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Embedding Sustainability in the Economics Curriculum (PRINTABLE)

CONTENTS

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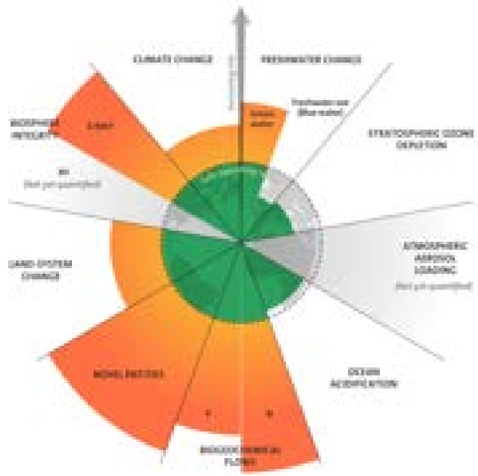
Back to top

1. Introduction

This Handbook chapter addresses the challenge of incorporating sustainability into Economics curricula. It has been revised to incorporate new developments, particularly behavioural economic perspectives.



Planetary boundaries diagram by Azote for Stockholm Resilience Centre via Wikimedia Commons

The need to incorporate sustainability has increasing urgency, given some of the extremely concerning projections from the IPCC and other reports about planetary boundaries being breached. Demand for an economics that incorporates sustainability remains high among current students, and if the School Strikes are an indicator, future students too. Increasingly we understand that the climate emergency is also a global health emergency. We constantly see its direct effects via heat and extreme weather events, but also its indirect effects on health, including new increasing pathogens, climate refuges, food supply chain changes and mental health. Thus, we recognise that environmental economics and climate change speak to many different economics subdisciplines, including labour, public, health, and behavioural economics, as well as economic history and industrial organisation.

Recent research (see Hickman et al., 2021) has also shown that climate anxiety plays an important role on children and young people having a negative impact on their daily life and functioning. Furthermore, climate anxiety and distress seem to be correlated with perceived inadequate government response and associated feelings of betrayal.

Political pressure has increased, via established political processes such as governments making commitments (NDCs) at successive COP meetings and the unconventional (for example, by Extinction Rebellion), and some legislative bodies have declared climate emergencies and/or NetZero policies. Globally, green new deals in various forms have been proposed by the New Economics Foundation, World Wildlife Fund and the Whitley Fund. The UN launched its seventeen Sustainable Development Goals (SDGs), covering economic, social and ecological dimensions simultaneously. The EU Council has formally adopted education for sustainable development (ESD) as a policy goal (Council of the European Union, 2010). In recent years, European countries performed well in relation to quality education (SDG No. 4, where ESD is incorporated as target 4.7) with 16 EU countries scoring above 90 out of 100 (from a scale that considers 0 = the worst, and 100 = the goal achievement). However, major progress and guidance are needed to strengthen ESD in education systems (European Commission, 2022).

Businesses and training organisations want people with the relevant skills. The QAA has launched ESD skills, including systems thinking, critical thinking and normative competence. Universities now have clear climate plans, commitments to decarbonise and are considering sustainability in all their operations, often via dedicated sustainability teams.

1.1 Economics and sustainability

As laid out in the new Economics Subject Benchmarking statement (QAAHE, 2023), a specific purpose of Economics degrees is that

> "graduates develop capacities that enable them to cope with and attempt to create solutions for the global crises we are currently facing, such as climate change, biodiversity loss, environmental (in)justice and potential, consequent instabilities reflected in social and economic inequalities. These problems are transdisciplinary and interdependent in nature".

As such, as well as problem solving skills, they require students to foster critical and creative capacities beyond the application of existing tools and models. The core economics competencies developed in our Economics programmes – for example, assimilation, structuring, analysis and evaluation of data – form a strong foundation for evidence-informed and sustainable policy and provide students with the skills required to engage with sustainability-related topics as they progress and specialise in their subject area. This allows them to develop additional competences (such as systems thinking, and anticipatory thinking) closely aligned with the learning outcomes suggested by the Education for Sustainable Development Guidance produced by Advance HE and QAA (March 2021), which go beyond solely environmental issues, and highlight the need to foster the intertwined nature of the three pillars of sustainability.

Indeed, economics continues to respond in various ways, for instance through wide-ranging reports such as those by Stern (2006) and Dasgupta (2021) in the UK. Ostrom and Nordhaus (2009 and 2018, respectively) won Nobel prizes for work in this area. Meanwhile, new developments in economics offer fresh perspectives on how economists might consider sustainability. One of these, featured in this chapter, is behavioural economics, which offers different ways of conceptualising the individual in relation to Nature, and policy proposals to have positive ecological impact. The 26th Cooperation of Parties (COP26) meeting stressed the need for behavioural change and called for immediate action to tackle the climate emergency. More recently, at COP27, the Egyptian presidency highlighted the need to shift the focus to action on the ground.

Furthermore, approaches informed by systemic analyses have informed policy: these include the much clearer incorporation of ecology into macroeconomic models; and the UK Government approach to valuing infrastructure is now underpinned by a systems of provision approach (Bayliss and Fine, 2020). Yet more approaches, from what some call Social-Ecological Economics, argue that sustainability is incompatible with current capitalism, and/or argue for economic de-growth and present visions of post-growth economic arrangements. These different perspectives illustrate a key point of debate between those who advocate individual behavioural change and others who advocate system change – and a range of others in between – as the route to sustainability.

Teaching has now embraced more regularly sustainability since Green (2013) reported that textbooks largely ignored the issue. CORE has placed the economy more squarely embedded in the ecology, even if some critics would like it to go further to include the biophysical. Doughnut Economics, as developed by Kate Raworth (2017), has had a large impact, developing a needed literature to increase awareness of climate emergency. Doughnut Economics echoes the planetary boundaries approach by recognising that there are limits within which economic activity must operate.

The challenge of embedding sustainability is considerable, but also interesting, even for those with no interest in the topic. Why? As will become apparent, the task of placing this issue in the curriculum involves a range of choices for the programme designer; it also requires the teacher to take an inherently multi-faceted, complex and interdisciplinary concept and place it in a disciplinary context. In addition, it forces the tutor to be aware of the pedagogical issues that become acutely manifest: the engagement of the student, helping them through their inevitable confusion, and the achievement of resolving their problems.

Top tip

Consider why incorporating sustainability is important to do. Discuss this with students.

However, there are several reasons for trying to meet these challenges, not least because overcoming them could be personally rather satisfying. Second, given the prominence of sustainability, students are likely to be already engaged with, perhaps enthusiastic about, the topic. Third, given the contemporary context – of climate change, resource crunch, biodiversity loss, food delivery challenges, and so on – dealing with sustainability is arguably important. Fourth, the students will gain tremendously: given the multi-faceted, complex nature of sustainability, students will develop depth of understanding, the ability to weigh up conflicting opinions and value systems and make decisions in the light of them and develop systemic thinking skills. Your students will come out better educated at the end and will develop several future-proofed capacities (e.g., global thinking, lateral thinking, and cognitive flexibility are only some examples). The development of these aspects is also likely to help students be more employable, both in having the relevant sustainability skills and aligning better with employers' concerns.

2. Getting Started

Back to top

Teaching sustainability involves choices. All teaching does, of course, but given the relative novelty of the subject and the lack of established resource bases, say, compared with core microeconomic theory, there are fewer ready-made guides on how to design sustainability curricula and how to deliver them. Advance HE, for example, provides useful guidance on how to embed sustainability into the curriculum, but not clear examples of how to teach sustainability. That lack of pre-existing structure can be liberating, but also daunting.

However, the choices are unavoidable. There are two main sets of choices to be made. One is whether to integrate sustainability across the curriculum (if it is possible within institutional constraints) or whether to create specialist niches within it. That choice is followed by others about the depth of integration and about the theoretical approaches considered. We shall return to those issues shortly. Before that, the tutor needs to consider what they understand by sustainability. Sustainability is a complex term that addresses the tension between different assets/capital (social, environmental and economic) and combines them into a single concept. This chapter is designed to help tutors make these choices.

Top tip

Use examples to illustrate unfamiliar sustainability concepts: make it personal not abstract. For example, ask students to consider their own consumption patterns, perhaps using a personal carbon or ecological footprint calculator. The WWF has a free option. Ask them to consider their university as a system. Murray (2011) may be a good resource.

2.1 What is sustainability?

A barrier to teaching sustainability is the lack of a clear definition. A common-sense definition of sustainability is that a thing can last. However, what is it that lasts? A firm, an economy, a society, a species, an ecosystem? And when it lasts, does it grow or improve, does it deteriorate, or none of these? The UN World Commission on Environment and Development generated the Brundtland Report and its definition of sustainable development as:

> "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987: 54).

However, this still begs many questions: is sustainable development possible? Is it possible to trade off one type of sustainability – say, ecological – against another – say, economic? Are human manufactured goods equivalent to those produced in the rest of nature? Given these questions (and others) it is perhaps not surprising that there are so many definitions of sustainability. This array of definitions can be a further barrier, but also a learning opportunity for students, as they show the complexity of the issues at hand, and that sometimes, single definitions are not available.

A key leader in defining sustainability has been the United Nations. The Brundtland definition (above) has now been supplemented by the UN Sustainable Development Goals (SDGs).

These goals are significant in themselves, in having UN backing which enables their adoption. The SDGs and their underlying approach also indicate several important elements within the literature on sustainability. The first point to note is that they are multi-dimensional, taking in ecological goals that go beyond preventing climate change, social and economic goals. Here, they resonate with approaches such as that of the Triple Bottom Line (Elkington, 1997), the three pillars, popular among some ESG professionals in businesses, and the 'Five Capitals' model (Goodwin, 2003), the five being natural capital, human capital, manufactured capital, social capital and financial capital. The model is the basis of one definition of sustainable development. A further useful definitional distinction is that between weak and strong sustainability (Pelenc 2015). In the former, natural resources are somewhat substitutable by human-made, whereas the latter rejects such substitutability.

It is important that students are exposed to (at least some of) these different definitions, to demonstrate that sustainability is a contested concept. That understanding ought to make it clearer to them why there is so much debate about sustainability. However, the tutor clearly cannot juggle all these balls in the air at once and must make some choices about how they define sustainability in their approach. This choice is also crucial because it will condition the extent to which they might wish to integrate sustainability into the curriculum, whether they take a more, or less, interdisciplinary approach, whether they consider (for instance) economic sustainability alone, and to what extent they wish to incorporate approaches to sustainability which lie somewhat outside the mainstream (for example in *ecological economics*). Indeed, definitions of sustainability help define the distinction between mainstream and ecological economics: the former favour very weak or weak sustainability, while the latter favour strong or very strong sustainability.

Identifying the components of sustainability is just one step, though. A more important question is how they interact; there is considerable debate about this and one way to engage with it is to consider the range of definitions of sustainability. As we move down the degrees of sustainability, we can see at play quite different views of how the economy and environment relate to each other, specifically whether they are separate systems or somehow embedded in each other, and of the possibility of trade-offs between the two (and with social and other dimensions too). Strong and very strong sustainability both suggest the growing recognition that the economy is embedded in the environment, as well as affecting it; and that trade-offs of economy and ecology are not smooth or trivial.

Goodwin (2003) suggests that for sustainability, the total stock of the five capitals should be maintained although the depletion of one type can be compensated for by the increase in others. For example, lost agricultural land (natural capital) could be replaced by a shopping centre (manufactured capital); or forests could be replaced by carbon capture and storage power stations. But this substitutability is frowned upon by adherents to stronger views of sustainability. However, it should be noted that mainstream economics is concerned with the flow of resources into the economic system while the discourse of sustainability focuses on stocks and the rate of depletion or degradation.

One approach that takes this view is Doughnut Economics as developed by Kate Raworth in 2017. Doughnut Economics relates the economy to both social values and goals (the inner ring) and (the outer ring) to a broad range of biophysical markers, reflective of the planetary boundaries approach of Rockstrom et al. (2009). The space between the inner and outer rings is the "safe and just space for humanity, in which inclusive and sustainable development can occur." The doughnut thus represents a system in which there is balance, and in which some trades-off are necessary, but also one in which one cannot trade-off health for education, for instance, or push growth so far as to cause negative ecological impacts beyond the capacity of the planet to cope.

The key idea of the doughnut approach reflects other, perhaps more radical takes on sustainability, in some of which, building on the work of Meadows et al. (1972), growth and sustainability are fundamentally incompatible. These authors hold that sustainability is incompatible with what might be described as ‘business as usual’. The Living well within limits (LiLi) project explores how economies can be re-designed to allow human flourishing without breaching planetary boundaries. The LiLi project uses a ‘systems of provision’ approach that stresses the interdependence of supply and consumption forces, including the importance of culture in driving consumption. For example, Mattioli et al. (2020) discuss structural and cultural barriers to reducing car use.

Other ecological economists draw on thermodynamic approaches and consider the economy in terms of social metabolism, meaning examining it as a system with flows of energy and materials in and out (see Martinez-Alier, 2013), necessary to avoid entropy (see Georgescu-Roegen, 1986 for his own retrospective). Related to that are the concepts of sustainable scale and steady-state economies, both of which are derived from the work of Robert Costanza and Herman Daly, two of the first leading ecological economists. Allied to these approaches are other visions of the economy such as the wellbeing, circular, foundational, de-growth or post-growth, all of which, as their names suggest, reject the typical focus on growth adopted by most economists, politicians and indeed the public.

2.2 Introducing sustainability

Given all the above and its complexity, as mentioned above, introducing sustainability can be a challenge, however, it also presents options. Introducing sustainability to students can be done in several ways. A simple way to introduce the topic could be by means of a word cloud (see Figure 1 below). The advantage of this approach is that the instructor can easily realise whether the students have been exposed to sustainability, which will be evidenced by visualising the relevant keywords (i.e., economic, social, and environmental) in the cloud. Clearly, if this is not the case, the instructor will fill in the gap starting a discussion about the three pillars of sustainability.

Figure 1: sustainability word cloud from Malesios et al. (2020)

Another approach could be to start from an ecological perspective, which sees natural cycles that support ecosystems as the implicit foundation of any discussion of sustainability. An overview of these natural systems is necessary as the basis for exploring the impacts of different economic systems and activities. A few natural cycles could be introduced in early lectures or virtual material. These might include the carbon cycle, making connections with climate change; and the hydro cycle, with a focus on areas of water shortage and the food chain, with discussion of the need for dietary changes if a growing population is to be supported. The advantage of exploring the ecological perspective from the outset is that the concept of sustainability is readily understood. If this approach is followed, the concept can be introduced as the preservation and encouragement of these natural cycles and ecosystems to maintain or increase bio-diversity.

Another approach is to introduce ecological systems when relevant to particular economic topics. However, this leads to a fragmented understanding of what is essentially an interrelated set of natural systems. This might be heavy going for those students not particularly committed to sustainability and be perceived as 'preachy'. Also, for economists the material might be somewhat inaccessible.

Further, if the tutor wishes to discuss sustainability in a broader sense, they might use the different definitions as entry points into debates about policy, good business practice, etc. Some policy options (for example, the so-called 'technological fixes') would be ruled out if one took a strong sustainability approach.

Top tip

Don't moralise. Admit that a great deal of the discussion around sustainability is value-driven and stress the importance of various different positions on it.

Top tip

Engage students in real problems; including discussing openly the global challenge of sustainability. What can be done? (see Box 1)

2.3 Integrate or specialise?

If a tutor regards sustainability as of fundamental importance, they may wish to integrate it fully into the Economics curriculum. Whether they can, of course, depends on institutional constraints and their own skills of negotiation. Those concerns are beyond the scope of this chapter.

Given that one could integrate sustainability, there are different ways to do this. At one end of the spectrum, a programme might be designed according to problem-based learning (PBL) principles: the problem to be addressed would be achieving an economy that supports a sustainable world, and all the learning would be working towards a solution (see for example, Forsyth, 2010). PBL in its purest form allows the curriculum to unfold as the course progresses.[1] That of course requires great skill on the part of the instructor. Witham and Mearman (2008) discuss some existing uses of PBL in ecological economics courses. That there are some examples of PBL in this area is perhaps not surprising, because sustainability lends itself to a PBL approach: clearly sustainability is a 'big', multi-faceted problem, meaning that the course could unfold in a multiplicity of ways. As discussed below (Assessment) one can design coursework assignments or exam tasks around specific problems. That there are some examples of PBL in this area is perhaps not surprising, because sustainability lends itself to a PBL approach: clearly sustainability is a 'big', multi-faceted problem, meaning that the course could unfold in a multiplicity of ways. As discussed below (Section 6 on Assessment) one can design coursework assignments or exam tasks around specific problems.

If PBL is a step too far, a course could still begin with the problematic of a sustainable biosphere and then explore the implications of that for an economy via more conventional teaching. Alternatively, sustainability could still be the central theme (or one of a small number of themes) in a curriculum. Where appropriate, all modules would be organised with sustainability in mind. That would involve constructing examples, exercises and assessment that are all concerned with sustainability. Box 2 discusses how to deliver standard concepts such as the circular flow of income with added sustainability content. Such tools would be useful even if sustainability were not a central theme, but instead was a topic which needed to be included in all modules. This last form would be the weakest form of integration, in which sustainability is tacked on to a standard module, often at the end. Section 3 below discusses a standard introductory and one standard intermediate economics course into which examples and applications from sustainability are incorporated easily.

In the strongest forms of integration, students may learn all they need about sustainability simply by doing other modules. However, in those cases, and certainly in weaker forms of integration, students may have had their interest in sustainability stimulated and desire more specialised, detailed knowledge. So, even if a student has been on a programme that integrates thoroughly sustainability at undergraduate level 1 (and/or 2), they might desire specialist modules at level 2 and/or 3. At this point, the choice for the tutor becomes one of which approaches to choose. Again, this may reflect their understanding of sustainability. Those who understand sustainability more narrowly may choose to deliver sustainability solely according to mainstream principles, as found in standard treatments of environmental and/or natural resource economics. Those who take a broader view of sustainability may wish to deliver an ecological economics perspective. In this latter group, as indicated above, it may be possible to begin with a discussion of a sustainable biophysical ecosystem and derive the economics from it. A third alternative would be to try to deliver the two approaches in parallel or debate. Such an approach presents many challenges but may also yield many benefits (see for instance Mearman (2017) on heterodox economics and pluralism).

The main body of the chapter examines in detail how these different alternatives could be delivered. Section 3 explores ways in which sustainability may be taught in standard economics modules. Sections 4 and 5 discuss different variants of specialist courses on the environment or sustainability: Section 4 discusses a course on economics of the environment, with sustainability emphasised, in which environmental and ecological economics perspectives are compared. Section 5 discusses a course in the economics of sustainability. Section 6 concludes, discussing issues related to Assessment.

Top tip

Don't try to shoe-horn in too much material. The course you create must remain coherent and varied.

Back to top

3. Teaching sustainability in a standard core module

The first available way to integrate sustainability into an economics curriculum is simply to tack it on as a subject at the end. However, in practice such topics tend to get dropped, or not included in assessments. A more effective way to integrate sustainability – though requiring greater co-operation from staff – would be to use examples from sustainability. Table 1a outlines an introductory economics course, taking in microeconomics and macroeconomics, into which applications to sustainability have been added. The table presents possibilities for inclusion: tutors can pick and choose topics depending on how deeply they wish to explore sustainability. The sustainability topics do have some logical progression, but they could be taught independently.

First, a caveat: the lay out below could be accused of looking how an introductory course *used to look*, before the advent of CORE (Curriculum Open-Access Resources in Economics), which takes a different approach. Instead of explicitly proceeding in a series of theoretical topics or concepts, CORE tackles real-world issues, including examining relevant data. Indeed, one of the issues it addresses is sustainability. So, under CORE the layout of the course could be quite different, with sustainability as its own topic. This does, of course, raise the possibility that sustainability is treated as a separate topic rather than one that is embedded. However, even under the CORE framework, students are gradually exposed to theoretical concepts, so laying out a series of concepts and their sustainability augmentations as in Table 1a would remain applicable.

Table 1a: Introductory economics course

Microeconomics	
Topic	Sustainability augmentation
Scarcity; 'the economic problem'	Scarcity: absolute versus relative

Microeconomics	
Topic	**Sustainability augmentation**
Decision-making	Multiple ethical bases: triple bottom line (see Elkington, 1997); Multi-Criteria Analysis (MCA) versus Cost-benefit Analysis (CBA): See Box 3
Markets: supply and demand	Carbon markets; oil market (could include 'peak oil')
Demand theory; elasticity	Effect of a tax on petrol; road charging
Theory of returns and costs	End-of-pipe technology (adaptations of existing plants to reduce pollution) and costs
Theory of the firm	Increase of resource/raw material/energy costs
Market structures	Joint profit maximisation – fishing and maximum sustainable yield
Market failure	Externalities of pollution, climate monetary/non-monetary policies (e.g., taxes vs subsidies vs nudges)
Micro policy	Carbon rations, petrol taxes; optimal amount of pollution; carbon taxes

Macroeconomics	
Topic	**Sustainability augmentation**
Circular flow of income	Circular flow extended to include biosphere (see Box 2)
Macroeconomic objectives	Sustainability as an objective; an extra trade-off (see Box 4 on recent macroeconomics of sustainability)
Economic growth	Sustainable development; alternative measures of well-being, such as Index of Sustainable Economic Welfare (ISEW), Happiness indices, and the Happy Planet Index (HPI)
Keynesian macroeconomics	Green stimulus packages, Green New Deals
Unemployment	Green jobs
Inflation	Price of green products; finite resource cost inflation; backstop technology as a response to inflation
Money demand and supply	Green economics treatments of money as debt; carbon as a currency; local currencies
Monetary policy	Green 'quantitative easing'; 'green bonds' and other aspects of 'green finance'

Macroeconomics	
Topic	**Sustainability augmentation**
Fiscal policy	Green stimulus packages; carbon and pollution taxes
International trade	Transport costs; global value chains; COP; localism versus globalism
Exchange rates	Carbon trading markets

Some of the sustainability topics included are easy to include, whereas others require more ingenuity. Examples of the former are the discussion of the effect of a tax on petrol as an example of elasticity; the carbon market as a market to study; the current debate on the use of monetary/non-monetary interventions with brief reference to green nudges (and their ethics); and the treatment of pollution externalities. On the macro side, the effect of natural resource costs on inflation, the use of fiscal policy for green stimulus, and the measurement of standards of living are also simple to introduce. In the category of more difficult topics would be those that require conceptual shifts, such as the discussion of multiple ethical bases, joint profit maximisation, and sustainability as an economic objective (see above; and see Box 4).

Top tip

Utilise the extensive range of software packages available. See Box 6 for some examples.

All would involve the commitment of some time by the tutor. Even more challenging (as hinted at by the discussion of multiple ethical bases) can be ventures into other disciplines. Examples are the extended circular flow of income (see Box 2), end-of-pipe technology and its effects on costs, green treatments of money (see Scott Cato, 2008: ch. 5), 'green' quantitative easing, and discussions of geological theories, such as peak oil. Whether or not and how these get taught will depend on how much time is available, the willingness of the tutor, and the availability of relevant supporting resources. As in Table 1b below, the topics above can be delivered either as an entire suite, or more likely, selected to enrich a standard module, alongside examples from other relevant broad topic areas.

The extended circular flow model has a natural resource stock located at the centre and the flows of materials and services to and from the household and productive sectors indicated by arrows. An approach that has proved successful is to present the conventional circular flow in a lecture and ask where the natural environment and ecosystem services are. It is conventional for students to answer that these are contained within land. Ask the class for examples of the inputs that come from land. Usually, students ignore the ability of the natural environment to provide waste assimilation services. They also ignore the waste assimilation and amenity services provided to households. That omission is the justification for making these ecosystem services explicit by adding to the diagram as above.

Clearly at the introductory level there is plenty of scope for examining sustainability issues. At the intermediate level, this is also true. In this case we shall discuss an intermediate microeconomics course with sustainability material included. One could of course also construct an intermediate macroeconomics course augmented for sustainability. The issues of integration, resourcing, specialist knowledge required, and time constraints are present as in the case of the introductory course. In some respects, they are even more acute because the technical level of the material is higher. In other respects, though, integration of sustainability is just as easy, if not easier. Table 1b outlines an intermediate microeconomics course augmented for sustainability. As above, although it is possible to deliver all these augmentations, that is not necessary. The suggested discussion topics can be inserted individually into a conventional course.

Table 1b: Intermediate microeconomics course

Topic	Sustainability augmentation
Consumer theory	'Economic human' vs. 'Real-human/homo realitus' vs 'Eco-human' (see Becker, 2006); willingness to pay (WTP), willingness to accept (WTA); cost benefit analysis (CBA)
Analysis of choice under risk and uncertainty	Problem of non-probabilistic (Knightian) uncertainty? Question the value of the expected utility hypothesis under uncertainty
Analysis of investment appraisal and long-term decision making	Assumptions made? Discounting and the environment? Precautionary principle
Isoquant theory	Questioning the nature of capital; natural capital; the shape of isoquants
Theories of the firm	Alternative goals: business ethics, including CSR and, ESG; sustainable business models (see Bradley et al, 2020), competition and sustainability
Labour markets	Basic income schemes
Market structure and efficiency	OPEC and oil prices
Game theory	Climate change negotiations and compliance –see discussion of classroom games.
Price discrimination	Peak flow pricing
General equilibrium analysis	Welfare effects of climate change
Public goods and merit goods	Environmental impact evaluation, green nudges, climate policy vs climate regulation

Topic	Sustainability augmentation
Externalities and their internalisation	Pollution and its abatement, green nudges, climate policy vs climate regulation

For example, once students have discussed consumer theory, it is an easy step to discuss the notion of an eco-human (cf. economic human) whose concerns with sustainability may override utility from consumption of some goods; or for whom preferences are lexicographic in favour of sustainably-produced goods.

Both can then be compared to 'Real-human/*homos realitus*' – a concept derived from behavioural economics – whose concern with pro-environmental behaviour is affected by behavioural biases (i.e. status quo bias, framing effect, overconfidence, licencing effect, confirmation bias, salience, bystander effect, sunk-cost fallacy, carbon footprint illusion) which prevent them to engage with and meaningfully act on climate related issues (see e.g. Barile, 2022; and Luo and Zhao, 2021; and Xie et al., 2019). Most of these biases are documented in the literature (see e.g., Hoggett (2019) and Marshall (2015)) and contribute to explaining why it has been difficult to build consensus around climate change not only in the scientific community (e.g., cognitive biases such as present bias, framing effect, bystander effect and sunk-cost fallacy are relevant here) but also among citizens (e.g., in addition to cognitive biases, perception biases such as confirmation bias, and overconfidence may play a role in this context). This is also exacerbated by climate mis/disinformation that is currently challenging climate action. Although the reality of the climate crisis is an undeniable truth, widely documented by the scientific community, climate deniers promote doubt about the existence, impact, and anthropogenic causes of climate change (see Lynas et al., 2021). Their tactics range from misrepresenting scientific data to accepting severe climate change but denying the possibility of meaningful action or advocating ineffective action (Oreskes and Conway, 2012).

Climate mis/disinformation has been recognised as a threat for outcomes of the Cooperation of Parties meetings. Therefore, during COP26, institutions including WWF International and the Centre for Countering Digital Hate were among 250 signatories to an open letter to the UN asking for action on climate misinformation. The letter, now available at Climate Action Against Disinformation (CAAD) and re-proposed to the COP27 Presidency, Country Delegations and UNFCCC, calls on world leaders and social media platforms to act against climate mis/disinformation. This could be used as a starting point to initiate a debate about climate deniers. The Climate Attribution Database then provides a useful tool to search for scientific research organised by thematic areas, which could be used to show students not only the causal link between human activities and climate change, but also how changes in the climate affect humans and ecosystems, including food security, productivity and labour supply (by means of impact attribution). Similarly, the World Weather Attribution (WWA) initiative offers attribution analyses on extreme weather events, and represents another invaluable source of information in this area.

In relation to other topics, indifference curve analysis can be used to discuss willingness to pay and willingness to accept (see for example, Perman et al., 2003: ch. 12) and introduce the status quo bias which leads to individuals' inertia to act.

Notions of compensating and equivalent variations help illustrate cost benefit analysis. The topic of valuation is discussed further in Box 5, which also discusses cost benefit analysis; and the software package CBA Builder (Wheatley, 2011) is discussed in Box 6. The analysis of choices under risk and uncertainty can be linked to the discounting debate and the concepts of weak/strong sustainability. It may offer an opportunity to better understand how 'homo realitus' deviates from rational behaviour and exponential discounting with present bias and hyperbolic discounting. It also helps introducing ambiguity aversion and interesting reflections on the need of discounting all goods the same (see Goodin, 1982), and using different discount rates for different assets depending on concerns regarding future generations (for a discussion on dual discounting see e.g., Kula and Evans, 2011; and Almansa and Martinez-Paz, 2011), which ultimately affect the pure rate of time preference in CBA.

For some of the topics shown in Table 1b the sustainability aspect is very clear: for example, general equilibrium, public and merit goods, and externalities are often taught anyway using environmental examples. For some of the other aspects it is also fairly trivial to introduce sustainability. For instance, OPEC is often used as a case study in oligopoly. The sustainability angle could be extended to discussing broader aspects of OPEC strategy, such as linking production to reserves. The theory of peak oil could be discussed at this point.

Sustainability also lends itself to a discussion of price discrimination. An interesting exercise in price discrimination is to present students with apparent examples of it – such as fair trade versus other coffee, feed-in electricity tariffs, organic versus non-organic food – and discuss whether (and why not) these are true examples.

Modelling climate change treaty negotiations and compliance could also be a good vehicle for teaching game theory. It is easy to use a simple Prisoner's Dilemma to discuss the likelihood that one country would renege on climate deals; and then discuss why this analysis might explain why climate deals are difficult to negotiate. It is also easy to incorporate discussions of sustainability into the topics of investment appraisal and long-term decision making. Clearly, as discussed in Box 5, discounting is a crucial feature of valuation of ecological objects, and of CBA. Some students may appreciate the chance to discuss concrete cases of a non-financial nature; others may wish to discuss what discount rates ought to be. Ackerman (2009) provides an illuminating discussion of discount rates from the viewpoint of sustainability. More difficult for economics tutors to discuss might be questions of the nature of capital (and therefore substitutability); and non-probabilistic uncertainty. Yet, uncertainty of this type is pervasive in sustainability questions. Sensitivity analysis can assist us in imagining future scenarios, but it is instructive for students to consider what they would do when they simply do not know future risks.

3.1 Introducing valuation to students

This is a very rich area for exploring issues in applied economic methodologies and for discussing underlying theoretical issues. As an introductory exercise, groups of students can be asked to choose an environmental asset to value and then be given roughly fifteen minutes to sketch a valuation methodology they might apply. Each group then describes their methodology, and this leads to some interesting discussion of problems and challenges.

For examples, in introducing the topic, students can be asked to think about the distinction between environmental goods and bads. Economic agents consider environmental goods as items that increase their utility and for which they prefer more to less (e.g., water quality and rainforests). By contrast, environmental bads tend to decrease their utility as they increase (e.g., noise, and water pollution). Clearly, some environmental goods and bads are mirror images of each other – e.g., river water quality (a good) and river water pollution (a bad).

Environmental valuation is considering the increase (decrease) in utility from an increase (decrease) of an environmental good or the increase (decrease) in utility from a decrease (increase) of an environmental bad. This is equivalent to say that it aims to measure the change in utility from a one unit change in the good or bad. This may lead to an interesting conversation about compensating variation (CV) (i.e., the amount of income an individual would pay to keep their utility as it was before introducing a change), and the equivalent variation (EV) (i.e., the amount of income an individual would accept to avoid the change), and how they link to WTP and WTA when considering a good or a bad.

Students can then be asked to reflect on how accurate this measurement could be. It is certainly difficult to measure environmental goods/bads, especially because most environmental goods are public goods, and most environmental bads are negative externalities, so it is very hard to come up with an accurate estimate of environmental amenities/assets and the benefits and costs of preserving them. However, not monetarizing environmental goods/bads means not placing a value on them, which negatively affect CBA (as many projects will not pass this appraisal exercise).

Cost Benefit Analysis (see Box 3) is very useful for students to consider. It has clear policy implications and usefulness and deals with concrete examples. CBA is used in a variety of contexts within government. It also serves as an excellent pedagogical tool, as it can stimulate discussion about what and how to measure objects, whether they are amenable to measurement and, if not, how to deal with them. CBA Builder (Box 6) is also a good tool for teaching and for students to master Excel. It is therefore useful on any applied microeconomics course. Further, attitudes to CBA are also one of the division points between environmental and ecological economists: the latter are sceptical of CBA and at best favour cost-effectiveness analysis.

Back to top

4. Teaching a contending perspectives course on economics of the environment

All the course structures contained in this chapter are of course simply materials from which to draw. Above, one could choose to teach the courses as laid out or pick elements to include in one's own introductory or intermediate microeconomics courses. Or they could simply be a set of concepts that are significant in this sphere. Both courses are core to the curriculum and are ideal if one's goal is to integrate sustainability into the curriculum. However, if one chose instead to create specialist courses, or if the goal was to allow students to build on earlier core courses, a different model is required. The next two sections discuss two possible options: one is a course on economics of the environment; the second (Section 5) is on economics of/for sustainability.

The first is presented again as a set of possibilities. There are several ways in which one could teach a course on the economics of the environment. A standard approach is to teach 'environmental economics'. Such a course would emphasise the principles of the left column in Box 7. This draws on literatures called 'environmental economics' and 'natural resource economics', which tend to be constructed on conventional economic principles. As an alternative, or complement, one might teach 'ecological economics', a literature in which the items in the right column of Box 7 are emphasised.

Again, there is a choice about to what extent one employs ecological economic principles and concepts. One could integrate them into an essentially conventional course on environmental economics, either extensively or piecemeal. Or one might choose to teach from the ecological economics perspective. In terms of sustainability, this could be justified if one agreed that ecological economics is the 'science of sustainability' (Costanza et al., 1991).

A third alternative is to teach both 'environmental economics' and 'ecological economics' in debate or, in parallel, i.e. as complementary or contending perspectives. Again, the instructor faces a choice of how to do this. In the course shown below (see Table 2) the contrast between the two views of economics is presented almost immediately.

Table 2: Contending perspectives course – environmental versus ecological economics

Topic	Emphases
Current state of the world	Major issues: resource depletion, global warming and climate change; pollution; combined problem of population growth and inequality
Two views on economics	See Box 7 on ecological and environmental economics
Ecosystems	Notions of materials balance; keystone species (Paine, 1969 is the seminal piece)
Thermodynamics	Laws of thermodynamics
Sustainability	Damage functions, assimilative capacity

Topic	Emphases
Growth and the environment	Environmental Kuznets Curve
Externalities and property rights	Optimal level of output and pollution; policies to achieve them
Cost benefit analysis	See Box 3
Ecosystem services – valuation	See Box 5
Sustainability and biodiversity	Quasi-option value see Box 5
Human populations and ecology	Food; agricultural sector; diet
Resource use and renewability	Finite and renewable resource models – MSY Hotelling model
Trade and pollution	Off-sets; UK exporting ecological/carbon footprint via FDI
Climate change	Carbon footprint; the Stern review; impact of climate change
Adaptation and resilience	Carbon capture and storage (CCS) technology; localism; flood defences; genetically-modified crops

The course begins by outlining the current world situation. It is hoped that this would stimulate interest. It is important to stress at that point that there are several issues to consider. Whilst it is important to bear in mind that there are dissenters to the near-consensual view on anthropogenic climate change, it is unproductive to get stuck on that issue; it is better to move on to questions of biodiversity loss, resource depletion and the like.

After this opening follows the discussion of the two contending (or complementary) perspectives. Again, at this point, the instructor must choose whether to see the perspectives as arguing over who is correct (contending) or as both providing insights that fit with those of the other (complementary). This choice affects the entire delivery of the course and is particularly acute in its assessment. Students can be asked to consider a problem from both perspectives and consider which one is better, how to use both, or even be invited to supersede each in a novel combination. Whichever of these routes is taken, there is a danger of confusing students; however, these dangers can be reduced if the contrast is introduced early in the process, and if it is reinforced often, particularly in assessment. Thereafter, the course is a series of topics on which each perspective has a bearing to differing degrees.

Top tip

Using multiple perspectives can be challenging to students. Guide them carefully, but do not push them through the contrasts.

It is true that much of the early material is from natural science and it would be unreasonable to expect economics instructors to be *au fait* with many of them. For example, most would not have a command of the laws of thermodynamics; however, some rudimentary knowledge of them would be required. The crucial point to get across is of entropy and of how it is necessary to have systems that are open. Similarly, it requires an ecologist to understand fully the nature of ecosystem services; however, the main point of this discussion is to make clear the roles of carbon sinks, etc. and to encourage students to think more broadly about, say, a field than simply its marketable value. Fortunately, standard texts in ecological economics deal with this need by offering definitions of concepts such as damage functions, assimilative capacity, and the like.

Many of the other points have already been discussed and draw on the material elsewhere in the chapter. On many of these there is considerable debate between environmental and ecological economics. For instance, on valuation (see Box 5) while ecological economics acknowledges that conventional valuation methods such as WTP and WTA, hedonic pricing, etc. are useful they are more sceptical about their value. Ecological economists are more likely to argue that vital ecosystem services are not amenable to valuation at all, or at least only with considerable scope for error.

The scope for debate continues throughout the course, finishing off with the highly contentious topic of climate change and the controversial Stern Review (2006). The Review is a very useful pedagogical device because it is possibly the most thorough application of techniques of economics of the environment to questions of sustainability (and certainly the most well-known) so provides an excellent vehicle via which to reflect on the rest of the material in the course. Also, the Review is useful because it has been vigorously opposed from both sides of the debate. For example, Nordhaus (2007) has argued that the discount rate assumed by Stern is too low. Dasgupta (2007) is concerned that Stern's discount rate does not consider sufficiently intragenerational equity. Ackerman (2009) criticises the attempts at valuation within the Review. An obvious capstone to this course would be a debate between groups of students on the Stern Review, in which they are expected to draw on relevant concepts from the course.

Back to top

5. Teaching an applied course on sustainability economics

The above course is one on economics of the environment, in which special attention could be put on sustainability. However, one could go a step further and construct a course specifically on sustainability economics, perhaps based on the programme of Baumgartner and Quaas (2010), which stressed the ethical basis of sustainability economics and identified efficiency as a goal in the service of environmental justice and included foci such as systems thinking, uncertainty, thermodynamic principles and used input-output models extensively. Courses on sustainability economics remain unusual. The course below (Table 3) is constructed based on one taught by the authors, combined with some other examples of good practice from around the world.

We feel that in a course on sustainability, starting by discussing a sustainable biosphere is unavoidable and desirable. It is essential that students understand the nature of the biosphere, and thence its sustainability, before moving on to consider what economic (and other) systems would be needed to achieve sustainability. One way to approach the question is to lecture about some basic concepts, but then take the main components of the biosphere: soil, marine, hydrosphere, natural forest, wetlands, etc., and divide the class into groups to report back on each part. This could be used as a model for the rest of the course.

Table 3: A course on sustainability economics

Topic	Tasks or exercises
Sustainable biosphere	Group reports
Complexity and systems	Complexity game (see below)
Entropy and thermodynamics	Energy hierarchy and its appropriate use
Circular economies and closed systems	Ellen Macarthur Foundation video; materials balance
Definitions of sustainability	Weak/strong sustainability
Core concepts in ecol econ – scale, distribution, efficiency	Ecological footprint
Economic growth and physical limits	Critique of Environmental Kuznets Curve; notion of critical resources: peak oil; (see LowGrow model in Box 6)
Measurement of economic activity	Happiness/HPI discussion
Triple bottom line	Ethics; campus walk (see Box 8)
Valuing natural capital	See Box 5
Cost benefit analysis	CBA builder (see Boxes 3 and 6)
Public goods	Classroom games (see Box 9)
Property rights	Notions of commons; anthropo-ecological systems
Eco-product design and lifecycle analysis	Biomimicry; show and tell: students bring products to discuss their design and production in terms of sustainability

Topic	Tasks or exercises
Population	Food; agricultural sector; diet

One of the consequences of teaching a sustainability course in this way is that students are exposed to economics of complex systems. This exposure may be of benefit in itself. Complexity economics is a relatively young discipline and shares many of its roots and much of its history with ecological economics; yet it has a broader application and has been expounded by significant figures in economics such as Kenneth Arrow and Thomas Sargent. Complexity economics has many implications for both theory and practice. It suggests that even with simple behavioural rules (and hence it has connections with behavioural economics) purposive agents in complex systems can generate unpredictable and potentially explosive outcomes. This has implications for theory – simple rational maximisation becomes less plausible; for methods – agent-based modelling is preferred, and the typical mathematics of economics is regarded as inadequate; and for policy – small policy changes can have large and unpredictable outcomes.

One way to explore this is via a simple complexity game in which students are divided into small groups; each student receives a card with four rules of behaviour on them (at least one of these might be their objective) to which they must adhere. The object of the game is to show the multiplicity of possible outcomes when faced with simple rules.

Top tip

Introduce students to a delicately balanced ecosystem, to understand the complexity of sustainability. Example: a delicately balanced ocean floor ecosystem, whereby bacteria process organic detritus in various ways, some of which lock up carbon and some of which do not, dependent, crucially on the presence of a virus (see *The Economist*, 2010).

By exposing students to these concepts, complexity economics can benefit them but also alarm them. However, arguably in studying sustainability, complexity is essential because it attempts to capture interconnections and systemic effects in ways that even DSGE models do not (see, for example, Colander et al., 2008). Further, by tapping into modes of thought currently used by governments and other researchers, students are increasing their employability.

The course contains several elements which could be applied to any of the other models above. For instance, the concept of ecological footprint captures the notion of sustainability quite well; and it is empirical and can be evaluated using the REAP software (see Box 6). Under the heading of growth, the macroeconomic consequences of low growth (or even de-growth) could be explored via the LowGrow computer simulation model (Victor, 2008) (see Box 6). A discussion of growth as an objective creates the potential for a discussion of happiness literature, which has much contemporary currency. The literature is varied but includes large econometric analyses so can be a valuable way to explore empirical issues as well as those associated with utility maximising consumers. The issues of valuation and CBA were discussed above, but clearly are important here. A show and tell session, in which students bring in examples of products into class for critical analysis, using life cycle analysis, might be an effective way to discuss that analysis but also asks the students to explore everyday objects from a new perspective.

In a discussion of ethics, following on from definitions of sustainability, is the notion of clashing ethical bases and contesting needs. This clash is captured well by the concept of the Triple Bottom Line (see Section 2.1). One way to explore this concept is via a campus walk or living lab (see Box 8), to demonstrate that each part of the university campus has on it competing demands which must be resolved. Obviously each one would be different and would need to be investigated beforehand.

6. Assessment

Back to top

As has been suggested many times already, assessment is crucial in delivering and generating learning of sustainability. This requires us to re-orient and innovate HE assessment methods to make sure students will be equipped with the relevant sustainable skills and competences. Kioupi and Voulvoulis (2022), for example, propose an assessment framework for evaluating the attainment of sustainability competences and align University's programmes learning outcomes to sustainability. The framework highlights how different types of assessments can be used as tools to develop sustainability competences in a Postgraduate programme that already had strong links to sustainability. Interestingly, they conclude that further pedagogy research is crucial in this area to understand whether the framework may serve the needs of different types of programmes (e.g., weaker linked to sustainability, or Undergraduate Programmes). We recognise the need for further analysis to guide curriculum review in light of recent policy developments (UNESCO, 2020) that advocates a more holistic approach to sustainability, calling for greater communication and collaboration between universities, businesses and local communities to promote sustainability competences (see also Cook, 2020). However, a few suggestions are provided below.

A key principle is to use assessment to encourage engagement. This can be achieved by basing it around practical problems and objects around the students. As always, where possible, a variety of assessment methods is desirable, reflecting the multi-faceted nature of sustainability.

Given the interdisciplinary content of the sustainability curriculum, students may be exposed to very unfamiliar concepts. Pop quizzes and short tests (including multiple choice) can provide easy ways to test understanding of these new concepts, and to provide instant feedback to the students on their own learning. The classroom exercises can also provide opportunities for formative assessment. For example, students can be asked to present their ideas on how to achieve economies of scale in the most sustainable ways. They might be asked to write a reflective piece on their walk around their campus. Indeed, the university can be a valuable source of material which to study. As an example, in a module called "Sustainable Business" Plumridge asked students to engage in coursework that allows them to study anything relevant to sustainability. In this case, almost two thirds of students choose to evaluate a real company or event. Many of those have been studies of what is going on at our university. The university has the advantage of being personally relevant to the students and therefore engaging; and of course, it is also convenient, and with some minimal co-operation from university facilities and administrative staff, students can gain access to a wide data set on which to base their analyses.

Other classroom exercises could be part of the strategy for formative assessment. One is that of a guided role-play. Students could be asked to consider a scenario and then take roles of various stakeholders in it. For instance, a planning application may have been made for an incinerator. Students could adopt the perspective of a local resident, a planning officer, a local councillor, an environmental assessment expert, and a representative of a group offering the alternative technology of pyrolysis. This exercise helps develop skills of argumentation and presentation, challenges students to think flexibly, and helps them develop an holistic approach to real-world problems. This exercise could be drawn on subsequently, say in the exam: students would be presented with text of a variety of perspectives and then asked to make an assessment. In the latter case, the exercise clearly forms part of formal assessment, but the former could be formative, and could easily be adapted to employ peer assessment and feedback.

Considering summative assessments, multiple choice tests, and exams help testing sustainability literacy (see e.g., Kioupi and Voulvoulis, 2022), whereas essays/reports and policy briefs may allow students to engage with various competences related to sustainability (e.g., systems thinking, dealing with complexity, future thinking, critical thinking, and strategic thinking). As an example, in an Introductory Environmental Economics module, we ask students to produce a policy brief on a specific environmental issue, explain why the problem is important and propose a preferred policy intervention with respect to alternatives, using economic analysis. In this case, we test the knowledge and understanding of the economic framework behind the environmental problem, but in providing alternative policy recommendations, students develop critical thinking competences as well as use a systems approach to understand interactions between policies and humans in different contexts and anticipate pros and cons of the suggested alternative approaches applied to the case study considered.

Top tip

Use assessment as a tool for engagement: some assessment early on ensures that students master crucial core concepts.

Evaluations of real cases tend to be either on current practices of a company or on the environmental impact (via CBA) of a major event, such as mining, or music festivals. The key determinant of success on this project is whether the student embraces and applies an analytical framework. Where students go wrong is when their projects are too descriptive or lack criticality. The same principles apply when using real-world case studies. In-class cases allow students to explore changes in practice, such as new product lines or production techniques. Again, there are formative assessment opportunities in asking students to present their reflections on these developments. Additionally, in exams students can be presented with such examples and asked to reflect on them. It would also be possible to make some element of the exam open-book assessment, in which students draw on work they have done in class to address either cases they have been working on, or cases new to them. Another option might be to provide a case study to be studied in advance of the examination, with the questions unseen until the exam. In this way, depth of understanding, knowledge and analysis is encouraged.

As already hinted at, available software resources also offer opportunities for formative and summative assessment, as well as means of engaging students with core material. Box 6 discusses a range of these, and boxes 3 and 10 consider software on valuation and life cycle assessment respectively.

7. Case studies

Back to top

- "The COP Negotiation Game." Alexandra Arntsen, Nottingham Business School, Nottingham Trent University
- "Sustainable communities and HE: the 3Cs approach to co-creation and sustainability education." Lory Barile, University of Warwick
- "Discussing climate change via the history of economic thought." Andrew Mearman, University of Leeds

Back to top

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Box 7

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. Paruelo, J., Raskin, R., Sutton, P. and van den Belt, M. (1991). **'The Value of the World's Ecosystem Services and Natural Capital'**, *Nature*, 387: 253–260. **https://doi.org/10.1038/387253a0**

Daly, H. E., (1991). Elements of environmental macroeconomics. in Costanza, R. (Ed.) *Ecological economics: The science and management of sustainability*, Columbia University Press. pp. 32-46.

Box 9

Copestake, J. and Ellum, T. (2010). "The Global Climate Change Game" The Economics Network **https://doi.org/10.53593/n1143a**

Guest, J. (2007). "Introducing Classroom Experiments into an Introductory Microeconomics Module" The Economics Network **https://doi.org/10.53593/n191a**

Hedges, M. R. (2004). "Tennis Balls in Economics" The Economics Network **https://doi.org/10.53593/n146a**

International Energy Agency (2021). **Net Zero by 2050: A Roadmap for the Global Energy Sector**. Paris: IEA.

McDonough, W. and Braungart, M. (2002). *Cradle to Cradle: Rethinking the way we make things*, San Francisco: North Point Press.

Piggott, J. (2003). "Follow up to 'Students' assignment as a piece of economics journalism'" The Economics Network **https://doi.org/10.53593/n580a**

Sloman, J. (2002). "The International Trade Game" The Economics Network **https://doi.org/10.53593/n141a**

Sloman. J. (2009). "Deal or No Deal – an expected value game" The Economics Network **https://doi.org/10.53593/n939a**

Sutcliffe, M. (2002). "The Press Briefing Role-Play" The Economics Network **https://doi.org/10.53593/n210a**

Box 10

Shaik Khaja Mohidin, A., Wong, M. L. D., and Choo, C. M. (2018) **"Environmental Life Cycle Assessment of a Standalone Hybrid Energy Storage System for Rural Electrification"** (preprint)

Books

These books are economics textbooks. They would be suitable at levels 2 and upwards, although for each book, clearly students at level 2 would need more help in understanding the material presented.

Common, M. and Stagl, S. (2005). *Ecological Economics: An Introduction*, Cambridge: Cambridge University Press.

Costanza, R. (1992). *Ecological Economics: the Science and Management of Sustainability*, New York: Columbia University Press.

Daly, H. and Farley, J. (2004). *Ecological Economics: Principles and Applications*, Washington, DC: Island Press (and workbook).

Harris, J. and Goodwin, N. (Eds.) (2009). *21st century macroeconomics: responding to the climate challenge*, Cheltenham: Elgar.

Scott Cato, M. (2008). *Green Economics: An introduction to theory, policy and practice*, London: Earthscan.

Soderbaum, P. (2008). *Understanding sustainability economics: towards pluralism in economics*, London: Earthscan.

Spash, C. L. (Ed.) (2009). *Ecological economics: Critical concepts in the environment*, Vols. 1–4, London: Routledge.

These readings are intended as companion texts; they are not textbooks. They deal with sustainability issues such as energy, change management strategy, and personal consumption decisions. They are suitable at many levels, although some of the technical detail is more suitable for higher level students.

Fanning, A. L., O'Neill, D. W., Hickel, J., Roux, N. (2021). The social shortfall and ecological overshoot of nations. *Nature Sustainability*, **https://doi.org/10.1038/s41893-021-00799-z**

Hardin, G. (1968). **"The tragedy of the commons."** *Science*, 162, 1243-1248. JSTOR 1724745

Murray, P. (2011). *The Sustainable Self*, Oxford: Earthscan.

Pirgmaier, E. (2017). The Neoclassical Trojan Horse of Steady-State Economics, *Ecological Economics* 133, 52-61. **https://doi.org/10.1016/j.ecolecon.2016.11.010**

Raworth, K. (2017). *Doughnut economics: seven ways to think like a 21st-century economist*. Chelsea Green Publishing.

Røpke, I., (2004). The early history of modern ecological economics. *Ecological Economics* 50, 293–314. **https://doi.org/10.1016/j.ecolecon.2004.02.012**

Stibbe, A. (Ed.) (2009). *The Handbook of Sustainability Literacy: skills for a changing world*, Totnes: Green Books.

Vale, R. and Vale, B. (2008). *Time to Eat the Dog? The Real Guide to Sustainable Living*, London: Thames and Hudson.

To supplement lecture material in a typical environmental/ecological economics module, and look at case studies, examples of essay questions, exercises and current debates on environmental and natural resources as well as climate change and sustainability, the following textbooks could be used:

Ackerman, F., & Stanton, E. (2013). *Climate economics: The state of the art*. Routledge.

Hanley, N., Shogren, J., & White, B. (2019). *Introduction to environmental economics*. Oxford University Press.

Harper, C. L., & Snowden, M. (2017). *Environment and society: Human perspectives on environmental issues*. Routledge.

Nordhaus, W. (2013). *The climate casino: Risk, uncertainty, and economics for a warming world*. Yale University Press.

Tietenberg, T., & Lewis, L. (2018). *Environmental and natural resource economics*. Routledge.

Udalov, V. (2019). *Behavioural economics of climate change: new empirical perspectives* (pp. 15-16). Switzerland: Springer.

The following books will provide examples of case studies to be discussed in the classroom on specific topics related to sustainability and climate change (e.g., the hidden drivers of climate change, extreme weather events, the impact of human activities on carbon footprint, rethink capitalism and growth in light of global issues such as climate change):

Berners-Lee, M. (2021). *There Is No Planet B: A Handbook for the Make Or Break Years*-Updated Edition. Cambridge University Press.

Davies, R. (2019). *Extreme Economies: Survival, Failure, Future–Lessons from the World's Limits*. Penguin Random House: UK

Hoggett, P. (Ed.). (2019). *Climate psychology: On indifference to disaster*. Palgrave Macmillan.

Lee, M. B. (2020). *How bad is bananas? The carbon footprint of everything*. Profile Books Ltd: London.

Marshall, G. (2015). *Don't even think about it: Why our brains are wired to ignore climate change*. Bloomsbury Publishing USA.

Mazzucato, M. (2021). *Public Purpose: Industrial Policy's Comeback and Government's Role in Shared Prosperity*. MIT Press.

Mazzucato, M. (2021). *Mission economy: A moonshot guide to changing capitalism*. Penguin UK.

Terzi, A. (2022). *Growth for Good: Reshaping Capitalism to save humanity from climate catastrophe*. Harvard University Press: London.

The following books can be used to illustrate how climate deniers reject the existence of climate change and unsustainable ways of living:

Craig, G. (2019). *Media, sustainability and everyday life*. Springer.

Lomborg, B. (2020). *False Alarm: How climate change panic costs us trillions, hurts the poor, and fails to fix the planet*. Hachette UK.

Moore, P. (2021). *Fake invisible catastrophes and threats of doom*. Ecosense Environmental Incorporated.

Notes

Back to top

[1] Throughout this chapter the terms *module* and *course* are used interchangeably.

Box 1: Sustainability: what is to be done, and by whom?

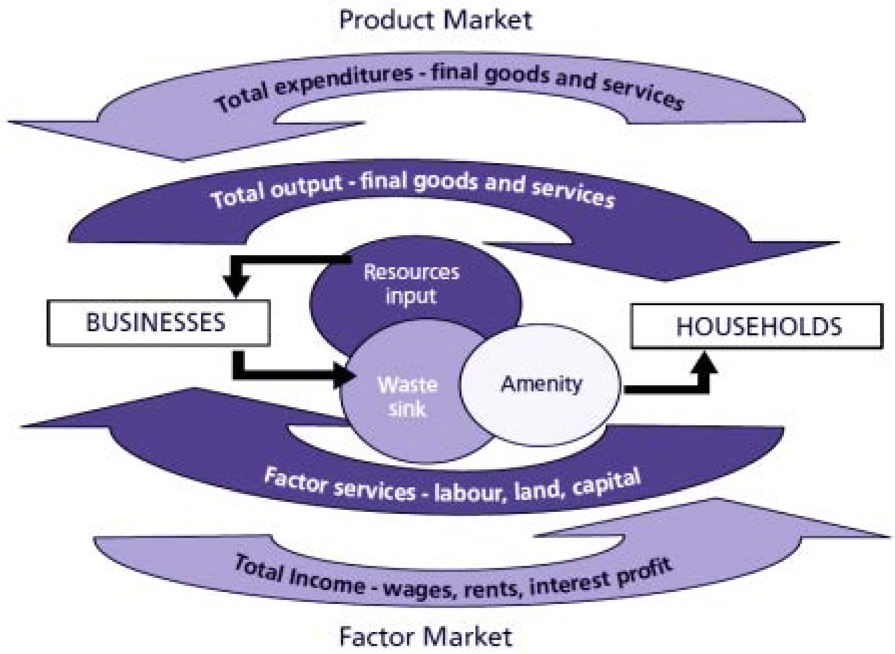
It is easy to stimulate discussion of views of sustainability around one or two issues of wide concern such as climate change, water resource shortages or marine acidification. A starting point might be to set students in groups to prepare an assessment of one or more of these problems to present to the class. Then, after each presentation, ask the class as a whole "**what** can be done about it?"

Usually, a range of positions emerges ranging from "no growth" through to "science will find a solution". The technologies discussed most change, but recurring types involve huge solar generation projects, electric transport, technologies that capture carbon emissions as they are produced, and even large-scale geoengineering schemes that suck already existing carbon emissions out of the atmosphere. Technological solutions such as these remain unsurprisingly popular as they support the notion of perpetually increasing prosperity. Adair Turner (2020) recently made the case for technological optimism. Of course, "science" is not an amorphous blob, it involves researchers working in firms and universities, various sources of funding, and households using (or not) the products of science.

So, that discussion suggests another question: "**who** do you think should be responsible to tackle the issues?" When students are asked this question, they often respond "Government", via its various policy tools to manage growth or invest in infrastructure, or indeed via supporting technological change. However, firms can make significant changes to production processes and supply chains, so are also important agents. Finally, some economists focus on individual households changing their behaviour, although clearly again this raises the question of how; and if part of the story is that households are nudged to change (see Barile, 2022), this raises the question of who is doing the nudging, Government, business, or some other agent?

Box 2: an extended circular flow of income

The circular flow of income is a foundational tool in economics and is typically found in introductions to macroeconomics. The typical circular flow model presents flows of income, expenditure, goods and services between groups of economic actors. The version below is highly simplified, collapsing government and import sectors into ‘businesses’.



One way to deliver this is to take the standard circular flow and ask students to add items. This can be a rich exercise, not least in helping students think about model building: initial attempts to extend the model can lead to extremely complex models that are more realistic but intractable. The final version seen above might be viewed as over-simple but can be argued to be a good representation in terms of capturing key processes.

Box 3: Cost-Benefit Analysis and Multi-criteria analysis

Cost-benefit analysis is an approach very commonly used in environmental valuation (see Box 4) and decision-making. However, it is perceived as being limited, using a single standard of value. Hence, Multi-Criteria Analysis, which will be discussed below. First, we consider CBA via a case study of a tourism development in Minorca, which can be used a classroom exercise, or as a homework assignment to be discussed in class. With software available, students can construct their own CBA using CBA Builder (see Box 9). It is an application of investment appraisal, that introduces core concepts such as one-off capital and recurring current expenditures, discounting, private (and social) costs and benefits.

The study compared the provision of 1000 bed spaces in an extensive villa-style development with concentrated high-rise resort development. The tables below show financial inflows and outflows, as well as capturing external (social) costs, for the two options.

Table 1: calculations for the Villa case. Net present value = £−1.34m per 1000

Year	Inflow (Profit £m)	Outflow Capital £m	Outflow Extern £m	Net Flow £m	Discount Factor	Net DCF £m
2004	6.50	35.00	1.54	−30.04	0.9091	−27.31
2005	6.50		1.54	4.96	0.8264	4.10
2006	6.50		1.54	4.96	0.7513	3.73
2007	6.50		1.54	4.96	0.6830	3.39
2008	6.50		1.54	4.96	0.6209	3.08
2009	6.50		1.54	4.96	0.5645	2.80
2010	6.50		1.54	4.96	0.5132	2.55
2011	6.50		1.54	4.96	0.4665	2.31
2012	6.50		1.54	4.96	0.4241	2.10
2013	6.50		1.54	4.96	0.3855	1.91
TOTAL	65.00	35.00	15.40	14.60		−1.34

Table 2: calculations for the high-rise case. Net present value = £0.93m per 1000

Year	Inflow (Profit £m)	Outflow Capital £m	Outflow Extern £m	Net Flow £m	Discount Factor	Net DCF £m
2004	2.50	15.00	0.13	−12.63	0.9091	−11.48
2005	2.50		0.13	2.37	0.8264	1.96
2006	2.50		0.13	2.37	0.7513	1.78
2007	2.50		0.13	2.37	0.6830	1.62
2008	2.50		0.13	2.37	0.6209	1.47
2009	2.50		0.13	2.37	0.5645	1.34
2010	2.50		0.13	2.37	0.5132	1.22
2011	2.50		0.13	2.37	0.4665	1.11
2012	2.50		0.13	2.37	0.4241	1.01
2013	2.50		0.13	2.37	0.3855	0.91
TOTAL	25.00	15.00	1.30	8.70		0.93

The students tend to think that villa-style development is more sustainable, and the IA shows that it provides a much greater private NPV. However, the external costs that are included in CBA show that the high-rise concentrated development generates a greater social NPV. This is largely due to the very great infrastructure cost of providing utility services and access to developments spread all over the island, together with the greater land take, energy consumption and water demand associated with villas each with their own swimming pools and air conditioning systems.

Of particular relevance to sustainability is discounting. There is an argument that intergenerational equity implicit in the resource-based view of sustainability demands a discount rate of zero. A valuable discussion of the theoretical basis of discounting can be based on issues of inflation, risk and time preference.

CBA leads naturally into the evaluation of environmental impacts (see above) The potential contribution of CBA to deciding macro policy priorities was illustrated in the Stern Review (Stern, 2006), in which it was the key methodology for assessing the benefits of intervening to reduce carbon emissions and thus to reduce the likelihood of further global warming.

Multi-Criteria Analysis (MCA)

MCA offers an alternative to CBA when evaluating multifaceted projects, especially those with considerable local impact. It allows a degree of democracy in deciding what impacts matter most and should be given most weight in decision making. It is less effective in deciding on projects with national or global level benefits to be set against local costs. It then can allow local interests to dominate. However, MCA offers scope for classroom exercises, as in the example below.

The class was asked to compare two possible courses of action: a resource tax and a carbon tax. The resource tax is an incentive to encourage organisations to move towards a circular economy. Resource taxes tax resource rents over and above the levies implicit in general income taxes, whereas carbon taxes are raised on an organisation's audited CO_2e greenhouse gas (GHG) emissions. For both options, a performance matrix can be devised, like the one below. A short form of this exercise would take the evaluations as read, but the class could, for instance from existing literature, build up the performance matrix, including deciding on its criteria.

Table 1: performance matrix

Type of tax	Impact on GHG emissions	Impact on biodiversity	Impact on local communities	Equity and fairness	Cost of implementation
Resource tax	Modest reduction	Fairly large positive effect	Some positive, some very negative effects	Unfair to some nations	Modest

Type of tax	Impact on GHG emissions	Impact on biodiversity	Impact on local communities	Equity and fairness	Cost of implementation
Carbon tax	Large reduction	Modest positive effect	Some large positive effects	Fairly uniform impact	Very high

The next stage of the process is criteria scoring. Criteria must be scored to give a numerical value, which in the case below are entirely fictional. Below a simple –10 to 10 scale is used but there are alternatives. Again, discussion points for students include how the scale might make a difference to the outcome, and how the scores are arrived at.

Table 2: criteria scoring

Type of tax	Impact on GHG emissions	Impact on biodiversity	Impact on local communities	Equity and fairness	Cost of implementation
Resource tax	2	7	2	−3	4
Carbon tax	9	2	4	−1	9

Third, the criteria must be weighted. Weights adding up to 100 must be decided. A key element is here is that individual students arrive at their own weights and then compare with their neighbour before the whole class tries to reach a consensus. This process often generates quite divergent results, again providing ample opportunities for further discussion.

Finally, the weights and criteria scores are combined to arrive at final scores for each option. The example below shows the effect of choosing equal weights between criteria. This is usually the democratic aspect of the process of MCA. This lends itself most to classroom discussion as little case-specific technical expertise is required. Equal weights are assumed for illustrative purposes but should use the weights derived from class discussion. Again, this can be used to explore the robustness of the scores and the potential implications of that.

Table 3: final stage scores

Type of tax	Impact on GHG emissions	Impact on biodiversity	Impact on local communities	Equity and fairness	Cost of implementation	Total
Weight	20	20	20	20	20	100

Type of tax	Impact on GHG emissions	Impact on biodiversity	Impact on local communities	Equity and fairness	Cost of implementation	Total
Resource tax score	2	7	2	−3	4	
Carbon tax score	9	2	4	−1	9	
Resource tax score x weight	40	140	40	40	-80	80
Carbon tax score x weight	180	40	80	-20	-180	100

Box 4: Sustainability as a macro-economic issue

One of the longest running debates in Economics is about how to conceive of the macroeconomy. Classical economists, whilst recognising individuals acted, focused their analysis on system-level outcomes and tendencies, such as population, growth and profit. Accordingly, they used class analysis and focused on shares to distributive classes as important drivers of the system. With the advent of marginalism came individualism and the notion that the economy is merely an aggregation of individuals, who, could be captured in terms of an average, representative individual. In the 1930s the idea of collective categories such as consumption and investment expenditures, which may or may not be aggregates, became key explainers of economy-level phenomena. However, over time such models got edged out by general equilibrium models. Despite some model pluralism in the 1970s, the computable general equilibrium and dynamic stochastic general equilibrium models began to dominate. Whilst large economic decision-makers such as the Bank of England employ a suite of models, at the heart of their decision process is a large complex DSGE model. In the area of climate change economics, a variant of this approach has also dominated: Integrated Assessment Models (IAM) try to capture the complexity of interacting complex environments, including the economy. A large assortment of IAM models exists (see UN 2022). Many of these models capture the economy via large general equilibrium models. For example, Nordhaus has developed his DICE (Dynamic Integrated Climate Economy) models which attempt to incorporate environmental damage. However, Nordhaus has been criticised for claiming that an increase of average global temperature of 4 degrees C above pre-industrial levels can be ‘optimal’, which is well out of line with climate scientists’ projections (Keen, 2019).

Ecological economists have developed alternatives to these DSGE approaches, arguing that the representative agent approaches underplay the complexity of individuals. In response, agent-based models have been developed which allow individuals to respond in slightly more complex ways than merely being assumed to move almost automatically to a utility-maximising outcome. Also, critics feel the DSGE's smooth responses to external shocks, back to equilibrium via price adjustments, are unrealistic. Victor (2008) developed a Keynesian model, *LowGrow*, with a specific treatment of forestry.

Most recently, Stock-Flow Consistent (SFC) models inspired by the work of Godley and Tobin (see Nikiforos and Zezza, 2018) have been developed, which claim to integrate rigorously the real, financial and ecological dimensions of the economy. The basic notion of SFC models is that, echoing input-output models, expenditures by each sector are incomes of other sectors; and, echoing balance sheets, financial assets of each sector are financial liabilities of other sectors, and vice versa. These models have been augmented to include principles of thermodynamics (see for example, Dafermos et al, 2015), allowing the integration of real, financial and ecological dimensions. One such example is the LowGrowSFC model discussed in Box 9.

Beyond these, still, are fundamentally different visions of the economy, including the doughnut approach of Kate Raworth (see section 2.1). The circular economy is another notion, albeit one that is contested, focusing on the reuse of materials and avoiding waste. It has been promoted actively, for instance by the Ellen Macarthur Foundation and adopted by some large firms, although it has been criticised for being too focused on environmental performance to the neglect of the socio-economic (Geissdoerfer, et al 2017). The foundational economy is the concept that there is a set of universal basic services that are provided, and that these should be done via an extended public provision (see Gough, 2019); however, the foundational economy is not seen as a single unified block, and that services are needed differently in different contexts. In the terminology of Bayliss and Fine (2020), indeed, systems of provision vary geographically but also sectorially, and are characterised not only by supply chains but by material cultures that sustain and organise demand as well as supply. These systems are argued to require urgent reformulation in order to be more sustainable, but will typically act to resist what may be desirable demand reductions.

Box 5: Valuation

Cost benefit analysis (CBA) is a common point at which to introduce the valuation of environmental assets. However, CBA has been criticised for failing to evaluate environmental impacts, merely describing them in physical units. Over the past 30 years, methodologies for evaluation in money terms have been evolving, although these are not widely used as they have proved expensive and unreliable. Nevertheless, it is often argued that it is better to have some monetary evaluation rather than a physical measure that is not included in the net present value and thus easy to ignore. The application of valuation techniques has been given a boost recently by attempts to evaluate ecosystem services and 'green infrastructure' by central and local government (see for example www.greeninfrastructure.org.uk).

Total economic value of natural capital

Discussing total economic value (TEV) with students as an introduction to evaluation encourages reflection on the meaning of value in economics. Some, for example, use the idea of the total willingness to pay (TWP), the logic being that the value of a particular resource use can be measured in terms of the sacrifice that people are willing to make to have the resource. At the most general level, this sacrifice is in terms of income, therefore TWP makes sense as a measure of economic value to the individual. This does not come without limitations, which is worth mentioning to students. Indeed, we need to accept that this measure is sensitive to changes in the distribution of income (for a discussion see Tietenberg and Lewis, 2018). TEV is generally made up of use value and non-use values. Use value can be direct where, for example, a lake is used for fishing, or indirect, where it provides the setting for a pleasant walk. Non-use value is usually divided into categories representing different ways in which a natural asset may bestow value (e.g., option value, quasi-option value, existence (or intrinsic) value, bequest value, and altruistic value).

Evaluating environmental impact

Environmental costs often occur because of the destruction or degradation of environmental assets or by causing pollution. For example, building a new road will interfere with natural drainage, cause pollution of watercourses, and act as a barrier severing wildlife habitats. It will result in noise and congestion to local communities in the construction phase. It will continue to have an impact on amenity by causing noise and pollution subsequently. In many cases, the impact will reduce the use value of the asset. Direct use may be associated with a marketed output and the reduction in this is the basis for evaluating impact. Indirect use may also be marketed where entrance fees are charged. Where there is no money transaction, it is difficult to estimate the demand for environmental goods and services. One way of doing so, is to think about the demand for a particular good as the WTP for the good. Economists have found some clever solutions to estimate the WTP for environmental goods and services. Some of them estimate the WTP looking at individuals’ actual behaviour, some others draw inferences from the demand for related goods, and some others use survey data to infer the WTP.

More generally, a distinction is made between revealed and stated preference methods. Revealed methods focus on actual and observable choices, where market prices are inferred directly or indirectly from human behaviour. Stated preference methods use survey analysis to elicit individuals’ WTP (their stated preferences) for environmental gains (or to prevent an environmental loss) and their WTA the absence of an environmental gain (or to compensate for an environmental loss).

Typically, the most discussed methods of evaluation are:

- *Contingent valuation method (CVM)* elicits values from a representative sample of an appropriate population by describing a context where an environmental asset is (usually) destroyed. Respondents are then asked how much they would be willing to pay (WTP) to preserve the asset or how much they would be prepared to accept in compensation (WTA) for the loss. Contingent valuation methods and the concept of WTP and WTA give instructors an opportunity to run the ‘mug experiment’ (**see Kahneman et al., 1990**) and discuss the impact of loss aversion, as a manifestation of the endowment effect (i.e., the idea that losses loom larger than gains), on the WTP/WTA gap which has important implications for public investment appraisal and CBA. Unique among valuation methods, CVM can capture all the components of TEV. However, as many other stated preferences methods, CVMs are subject to various limitations pertaining survey analyses (e.g., strategic bias, information bias, starting point bias, and hypothetical bias to mention some).

- *Travel cost* assumes that the expense of travelling to visit an environmental asset is a good proxy for a price for the benefits of the visit. By surveying a sample of visitors to the asset and collecting travel cost and other socioeconomic data, it is possible to generalise to the total population of visitors and construct a demand curve for the benefits flowing from the asset. The method only captures use value. A simple way to introduce travel cost methods is to provide an example of a touristic site that students might be familiar with (e.g., Stonehenge in the UK).

- *Hedonic pricing* uses the variation in the prices of dwellings or remuneration levels associated with different environmental conditions as a source of evidence of the WTA for tolerating those conditions. The most frequent application has been the variation in house prices with proximity to some nuisance (such as aircraft noise from an airport) or some environmental asset (such as a riverside location). Storytelling could be a very engaging way to introduce hedonic pricing methods, especially for year 1 UG students. Think about the possibility of showing students the video of **dowisetrepla** from the famous TV series ‘How I Met Your Mother’. In this episode ‘Down Wind of the Sewerage Treatment Plant – dowisetrepla' the two main characters sadly discover that the house they recently bought was close to a sewage treatment plant, thus revealing why the real estate agent wanted them to view the house only over the weekend, when the plant was shut down. In terms of how to apply the technique, hedonic pricing requires collecting house price data in the area, together with house and neighborhood characteristics that might also influence price. Econometric estimation of a house price function will allow the component of the price associated with the environmental attribute of interest. This is the basis for deriving a WTP or WTA associated with the attribute. Again, this method only captures use values.

A detailed discussion of each of these methods, their operationalisation and limitations can be found in standard textbooks (e.g., **Tietenberg and Lewis, 2018**; and **Hanley et al. 2013**). Suffice it to say that, as the number of studies has built up, the range of values for similar assets has been disturbingly wide, suggesting serious reliability issues.

Box 6: software and resources for embedding sustainability in economics teaching

Various software packages can be useful in facilitating teaching sustainability, both from the broadly macro- and broadly micro-economic perspectives. Here we discuss a few; however, new packages are developing all the time, so what we show is a mere snapshot.

LowGrow is a computer simulation of a macroeconomic model for Canada developed by Victor (2008). The model is an aggregate demand-aggregate supply framework – marrying a typical Keynesian expenditure function with a conventional production function. However, the model has several novel features that make it useful for teaching sustainability. The model has outcomes for conventional macroeconomic variables such as unemployment and growth but in addition tracks greenhouse gas emissions, forestry and poverty. This last element addresses the aspect of sustainability concerned with equity. A further central feature is that, as the name LowGrow suggests, the model examines low growth scenarios.

Students can interact with the computer model by changing key policy variables and witnessing the outcomes. Furthermore, the model has several pedagogically advantageous features. Most of its variables and policy tools are quite conventional, so students familiar with typical macroeconomics syllabuses can easily adapt to the model. Further, Victor (2008: ch. 10), in conjunction with Victor and Rosenbuth (2007), explains the model in detail. He shows how the model can be represented graphically and in equation form. Victor also discusses the econometric work underlying the calibration of the simulation model. LowGrow therefore has several aspects that make it excellent for teaching, at many levels.

More recently, reflecting developments in macroeconomic modelling discussed elsewhere in this resource, Peter Victor and Tim Jackson have updated LowGrow to become LowGrowSFC, a stock-flow consistent model in the heritage of Godley and Lavoie (2006). The interactive resource allows one to explore the four scenarios laid out by Jackson and Victor (2020) – ranging from a base case scenario to one of net zero carbon sustainable prosperity. In addition, one can create one's own scenarios, which is pedagogically the resource's most beneficial element, as it allows students to discuss the possible impact of a set of relevant variables, see their changes play out in the model and discuss why this happens, and discuss the nature of the model and, even more broadly, uses of modelling itself.

CBA Builder (Wheatley, 2011) is an Excel-based program designed to allow the user to conduct a cost benefit analysis, together with a sensitivity analysis. The software has several features that make it a useful resource for teaching. It is quite user-friendly and has an accompanying manual containing information on the calculations it performs. Hence it can be used as a tool for reinforcing concepts such as discount rate, net present value and more general concepts such as short and long-run costs. It can therefore be used as an investment appraisal tool. However, by adding in data on externalities CBA Builder can be used for environmental analysis. The sensitivity analysis allows students to understand contingency, which in turn fosters their ability to use judgement and caution in policy decisions. The other benefit for students is in terms of employability: Excel is regarded as a highly useful tool and CBA Builder allows them to develop further their competence in it. CBA Builder has received positive feedback from users.

Several spin-offs have been developed around the concept of the doughnut. One such example is an **interactive version,** which allows users to explore the parameters of the doughnut. Finally, there are various carbon footprint calculators (e.g., **giki Zero**, **WWF calculator**, and **MacKay Carbon Calculator**), which can be used to give students a general idea of how their daily-life behaviour help generating GHG emissions, reflect on the link between human actions and pollution emissions and think about workable solutions to adapt their actions to live in a more sustainable way.

***The Resources and Energy Analysis Programme* (REAP)** software, developed by the Stockholm Environmental Institute at the University of York, enables students to engage with several sustainability issues relating to lifestyle. The current consumption patterns across the UK based on MOSAIC data are used to derive area sustainability profiles in terms of ecological footprint in global hectares, carbon footprint in tonnes and footprints of a range of other pollutants. Geographical areas down to district level can be accessed or new study areas created by aggregating districts. REAP is conceived as a policy instrument whereby local authorities can try out different policy scenarios covering areas such as transport, housing and population growth, and gauge the footprint impact.

A workshop that engages students can be based on their own home district. Overseas students can choose an area they have visited. Initially, students can be asked to find a series of footprints relating to their areas. These can be compared in group discussion and some reasons for differentials suggested. As a second stage, students can enter the scenario mode of the software and try policies which might reduce footprints in their areas. It is a sobering exercise for students to try and evolve policies that bring the ecological footprint down to the sustainable level of 1.8gha.

Experience with using the software suggests that it is best to start with an introductory group session in a PC lab, defining the metrics and investigating home area profiles. The scenario capability of REAP should be introduced and then students set the footprint reduction exercise to be completed in their own time.

The Stockholm Institute has many resources in addition to REAP, including tools for understanding commodity footprints for an extensive range of goods, as well as specific tools for examining key commodities such as steel, or key natural resources such as water. They also provide tools for decision-making, and others which facilitate systems thinking and anticipatory thinking identified as ESD skills.

Box 7: Environmental and ecological economics approaches

Economic treatments of sustainability are diverse; however, as a heuristic the distinction drawn here between environmental and ecological economics approaches might be useful. Given time, a discussion of the distinction can be useful in understanding the concepts as well as helping students develop critical and contrastive thinking capacity.

Environmental economics	Ecological economics
'Mainstream' approach rooted (in general) in neo-classicism, emphasising rationality, optimisation economics, and efficiency. Recent behavioural insights question rationality assumption.	More affinity with heterodox, non-orthodox economics, emphasising power, change and social nature of the economy
'Economy–first' approach. Applies economics to the environment.	'Ecology-first' approach. Draws on natural sciences.
Efficient allocation of scarce environmental resources.	Scale crucial. Efficiency and distribution also important. Importance of equity.
Predictability of the long run (at least probabilistically)	The long term is inherently uncertain. The long term is paramount. The precautionary principle applies.
Microeconomic emphasis	Macroeconomic or holistic or systemic emphasis
Analysis is value-free: there are no over-riding moral imperatives	Analysis is inevitably value-laden: there can be a moral imperative to protect the environment, other species, etc., as well as a survival imperative.
Markets are generally efficient and produce socially-optimal economic outcomes. Market and exchange solutions to economic problems are emphasised. Public goods do represent problems.	Markets are social institutions, which might or might not (generally thought not to) produce so-called optimal economic outcomes.
Externalities emphasised.	'System' approach makes nothing 'external'.

Environmental economics	Ecological economics
Government intervention might be a necessary evil in some cases (e.g. public goods). Proper allocation of private property rights should solve most problems.	Government is on the whole inevitably necessary to intervene in markets, which will not generally work, and to negotiate international treaties on climate, etc.

Many of the concepts in the left-hand column of Box 6 are familiar to most economists, being derived from standard theory. A typical course on environmental economics might look something like the left-hand column. Another variant is to deliver 'natural resource economics' in which both renewable and non-renewable resources are considered. Ecological economics is a somewhat younger branch of the discipline (see Spash, 2017). The focus is more on approaching ecological processes than from an economic perspective. Two names are particularly prominent in ecological economics: Herman Daly and Robert Costanza. They demonstrated the immense value of natural systems by attempting a monetary valuation of them, and the total value they derived dwarfed the value of other inputs into economic systems (Costanza *et al.*, 1991). Daly also proposed a steady-state economy in the sense that it operates to avoid further ecosystem degradation but rather enables natural systems to recover (Daly, 1991). There is considerable overlap in the subject matter of ecological and environmental economics. The key difference is one of orientation: environmental economics tends to embrace the neo-classical paradigm as an analysis of the economic system and seeks to incorporate environmental assets and services into that behavioural model. The objective is to maximise economic welfare. Ecological economics gives priority to the health of complex interrelated ecological systems and considers how economic behaviour can be modified to that end.

Box 8: Campus walk and living labs universities

It is essential that students see concrete examples of sustainable and non-sustainable design and practice. Case studies can be useful in this regard, as can an assessment that requires the students to go out to evaluate actual organisations. A useful place to start is on one's doorstep: the campus. Many educational institutions have made recent efforts to be more sustainable, often through energy efficiency measures which can generate financial savings. So, one would expect to be able to find many examples of sustainable buildings and processes on university campuses. Start in the classroom. Ask students to look around and identify sustainable and non-sustainable objects or design features. Students will note double-glazed windows, motion sensors, thermostats and even carbon dioxide sensors, the amount of natural light entering the room, and the number of electrical appliances, for example. Leaving the classroom, students can observe how corridors are lit and heated, whether doors and windows are closed, and how frequently they spot a recycling centre, for example. A campus with some design innovations assists in this task, as students may see – or be invited to see – smart heating and lighting systems, electricity generation or water heating from solar panels, integrated drainage systems, improvised wildflower and wildlife areas, and innovative spaces that are naturally lit and facilitate social activities that enhance social sustainability. All of these are potential cases for cost benefit analysis.

Pedagogically these campus walks are also valuable. There is a significant element of active learning present. Clearly the tutor must act as a guide and plan a route that is likely to have items of interest on it. The instructor must also be open to surprise finds and consequently odd questions. The students must be sufficiently knowledgeable to be able to spot relevant features; so, it may not be advisable to schedule the campus walk early in the year. However, as part of a PBL approach, students may be directed to a feature of the campus with particular sustainability issues. Instead, or as well, the university or campus itself could be the problem object to be studied. Such an approach allows students to be more engaged with the topic, and with their campus. It may be that an unforeseen consequence of this activity is that students do things on campus that they otherwise would not. If there is flexibility in assessment, these new student activities could themselves become objects for analysis. For example, students could film their own campus walks, perhaps as group activities, and then show them to their peers.

More recently, the pressure to embed sustainability within the HE curriculum has seen the development of a living labs approach to sustainability. This provides not only opportunities to develop a more sustainable campus but allows also staff and students to work collaboratively and co-create solutions to real-life issues, encouraging students to apply their knowledge to a real-world context. The use of a living labs approach to sustainability is not as widely used as it can- or should-be. Most universities now recognize that there is a need to train students to be prepared for the global challenges that we are all facing. The recent Covid 19 pandemic taught us that the world is changing, and we require new ways of thinking, acting and treating ourselves as a community of life. Education has the potential of fostering social transformation processes, but in doing so, we may need to reorient and strengthen the role of educators and education to build more just, sustainable, and peaceful communities where to live. This means universities require innovative sustainability pedagogical methods embracing experiential learning to allow students to become global and responsible citizens equipped with the skills needed to solve the challenges that they will encounter in their future careers. As a result, we might need to abandon traditional pedagogical methods that over-simplify real-life and complex trade-offs and decision-making processes into right/wrong answers. A more holistic approach to sustainability is essential here: skills like systems thinking, future thinking, and cross-disciplinary competencies rooted in sustainability thinking become fundamental in this transition. The case studies in Section 7 provide examples of best practice of more holistic approaches to sustainability.

Box 9: classroom games for embedding sustainability in economics teaching

Classroom games have been identified as a way of engaging students with economic concepts. Some existing Economics Network resources explicitly address sustainability issues. Others can be adapted.

Copestake and Ellum discusses a climate change game that can be played in different formats to allow for different levels of economic knowledge and different levels of complexity in the game. The game explores concepts such as public goods and the iterated Prisoner's Dilemma to explore some of the economic issues connected to climate change negotiations and compliance. The game can also enhance students' transferable skills by employing Excel spreadsheets. As always, such games can be adapted to take into account different theoretical frameworks. In this case, the game rests on theoretical presuppositions, such as the simple self-interest of nations. Tutors might wish to explore that presupposition and the consequences of abandoning it. On the same topic, the BBC has designed a climate change game, which could be used to explore the issues around climate change negotiations and compliance.

Sloman (2002) discusses an international trade game in which some countries are natural resource rich and others may have more manufactured capital. That allows for the immediate discussion of types of capital and their substitutability. The purpose of the game is then for each country to engage in trade to its national advantage. The game is designed to allow 'shocks' to occur, so it is an easy adaptation to introduce into the game ecological shocks, perhaps through the forms of resource price spikes, and to investigate their consequences. Guest (2007) discusses a set of games with implications for sustainability, including on public goods, auctions and trading. These latter two are important in a sustainability context because of the growing importance of emissions trading, carbon permits and other market-based carbon reduction schemes.

The Economics Network resources also contain several games that are more general but again have uses in courses on sustainability. Sloman (2009) discusses an expected value game based on the television programme *Deal or No Deal*. Clearly this game has applications for sustainability, for example in the notion of risk. This can be extended to discuss non-probabilistic risk and the concept important in sustainability of the *precautionary principle*. Sutcliffe's (2002) press briefing game and Piggott's (2003) journalistic writing assignment are useful in the context of sustainability given its inevitable political dimension and the importance of communicating findings on sustainability effectively to the public.

The paper aeroplane game, discussed by Mearman, has some similarities to the tennis ball game discussed by Guest and by Hedges (2004). This is a game originally designed to illustrate diminishing marginal returns in production, but is easily adapted to explore aspects of sustainability. The game asks students to make paper aeroplanes in groups in which increasing numbers of students are involved in production. In the basic form of the game, it is expected that marginal productivity would eventually stop increasing. Students can explore how design of the product and of the production process can affect productivity. There are several sustainability angles on this. Students may consider how efficient the process may appear if energy use is taken into account. Students may also debate the extent to which waste is produced in the process. Students could discuss the likely sources of raw materials and the associated sustainability issues. They might also consider product design and the potential for remanufacture and maintenance of the product. One of the principles of cradle-to-cradle production (McDonough and Braungart, 2002) is that the product should be produced where possible from recycled materials, and that there should be no waste from the production process.

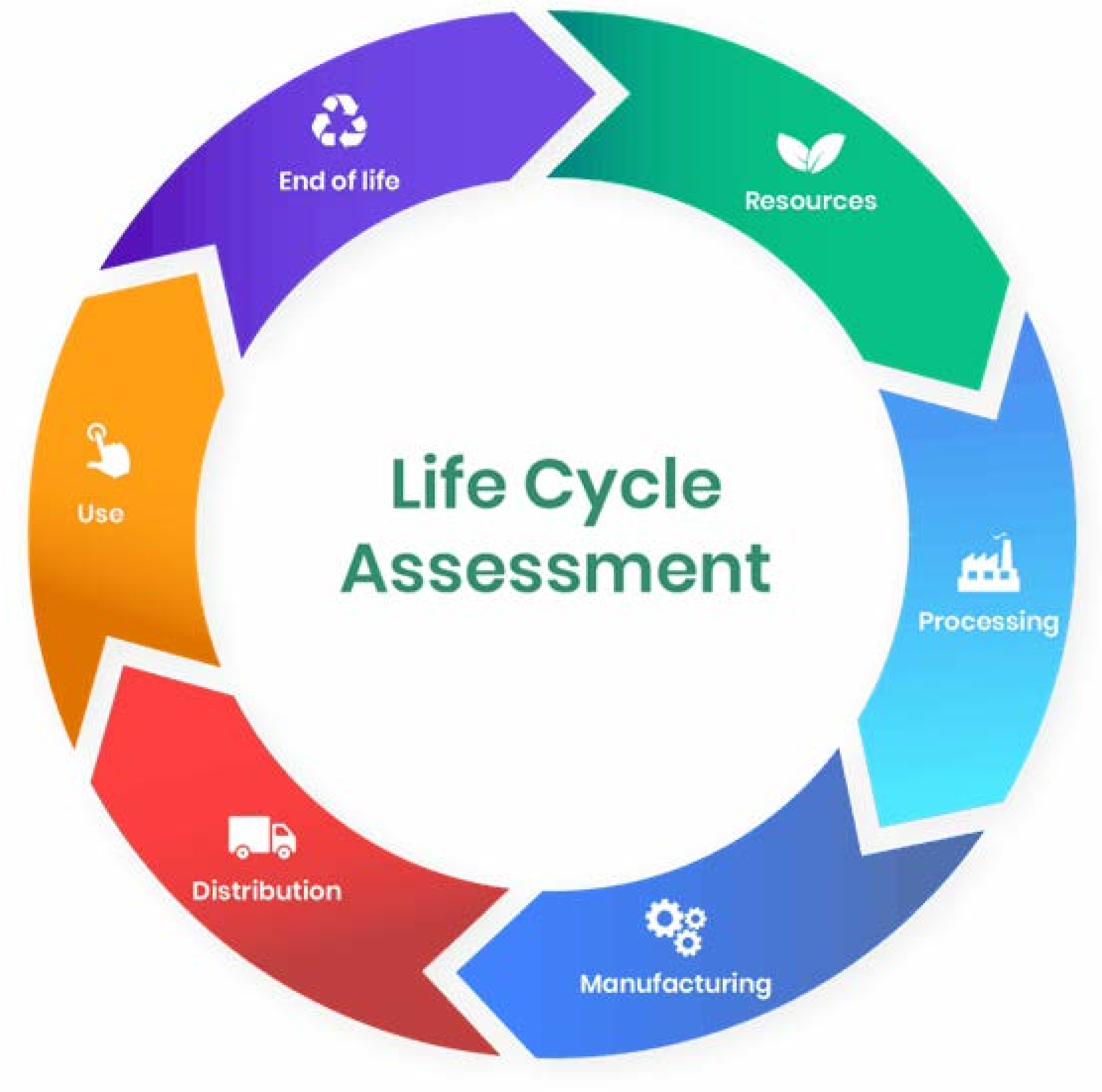
Classex offers additional games that can be played with students with reference to sustainability and/or climate change. To give some examples, there is a fish pond game that links to the tragedy of the commons (Hardin, 1968) and resource overexploitation; there are various public good games (with/without punishments) that, using experiential learning, can help introducing the non-excludable and non-rivalrous characteristics of public goods; and there is a coal market game offered as part of the CORE Project, where students can familiarise with Pigouvian taxes and permits as possible solutions to a negative externality problem.

The Financial Times has recently introduced the FT Climate Game: Can you Reach Net Zero?, which essentially aims at reducing GHG emissions from the current 36bn tonnes a year to net zero by 2050 and brings to life a decision-making process that is often seen abstract and complex by citizens. The game consists of asking a set of questions focused on four different sectors (energy, transport, building and industry) mainly responsible for GHG emissions as evidenced by the International Energy Agency (IEA)'s *Net Zero By 2050* report (IEA 2021). The players need to decide the best course of action to reduce emissions by 2050, and in doing so they face a trade-off between costly effort (increasing when 2050 is looming) and CO_2 emissions reduction. In playing the game, students can experience a sense of control over their actions and get an understanding of how things interact within the process, dealing with the complexity and uncertainty aspects of sustainability issues and developing systems and future thinking competences.

Box 10: Life-cycle assessment (LCA)

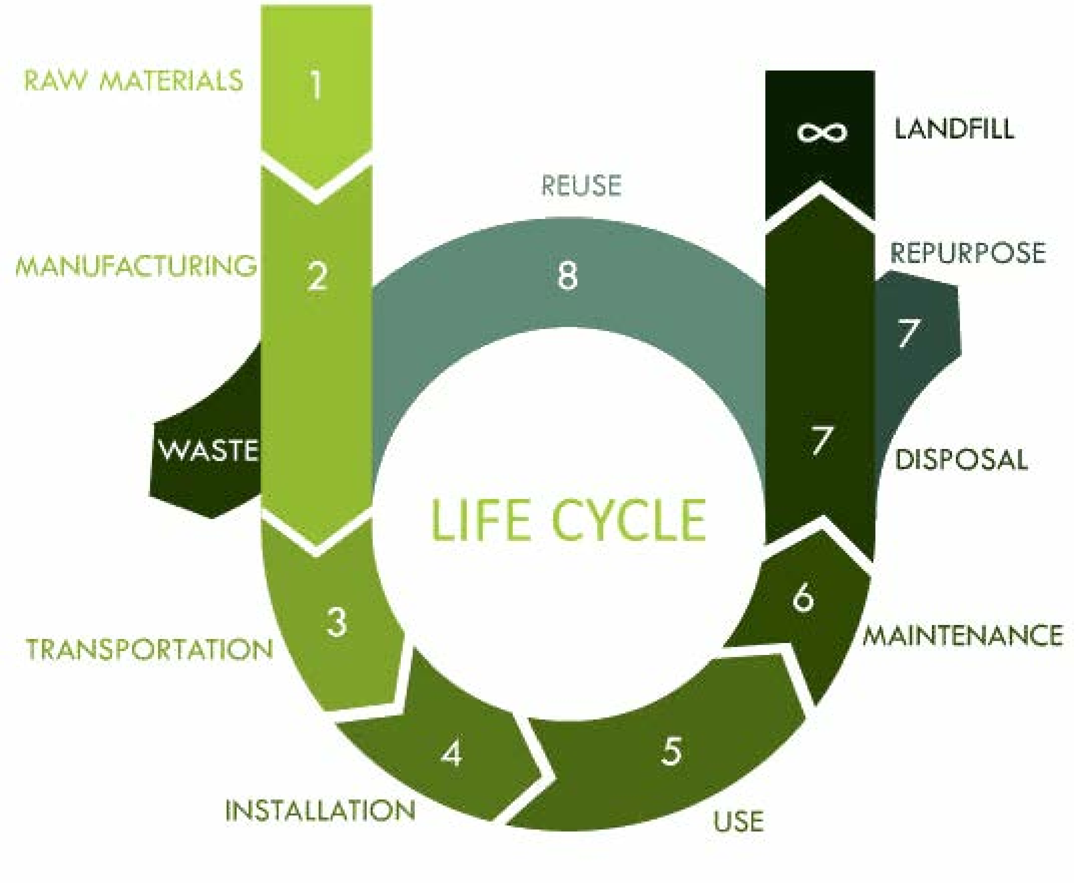
LCA, via Carbon Accounting, gives a useful framework for analysing the impact on sustainability of a particular product, by considering the GHG emissions associated with a particular product. It is sometimes formulated as "Cradle to Gate" which includes all impacts up to the point of dispatch from the manufacturing facility, or alternatively "Cradle to Grave" which includes all stages in the products' life including distribution, use and eventual disposal. Two diagrammatic representations are shown below. The first diagram represents the basic interpretation of LCA.

Figure 1: Life Cycle Assessment. Source: https://www.oneclicklca.com/life-cycle-assessment-explained/



The second (Figure 2) shows an adaptation to include some aspects of the Circular Economy (see Figure 3 further below).

Figure 2: LCA with application to the circular economy. Source: **Shaik Khaja Mohidin (2018)**

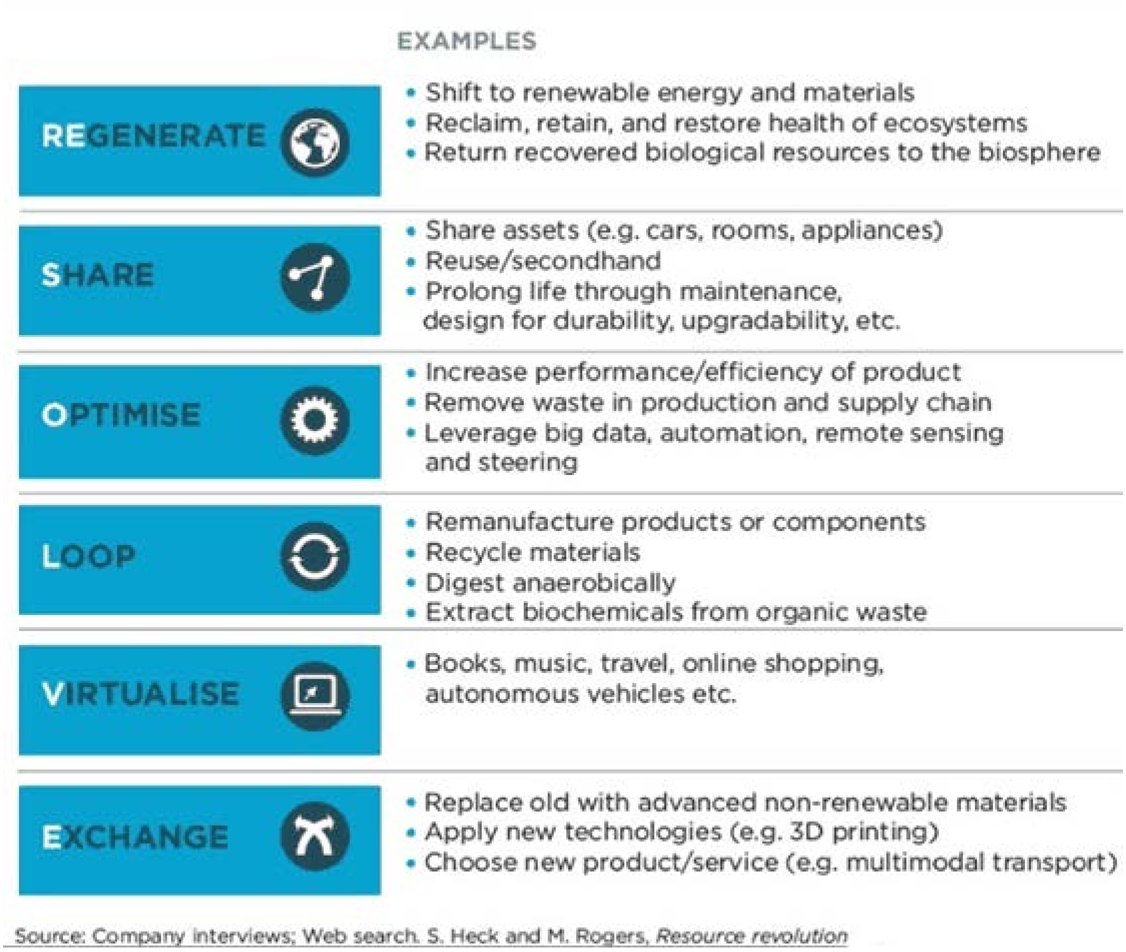


The LCA provides a suitable introductory exercise asking students to consider the social and environmental impacts of a particular product such as an Electric Vehicle (EV). A further teaching idea is to use the interesting, though dated, online software package, the Economic Input Output Life Cycle Assessment (EIOLCA) model developed by Carnegie Mellon University. The software combines LCA and Economic Input-Output analysis to provide a sector-based model for estimating the impact of a stimulus in a particular sector of the (US or Canadian) economy. Unfortunately, this is a 2008 vintage creation and applies to the US economy but nevertheless is valuable for understanding the relationship between the economic stimulation of a sector and the associated environmental impact (including GHGs, air pollutants, energy use and water demand). It is easy for students to make use of the model with little guidance and can form the basis of a valuable seminar activity. It would be ideal for the tutor to access the model description and underlying assumptions by clicking on the documentation tab on the website. She or he would then be better able to answer student questions.

LCA and the circular economy

One way of introducing elements of the circular economy into LCA is to refer to the RESOLVE framework below.

Figure 3: the RESOLVE framework. Source: McKinsey's Centre for Business and the Environment



The circular economy concept lends itself to several class exercises and discussions: for example, a discussion based on the relevance of the concept for a service-oriented economy such as the UK; alternatively, a discussion based on the barriers to the adoption of the CE in advanced economies.

Back to top