

The identity of ecological economics: retrospects and prospects

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The paper first reveals the relevance of ecological economics in the time of a triple crisis—ecological, social and economic—and promotes it as a distinct paradigm comprised of two interconnected and interdependent aspects: the qualitative framework within which it operates; and the quantitative models and techniques it uses to observe ecosystem resilience, measure progress towards sustainability and evaluate policies. While acknowledging the progress that has so far been made, the paper argues that divergences in understanding the meaning and content of ecological economics hinder its effectiveness and influence on real-world policy making, and calls for a unified framework as a common ground that would strengthen the field and direct research. The implication of this position then follows, pointing out what has so far been missing from the ecological economics' analysis and what should be done for it to become a more problem-oriented and policy-relevant alternative.

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1. Introduction

Ecological economics recognises the interconnections and interdependence of the economic, biophysical and social worlds, treating human economy both as a social system and a system embodied in the biophysical universe. While the roots of ecological economics can be traced back to the writings of Thomas Malthus and John Stuart Mill (Martinez-Alier, 1990), researchers from various disciplines contributed to the formation and advancement of this new transdisciplinary field in the aftermath of World War II. The limits-to-growth discussions (e.g. Boulding, 1966; Meadows *et al.*, 1972), the pioneering works on ecosystem stability and resilience (e.g. Holling, 1973), the discussions on energy and materials grounding economics in the physical world (e.g. Ayres and Kneese, 1969; Georgescu-Roegen, 1971; Odum 1971), and the proposals of steady-state economics (Daly, 1977) all influenced, in the 1960s and 1970s, ecologists and economists in a myriad ways and became important driving forces for the development of a field aiming at integrating human activities with ecology. In the 1980s, a second generation of natural and social scientists (among others, AnnMari

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Jansson, Joan Martinez-Alier and Robert Costanza), building on the ideas and insights of the older generation, initiated a series of meetings and publications (e.g. Costanza and Daly, 1987; Martinez-Alier, 1990), and institutionalised the field by formally establishing the International Society for Ecological Economics in 1988 and its journal *Ecological Economics* in 1989 (Ropke, 2005). A broad range of literature now exists on the history of ecological economics (e.g. Martinez-Alier, 1990; Costanza, 1991, 2003; Ropke, 2004, 2005; Spash, 2009A).

Representatives of the field also recognise the tension within ecological economics regarding what it precisely comprises, since its interdisciplinary nature makes it difficult to define a unified methodology. As contributors to the field have different disciplinary backgrounds or diverse perspectives within the same discipline or dissimilar views on the meaning and practice of science, variations over what it is that is distinctive about ecological economics, as well as what should be the standards and priorities for the direction of research, undoubtedly emerge (Ropke, 2004). More specifically, some scholars, acknowledging the importance of life-support functions and ecosystem health, concentrate on modelling the interrelationships between ecological and economic systems with an objective and technical viewpoint; some others, however, adopting a socio-economic approach, position ecological economics as a distinct paradigm aiming at changing the economics discipline in a more radical way, encourage analysis of the social aspects of environmental policy, and search for cooperation not only between economists and ecologists but also with other scholars, such as sociologists, anthropologists and philosophers (for discussions, see Spash, 1999; Özkaynak *et al.*, 2002; Ropke, 2005). With most of the first group being in the USA and most of the second one in Europe, continental differences have presumably fostered such divergences, as well as other factors. It is telling that this rupture is unavoidably manifested in the choice of coverage for the edited collections and textbooks on ecological economics aiming at providing an overview and vision by leading figures (Martinez-Alier, 1990; Costanza, 1991; Martinez-Alier and Ropke, 2008; Perrings, 2009; Spash, 2009B).

Even though some find an element of richness in the current state of ecological economics, Ropke (2005) has certainly a point in claiming that ideological and methodological divisions in the field and its fragmented nature have resulted in a relatively weak identity. Concomitantly, this divergence in understanding the meaning and content of ecological economics, as this paper will argue, prevents a more effective ecological economics and hinders the influence of the field on real-world policy making (e.g. Shi, 2004). That is precisely why Gowdy and Erickson (2005A) and Spash (2009A), among others, see ecological economics at a crossroads.

Taking this as a backdrop, the paper, while acknowledging the progress that has so far been made within ecological economics, draws attention to the need for a unified framework as a common ground that would strengthen the field and direct research. This is mainly because transdisciplinarity does not mean bringing to bear different existing—and often methodologically incompatible—disciplines, but rather the coevolution of the existing disciplines themselves. In this context, the paper outlines a way forward for ecological economics so that the approach may realise its full potential and deal with real policy issues.

We begin by positing our own view on the identity of ecological economics by defining it as a distinct paradigm comprised of two interconnected and interdependent aspects: the qualitative framework within which it operates (i.e. the laws of thermodynamics,

the coevolutionary perspective, and the means of managing uncertainty and complexity—‘post-normal’ science, ‘procedural rationality’ and ‘deliberative institutions’); and the quantitative models and techniques it uses to observe ecosystem stability and resilience, measure progress towards sustainability, evaluate policies, and assist decision making (such as biophysical indicators, sustainability indices, ecosystem modelling and multicriteria evaluation). We then investigate the implications of such an understanding by pointing out what has so far been missing from the ecological economics analysis and what should be done for it to become a more problem-oriented and policy-relevant alternative.

2. What is distinctive about ecological economics?

Ecological economics embraces a view of the natural world that acknowledges the centrality of interdependence, complexity, uncertainty and dynamism, and as such has a distinct pre-analytic vision, implying a fundamental change in how problems are perceived and addressed. In specifying which categories of life-support functions need to be protected and in setting threshold levels for ecosystem health, ecological economists maintain that standard economic valuation methods that are based on the aggregation of individuals’ values in relation to nature cannot be used on their own, and possibly not at all. This is not only because the complex systems involved are unpredictable and possess inherent uncertainties, but is also due to prevailing inequalities in the distribution of wealth and income. Instead, ecological economics situates economic analysis within thermodynamic and coevolutionary frameworks, and introduces post-normal science, procedural rationality and deliberative institutions into decision-making processes as a means to manage uncertainty and complexity. Each of these concepts contributes to understanding the vision of ecological economics and what makes it distinct (see, for general references, Costanza, 1991; Munda, 1997; Spash, 1999; Özkaynak *et al.*, 2002; Daly and Farley, 2004; Ropke, 2004, 2005; Gowdy and Erickson, 2005B; Söderbaum, 2008; Spash, 2009A).

The role of thermodynamics and coevolutionary frameworks is well established and well documented in the field. The former involves a view of the economy as embedded within the ecosystem, implying limits on the biophysical flow of resources from the ecosystem to the economic system and then back as wastes. In this context, the notion that the transformation of energy and material is subject to the laws of thermodynamics—or ‘entropy’—is central. The concept, first introduced to economics by Soddy (1926) and then elaborated by Georgescu-Roegen (1971), provides a powerful metaphor and a unifying aspect of ecological economics (see also Faber *et al.*, 1996; Mayumi, 2001).

The first law of thermodynamics indicates that matter and energy are constant in any closed system, can neither be created nor destroyed, but may appear in different forms, such as heat, chemical energy, kinetic energy, work, etc. The second law, also known as the entropy law, states that in any thermodynamic process, in an isolated system, the amount of energy available for work, i.e. energy with low entropy, decreases with use (Faber *et al.*, 1996, Costanza *et al.*, 1997). It was the observation that energy and matter are transformed in economic processes, as low-entropy energy and raw material enter the economy and then leave it as high-entropy waste and dissipated energy, that led Georgescu-Roegen (1971) to state that economic processes are subject to the second law of thermodynamics.

Being aware of entropy and the thermodynamic analysis provides insight on the importance of the scale of economic activity and of economy–environment interactions (Costanza *et al.*, 1997; Daly and Farley, 2004). Thermodynamics is a guide for modelling both the source and sink sides of the economy, and provides the basis for the quantitative analysis of transformations taking place within the processes used to study social metabolism and estimate exchanges between economic and ecological processes. Biophysical accounts in general are important in monitoring ecosystem sustainability, since they involve information input not directly characterisable in the language of individual preferences (Ayres and Warr, 2005; Toman, 2006).

In ecological economics, a complementary way of dealing with the scale issue from an ecosystem perspective is based on the concepts of stability and resilience— notions in theoretical ecology originating from the ideas of the Canadian ecologist Holling (1973)—which draw attention to risks related to the disturbance of ecosystems when the human economy grows abnormally in relation to its environment. These concepts have deeply influenced integrated modelling and adaptive management approaches in the study of ecological–economic interactions (Perrings *et al.*, 1995; Perrings and Stern, 2000; Folke *et al.*, 2004; Walker *et al.*, 2004) and have later been picked up by economists as well. Contributions by Berkes (1989), Berkes and Folke (1998), Costanza *et al.* (2001) and Ostrom (2005), among others, can also be seen in this vein, since they highlight how institutional arrangements respecting ecosystem resilience can be created, thus preventing ecosystem collapse, and how common pool resources can be successfully managed by groups using them.

Moreover, the coevolutionary perspective adopted by ecological economics recognises the instability, multidimensionality and increasing complexity of natural and social systems, such as the environment, technology, population and culture (Norgaard, 1984). All these elements are seen as being linked by a dynamic equilibrium, with a change in one of the systems requiring adaptation of the others. Thus, coevolution is thought of as a set of equilibrating mechanisms between society and nature. Norgaard (1985), in that regard, argues that different worldviews affect the process of coevolution and *ipso facto* the way in which social systems are characterised as interacting with ecological systems. The point being made here is mainly the way in which science, knowledge, technology, social organisation and environment have all coevolved around fossil hydrocarbons.

Particularly, our technological basis has been focused on fossil fuels since the Industrial Revolution, which is also referred to as a technological lock-in in the field (Dosi *et al.*, 1988; Kemp, 2002). In addition, our fossil fuel-driven economy has coevolved with society and ideology as well, since industrialisation advanced through the development of capitalism, which promoted individualist as well as materialist values and favoured the development of reductionist understanding at the expense of systemic understanding (Söderbaum, 2008). Jacobs (1997), in that regard, argues that the model rewards itself in the sense that it alters the way the environment is viewed, since the materialistic and individualistic values it assumes become more and more socially accepted. This is then a social lock-in. In short, the capitalist industrialisation process caused fossils fuels, technology, society and the capitalist system to all coevolve together (Martinez-Alier, 2002A; Fischer-Kowalski and Haberl, 2007).

Regarding uncertainty and complexity, ecological economics insists that scientific analysis alone cannot be an adequate basis for decision making on key environmental issues. On the one hand, this is because the systems involved are so complex that the current state of scientific knowledge is subject to considerable uncertainty; yet

the issues are so pressing that there is insufficient time for further scientific research to significantly reduce uncertainty before decisions are made. On the other hand, as Funtowicz *et al.* (1999) rightly note, there is no unique, privileged perspective on the system: the criteria for selection of data, truncation of models and formation of theoretical constructs are all value laden (reflecting, e.g., the weight given to the precautionary principle in any given situation; see Funtowicz and Ravetz, 1990, 1994; Müller, 2003).

It is for this reason that, as a complement to the state-of-the-art techniques, such as computer-based dynamic modelling, forecasting and geographical information system applications, ecological economics favours approaches based on processes and procedures that bring together a range of information and views necessary for decision making, and hence proposes procedural rationality. In this sense, by dropping the mainstream optimisation principle and adopting an alternative consensus-building strategy, ecological economics tries to guarantee the quality of the decision-making process rather than concentrating solely on the final result. It pursues this through dialogue within an extended peer community, including all interested and affected parties, the aims of which emerge as being to identify the sources and extent of uncertainty, and to communicate values. Accordingly, any environmental issue requires a pluralism of methodologies, with scientific inputs and policy consequences involving a number of disciplines, along with relevant ethical and social considerations (Funtowicz and Ravetz, 1994; O'Connor *et al.*, 1996; O'Neill, 2007). Obviously, unlike market approaches to environmental problems, this is a problem-solving process rather than a preference-aggregating one, and planning within this context is more about maintaining a process than about the achievement of any particular outcome (Barry, 1999). Essentially, deliberative institutions are thought to serve this purpose by having 'public forums' at different levels of decision making, where people are brought together to debate prior to passing judgement and engage with other people, and, hence, are exposed to a wide range of opinions (Jacobs, 1997; Dryzek, 2000; Paehlke, 2004; Devine, 2010). All these of course give to decision-making practice a normative role, and draw on a wider range of human and social science disciplines and knowledge frameworks than is currently the case.

Given the crucial unifying elements discussed above, one of the main branches of work in ecological economics has been the development of different types of biophysical indicators and indices of (un)sustainability, such as the human appropriation of net primary production, ecological footprint and energy return on energy input (Martinez-Alier and Schandl, 2002). To the possible objection that these physical indicators are another kind of reductionism—perhaps not monetary, but physical—Faucheux and O'Connor (1998) and Funtowicz *et al.* (1999) explain the appropriateness of multiple indicators by showing that each can be defined relatively unambiguously and that each signals some important feature of economic or environmental change, provided they are not reduced to a single aggregate indicator, since they are intrinsically incommensurable. In fact, the need to develop a methodologically pluralistic approach in complex decision-making problems, where different evaluation perspectives should be considered, is one of the main reasons why ecological economics is closely associated with multicriteria analysis.

The key promise of a multicriteria analysis is that it renders the analysis of the trade-offs between different objectives or concerns transparent by taking into account indicators in a variety of forms, such as monetary units, physical units and the qualitative

judgements of different decision makers (Munda, 1995, 2008; Froger and Munda, 1998). Moreover, as Martinez-Alier *et al.* indicate, multicriteria analysis facilitates learning about the problem and alternative possible actions by enabling people to think about their values and preferences from several points of view: 'multi-criteria evaluation techniques cannot solve all conflicts, but they can help to provide more insight into the nature of conflicts and into ways to arrive at political compromises in case of divergent preferences' (Martinez-Alier *et al.*, 1998, p. 281), so as to increase the transparency of the choice process. In this sense, providing support in decision making and trying to shed light on an initially ill-structured decision-making process is the main idea, rather than the mere application of a technical tool.

With these qualitative and quantitative aspects of ecological economics to hand, Daly and Farley (2004) rightly claim that for achieving sustainability an ecological economist should stick to the following sequential process: first, monitor the scale of the economy relative to the ecosystem and ensure it is within the carrying capacity of the ecosystem at any time, so that the ecosystem's resilience is respected; second, establish a fair and just distribution of resources, both in relation to income and wealth, and to market as well as non-market goods; and, third, once the scale and distributional equity problems are solved, allocative efficiency can be aimed at.

3. Implications: what should ecological economics be doing?

Having briefly set out the nature of ecological economics as we see it, we now turn to the implications of such a framework and discuss what ecological economics should be doing to develop as a policy science and better influence real-world decisions on sustainability. The discussion will be conducted, in conjunction with the above framework, with reference to the laws of thermodynamics and ecosystem resilience, the co-evolutionary perspective, and the means of managing complexity and uncertainty.

3.1 *In relation to the laws of thermodynamics and ecosystem resilience*

The laws of thermodynamics and work on ecosystem resilience require us to be aware of ecological limits. In this context, ecological economics emphasises the impact of the scale of human activity on non-human nature and the limit that a finite world places on the possibility of endless growth, unlike the mainstream approach, which assumes that technological developments and substitutability will enable continuous but nevertheless ecologically sustainable growth (Ayres, 1995; Daly, 1997; Martinez-Alier, 2009). In fact, as Shi (2004) notes, ecological economics has been successful in shifting the focus of sustainability debates from natural resource scarcity to ecological sustainability and social equity. Yet, the lack of absolute limits in current sustainable development plans with regard to ecosystems' carrying capacity in terms of limits related to sources and sinks is still problematic.

Therefore, two major tasks are waiting for ecological economists. First, they should further expose the myths about production and substitution possibilities that run counter to the laws of thermodynamics. Second, they should continue to seek biophysical assessments of economy–environment interactions and generate information on biophysical accounts as well as instances of ecosystem collapse (e.g. extinction of species due to overexploitation) as part of historical evidence and societal memory. In fact, Martinez-Alier and Schandl (2002) note that, as ecological economics thrives, it

is important to develop an environmental history, or the history of the so-called social metabolism, that illustrates the impact of technological and societal changes, as well as of growing economies and increasing use of fossil fuels, on the environment. McNeill (2000), Weisz *et al.* (2006) and Fisher-Kowalski and Haberl (2007) all make contributions in this direction.

Today, despite hopes for the 'dematerialisation' of the economy in absolute terms, given the present technologies in production, transportation and building construction, and the social 'lock-in' in consumption habits and urban settlement patterns, economic growth still leads to increased material and energy flows (Haberl *et al.*, 2004; Reisch and Ropke, 2004; Jackson, 2009). In this context, Jackson (2009) notes that overall reductions in resource throughput (absolute decoupling), or environmental Kuznets curve effects, have been the exception rather than the rule. This is because improvements in material or energy intensities (relative decoupling) are almost always offset by increases in the scale of economic activity and in continuous growth in real output per head over the same period—known as the rebound effect or historically called the Jevons' paradox. As Alcott (2005) rightly suggests, given that not only all governments but also some ecologically concerned economists are favouring the efficiency strategy towards sustainability, ecological economics should take more responsibility for identifying the end results of energy and efficiency policies, both theoretically and empirically, and particularly for disseminating evidence at the micro/macro scale on the rebound effect (Giampietro and Mayumi, 2009). This inquiry could also be used to promote the relevance of Daly and Farley's (2004) prioritisation and to argue that savings from efficiency gains cannot be used to violate the sustainability goal.

Ecological economics research should not only focus on the biophysical bases of economic activity, but also critically examine the relationship between economic (GDP) growth and prosperity. In the ecological economics literature, many strong voices have been raised against economic growth in rich countries and in favour of a steady-state economy (Daly, 1977; Daly and Farley, 2004). The latest contributions to the field also discuss the relevance of GDP as an indicator of wellbeing or progress and thereby as a key policy goal (Harris, 2007; van den Bergh, 2009; Latouche, 2010). Accordingly, economic growth, defined in terms of rises in GDP per capita, is rightly criticised on the basis that it no longer serves a useful purpose for society in developed countries—certainly not in the case of poverty, wellbeing, environmental protection and social justice (van den Bergh, 2009; Schneider *et al.*, 2010).

In the past, several attempts have been made to construct 'green national accounts' that reflect the depreciation of natural capital and environmental pollution not captured by conventional GDP. Cobb and Daly's index of sustainable economic welfare and other proposed corrections (e.g. Lawn, 2003) aim to capture this. Each is based on differing assumptions, but they all share the goal of quantifying economic-environment interdependencies in an overall-system measure of economic performance (Costanza *et al.*, 1997; Shmelev and Rodríguez-Labajos, 2009). However, these monetary corrections to GNP imply strong comparability, and in most cases strong commensurability, since end results are still based on a monetary figure (Martinez-Alier *et al.*, 1999; Shmelev and Rodríguez-Labajos, 2009). Yet, as Harris (2007) and van den Bergh (2010) underline in their critique of the GDP-growth imperative, ecological economists should work more forcefully on pursuing good social and environmental policies for their own sake, and consequently call for goal- and policy-specific indicators, better reflecting Daly and Farley's sequential triplet mentioned above.

The multicriteria macroassessment framework proposed by Shmelev and Rodríguez-Labajos (2009) is an effort in this direction. The authors apply the multicriteria approach to the specific case of Austria and, by using a panel of sustainable development indicators, assess Austria's development at the macro level. This study not only provides a dynamic assessment of progress towards sustainability on the macro scale, but also reflects the social and technical incommensurability aspects of a sustainability assessment exercise. As the authors suggest, a multidimensional assessment of sustainability at the macro level, using multicriteria tools, renders the analysis of future development scenarios possible, including their socio-economic and environmental implications and consequences for different constituencies, and provides the necessary support for policy makers in establishing priorities for development. Ecological economics should engage in exercises like this more often. Such exercises, therefore, would be a subjective yet systematic mind walk, which fosters inquiry, creates awareness, spreads political responsibility and action, and provides a rich background against which one can explore and formulate the paths that need to be taken within a multilayered system of governance.

Obviously, using biophysical and other alternative indicators of sustainability in assessment exercises would work to expand our field of knowledge and also address important policy issues, particularly in relation to cases of environmental injustice on the local and global scales. On the global front, for instance, given growing economic and ecological disparities, there is a need for continuous research on the relationship between trade and the environment, to support the worldwide justice movement in preventing trade from being a legal framework that allows rich countries to destroy resources from the underprivileged South (Martinez-Alier, 2002A; Weisz, 2007). More specifically, attempts to quantify environmental damage caused by transnational corporations outside the legal country of residence, toxic exports, and the disproportionate use of carbon sinks and reservoirs in the South would be important ingredients in calculating the environmental liabilities the North owes the South, the sum of which would amount to an enormous ecological debt (Martinez-Alier, 2002A).

3.2 In relation to the coevolutionary perspective

The coevolutionary perspective recognises that all the different aspects of a holistic system are interdependent and evolve together; a change in one affects and brings about changes in all the others. As already discussed, the interdependency principle referred to in the ecological economics literature is the coevolutionary development of fossil fuel-based technology and industrialisation—the transition from craft-based production and traditional agriculture to modern methods of production using carbon-based inputs. It is this insight that accounts for the backward-looking stance of some strands of the deep ecology movement, which advocate a return to pre-industrial subsistence modes of production and living. However, to assume that the existing form of modernity, including the technology that coevolved with industrialisation, is the *only* possible form of modernity would be a mistake, since in the nineteenth and twentieth centuries carbon-based industrialisation also coevolved with a historically-specific socio-economic system—capitalism. Although different varieties of capitalism currently exist, which place more or less emphasis on market regulation, particularly with regard to income and wealth distribution and environmental protection, experience so far indicates that all have a structural requirement for growth. As Jackson puts

it: 'a key element in the political economy of all capitalist nations appears to be the role of government in protecting and stimulating economic growth' (Jackson, 2009, p. 166). It was in fact this quest for growth that gave rise to carbon-based industrialisation and unprecedented rates of resource depletion and environmental degradation in the past two centuries.¹

Much of the ecological economics literature emphasises not only the importance of scale, but also the importance of equity (Erickson and Gowdy, 2007; Lawn, 2009). However, while it attributes the problem of scale to the process of industrialisation and growth, it does not primarily discuss the capitalist socio-economic system that creates and depends on inequality (Shi, 2004). Whether there could be an alternative equitable and sustainable but non-growing capitalist economy in harmony with the ecosystem is a pending question that needs to be properly addressed within this coevolutionary line of thought, although the logic of capitalism and the historical evidence suggest that it is unlikely.

Coevolution, then, should be thought of as having two central strands: a material dynamics strand, focusing on the issue of scale; and a socio-economic strand, focusing on the issue of equity. If the implications of the coevolutionary approach are to be fully realised, then ecological economics needs to take on board both strands. This may be illustrated in relation to two aspects of technological development. First, recognition of the finiteness of non-renewable resources implies that technological development should economise in the use of such resources. However, the direction of technological development is determined by the profit-seeking behaviour of dominant corporations in the extraction and consumption industries. An obvious current example of this is the technology developed in recent years for oil extraction from tar sands and deeper and deeper seabed drilling and extraction (Madra, 2010). An alternative socio-economic system might instead direct resources towards renewable energy technology and the promotion of less energy consumption in daily life.

Second, the dominant response to the belated recognition of the dire consequences of most environmental problems has been to focus on increasing efficiency in resource use and waste disposal, as best exemplified in the case of climate change. So far, however, the effect of increased efficiency has been only relative decoupling, a reduction in energy input and carbon emissions per unit of output. However, as already mentioned, growth increases the number of units produced, thus increasing total energy input and carbon emissions despite the per unit reduction. Hence, absolute decoupling has so far not been achieved.²

These two examples demonstrate that technological development coevolves with the socio-economic system in an intertwined manner and that the question of scale cannot be dealt with solely by technological development. If climate change is to be kept within acceptable bounds, for instance, action is needed in relation to both technology and demand. Resources must clearly be deployed to develop renewable energy sources and economise on resource input and waste output per unit of production. Yet, at the same time, growth, at least in developed countries, needs to be replaced by a

¹ From ad 1 to 1820, world growth rates averaged between 0.01% and 0.32% per annum; since 1820 they have averaged between 0.94% and 4.90% per annum (Maddison, 2007, p. 71).

² Between 1990 and 2007, carbon intensity decreased by 0.7% pa. On the basis of projections for global population growth and per capita income increase, the Intergovernmental Panel on Climate Change's *Fourth Assessment Report* (2007) estimated that to achieve a 450 ppm target by 2050, carbon intensity would have to decrease by 7.0% pa—10 times faster than the 1990–2007 rate of reduction.

steady-state economy, or possibly even a period of ‘degrowth’ (Schneider *et al.*, 2010). The capitalist socio-economic system that coevolved with carbon-based industrialisation is likely to be incompatible with the transition to a steady-state society based on renewable energy.

One implication of this analysis for ecological economics, as rightfully argued in the field, is the need to finally break from reducing complex interdependencies of the coevolved holistic system to a single dimension—as, for instance, the economic one, which is the one widely used today (e.g. Ackerman *et al.*, 2007; Spash, 2007). Instead, the focus should be on analysing interactions between human activity and non-human nature within the prevailing explicitly capitalist socio-economic system, the differential impact of that interaction on different countries and different socio-economic groups within them, and how to move towards a globally and locally just distribution of resource use within the finite carrying capacity of the planet.

This will require the expansion of current transdisciplinary work, drawing in particular on the disciplines of ecology, geography, history (including the history of science and technology) and social science (including political economy). However, it must also be acknowledged that the evolution of these disciplines has led to fragmentation and compartmentalisation, which is inimical to a holistic view. Transdisciplinary work cannot be achieved simply by bringing together scholars working in the separate disciplines as they have currently evolved. The disciplines themselves have to evolve to take into account the new demands brought up by the current conjuncture of interacting ecological, social, economic and financial crises, and there needs to be a unified framework where all these coevolved disciplines are brought together around a core understanding.

3.3 In relation to the means of managing complexity and uncertainty

As discussed, a key distinctive aspect of ecological economics is its recognition that ecological systems and their interactions with other subsystems that together make up the whole are highly complex and subject to irreducible uncertainty. Given that there exist complexities at both ontological and epistemological levels (of the observed system and of the observer, respectively), scientific inquiry inevitably incorporates value judgements as well (Funtowicz and Ravetz, 1990, 1991; Ravetz, 2011). Complexities and associated uncertainties are more accentuated when the issue at hand has a distant future characteristic, as in the case of climate change or GMOs. We should therefore recognise that many present-day decisions that concern ecological systems have to be taken before further scientific work can significantly reduce the degree of uncertainty associated with them. This is why the precautionary principle is so crucial. However, if science cannot tell us precisely what needs to be done to achieve a desired outcome, then on what basis should decisions be made? Ecological economics argues that these decisions should be made on the basis of procedural rationality, through deliberative institutions involving all those likely to be affected by the decision made—the so-called extended peer community. Of course, as emphasised by Ravetz (2011), the extended peer community should never be conceived as a replacement for the scientific peer community, but should rather draw upon the current state of the scientific research.

Given irreducible uncertainty and the incommensurability principle, procedural rationality requires those likely to be affected by the decision made—who will often be affected differently and/or have different values and criteria for evaluating possible

outcomes—to deliberate over the various factors that have to be taken into account and to together reach a decision they all can live with. How much weight should be given to the precautionary principle is not something that can be decided purely on the basis of the best available scientific evidence, although it will of course be heavily influenced by it.

However, largely missing from this body of work on procedural rationality is any discussion of the conditions necessary for such a decision-making process to be realised in practice, rather than remaining only as a recommendation as to what should, but fails, to happen. What are the obstacles that prevent this decision-making process from being actualised? While ecological economics recognises the importance of equity, it does not normally analyse the political economy of the context in which decisions are made or the prevailing distribution of power that distorts or even precludes such a process. There are many projects and individual case studies undertaken within an ecological economics framework that seek to ensure the multiple stakeholders affected by a decision can make their voices heard, soliciting their views using a variety of techniques, and identifying areas of both agreement and disagreement (e.g. Agarwal, 2001; Akbulut, 2010). And such exercises are very valuable, since they show that the quality and design of the decision-making process is crucial, with different designs leading to different recommendations.

But such participatory exercises are at best exercises in consultation, not proper participatory decision making. Rather, they simulate a decision-making process in which the distribution of power between the stakeholders is equal, even though it is not. As a result, no decision is actually made through these exercises—the real decisions are made elsewhere. In these respects they are similar to the comparable procedure of ‘citizens’ juries’, in which people randomly selected from various interest groups that have been identified are presented with the current state of expert knowledge and then asked to arrive at a recommendation in relation to the particular question at issue (Ward, 1999).

While such exercises give people the useful experience of participating in decision making, they may also potentially be harmful. Participation, which in the end has no impact on the outcome, tends to lead to cynicism and alienation. There is a danger of it becoming a sort of ‘participation wash’. This analysis all in all suggests a fruitful area for future ecological economics research. There is a need for follow-up studies to monitor projects and case studies that examine stakeholder views, to assess the extent to which the recommendations that emerged from the consultation exercise actually affected the decisions eventually be made. Insofar as they did not, follow-up studies should examine why the recommendations were not influential—e.g. differences in knowledge, the distribution of power or other factors, such as gender. This would allow ecological economics to shed light on why the decision-making process it recommends fails to be effective in practice and to identify the obstacles that need to be overcome. And this will most likely involve the appraisal of the existing socio-economic system, with the corollary that for real participatory decision making to be possible there may need to be changes in that system, particularly in the distribution of power. Unfortunately, current research in ecological economics does not pay the attention to power that it deserves, despite the existence of important but still all too few contributions (Boulding, 1991; Martinez-Alier, 1991; Boyce, 2002). This is interestingly so, given that ecological economics has itself been largely disregarded by the status quo, be it in mainstream economics institutions, in the media or in real-world policy making.

Perhaps at this junction ecological economists should pay more attention to Boulding (1991), who, in addition to threat power (in the form of taxation and regulations) and economic power (in the form of widespread boycotts), argued for the importance of 'integrative power'—the power of legitimacy, loyalty, respect, love and truth, which can mainly be created through a teaching and learning process.

This said, the importance of the insights ecological economics provides into the need for participatory decision making should not be underestimated. There are many cases where the early warning of problems or impending disasters was ignored or suppressed, with disastrous consequences, due to the absence of participatory deliberative processes involving all stakeholders. Conversely, there are also well-documented cases where cooperative deliberation among equals actually appears to make the sustainable regulation of different types of commons possible (as in the case of successful collective action by fishermen to regulate their catch level; see Ostrom, 1990). We argue that added emphasis is needed in examining why it is so difficult to achieve procedural rationality through deliberative institutions in practice, when systemic parameters are kept constant, and in investigating the necessary conditions that would facilitate its more frequent realisation in actual decision making.

4. Ecological economics of real-world cases

Based on the theoretical framework developed in Section 3, this section clarifies the ways in which ecological economics should be looking at a number of issues that are relevant and important in today's world, so that it realises its full potential and becomes more policy relevant. The ecological economics approach to policy making can be summarised as follows: the current state of scientific knowledge, including the degree of uncertainty involved, is brought together with the values and priorities of stakeholders. Both are then subjected to a process of procedural rationality through deliberative participatory institutions, with the aim of arriving at an agreed decision. When it comes to policy, ecological economics focuses primarily on issues of scale, equity and efficiency, in that order (Daly and Farley, 2004). A current example of how this procedure might have been followed, but in fact was not, is the Copenhagen negotiations concerning the successor to the Kyoto agreement.

At Copenhagen the starting point was the assumption that a policy agreement was needed on measures to stabilise average global temperature at no more than two degrees Celsius higher than the level before the Industrial Revolution (Müller, 2010). However, at the last minute a group comprising the most vulnerable countries tabled a proposal to aim for an increase of no more than one and a half degrees. The issue here was clearly the question of scale. Different scales of carbon emissions were associated with different increases in temperature, which would have very diverse implications for different countries. This then raised the issue of equity.

Less developed countries argued that developed countries were overwhelmingly responsible for the problem—resulting from emissions accumulated over the past two centuries—and therefore should now assume responsibility for the bulk of emission reductions required to achieve whatever global average temperature target was eventually agreed on (Vidal, 2009). A possible, although compatible, alternative approach was that of the Global Commons Institute (GCI), which in the early 1990s proposed a strategy for 'contraction and convergence', involving a staged reduction in global greenhouse gas emissions based on a process of convergence towards equal per-capita

emissions worldwide. While allowing for a transition period, this proposal is clearly based on the ethical principle that the only equitable situation is one in which all people are treated equally.

There remains the issue of efficiency. Once a physical level of global emissions has been agreed on, and responsibility for realising it allocated to each country, how might the required emission reductions be achieved most efficiently? The unquestioned assumption in Copenhagen was that this would be through a system of carbon trading, in which permits to pollute would be allocated on some agreed basis. These permits would then be sold and bought in a carbon-trading market, with provisions for offsets if it could be established that investments in emission-reducing projects elsewhere were adding to projects already in existence or underway. The theoretical foundation for such carbon-trading schemes is the mainstream assumption that market trading is the best way to achieve efficiency, an assumption that has been subject to compelling criticism, not least from ecological economics (Tietenberg, 1996). Spash (2010), in particular, forcefully shows that the reality of marketable permit trading, when moved from economic textbooks to policy agendas, has been far from the promise of achieving the outcomes predicted from abstract theories. In reality, corporate power and financial gains have been, as they inevitably would be, major forces affecting emissions market operation and design, with little regard for environmental and social consequences. Despite this apparent failure, according to Spash, emissions trading and offsets continue to be the schemes spreading among industrialised nations. The problem is that the predominant focus on such markets is crowding out voluntary actions and is creating a distraction from the need for changing human behaviour, institutions and infrastructure. This is also why ecological economics should argue that even if markets do a reasonable job at resolving the efficiency goal, a big 'if', they are woefully inadequate at dealing with equity and sustainability targets.

The Copenhagen Summit failed to deliver a binding document. There was no consensus on the targeted scale and no agreement on the distribution of required emission reductions. The USA and several other major players cobbled together a last-minute agreement and presented this as a *fait accompli*. Copenhagen has been widely condemned by environmental organisations and ecological campaigners as an abject failure (see, e.g., the Climate Justice Action web site: climate-justice-action.org). One conclusion dominant countries drew from the fiasco is that the United Nations is too unwieldy a body to reach sensible decisions; thus, in the future such issues should be decided by the key powers that really matter. This is obviously not a conclusion that the ecological economics approach would support, but we have to recognise that procedural rationality through deliberative institutions involving all stakeholders was never on the cards in Copenhagen. What mattered was the realpolitik of power.

The sorry tale of Copenhagen is a reminder at the highest macro level—the global one—that the necessary conditions for the decision-making approach recommended by ecological economics are currently non-existent, given the prevailing socio-economic system and distribution of power. The question, then, is how should ecological economics respond to this? What proposals should ecological economics be putting forth? Before engaging with these questions, let us remind ourselves that, although in recent years global warming has dominated the political agenda, the number of other pressing ecological issues is certainly not a small one. What is sad to acknowledge is that similar failures, as experienced in Copenhagen at the global level, are being observed for these cases at local levels as well.

As a first category, the environmental load displacement of growing economies is destined to bring about environmental conflicts at the meso and micro levels across the world, since they occur under unequal power distributions. As part of a long list, Martinez-Alier (2002A) documents the struggle of villagers defending their mangroves against shrimp-farming in Ecuador; Guha (2000) presents the case of rubber tappers of the Amazon forests fighting against deforestation; Boyce (2002) and Ballard and Banks (2003) analyse many communities around the world that are disproportionately exposed to environmental hazards on the basis of their ethnic or racial identity; Arsel (2005) sheds light on the Bergama villagers' struggle against gold mining, as do Bebbington *et al.* (2008) for the case in the Andes; and Zografos and Martinez-Alier (2009) describe the uneasiness the neighbouring villagers feel concerning the installation of wind farms on their territories to supply energy to Barcelona. Common to all these cases, however, is an intruder (sometimes the state itself) with political power that negatively affects the lives of local people who lack adequate power to counter the interventions.

In other cases, it is the quest for growth—mainly fuelled by short-sighted corporate profiteering motives—that critically undermines the sustainable use of renewable resources, be it water, fish stocks or forests (e.g. Dietz *et al.*, 2003). Ecological economics should be more explicit about growth fetishism and the role of corporations in this regard. And a final area where ecological conflicts arise involves the use of technologies that come with too much risk for the local population, well above the precautionary principle. The obvious case is nuclear power generation (Sjöberg, 2009), where locals who live near the area express deep concern that something might go wrong at any given time. In fact, many human-made disasters did come with clear and credible warning signs, but these were not taken seriously, as in the cases of radiation emergencies, asbestos poisoning and mad-cow disease (Harremoës *et al.*, 2001). In most of these cases the power centres, whether corporations or states, have opted to ignore these signals/concerns because they would have interfered with economic incentives—an issue that deserves further attention by ecological economics.

In the face of such events, a policy-relevant ecological economics might be expected to, first, identify the socio-ecological impact of the economic activity on the environment and local communities, and quantify it in biophysical, social and economic terms. Next, it would attempt to estimate the gains and losses from these projects, analysing both the direct beneficiaries and the people who were likely to suffer most through investigating their preferences, priorities and values by means of both qualitative and quantitative social research methods. Students of ecological economics should be made aware of a growing literature along this line, where ecological conflicts are analysed with an understanding that conflicts are multidimensional—arising not only from economic interests, but from value systems and cultural identities as well (e.g. Martinez-Alier, 2002A, 2002B; Escobar, 2006; Avcı *et al.* 2010).

The interim conclusion that emerges is that ecological economics acknowledges an alternative understanding of the human–ecology relationship, is now able to provide a much more detailed picture of the cases it examines compared with the mainstream approach, where contextualisation is narrowly made with reference to utility-maximising atomistic agents, and is well established in academia. Yet, despite these intellectual achievements, as Farley *et al.* sadly note, ecological economists 'have failed to galvanize public acceptance for the policy goals of sustainable scale and just distribution,

thus failing to effectively communicate their perspectives on problem definition and/or policy solutions to policy makers and the voting public' (Farley *et al.*, 2007, p. 344). What is the basis of their distress and how can we make ecological economics politically relevant?

One should at the outset acknowledge the difficulties in changing the status quo, since the coevolutionary world itself shapes and reshapes the stakes, beliefs and values of the people who drive it, necessitating a *gestalt* change to alter the current pathway we are on. This is indeed a formidable task. Yet, the fact that ecological economics currently is unable to stand as a united front does not make things easy, either.

As we have argued, we believe ecological economics does not go the full distance when it comes to discussing the political and socio-economic framework within which the proposed changes it advocates are decided on and operationalised. This is because the context in which ecological problems are addressed remains essentially that of twenty-first-century global corporate capitalism and the increasingly crisis-ridden representative political democracy of the major capitalist countries. It is true that ecological economists are heavily concerned with distribution, equity and uneven capitalist development, and most tend to agree that sustainability requires the simultaneous application of ecological principles and social justice. However, their methodology is largely based on negotiation and an emphasis on the quest for societal consensus on key environmental issues, which takes place within a pre-existing capitalist market economy—a problematic matter, since its compatibility with the proposed social deliberation mechanism is very much open to question. It is difficult to conceive of dialogue and informed participation by all affected parties that confers real legitimacy to people, other than between those who are social equals.

This lack of consideration of the political and socio-economic framework and implicit recognition of the existing capitalist system not only renders ecological economics less policy relevant, but it also hinders the need to investigate thoroughly the extent to which various policy instruments are appropriate. If the capitalist market economy and the private property system juxtaposed with it are not critically analysed, for instance, one might easily consider the idea of extending property rights in dealing with environmental issues, or proudly announce that the marketable permits system is the most efficient one (as discussed above), without properly evaluating their limitations and undesirable effects. In fact, there is a pressing need for ecological economics to discuss how compatible different environmental policy tools are with its overall philosophy and features. A more appropriate approach would be to defend a direct regulation system that is based on participatory decision making as well as a universal justice principle.

We believe that the only way to develop something enduring and politically effective with respect to both ecological sustainability and social justice is to recognise the interdependence of the two, by politicising the economic sphere and seeking to organise and coordinate economic activities in a way that combines economic and ecological concerns with social justice based on the specific interests of those affected. This is surely a long political process, involving above all a *gestalt* change in the current set of beliefs and values, yet without claiming a blueprint for dealing with the ever-increasing and rapidly changing real-world problems. Ecological economics, with a well-established socio-economic core and a well-defined identity, along with the set of research directions and policy tools discussed above, should be able to contribute successfully to meeting this formidable challenge.

5. Conclusion

In this paper, a critical retrospective and prospective analysis of ecological economics was undertaken, with the aim of advancing the policy relevance of the field. We began by outlining our understanding of ecological economics, suggesting that for its proper identification it is crucial to acknowledge its two aspects: (i) the qualitative framework within which it operates (i.e. the laws of thermodynamics, the coevolutionary perspective, and the means of managing uncertainty and complexity); and (ii) the quantitative techniques it uses to measure ecosystem resilience and progress towards sustainability, evaluate policies, and assist decision making. We then examined what was missing from ecological economics' analysis and what should be done to influence real-world policy making. If the potential of ecological economics to make a distinct contribution to policy making is to be realised, we argued, ecological economics needs to promote a unified core that would enhance and direct cross-dialogue and transdisciplinary collaboration, as required by the multidimensional nature of sustainable development problems. We then suggested that this necessitated equally the identification of environmental policy instruments that are compatible with the basic ecological economics' framework. We therefore concluded with a call for added emphasis on the qualitative, procedural features within a political economy perspective, and for more research studies on policies and models of economic development that would reflect the needs of both ecosystem integrity and social justice.

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