1

Sustainability: a word of our time

1.1 INTRODUCTION

Sustainability, often employed as a short-hand term for sustainable development, is truly a word of our time. In the early twenty-first century we inhabit a world which is witnessing a dramatic change in climate, the rise of new economic powers, a crisis in the global financial system and technological breakthroughs that happen almost on a daily basis. All of this can only enhance what we all intuitively know – that the planet is in a state of flux when assessed in environmental, economic or social terms. What we see around us today may not be what we see in the future – the world will be different. But what will that world be like, or perhaps more to the point, what do we wish it to be like? Do we want our children and our children's children to be able to enjoy the environment we have today or do we want them to have better than that? These are important questions, but in the busy lives we lead trying to do better for our families in this generation, it can be tough thinking that far ahead.

Sustainability is all about people and time; the past, present and the future. The past because it teaches us a great deal about human existence and how we have responded to stresses, the present because we have a moral duty to make sure that those alive today have the best quality of life that can be provided and the future because what has been done in our past and present should not damage the ability of future generations to enjoy a good quality of life. Thus, for example, we have a duty not only to limit any damage we do to the environment, but to ameliorate any damage done by past generations.

This book is about sustainability, but it is specifically about how the science of biology is a vital component of sustainability. The classic diagram of sustainability as the intersection of three

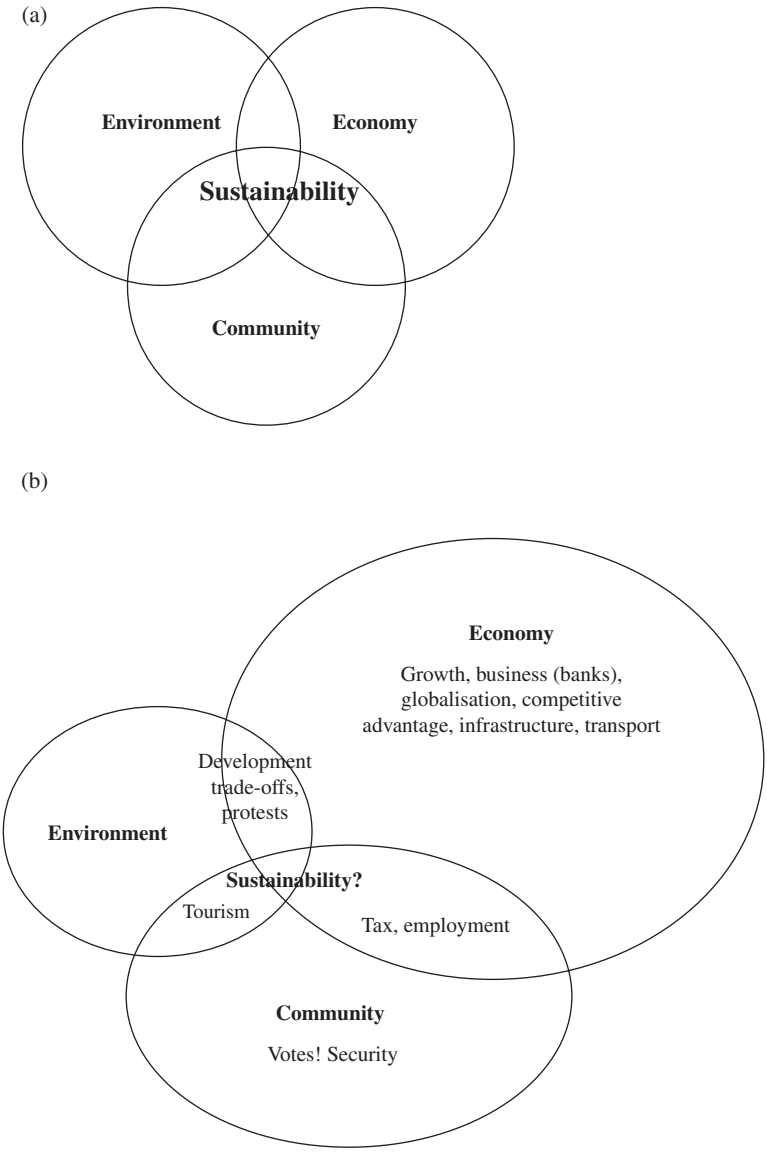


Figure 1.1 The three interlocking circles of sustainability: (a) three equal circles implying an equal consideration to each; (b) dominance of economics and community.

circles (Figure 1.1a) bearing the labels 'environment', 'economics' and 'community' (or variations of those terms) does not usually mention biology as one of the key elements. Instead we tend to think of biology as being somehow wrapped up within the 'environment'. After all, ecology is a sub-branch of biology and surely 'environment' is at least in part about ecology? Sustainability occupies the overlap of the three ircles; implying that we need all of these fields to be considered on an equal basis. We cannot have sustainability solely by protecting the environment and ignoring people. Unfortunately, sustainability is so often seen by politicians as more a sub-branch of economics than anything else; the circles unfortunately don't have the same size (Figure 1.1b) and the issues become rather one dimensional. Figure 1.1b might be a rather jaundiced view of a society dominated by concerns of economic development, the need to win elections and environment as a place to be used by us rather than something which demands a moral need for protection, but I wonder whether there is at least some resonance with what we see around us? In this book an effort will be made to redress that balance and make those circles more equal. The case will be made for the importance that biological science and biologists can play in sustainability. But in doing so, it is important to stress how biologists need to interface with other fields, especially with the social sciences. In other words, this book is about the overlaps in Figure 1.1.

1.2 SCIENCE AND SUBJECTIVITY

The notion of 'sustainability' seen in its most basic sense as an acknowledgement by people that what they do now could have consequences for the future is arguably as old as the human race. Neither is it a prerogative of 'Western', 'Eastern' or any other civilisation. The adjective 'sustainable' can be applied to a host of human activities and structures to imply that they can continue into the future without detriment to either people or their environment. It has been used for activities such as agriculture, water supply, resource management and development, as well as the institutions charged with supporting them. We often forget that it is the activities which are the important elements (and generally well defined) and 'sustainable' is added to convey the importance of the activities continuing into the future without detriment. As a result there is some plasticity as to the meaning of 'sustainable'. How far into the future are we talking about, and what exactly does detriment mean and to whom does it apply? Unsurprisingly, the evolution of sustainability has been long and

complex, with rich intersections to economics and politics. Given that agriculture, water supply and so on are described in terms of what people do, then sustainable is a human-centric adjective; it is defined by people to be applied to people.

So where does biology fit into this landscape? Given that human beings are biological, then biology is arguably fundamental to sustainability. After all, can there be such a thing as sustainability without sentient beings to care about their future? Life on Earth is thought to have originated some 3.5 billion years ago, at least that is our best guess based upon what appear to be microbe-like objects we can find in ancient rocks, and this is only one billion years after the Earth itself came into existence. Since that time, life has evolved into a myriad of different species, many of which have become extinct. Employing our human-centric definition, then these extinct species were certainly not sustainable! Many extinctions have occurred during the 3.5-billion-year history of life on Earth and there have been periods where the rate accelerated (Raup and Sepkoski, 1982; Rohde and Muller, 2005). Figure 1.2a is a graph showing changes in marine biodiversity up to 540 million years ago, while Figure 1.2b shows the extinction rate over that same period. It may surprise the reader to see that marine biodiversity now is much higher than it has been. In Figure 1.2b it can be seen that there have been a number of major extinction events, with the one at the border of the Permian-Triassic (250 million years ago) being especially noteworthy when up to 96% of marine species disappeared. It is the only known mass extinction event for insects. As a result this event is called the 'great dying'. What are the causes for the extinction events we see in Figure 1.2b? Well, there are many suggestions, including increased volcanism and the impact of an asteroid or comet, but it is as well to remember that people have not been involved in any of them; they were 'natural' events. Thus, while extinctions have occurred, and it has been estimated that 99% of all species that ever lived have become extinct, life has proved itself to be very durable. Indeed it is now known that some prokaryotic species are durable enough to survive in the hostile environment of space and could potentially seed other planets. Thus the evidence of life on Earth is that it is highly 'sustainable' – it is a great survivor. If humans disappeared from the Earth, if we were shown to be unsustainable as a species, then life would go on adapting and perhaps survive almost to the very death of the planet.

Biologists are used to studying change, and replacement of some species in the fossil record by others has no value judgement associated with it. Indeed, in biology we don't normally use the term 'sustainable'

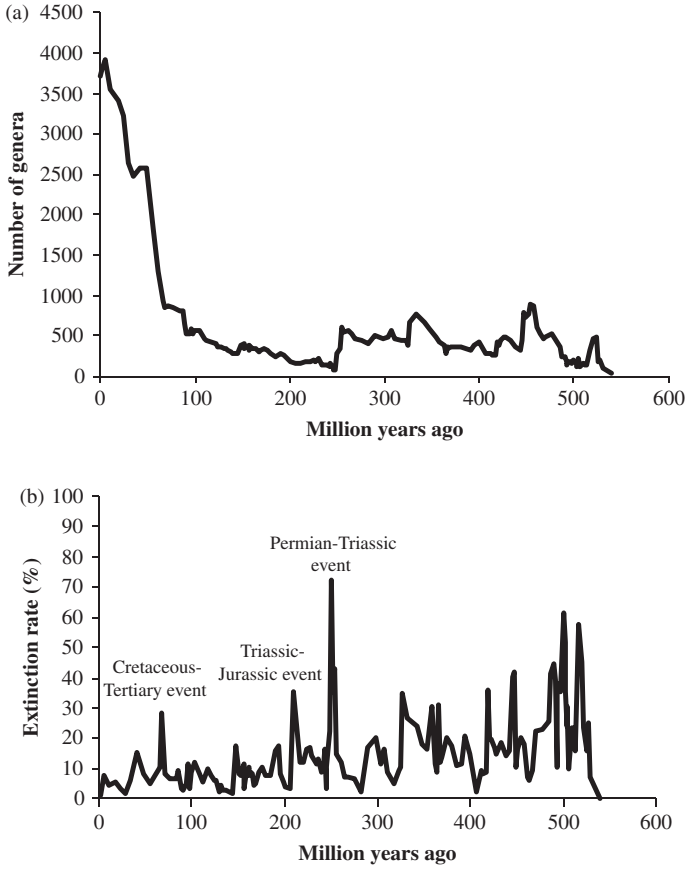


Figure 1.2 Extinction events and change in biodiversity: (a) biodiversity (assessed here as number of marine genera); (b) extinction rate (assessed as % of marine genera), estimated as the percentage of genera entering a period, but not surviving to the end of it.

Data taken from strata.geology.wisc.edu/jack/. Based upon the work of Sepkoski (2002).

for life. After all, life is a catchall phrase that covers species which feed and reproduce in many ways, including some that depend upon exotic sources of energy such as deep-sea volcanic vents. But the phrase 'life is sustainable' is not one that is used much, if at all, in biology. Instead we talk of the 'durability' or 'resilience' of life; it's ability to continue after shocks and protuberances, of which there have been many since the birth of the planet. Sustainable is a human-centric term; it is applied to people and the interactions we have with our environment. Thus when we are talking of the role of biology within sustainability, we mean the

role that biology plays vis-à-vis people, and we are talking of very short timescales relative to those in Figure 1.2. The most commonly used definition of sustainable development is:

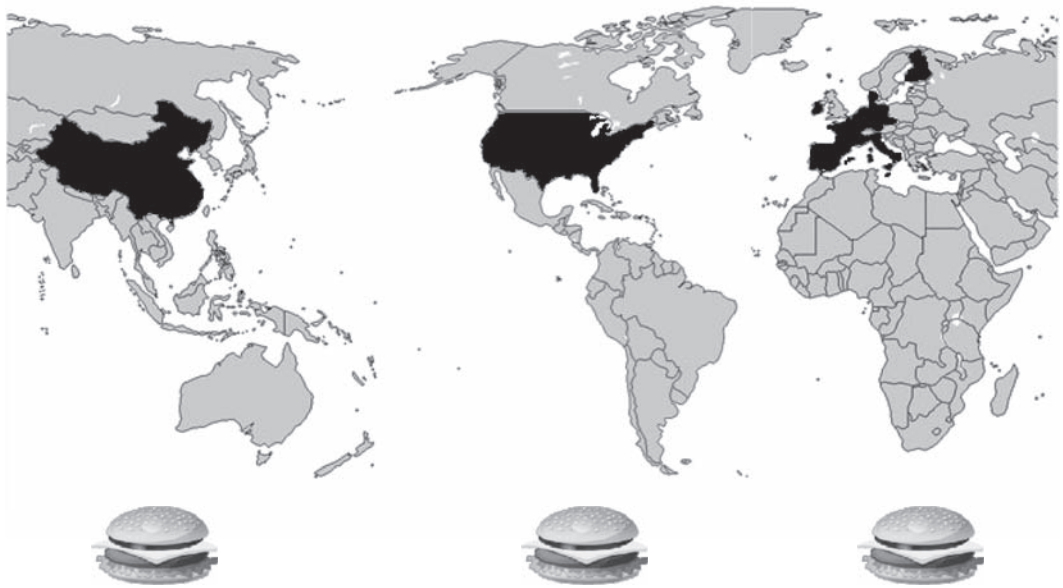
> *development that meets the needs of the present without compromising the ability of future generations to meet their own needs.* (WCED (1987, page 8))

The generations being referred to in this definition are those of *Homo sapiens*; of us. Thus the timescale is perceived in terms of human lifespans and we are in the realm of decades, not millions of years. But if a disaster occurred (man-made or otherwise) and human beings were almost wiped off the planet, as the evidence suggests we nearly were following the volcanic eruption of Lake Toba in what is now Sumatra, Indonesia, some 75 000 years ago, we don't regard the survival of a remnant population of humans hanging on for survival in caves as being 'sustainable', although technically they would be 'future generations'. The key word in the WCED definition is actually the most plastic – 'needs'. This is a highly subjective term and will vary a great deal depending on personal tastes and ambitions, but whatever the starting point, the desired change in this context is almost always for the better. So what are these 'needs'?

People are, of course, biological and some of our basic needs include adequate supplies of food, water and air, as well as freedom from disease, parasites and harmful chemicals. These can be expressed in clear terms. For example, it is estimated that a human male adult needs to consume on average some 2500 calories each day, along with associated minerals and vitamins and 3 litres of water. The average male adult takes 12 to 15 breaths in a minute while at rest and each of these involves the intake of 0.5 litres of air. This approximates to 9000 to 11 000 litres of air being breathed in a day or 1800 to 2200 litres of oxygen. All of these requirements can change, of course, depending upon factors such as environment, age and activity, but they are relatively stable and the figures are not plucked out of nothing, but have arisen from research. We know that consuming less or indeed more of these requirements can imply or lead to problems with health. We can formulate policies which provide these needs for food, water and air free of disease and contaminants, and also to encourage people to avoid over-consumption of food, which can be harmful to health. Thus at a biological level the 'needs' talked about in the WCED definition can be identified.

But the WCED were talking of 'needs' not only at this fundamental level of biology, but also in terms of the need for adequate

income, education, clothing, leisure etc. and here matters are far more subjective and far less scientific. For example, the oft-quoted income figures of $1/day and $2/day to be achieved through the Millennium Development Goals (MDGs; www.un.org/millennium-goals) are remarkable examples of durability in themselves, but what do they mean? Well $1/day can be easily translated into local currencies via the exchange rates we are used to seeing in banks and tourist centres, and they fluctuate on a daily and even hourly basis in ways which are difficult to predict. Sometimes the exchange rate value of the US dollar goes up relative to another currency (you get less local currency for each dollar) and sometimes it goes down (you get more local currency for each dollar). But not only do we have these currency fluctuations, but also the local purchasing power of $1/day can vary a great deal across nation states and even places within the same nation state. One famous and light-hearted method of illustrating the differing 'purchasing power' of an international currency such as the US dollar was invented by *The Economist* magazine. They came up with 'burger-nomics' based upon the local retail price of a 'Big Mac' hamburger as sold by McDonalds, a large international restaurant chain. The 'Big Mac' hamburger is much the same wherever it is sold, and thus we can use it to compare the purchasing power of a US dollar. In Figure 1.3 we have the prices of the 'Big Mac' in three places (based upon a survey carried out in 2009 by *The Economist*); China, USA and the 'Euro Zone'. The local prices are, of course, different. In China a 'Big Mac' costs Yuan 12.50, in the USA it costs $3.57 and in the Euro Zone it costs €3.31. However, once converted to the US dollar (based upon currency exchange rates) we see very large differences. The 'Big Mac' in Chwina looks like excellent value at $1.83, while in the Euro Zone the price is $4.60. Thus $2 will buy you one hamburger in China (with change), but won't even buy you half a hamburger in the Euro Zone. Why the large difference? It must be noted that hamburgers are not produced in the USA and shipped across the world. If that were the case then hamburgers everywhere would probably be more expensive than in the USA because of the added cost of global transportation. The hamburgers are, for the most part, produced from locally sourced materials in each of the countries where the chain has a restaurant. Therefore the large disparity when converted to US dollars is due to a host of factors, including local wage rates and differing costs of locally sourced materials such as beef, as well as local transportation. Thus the meaning of $1/day in real purchasing terms can vary enormously from place to place, yet it serves



CHINA				USA				EURO ZONE			
Price (local currency)	ER	Price (US$)	**under/over valuation**	Price (local currency)	ER	Price (US$)	**under/over valuation**	Price (local currency)	ER	Price (US$)	**under/over valuation**
Yuan 12.50	6.83	1.83	**–49%**	US$ 3.57	1	3.57	**0**	Euro 3.31	0.72	4.60	**+29%**

Figure 1.3 Burger-omics: purchasing power parity calculated on the basis of a cost of a 'Big Mac' hamburger (*The Economist*, 16 July 2009). Prices are those of the 'Big Mac' hamburger sold in the McDonalds chain of restaurants. Exchange rate (ER) of local currency to the US dollar (as of 13 July 2009).

as a convenient banner or clarion call, which if realised will make a difference to the lives of millions of people, and economists have no choice but to factor in the 'purchasing power' of currencies when making international comparisons.

Indeed, going a step further, income is not the be-all and end-all of quality of life. There are other factors which matter, and these may well be quite different from person to person. There are the obvious ones like education, clothing and health care, but water provision, power supply, sanitation, quality of housing and infrastructure, availability of amenities such as shops, climate, pollution, traffic, neighbours, mobile phones, access to the internet and so on can also be important. Some of these are 'measurable' in the same sense that we can measure biological needs and 'purchasing power', while others are not, and even if we could 'measure' them it is likely that what one person perceives as 'good' could be different from someone else's perspective. Here we are moving far away from the biological or even economic needs and into a realm which is far more subjective and value laded. As a scientist, this innate immeasurability, except in rather simplest forms such as 'scoring' or 'ranking', may be frustrating, but I'm afraid that is the nature of the beast we call sustainability. Any attempt to reduce that complexity of 'need' to say economics will inevitably provide us with a very partial picture and could fail to recognise changes that may be occurring in another dimension which are also important. Therefore in this book the reader will come across many faces of sustainability which are not 'science'.

1.3 ROOTS OF SUSTAINABILITY

There are many roots to sustainable development, and here it is really only possible to provide a few of the highlights in that complex history. If the reader wishes to delve deeper into this story then I can recommend Pepper (1987), as well as Kidd (1992), Goodland (1995), Mitcham (1995), Mebratu (1998), Adams (2001) and Costanza *et al.* (2007). Indeed, if we pick apart this phrase into its two components we can gain an understanding as to why this is such a complex term with a long history. In biology the verb 'develop' means to grow or to change (as in the development of an embryo), but here we are using 'develop' to broadly mean to improve or to make something better. Thus we talk of 'human development' not so much as development of a human being from an embryo through a child to an adult, with associated anatomical, physiological and psychological changes, but an improvement in

people's lives. As the United Nations Development Programme (UNDP) puts it:

> *Human development is a process of enlarging people's choices. In principle, these choices can be infinite and change over time. But at all levels of development, the three essential ones are for people to lead a long and healthy life, to acquire knowledge and to have access to resources needed for a decent standard of living. If these essential choices are not available, many other opportunities remain inaccessible.* (UNDP HDR (1990, page 10))

Human development in the sense of us improving our lot is as old as the human race, and the pace and extent of change has often been spurred by changes in the environment. The first sedentarisation (or semi-sedentarisation) of people is said to have occurred as early as 12 000 BC in the Mediterranean region; occupying what is now Israel, Lebanon and Jordan. The Natufian culture existed even before the development of agriculture and its people lived through hunting and gathering just as their ancestors had done, but the carrying capacity of the environment was high enough to remove the need for a nomadic lifestyle. Thus people no longer had to keep moving to find food and water. Sedentarisation in turn helped facilitate the development of agriculture in that part of the world between 10 800 and 9500 BC. The latter was perhaps aided by a change in the climate towards one which was cooler and dryer, thereby reducing the hunting/gathering-based carrying capacity (Munro, 2003, 2004). Interactions of cultures, either positively through trade or negatively through colonialisation and even war, have also acted as catalysts for change. Even during the years of European expansionism in the nineteenth and early twentieth centuries, the colonial powers continued to stress the positive changes which they were bringing about through creation of physical infrastructure such as roads, railroads and ports, but also through education. The latter was particularly so for the Christian missionary movements, which founded schools and hospitals wherever they went. Thus sustainability is not the same as stasis, and change can often be spurred by stress. We are facing such stress now with the current theories on human-mediated global warming and the impacts that could have on our societies. Indeed it is perhaps no accident that the rise in popularity of sustainability in the latter years of the twentieth century corresponded with a time when we realised that there is nowhere else for us to go; this planet is our home and despoliation of its carrying capacity will negatively impact upon us all.

Rightly or wrongly, the birth of what we today regard as modern development is often taken to be President Truman's programme for