the other hand, by stating that freedom depends on a complex articulated society, on such an artificial social construction as 'a republic with a constitution' (see Young-Bruehl, 1993: 511), she rejected the nostalgia for the return to an imaginary 'natural community'. The criterion that comes off, that civilization implies to overcome the naturalism and also to impose limits to the hubris, constitutes a quite fruitful formulation of the social conditions of sustainability.
9. You may have probably noticed that – so far – the argumentation of this chapter flows totally separate from the thesis which states that there is no problem in getting wealthier because then there will be more resources for the cleaning of the environment (post-industrialism) and a greater social willingness to do so (post-materialism). It is obvious that this is only meaningful, and only partially meaningful, if the portion of the product devoted to make up for the environmental damage is small. If such a portion increases a lot (let us play the numbers game again: up to what? 10%, 50%, 90%?) then the assumed wealth would be undermined and canceled. This is more or less what Jim O'Connor (1991) noted in his thesis on the second contradiction or the growing cost of supplying the natural conditions of production.
10. One of the attempts in this regard – probably the most ambitious – is Fritsch et al., 1994 (see Chapter 3 and 4 especially).
11. Georgescu-Roegen's classic, *The Entropy Law and the Economic Process* (1971), is a compulsory reference. The controversy caused with what he called 'the energetic dogma', that is, the belief that no materials scarcity will impose limits provided there is abundant energy, was developed in different works (see Georgescu-Roegen, 1975, 1979, 1982a, 1982b).
12. Georgescu-Roegen's conviction that 'matter matters too' led him to the formulation of an entropy law for materials (the so-called 'fourth law of thermodynamics'), according to which matter, the same as energy, exists in available and unavailable qualities, and it is also subject to irreversible degradation (1993: 197). Many critics of this idea have disregarded its economic, anthropomorphic context, and they have perceived it, at best, as a blurred extension of the second law. Well, perhaps it is not a good physical law, but it is sensible to take it into consideration as a good economic law, as it may be known by anybody familiar with already existing experiences of recycling.
13. Riechmann (1991) is a contribution to the current debate on the environmental crisis – more concretely, to its political dimensions – inspired by Benjamin's metaphor.
14. Giddens, for instance, supports that 'at present, everyday actions of the individuals have global consequences'. He describes worldwide trade as the main indicator of interconnectance, illustrating this idea in the following way: 'My decision to buy a particular clothing item, for instance, or a specific type of food, has many global implications' (Giddens, 1995: 57-58). But then, it makes sense to say that consumers are 'more global' when they are 'more affluent' (in a double sense: they have more money to buy things and a greater diversity of options).

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