Sustainability

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Sustainability means different things to different people. This paper proposes a universal definition of sustainability and a methodology to measure it. Its purpose is to provide both a functional definition of sustainability, and a simple-to-understand overview of how long we can sustain our current life-styles. It also provides methods of assessment that fully integrates with the new economic models that place human wellbeing as their primary objective.

Definition

Sustainability is the ability to reprocess resources to sustain life, indefinitely.

The following points are helpful to interpret the definition:

- Reprocessing a resource means changing its existing state, including its chemical or biological constitution, its combination with other resources, or its location.
- The objective of reprocessing resources is to create consumption necessary to sustain life, where life refers to both the quality and quantity of life.
- Being human, we favour human life over other life. In the long-run the distinction becomes less relevant because the quality and quantity of human life is directly impacted by the quality and quantity of all life. But in the short run, there may be a conflict between the two, which is where our bias becomes relevant.
- Another term for reprocessing of resources is production. In the context of sustainability, the value of production can be measured in terms of either quality/quantity of resources used, or quality/quantity of human life it delivers. The efficiency of production is a function of the quality/quantity of life delivered by society relative to the quality/quantity of resources used.

Components of Sustainability

There are three important aspects to sustainability.

- It is a deliberate, human-driven process that changes the state of resources. Resources come in different shapes and sizes. The resources that sustain life, either actually or potentially, are referred to vital resources. They include oxygen, water and sunlight. All other resources are referred to as inert resources. They include volcanic rock and plastics that are not capable of reuse. It is arguable that all resources have the potential to sustain life. Volcanic rock, for example, can create fertile soil to host plant life. Inert plastics are generally inert only because it is not economically viable to reuse them. So when we describe a resource as inert, we mean that it currently has no reasonable prospect of being or becoming an economically viable input to production for the foreseeable future.
- Its purpose is to sustain life. Nature does its own processing of resources, in its own time. Humans can advance their fortunes by engineering additional processes that favour us. We can advance both the quantity of life (eg. through enhanced farming methods), and the quality of life (eg. through the invention and creation of protective clothing). Where life is compromised as a result of human processes, the cost must be reflected in the assessment of sustainability. Similarly, no assessment of sustainability will be useful unless it assesses the net depletion of vital resources against the extent to which those resources sustained the quality/quantity of life.

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- It visualises a future. When we describe a society as sustainable, we means it is capable of supporting a given standard of life into the future. The time-frame may be a matter of a few years, a generation or millennia. The essence of sustainability is the change in vital resources over time. The period opens with a finite level of vital resources, and closes with a different level. Where the level of resources remains static or increases, output is sustainable. Where it declines, sustainability is called into question. The greater the rate of decline, the less sustainable is society's output. Sustainability can therefore be measured in the depletion rate of resources relative to expected needs and reasonable desires.

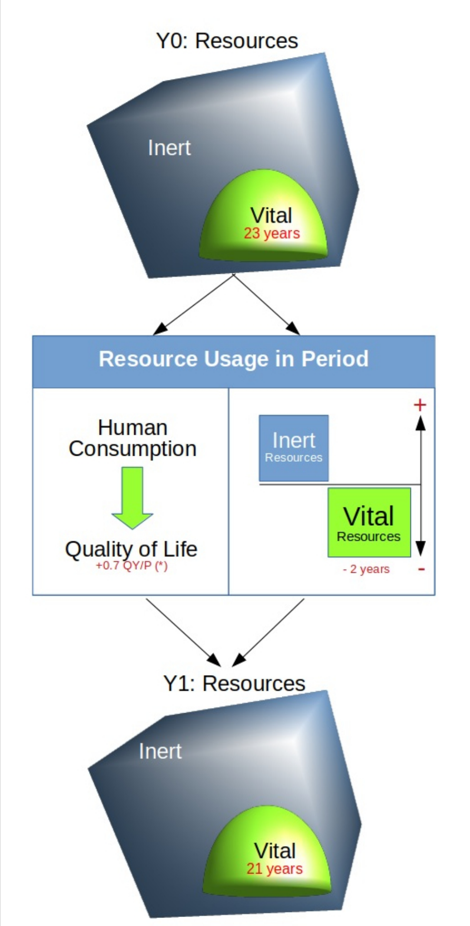
The Goal of Sustainability

The goal of sustainability is to end a period with no less than the level of vital resources as at the start.

The fundamental question for sustainability is whether the number of quality years delivered by society justifies its depletion of vital resources, and for how long can this rate of depletion be sustained? We need answers. We need them to understand the rate we are using up scarce resources. We need them to gauge whether we can realistically expect to provide for our future needs where we employ unsustainable processes.

The Sustainability Model

The sustainability model provides a basis for measurement of sustainability, and is illustrated below.



At the start of a period (Y0), there is a finite quantity of resources. Some are inert, and others vital. (In this example, there are 23 years of vital resources remaining, meaning the finite amount of vital resources would sustain 23 years of production for the current population, using existing production methods).

During the year, vital resources are reprocessed. Vital resources are converted to other vital resources towards or ready for consumption, or to inert resources. Some resources are simply wasted. (In this example, two years of the stock of vital resources are depleted during the process of production and consumption).

Vital resources are reprocessed to deliver an output that consumed to enhance the quality/quantity of life for society’s population. (In this example, society delivers an average of 0.7 quality years per person, depleting 2 years of vital resources in the process. The production process delivers an approximate one year of life per person, multiplied by an average quality of life of around 70% per person).

At the end of the period, there are slightly more inert resources, and slightly less vital resources. (In this example, enough to sustain 21 years of production). There is no need to quantify the level of inert resources.

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The Nature of Resources

Defining what constitutes resources can be complicated. Resources can be categorised, either by their sources or their life cycle:

Sources

- Finite (eg. rare earths)
- Replenished (eg. wood)
- Regenerated (eg. solar energy, human capacities)

Replenished resources are can be grown or replenished in other ways. They require time to replenish, and may involve economic cost where we choose to accelerate or direct the replenishment process.

Regenerated resources have a "use-it-or-lose-it" nature. Harvesting sunlight through solar panels or plants, for example, can be done only the split second in time at which it is available for use. Otherwise, that particular unit of resource it is no longer available to the production process.

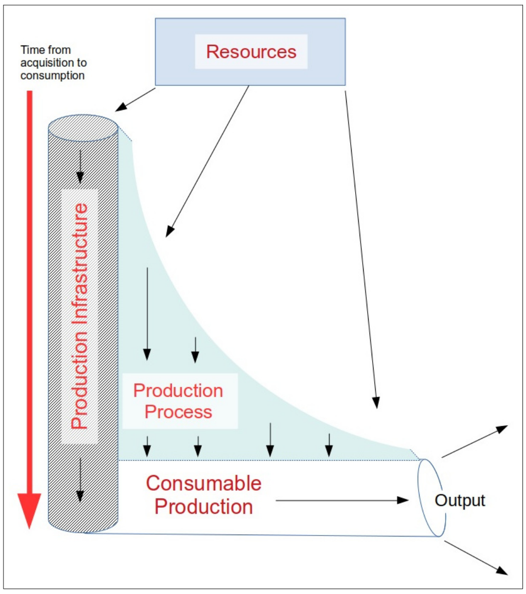
Life Cycle

- Single use (eg. coal, ice cream or comedy show)
- Multi-use (eg. buildings)
- Recyclable (eg. paper)
- Recoverable (eg. water)

Recyclable resources can be reused, usually by being passed through additional resource-conversion processes.

Recoverable resources are components of used resources that can be recovered from their consumed state. Waste water, for example, typically evaporates and is recycled by nature into rivers, lakes and seas.

The end of a life cycle is not determined by the destruction of the resource, but by its change of state from a vital resource to and inert one - from being an economically viable component of production to uneconomical.



In the chart on the left, resources are channelled into both the production infrastructure (eg. manufacturing plant or roads), and the production process (eg. rubber, or the energy that powers a tyre moulding machine). The resources are re-processed, either directly or indirectly, into consumable output. The output is then distributed and consumed.

The time from original acquisition of resources to their ultimate consumption represents society's stock and investment in production.

In resource terms, consumable output is a combination of reprocessed resources, a proportion of which will end up wasted, without ever being consumed.

The length of a resource's life cycle is defined by what happens to it after it has been consumed or discarded.

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Measuring Resources

The vast complexity of measuring resources means that any chosen method is, at best, an illumination. The proposals in this paper are designed to illuminate the limitations on our ability to provide for our future from unsustainable processes. We can choose to ignore the limitations, and face the devastating consequences which grow exponentially the longer we ignore them, or we can use this understanding to devise more sustainable ways of providing for our needs, for a more hopeful future.

In the context of sustainability, we are primarily interested in measuring vital resources. We measure the quantity of vital resources available at the start and end of a period. Sustainability is measured by reference to the rate of depletion of those resources.

Appendix I provides an illustration of how vital resources can be measured. Appendix II discusses which resources are measured and which are excluded from the calculation.

The model is an entry point to a discussion. It is not an answer in itself. The results' limitations are possibly as significant to any decisions about sustainability as the results themselves. Examples of limitations include:

- Some resources are more accessible than others. Vital resources may be classified as inert where it is not economically viable to them make them available to the production process.
- Where technological advances make resources economically viable, or where scarce resources can be replaced with less scarce resources, the depletion rate may need adjusting to reflect the new reality. This can make it challenging to evaluate sustainability over prolonged periods.
- As a resource becomes more scarce, its cost rises. In free markets, it creates the pressures to curtail its use. In markets that are artificially influenced (say by governmental, monopolistic or corrupting influences), the natural cushions against scarcity are weakened. In treacly markets, greater urgency needs to be triggered with the emergence of high depletion rates.
- The depletion rate is a historic measure. Where demand for a particular resources is expected to change in future periods, it may be appropriate to heighten the urgency associated with depletion rates that may otherwise appear containable. Examples include increasing populations or expectations of raising living standards.
- Sustainability of individual resources may vary by region or application. Resources may be more accessible in some parts of the world than others, or more accessible to some groups or sectors than others. This implies care needs to be taken to reflect the scope of assessments when evaluating results.

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Measuring Sustainability

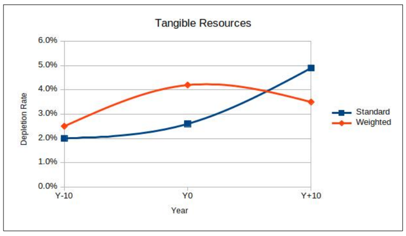
Sustainability articulates a prediction. It predicts future demand for resources required to deliver a quality and quantity of life, which is assessed against the availability of those resources. The further the prediction peers into future, the less reliable it is likely to be. No measurement of sustainability is complete without identifying the period of evaluation.

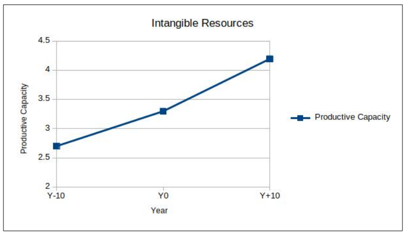
Our understanding of sustainability is achieved over three domains. One is a snapshot prediction based on our aspirations for life relative to expected resources. The second is a focus on a handful of critical resources, each of which has the potential to derail or deliver our future prosperity. The third is an assessment of the existence of life itself.

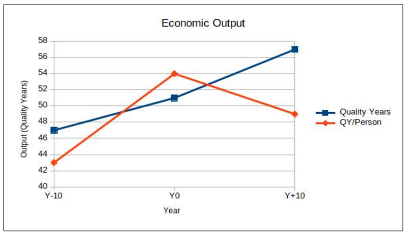
Sustainable Resources Snapshot

The sustainable resources snapshot paints a picture of the movement in productive capacity of measured resources over time, in relation to its impact on society.

This is what Sustainable Resources snapshot looks like.







The first illustrative graph plots the depletion rate of tangible vital resources over time. The depletion rate represents an amalgamation of the percentage decline in every vital resource we use, over a defined period from ten years in the past to ten years into the future. The graph plots two views. The standard view is a simple average of the depletion rate of vital resources. Despite its arbitrary nature, it is presented to reduce the ability to manipulate the picture. The weighted view offers the opportunity to draw attention to existing rates of depletion that will have a more significant impact on human life (such as depletion of drinking water), and to changes in policy that will impact future trends (such as population growth, or action taken to mitigate global warming). Appendix I describes how the overall standard and weighted depletion rates are arrived at.

The second illustrative graph plots the capacity of intangible vital resources over time. Intangibles include solar energy and human productive capacity. They present a particular problem in their role in sustainability because there is no start or end point, and because capacity is not the same as usage. Human capacity, for example, is wastefully underutilised in the way society is currently structured. Plotting capacity over time allows an evaluation of the capacity of intangible resources to limit or enhance our future productivity.

The third illustrative graph plots the outcomes of how we use resources in terms of human wellbeing. Quality Years is a measure that combines the quality of life (measured as a percentage of individual nirvana), and the quantity of life (measured in life expectancy). The graph plots the outcomes of the population as a whole, and of individual averages. The differences reflect population changes.

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The graphs can be created in any chosen sphere of interest. The sphere of interest may be limited to a particular industry (such as food production), or purpose (such as health), or it may encompass global activities (such as global challenges from population growth).

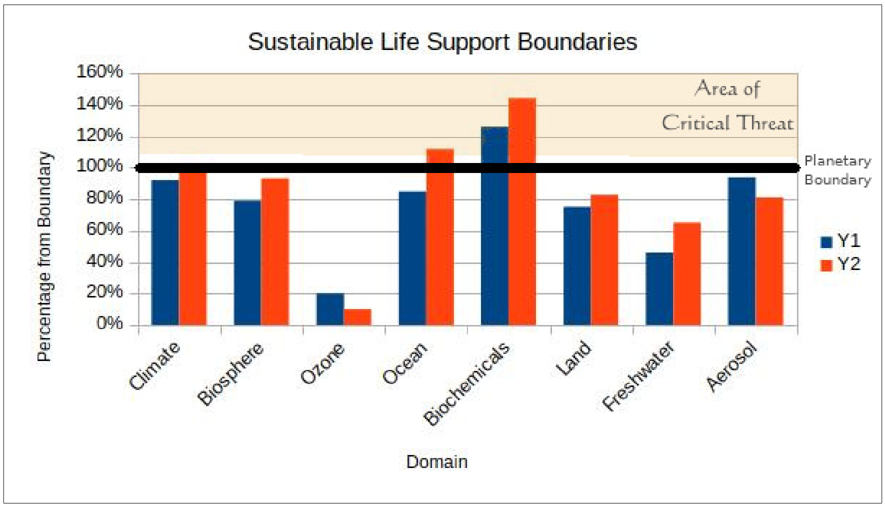
Appendix III sets out come considerations of whether sustainability should focus on all life, or just human life.

Critical Threats Snapshot

The critical threats snapshot concerns itself with the unintended impacts of human or natural activity.

Under normal circumstances, unintended impacts of human activity are reflected in the human-centred measures of economic output. But some threats are both vast in scale and accumulate over time. These threats become critical when they become such an enormous risk to future prosperity, both of humans and to the planet, and need to be reflected in any evaluation of sustainability. When evaluating global sustainability, we refer to the critical point as a Planetary Boundary.

This is how a critical threat can be measured:



A critical threat is relevant to sustainability because it has the potential to negate the forecasts inherent in the sustainable resources snapshot. It does not necessarily relate to scarcity.

A common characteristic of critical threat has the potential to destroy not just our way of life, but life itself. Concerns about CO2 emissions flow through to global warming. This creates the risk of rising sea levels, flooding in some parts of the world, and drought in other parts. It threatens to change environments in which animal and plant species who have adapted so perfectly risk becoming extinct. Concerns about depletion of drinking water flow through to declining crop production and desertification of many fertile areas around the world, threatening human, animal and plant life and forcing mass migrations.

The model for identifying critical threats highlights how close we are to the tipping point. The world is such a complicated, integrated place, the charts are useful as an alert to impending disaster, and as a base point from which to monitor the impact of any evasive actions we take.

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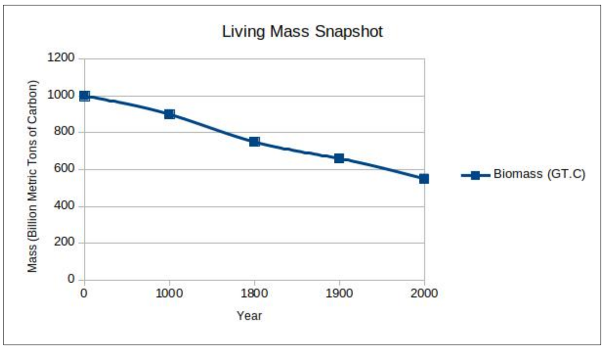
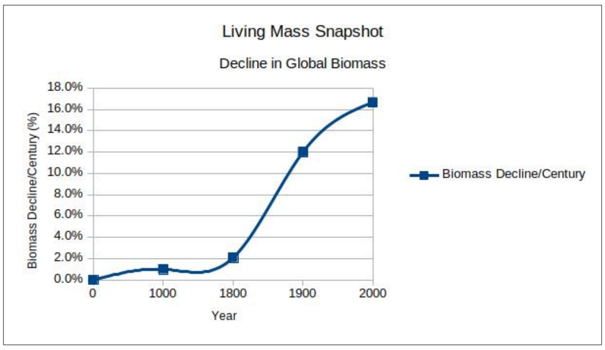
Living Mass Snapshot

The living mass snapshot concerns itself with life itself.

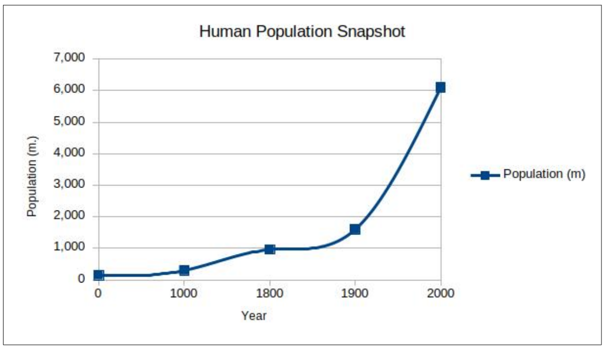
Sustainability is measured over decades or more. Even when we recognise threats to sustainability of the quality and quantity of life, it is rarely possible to get a precise understanding of the impact of the threat. So the final snapshot provides a measure of sustainability looking from outside in. It charts the trends of life on earth.

The chats below are based on a report on the total biomass of all life, measured in weight (in billions of tons of Carbon contained within each life form)[1].





A very different picture is presented when we look through the prism of human life alone.



Human growth over the last two thousand years, has been achieved at the expense of 50% of the remaining life on the plant. Since human life is dependent on other forms of life for our food, it is self-evident that wiping out the remaining 50% of the planet's physical and natural resources is not sustainable for much longer at our current, growing rates of decimation.

Global Leadership

All three domains of sustainability require us to think about our future. None tells over which period to look. As a very minimum, we should think about global sustainability over a 20 year, 50 year and 200 year time-frame.

This time-frame is well beyond most political cycles. The world is crying out for new structures of leadership that both fairly represent our entire population, and which carry the global authority to structure and implement actions with the longer-term perspective needed to cope with unsustainable global interaction.

1 Report by Vaclav Smill, Harvesting the Biosphere

Appendix I : Measuring Resources

Within the context of sustainability, resources are measured in terms of their depletion rate.

Humans use a vast number of resources in making our lives better. It may be overwhelming to incorporate the depletion rate of every resource we use. It would be unproductive if the key messages of sustainability are drowned out in a sea of detail. We need to be discerning about which resources we include in our evaluation of sustainability.

In the illustration below, the review is limited to identifying a specific group of vital resources that are depleting. It examines four categories of depleting resources. Old metals represents the traditional metals used in production. New metals represents resources that have become available during the current period, perhaps due to technological advances in metal extraction, or scientific understanding of how to make use of new metals.

	Tangible Resources				
	Old Metals (Tonnes m)	**New Metals** (Tonnes m)	**Food Sources** (Carbon t)	**Replenishable** (Tonnes m)	**Totals** (Avg Rate)
Y-10	1,000		2,000	9,000	
New sources		500			
Obsolsecence	(400)				
Consumption	(100)	(50)	(400)	(100)	
Y0	500	450	1,600	8,900	
No Years	10	2	10	10	
10 yr Depletion Rate	20.0%	55.6%	25.0%	1.1%	
Unweighted					
Weighting	25%	25%	25%	25%	
Weighted rate	5.0%	13.9%	6.3%	0.3%	**25.4%**
Weighted					
Weighting	25%	5%	50%	20%	
Weighted rate	5.0%	2.8%	12.5%	0.2%	**20.5%**

The depletion rate is calculated based on the closing level of each resource. If the depletion rate is negative or greater than 100%, its value is set to 0% or 100% respectively.

In the "Unweighted" section, the overall depletion rate is a simple average of depletion rates of the resources being evaluated. This simple averaging takes not account of the degree of reliance we place on individual resources. For example, depletion of food sources, once it reads a particular threat level, may be much more serious that depletion of metals that may be used exclusively in space travel.

In the "Weighted" section, the authors of the report allocate a weighting to the significance the attach to each resource. The weighting they apply will depend on their objectives of the report, allowing them to highlight different aspects of the evaluation. Whenever weighting is applied, the report needs to identify and explain the basis of weighting.

Appendix II : Component Resources

Sustainability is impacted only by the effect of vital resources. We do not need to include inert resources in our model, because by definition they are not life sustaining.

Vital Resources

There are three models of vital resources we can use, depending on what is being evaluated.

- All vital resources. Resources that are not depleting have a depletion rate of 0%. An increase in the quantity of resources over time means we are not using up resources. This is why there can never be a negative depletion rate. If we include all resources, the overall depletion rate will be very much less than where we include just those resources that are depleting, or depleting at a critical rate. We have access to the weighting mechanism to draw attention to the key components of the evaluation.
- Only depleting resources. This removes the unhelpful focus on resources we replace, but it risks giving a misleading impression on the feasibility of replacing depleting resources with others.
- Only critical depleting resources. This focuses attention on the areas of sustainability that are most important for us to deal with. It is subjective, in the sense that the authors choose what to include.

Reusable Resources

One challenge for the model is how to treat renewable/reusable resources. How do we distinguish, for example, a resource that is designed to be used only once (eg. a syringe needle) from one that is designed to be used multiple times (eg. a road)? Strangely, the answer is we do not need to.The its nature of multiple use is reflected in a reduced consumption rate. Where a road is so poorly maintained that it becomes unusable within 10 years, its consumption rate is 100%. Where it is used over a 100 year period, its consumption rate is very much lower. It seems the capacity of resources is irrelevant to sustainability. What matters is the change in availability of resources over time – the depletion rate.

Intangible Resources

Intangible resources are a little more complex. Examples include solar energy and human capacity. They are available a single point in time. If they are not used, they are lost. Intanigble resources are not included in the calculation of depletion rate because there is no starting or ending stock of resources.

The significance of intangible resources is identified by comparing its use over time, and the impact it has on tangible resources. Once solar energy is used in place of tangible fossil resources, the equation on the tangible resources changes quite dramatically, with reduced consumption rates relative to existing stock levels. Once the switch is significant enough, the fossil resource's weighting will be reduced.

In practice, intangible resourced may be partially stored. Huge efforts are being made to create reliable ways to store renewable energy sources. Human energy can be indirectly stored, as a component of an re-processed resource. Where intangible resources are stored as components of tangible assets, they are reflected in the depletion rate calculations. Where renewable energy can be effectively stored in its own right, there is a case for switching its category to replenishable, depending on the significance and nature of its storage.

Appendix III : The Scope of Life

Sustainability focuses on the quality and quantity of life. It intentionally avoids defining whose life. Sustainability can be explored in the context of human life alone, or of all life. The difference has profound implications for how we structure our economy, our politics and our society.

It is inevitable there will be differences of opinion over whether we need to extend our concern to the lives of other animals and plants on the planet. Few would disagree, however, that our priority is human life, where it is in conflict with other life. There is much greater disagreement over our responsibility to preserve life that is not in conflict with ours. Perhaps it is sufficient in this paper to note that almost everything humans eat comes from other plant or animal life. We have identified that critical threats are either processes or resource depletions that threaten our existence.

We have destroyed roughly half of life over the last 2,000 years, with the rate accelerating out of control. There is a strong argument that our destruction of so many other forms of life on earth has become a critical threat. Whereas the threat of extinction of individual species, such as the snow leopard, is not of itself critical to mankind, our wholesale destruction of our natural ecosystem does have the potential to decimate the life on which we depend for nutrition.

It is inevitable that there will be disagreement over the priority we place on preserving all life on earth, but any disagreement will become less polarised if we fail to address the issue of our place in nature.

The objective of evaluation of sustainability is to alert us to impending disaster in time to change our ways. Surely everyone can agree we need to direct at least some attention to the wider sustainability of life on earth.