EDITORIAL

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Sustainability in the Twenty-first Century

It is well established that there is a differentiated historic responsibility in the progressive erosion of the bio-geo-chemical systems that support life on the planet due, principally, to the action of human beings. The damage has reached such a degree and global spread that many are beginning to talk about a new geological era: the Anthropocene (Crutzen 2002).

These impacts have been generated, by and large, under the dominant social productive relationships; that is, according to a logic that stakes everything on infinite growth on a finite planet.

As a result, we observe greater and increasingly asymmetrical patterns of consumption, provided by production methods with a great social and environmental impact. In the XX century, while population grew about four times, average global energy consumption shot up twelve times, metal consumption 19 times, and construction materials 34 times (in the case of cement) (Krausmann *et al.* 2009). This entailed, at the beginning of the XXI century, the extraction of between 48.5 and 60.0 billion tons annually (of which a third were biomass, 21 percent fossil fuels, and 10 percent minerals) (Krausmann *et al.* 2009), while the richest ten percent of the population controls 40 percent of the energy and 27 percent of the materials (Weisz and Steinberger 2010).[1] This extraordinary increase in humanity's demand for resources and energy has caused great transformations in the ecosystems and in the physical and bio-geo-chemical cycles on local and global scales, the consequences of which have not yet been fully determined.

Together with these growing production-consumption patterns, the generation of waste has also increased; the data on collected municipal solid waste (the most complete information on waste generation available) are useful for a

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1 This is a level of consumption by humans calculated on the same scale as the principal global flows of materials within the ecosystems, such as biomass produced annually (Krausmann *et al.* 2009).

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preliminary approach.[2] In just half a century, the generation of this type of waste quadrupled from 360 million tons in 1960 to 1,160-1,300 million tons in 2010/2011 (Lacoste and Chalmin 2006; Hoornweg and Bhada-Tata 2012), a figure that could double again in 2025, considering that 2,200 million tons annually are predicted for that year (Hoornweg and Bhada-Tata 2012).

Rates of exploitation and erosion of nature have been studied from the point of view of *planetary boundaries*, or "limits" of anthropic disturbance of the planet Earth's critical processes, which, if they were not perturbed, would result in a relatively safe operating space for human life.

The frontiers are not necessarily breaking points, but rather red lights that should cause society to react and take the necessary actions to prevent the transgression of these limits, which have been developed within the framework of the precautionary principle. Planetary boundaries are conceived as a safe operating space for humanity based on our evolving understanding of the functioning and resilience of the Earth System. Planetary boundaries are not equivalent to a global threshold or tipping point, it is rather the final "safe" end zone of uncertainty, meaning that their transgression doesn't mean that they will generate undesirable consequences immediately; what is clear, however, is that the more the frontier is violated, the greater the risks of regimen changes, destabilization processes within the system, erosion of resilience and, consequently, less opportunities for applying effective measures to prevent or contain a regimen change. Steffen *et al.* (2015) point out sensibly that "…it would be unwise to drive the Earth System substantially way from a Holocene-like condition".

Steffen *et al.* (2015) suggest that there are two levels of planetary boundaries. On the one hand, they propose Climate Change and Biosphere Integrity as core boundaries that, on their own, have the potential to change the operation of the Earth System. On the other, they identify several boundaries with the potential to affect the quality of human life and at the same time influence the core boundaries; however, on their own they couldn't cause a new state of the Earth System.

Climate Change and Biosphere Integrity are phenomena that emerge systemically, and closely linked to the rest of the planetary limits; thus, their relevance and critical character.

Table 1 shows identified ecological planetary boundaries, their state before the use of fossil fuels, and at the beginning of the Twenty-first century.

2 We consider that municipal solid waste represents between a quarter and a third of the total waste generated (including waste that enters the illegal flow of final disposal, toxic and other types of waste that require special handling and that are not considered municipal, etc.).

Table 1. Planetary ecological boundaries.

Planetary boundary	*State before 1850*	*Proposed boundary*		*Present state*
		Rockström *et al.* 2009	Steffen *et al.* 2015	
Climate change*	280 parts per million	‹350 parts per million	‹350–540 parts per million	396.5 parts per million
			Energy imbalance +1.0 Wm^{-2}	2.3 Wm^{-2}
Change in biospheric integrity		Loss of biodiversity (10 species per million)	Genetic diversity (10 species per million, with an aspirational goal of 1 per million)	100 species per million
			Functionality of diversity (90% intact biodiversity index)	84% (based on southern Africa only)
Stratospheric ozone depletion	290 DUs***	276 DUs	‹5% reduction from preindustrial level of 290 DUs (5%–10%) assessed by latitude	283 DUs (Rockstrom *et al.* 2009); only transgressed over Antarctica Austral spring (–200 DUs; Steffen *et al.* 2015)
Ocean acidification**	3.44 Ω arag**	2.75 Ω arag**	≥80% – ≥70% of preindustrial aragonite saturation state of average oceanic surface	290 omega Ω arag (Rockström *et al.* 2009); about 84% of the preindustrial aragonite saturation state (Steffen *et al.* 2009)
Nitrogen biochemical cycle	0 tons yr^{-1}	35 million tons yr^{-1}	62 Tg N yr^{-1}	121 million tons/year (Rockström *et al.* 2009); about 150 Tg N yr^{-1} (Steffen *et al.* 2015)
Phosphorus biochemical cycle	1 million tons yr^{-1}	11 million tons yr^{-1}	Global cycle not greater than 11 Tg P yr^{-1}	8.5–9.5 million tons per year (Rockström *et al.* 2009); about 22 Tg P yr^{-1} for the global cycle and about 14 Tg P yr^{-1} for the regional cycle (Steffen *et al.* 2015)
			Regional cycle not greater than 6.2 Tg yr^{-1}	
Land-system change	Low	15%	Original forest area on a global scale (75–54%) and forested land as a percentage of potential forest as part of a biome (tropical: 85–60%; temperate: 50–30%; boreal 85–60%)	11.7% (Rockström *et al.* 2009); 62% (Steffen *et al.* 2015)

Table 1. Planetary ecological boundaries (continued...)

Human use of freshwater (alteration of water cycle)	415 km³	4,000 km³ yr⁻¹	Global use of 4,000 km³ yr⁻¹ and monthly withdrawal no greater than 25–55% at basin level in low-flow months; 30–60% in intermediate flow-months, and 55–85% in high-flow months	2,600 km³ yr⁻¹
Atmospheric aerosol burden	——	——	Global Aerosol Optic Depth (AOD)	0.30 AOD in the southern Asian region
			AOD as seasonal average for a given region (Study case, monsoons in South Asia)	
Introduction of novel entities	Non-existent	Unknown****		Unknown****

Source: Compiled by the authors, based on Rockström *et al.* (2009), "Planetary boundaries: exploring the safe operating space for humanity". *Ecology and Society*. Vol. 14. Nº 2. Article 32; Steffen *et al.* (2015). "Planetary boundaries: Guiding human development on a changing planet". Sciencexpress. DOI: 10.1126/science.1259855.

* It is estimated that, as from 1751, 337 billion tons of carbon have been emitted, exclusively by burning fossil fuels.

** A reduction in the value means an increase in acidification. The figures represent the state of aragonite saturation.

*** A Dobson Unit, or DU, is the equivalent of 0,01 mm. depth of the ozone layer in normal pressure and temperature conditions.

**** There are no indicators that might enable us to measure this type of pollution in a standardized way, although there are some methodological proposals for specific toxic substances. Some of the substances singled out are persistent organic polluting substances, plastics, endocrine disruptors, heavy metals, radioactive waste and nanomaterials.

The sustainable development dominant discourse

Considering the undeniable environmental crisis that was deeply evident in the second half of the twentieth century, a group of investors and scientists founded what became known as the Club of Rome (1968), which commissioned the report *The Limits of Growth* published in 1972.[3] The first *Earth Summit* was convened that same year, in which the United Nations Environment Program (UNEP) was created with the aim of promoting actions on an international scale within the framework of the United Nations.

3 For a review of the history and role of the Club of Rome, see: Mihaljo Mesarovic and Eduard Pestel, *Mankind at the Turning Point. The Second Report to the Club of Rome*, New York: E. P. Dutton (1974).

The publication of the Bruntland report, under the title *Our Common Future*, in 1987, can be considered a decisive event in the formulation of the sustainability discourse and the consequent actions taken by governments. The report introduced the concept of *sustainable development,* understood in those days as "…the ability to ensure present needs without compromising the ability of future generations to meet their own" (United Nations 1987). Both the UNEP and other international stakeholders linked sustainable development with economic growth. In the report itself, paragraph 27 specified that, even though the concept of sustainable growth implied limits, these were not absolute, but "…limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organization can be both managed and improved to make way for a new era of economic growth" (United Nations 1987).

A decade later, this notion of "sustainability" that allows infinite economic growth on a finite planet was already well established in the UNEP's vision. The report *Global Change and Sustainable Development*, published in 1997, made clear that sustainable development was "…an integrated approach to policy- and decision-making in which environmental protection and long-term economic growth are seen not as incompatible but as complementary, indeed mutually dependent: solving environmental problems requires resources which only economic growth can provide, while economic growth will falter if human health and natural resources are damaged by environmental degradation" (United Nations 1997).

This association, or "virtuous circle" of sustainable development recognizes in its own way the existence of the ecological planetary boundaries described previously, but it believes and advocates that efficiency in the use of resources will be such in the near future that they could stimulate each other: greater consumption with reduction of environmental impairment. Thus, the wager should be on growing efficiency, especially in the technological field. This is the basis of the so-called "green economy" that the UNEP heavily promoted in the framework of Río + 20, the second edition of the United Nations Conference on the Environment and Development, in which *Agenda 21* was voted. Before Río + 20, the Millennium Summit was concluded in which the "Development Objectives of the Millennium" were defined; there were also other international events focusing on specific environmental problems (such as water, biodiversity, the ozone layer, etc.).

The green economy discourse can certainly be attractive; however, it contains a central flaw: capitalist production logic itself. The data bear this out: the existing production system has achieved a relative efficiency increase of 20,000 percent in the last two centuries (Newman, Beatley and Boyer 2012). This relative efficiency refers to the efficiency of sub-components of the system, but not to the system itself; this would be absolute efficiency. This last measure has not increased; on the contrary, it has been overrun by the ever-growing, but asymmetric, consumption patterns of a growing population. In consequence, we must warn that economic growth is not, in practice, the equivalent of a better quality of life (as a matter of fact there is ever-growing poverty in the present production system); so absolute bio-physical efficiency, that is, lower global consumption of materials and energy does not mean necessarily a diminishing quality of life for the majority of the population, as long as the distribution of wealth is more symmetrical and the logic of production is based on the reproduction of life.

However, if the present trend continues, there will be an increase in extractive activities of as much as three orders of magnitude by 2050, so that by that year it would reach 140 billion tons of energy and materials per annum. If we depart from a "moderate" scenario, in which the central or "developed" countries reduce their consumption by a factor of two, and the peripheral or "underdeveloped" nations increase theirs by a judicious amount, extraction would reach 70 billion tons per annum, or 40% more than in 2000 (UNEP 2011, 29-30). Just maintaining the consumption patterns of the year 2000, requiring some 48.5 billion tons per annum, would mean that the central countries would diminish their consumption by three to five orders of magnitude, while other developing nations would have to do so by 10-20% (*Ibid.*). Notwithstanding that the data is clear in the sense that consumption and environmental deterioration are still rising, and that, in per capita terms, the developed countries are responsible for a major part of the negative impact, there is a constant insistence on providing aid and assistance to the developing countries as the principal measure of containment. The assumption would seem to be that the developed countries would do what should be done (in terms of climatic change, this clearly hasn't happened), while the developing countries will need help, not only because of their limited resources, but also because it is considered that they will face greater population growth and bear the brunt of environmental and climate changes in the coming decades.

However, as the international economic structure is not identified as the problem, suggestions are limited to certain adjustments and the exhortation that the rich should help the poor so that the latter should include environmental and climate related criteria, by means of aid, cooperation and philanthropy (Delgado and Romano 2013). Thus, the discussion focuses on how much aid should be given to the non-developed countries, in what way and under what conditions, without any thought to the historic and structural differences been one and the others. Although the fact is recognized that spendthrift consumption patterns are a problem, there are no major propositions to solve it, especially considering that plans to promote *sustainable consumption and production*—without specifying what that means—are formulated stressing that all programs are voluntary.

Thus, green economy is an *ad hoc* proposition to the existing production system, as it departs from the notion of fomenting economic growth essentially by means of "green investment" and business ventures with "green" technologies (whether in energy, food production, water management, waste disposal, or whatever). The link with some social benefits is, of course, a plus, but essentially it is a secondary issue as the market is always the central mechanism in the distribution of wealth and eventual benefits.

"Green business" is very attractive because the estimated annual investment is around 1 to 2.5 trillion US dollars (UNEP 2012). This model—which assumes the triple cycle of (1) better design and development of sustainable products (2) will attract more customers, that in turn will result in (3) more sales—is flawed from its inception because, as mentioned earlier, the energy-material efficiency of a product does not imply a reduction in consumption of energy and material (apart from waste generation) on the part of the economic system as a whole; very much to the contrary, if sales improve, very probably total consumption will rise too, and this will result in greater production cycles, more efficient in terms of units produced, but very probably more devastating when considered in their entirety (at this point, then, it is basic to account for not only relative or partial efficiencies, but absolute efficiency too). Of course, in the process, corporative profits can be substantial, if and when consumption patterns are not limited, and the flow of direct and indirect subsidies is maintained.

Nevertheless, sustainability can be examined positively, that is to say, as a broad range of societies, culturally different, that live together in concrete and bio-physically diverse territories, sharing certain common traits; that is, they recognize themselves as part of nature and consequently, though they aspire to the best quality of life possible, they simultaneously recognize and operate within planetary ecological boundaries, thus becoming more thrifty, socially fair, less reactive and more preventive. Sustainable development from this point of view doesn't consider economic growth as a goal; instead, it does stress the development of humans as such, with the advancement and thriving of their capacities. This aim, in constant state of renovation, requires provisional ways and growing experiences to enable it to break out—in greater or lesser degree—from the present systems that have proved to be unviable. In this sense, the *praxis*, the co-production of knowledge and culture are central elements in the territorialized construction of sustainable development. Some authors refer to these experiences as “the territories of difference” (Escobar 2008); others call them “bio-cultural resistances” (Toledo and Ortiz Espejel 2014).

Consequently, the concept of sustainable development presents a variety of interpretations that are associated with notions of sustainability weak or strong, this is, to those more anchored in the valuation of anthropocentric and unilateral nature through market valuations multicriteriales or they attempt to break with positioning anthropocentric, transistoricos and linear, respectively.

Complexity and interdiscipline as key features in new socio-ecological perspectives[4]

In recent ecological literature, society tends to be described as a network of relationships, a highly complex weave of flows, actors and socio-natures that becomes embodied in multiple spatial and temporal dimensions, thus expressing a diversity of interconnections and synergies. This becomes clear, for example, in the generation and development of the planetary ecological frontiers we have already mentioned. To analyze this sort of complexity, we observe progress in the production of interdisciplinary knowledge that tends to result in novel approaches or hybrid perspectives, necessary to reach a holistic understanding of the constantly changing and increasingly complex (and certainly destructive) relationship between humans and nature (of which humans are part).

The new hybrid perspectives have become embodied in hybrid disciplines like ecological economy, social ecology, political ecology, sciences of sustainability, and others. Even if these (new disciplines) take up pre-existent concepts and schools of thought,[5] they also cause the renovation, and even the re-formulation of thought and discourse, whether on nature, society, politics or other issues considered relevant, always from a point of view that—given the present global crisis—strives imperatively to identify and understand present challenges, as well as proposing possible futures and road maps for transition. A second level of hybridization takes place, too, between different hybrid perspectives or disciplines and other forms of knowledge, determining fields of hybrid thought, that is, approaches that can hybridize with multiple perspectives—as many as are necessary to better understand the phenomena under observation—and that, consequently, attempt to even transcend the frontiers posed by the hybrid disciplines themselves (in many cases, unintentionally, rather as the product of

4 Based on Delgado Ramos 2015.

5 This includes “conjugated disciplines” such as political sociology, environmental economy, human ecology, human geography, environmental geography, etcetera. For details on the difference betwen conjugated and hybrid disciplines, see Delgado Ramos 2015.

practice itself and the limitations of groups or individuals when it comes to building more complex and robust analyses). As a result, both hybrid disciplines or domains, and fields of hybridized knowledge, are knowledge production modes in permanent construction, and may even overflow formal scientific practice.

The *co-production* of knowledge, based on the continuous knowledge-dialogue between different actors direct or indirectly related, becomes a key element because, seen in a positive light, it should account for not only validated scientific knowledge (whose accepted showcase is the ensemble of peer-reviewed journals), but also, on the one hand, non-validated or non-peer reviewed scientific knowledge that can, however, trigger new approaches, perspectives and findings within the generating structure of validated scientific learning, and on the other hand, knowledge in the form of traditional-popular practices, values and/or interests, that are at least ethically valid and consequently important for any integrated interdisciplinary approach. As Ungar and Strand (2005, 40) write:

> Emergent complex systems are based on the recognition of the influence of intentionality and values on the whole investigation [and for this reason] the study object cannot be described without reflectivity on the part of the scientists, because uncertainty is a consequence of scientific activity itself. The presence of other experts—the local population, for example—in the process of building knowledge is not, in essence, a *useful* tool for approaching reality, a complementary part of scientific activity […], but a method of guaranteeing the quality of this process […]. Ordinary people supervise, question, re-formulate if necessary, the work of the scientists.

Furthermore, it is visible that social movements and their networks increasingly generate subjectivated knowledge, articulating information and experiences that many times pass unnoticed by the formalized knowledge circuit. We are talking about, therefore, a co-production of knowledge that strives "…to enrich the way towards localized discourses that have scientific work as their ally and not as their rival" (Ungar and Strand 2005). Such co-production of knowledge is relevant to the search for routes towards genuine sustainability because, paraphrasing Fazey *et al.* (2014), it is possible to affect or stimulate the capacity to generate innovative solutions, increase the relevance of results for political decision-making, or by grass roots movements, or the degree of participation in the process and in learning. This is why socio-environmental resilience cannot be built integrally other than by the co-production of knowledge, by means of localized practice and backed by social consensus.

Complexity and interdiscipline in the sciences of sustainability[6]

The sciences of sustainability are an emerging field of knowledge that searches for answers to the growing concern of scientists in various fields about how the Planet can face the problems of growing population and, as mentioned above, the growing use of resources demanded by the economic patterns now dominant, within planetary boundaries.

The sciences of sustainability analyze the interactions between natural and social systems, and how these interactions affect the challenge of building a fair future, both socially and economically, as well as environmentally viable.

Works that attempt to offer answers to this intricate and inseparable relationship between the socio-economic and natural worlds have multiplied. We can mention authors like Burnside *et al.* (2012), Burger *et al.* (2012) and Hodge (2013), among many others, who point out the emergence of macro-ecology as a form of latching on to the comprehension of sustainability from the point of view of biological sciences, and how humanity is integrated into, and limited by, Earth systems. These authors define human macro-ecology as the study of environmental interactions measured according to temporal and spatial scales, integrating large and small scale relationships, as well as the emerging patterns and processes that drive them, characterizing dimensions and consequences of the human contribution with the interactions with the environment that affect the abundance, distribution and diversity of species, as well as social, economic and technological development of human populations.

Sustainability demands that we internalize the environmental and social costs of development, so it is imperative to structure new forms of measuring, analyzing and conceptualizing this notion. No solutions will rise from simple extrapolations of present day practices; it is urgent that we understand the interconnections between the different components of the Earth system, including the reconstruction of the human dimension and development. The basic unit of analysis should include both the ecological and human dimensions, making the sciences of sustainability necessarily interdisciplinary, which makes it an hybrid perspective.

Considering the effects that are already apparent as a consequence of the alteration of processes that determine planetary boundaries, one approach to enabling the development of capacities that would allow us to face expected and unexpected changes is that of socio-eco-systemic resilience, that proposes transcending the analysis of ecosystems dynamics as a factor that is independent from humans, and focusing on understanding how we are part of these

6 Based on Imaz, Ayala and Beristain 2014.

ecosystems and how we interact with the bio-geosphere. This integrating analysis cannot be constructed simply with the sum of its parts; it requires changes in our understanding and the comprehension of complex behavior, unpredictable as it is, and with growing connectivity with planetary and social systems, thus creating a high level of uncertainty and leaving little margin for predictions because, even in cases of relatively simple systems—at least in the environmental and social fields—understanding and visualizing are not synonymous with the capacity to predict. Thus, the sciences of sustainability must learn to contend with the numerous sources of uncertainty that emerge from the very object of analysis: socio-ecosystems.

Final consideration

We argue that a genuine sustainability besides trascending the dominant notion of sustainability, must break with any attempt to introduce a division between human beings and nature, thus to be able to visualize socio-ecologically harmonious routes, with multi-spatial and multi-temporal visions. In this sense, an interdisciplinary approach, as in complex systems, is necessary for the permanent production of knowledge (along with the various epistemologies and ontologies it entails) and agreeing upon design of actions and knowledge necessary for the construction of sustainability.

In practice, this process implies—among many other issues—the democratization and co-production of knowledge, the liquidation of the strong existing socio-economic and gender-related asymmetries, the defense of public and common goods, the recognition of the intrinsic value of nature, and the stimulus to public policy and productive practices that prioritize the common good, that depend on maintaining Holocene-like eco-systemic conditions, in which the central value is life and not accumulation of capital.

This inevitably requires a paradigm shift in the relationships society establishes both with nature—of which, we insist, we are part—as well as among its members; that is, in terms of power structures and decision-making, as well as production relationships, including distribution and consumption that, at present, are increasingly revealing their socio-environmental dysfunctionality.

Genuine sustainability is that which is built from a variety of socially, historically and culturally diverse proposals that, openly and deliberately, search for ways to transcend the state of metabolic fracture or growing transgression of planetary ecological boundaries and social alienation. Id

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