

# “Mis-measuring Our Lives: Why GDP Doesn’t Add Up”

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## Chapter 3

### SUSTAINABLE DEVELOPMENT AND ENVIRONMENT<sup>1</sup> (REFRAMED)

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## Preface

We begin by stating that more and more people are sensing and noticing and observing and documenting that the collective effect of the growing number of humans combined with specific unsustainable behavior has become a critical issue that must be addressed today. For the sake of future generations of homo sapiens and the other 1.9 million living species that share this planet, it appears that humans must change certain portions of their behavior. There does not appear to be any fundamental reason or law of the Universe that would prevent a large population of humans from living in right relations with all other species on a finite planet – in a

mutually beneficial manner – just as the vast majority of non-human species have evolved to do. Having found the boundaries of right relations, we humans can then exercise our seemingly infinite gift of free will to enjoy happy, creative, caring, responsible, interdependent lives.

The social systems we humans create are intended to influence our lives so that we can exercise our free will and individual freedom but do so in a mutually beneficial manner - in a responsible manner.

The economic system we created and are using in America is reviewed herein.

### Why is “Mis-measuring Our Lives” by Stiglitz, Sen and Fitoussi, so important?

Why is “Mis-measuring Our Lives” by Stiglitz, Sen and Fitoussi, published three years ago so important to not just economists but to every one of us?

There are several reasons.

- 1) Because in the first sentence of the Foreword to this book, Nicolas Sarkozy, who initiated and appointed the Commission that conducted this work states:

*“We will not change our behavior unless we change the ways we measure our economic performance.”*

- 2) Because this book documents the collaborative year-long effort of a commission of 24 people from 4 countries with expertise in economics and sociology – experts who conclude that our current use of GDP<sup>2</sup> to monitor our economic performance and social progress is indeed an inadequate measure of our overall well-being.

We acknowledge that a growing number of highly acclaimed ‘economists’ around the world are telling us that “One of the reasons that most people may perceive themselves as being worse off even though average GDP<sup>3</sup> is increasing is **because they are indeed worse off.**”<sup>4</sup>

Yet the governments of developed nations continue to use this obsolete measuring stick that methodically indicates the economy is ‘improving slowly.’ Most people, about 99%, know their personal lives have not improved over at least the past decade or two or three. This discrepancy between what we hear and what we experience is undermining our confidence in our current political /economic system – the very system we created to help influence our lives in a positive manner. We understandably are beginning to think that we are being lied to. However, in their defense, well-meaning economic experts and political officials are simply reporting the numbers derived by turning the crank of their machine that computes the GDP.

Stiglitz, Sen & Fitoussi, along with the other 21 members of the Commission on the ‘Measurement of Economic Performance and Social Progress’ address this discrepancy between what we are told and what we know about our well being and propose a three prong approach for change:

- Chapter 1: Modify the classical GDP to correct obvious deficiencies,
- Chapter 2: Augment the GDP with some means of expressing the “Quality of Life,” and
- Chapter 3: Augment the GDP with a measurement of “Sustainable Development and Environment.”

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<sup>2</sup> See Appendix A for more detail about the Gross Domestic Product

<sup>3</sup> Gross Domestic Product - a common measuring stick for capitalist economic systems

<sup>4</sup> “Mis-measuring our Lives” Page xi,

To the lay person, the Commission is acknowledging that any correlation between GDP and Quality of Life or Sustainable Living is purely coincidental. This is a serious admission and a red flag requiring immediate attention by ‘We the People’ because our elected government officials (as well as the financial sector) continue to use the GDP as a measure of American economic health.

## Why are We Focusing on Chapter Three: “Sustainable Development and Environment?”

So why are we specifically discussing and “reframing” Chapter Three: “Sustainable Development and Environment?”

Again there are several reasons.

- 1) Because Chapter Three acknowledges that the GDP alone does not give us the information needed to assess whether or not we are living sustainably.
- 2) Because Chapter Three, as originally written, focuses only on how we can better measure our current economic system with respect to ‘Sustainable Development and Environment.’
- 3) Because there is a growing number of people who are informing us that our American **economic system itself is broken**. In effect they are telling us we are using a broken measuring stick to measure a broken economic system. Apparently two ‘brokens’ don’t make it right.
  - A growing number of economists around the world are telling us the economic system is broken by identifying internal inconsistencies within the system itself (Korten, Stiglitz, et. al. )
  - A growing number of economists are telling us that the economic system is broken because it is not consistent with the Real World that consists of a finite planet with finite resources. (Krugman, Korten, Zeitgeist, etc.)

They remind us that our economic system was created by humans to influence our choices and therefore channel our enormous free will in the direction of social order in a reasoned manner. They remind us that if our system is not working as we would like, we can change it, we can improve it. In fact, since we made it and we broke it, we now have the responsibility to fix it for the sake of all future generations of homo sapiens - as well as all other Life on the planet.

So we are re-examining and reframing Chapter Three. As we read through it line by line, we attempt to view it from the Real World perspective<sup>5</sup> - a place where we can identify any inconsistency between our human-created “real world” of wishful thinking and what we observe in the Universe-created Real World. As children of the Real World immersed in our virtual ‘real world’ we each must point out to one another the inconsistencies we can observe and suggest changes to the human-created “real world” so that it merges into right relations with the Real World. This is how collective learning adds to evolving collective consciousness.

An unstated goal for homo sapiens is to evolve to where we have developed an awareness – a consciousness that is completely consistent with the Real World. Knowing that each child of the

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<sup>5</sup> The “Real World” perspective ranges from stepping off the planet to take the lofty viewpoint of an astronaut to view our Earth as a Blue Marble, as a complex system of systems called Gaia traveling in the vastness of space, alone, bathed in sunlight – our primal source of Life – to learning to think like (empathize with) a close family member, to thinking like any passenger on our common planet, to think like a distant living cousin, another animal or plant, to thinking like a rock, to thinking like a single molecule or atom. A more detailed discussion of the “Real World” versus the “real world” can be found in Appendix P

Universe has a unique consciousness, it would seem that homo sapiens could serve to integrate all these dimensions of consciousness – and in that manner be in right relations with the Universe – in that manner be able to negotiate more and more of the infinite sustainable paths through the realm of creativity – and do so with mutual benefit.

Goodness celebrates and promotes the diversity of Life and hence the evolution of collective consciousness. The opposite would be considered evil. Each past, present and future form of Life illustrates yet another path.

Empathy is a great concept. It seems to range from being able to think like a quantum of energy, to a Higgs Boson, to an electron, proton, neutron, to and atom, to a molecular group of atoms, to systems of molecules, to systems of systems, to systems of systems driven by an external source of energy - Life – beings.

## What is “Reframing?”

We describe this review as ‘reframing’ because the original publication of Stiglitz, et. al. is being re-viewed from a different perspective than the one in which it was written – a different frame of reference.

Our particular approach to ‘reframing’ is quite simple.

One on side of our desk, we open the Universe Story<sup>6</sup> – the recorded observations of our 13.7 billion year-old expanding Universe, the formation of our Milky Way galaxy, our solar system, and the 3.5 billion years of evolution of life on planet Earth with the relatively recent emergence of a species we call homo sapiens some 100,000 years ago. Today over 1.9 million diverse forms of life (species) have been documented and are now known to have common ancestry. Yes all Life is clearly one genetic family illustrated by the phylogenic tree of life constructed from current knowledge of DNA/RNA sequencing. Together, we form an interdependent web of life that is totally dependent on the incoming energy from the Sun.

The Universe Story describes the emergence of the Real World of which we humans are an integral interdependent part. The Universe Story is written for our children – it is our means of passing along the collective knowledge and wisdom of the past and present generation to the next.<sup>7</sup>

On the other side of our desk we open a story of a particular human creation. In this case the story of a human-created economic system – a sociological invention intended to influence our choices supposedly for the well being of all. The creation of an economic system is yet another ‘tool’ that humans consider a part of their ‘real world.’

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<sup>6</sup> For more information about today’s Universe Story see Appendix A. The Universe Story tells us we are but one of over 1.9 million living species on planet Earth – species living.

<sup>7</sup> As we watched Tortoise Tad emerge from his burrow today and begin his spring/summer search for edible plants in the Mohave Desert we could not help but reflect on this ancient species of Life. Tad depicts a living being able to pass along all necessary survival skills needed to inhabit the desert embedded in its DNA. The mother tortoise leaves her eggs in a burrow, they hatch- peck their way out of their shell, and begin life alone – without the protection of a parent, without the milk of a breast, with only a sack of reserve energy to get them thru the year to the next spring. During that first year, (the latter half spent in hibernation,) they must learn to explore their new world, learn to find the energy needed to sustain life and be lucky enough to avoid the many predators around them. Starting out as a 1 inch long hatchling, this is no mean task. Perhaps even more important is the information packed within the DNA sequence that attracts them to the opposite sex, and the instincts to come together in a way that joins them for procreation.

Then we compare the two stories. We ‘reframe’ the human-created “real world” by viewing it from the context of the “Real World.” In the event of conflict between the two worlds, we know for a fact that the “Real World” provided by the expanding Universe always has and always will ‘trump’ the human created ‘real world.’ Generally the difference between the Real World and the real world is that the ‘real world’ leaves something out, or fails to acknowledge something sometimes out of ignorance but more often because of some nefarious motivation.

To illustrate how this “reframing” process works, we have used several actual events as examples in Appendix O.

### **The Economic System we are mis-measuring is itself broken and requires reframing.**

Although we concur completely with Sarkozy’s opening line of the book, we also sense that the economic system itself – the system we humans designed and created to influence our choices is also broken. The system we created has now become a root cause of our unsustainable behavior. We would do well to identify how to fix/change the economic system so that it influences us to make choices that are sustainable as well as fix/change the method of measuring its performance. In that context, we are motivated to reframe Sarkozy’s observation as follows:

We will not change our **unsustainable** behavior unless we change the ways we measure our **behavior** – for example, our **economic performance**<sup>8</sup> AND we will not change our unsustainable behavior unless we change the very system we created to influence our behavior – only then can we hope to freely choose to live sustainably.

There is an emerging awareness that certain human-created “systems” designed specifically to advise humans on appropriate behavior are influencing us to make choices that are unsustainable.

By human-created “systems” we mean economic systems, financial systems, political systems, educational systems, transportation systems, religions, production systems /corporations, legal systems, tax systems, communication systems, agricultural systems, urban systems, even down to neighborhood & home owners associations, as well as cultural and family systems, etc.

By unsustainable we mean suicidal, genocidal, and ecocidal behavior – behavior that can lead to the death (the end of life) or extinction (the end of birth) of our own species as well as many of the other 1.9 million documented living species on planet Earth – species that we humans depend on for our own existence.

By unsustainable we mean human behavior that leaves the planet less livable for future generations.

By less livable we mean a planet with depleted resources, with fouled air, water and soil, with depleted reserves of ancient hydrocarbons (petroleum, coal, natural gas, tar sands oil, shale oil), with depleted aquifers filled with ancient water, with human-created radioactive waste dumps and spent reactor sites that will remain lethal for tens of thousands of years, with genetically modified organisms that have lost the adaptability acquired through 3.5 billion

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<sup>8</sup> e.g using a single number derived from a single perspective such as GDP

years of evolutionary history, with vast numbers of species extinctions linked to human behavior, with seriously depleted biological diversity.

By future generations we mean the next 20,000,000 (20 million) generations – the deep future that extends to the next 500 million years – the time frame the Earth is expected to remain habitable for Life as we currently know it. **See more about fg later**

When we become aware that we have created an unsustainable system - a system that is promoting our individual and collective demise, it is prudent to stop and reflect for a moment, and then use our collective consciousness to propose and implement change. This, in the words of Thomas Berry, is the 'Great Work' that lies ahead for the human race – work that requires our immediate and full attention.

Let's begin.

## Reframing Sustainability

Let's discuss the concept of sustainability or sustainable living. A 20 year old IMAX documentary, "The Secret Of Life On Earth<sup>9</sup>" does an outstanding job in illustrating sustainable living by capturing some of the little known life of non-human species on film – all of which have evolved within an interdependent web of life – a network that is totally dependent on the daily energy of Sun. In general, there are 1.9 million documented species on the planet that are living sustainably – with only one major exception – homo sapiens. Non-human species extract basic materials from the air, soil, water needed for their growth and subsistence. At the end of life, every atom of these resources is returned for use by another generation or another species. Homo sapiens also extract basic materials from air, soil, and water and from other species they ingest for their growth and subsistence – but in addition, humans extract materials for their "tools" their extensions of themselves and it is these materials that not returned for use by future generations. Recycling every atom of Earth's resources, like other forms of life do, is not only important for sustainable living, it is mandatory.

Sustainable species harvest the energy they need to live. Homo sapiens are in a phase where they do not -

In its seemingly endless pursuit of "development" certain homo sapiens, hell bent on personal gain continue to alter, destroy, burn, eliminate niches – living space for other living species – this anthropocentric perspective pretends that there is little or no value in respecting the habitat of other members of our living family – it naively and falsely assumes that humans are the most important and perhaps only species of any consideration – greed and arrogance run rampant and are dominating the behavior of these insensitive (and to be truthful, ignorant self-serving mentally ill people who are in fact suicidal – no problem – suicide may be an appropriate behavior in some circumstances – but their behavior is worse – it is ecocidal as well – and that where the human race – all homo sapiens – and all 1.9 million species should step in and say NO MORE. Humans must stop increasing in number – 7 billion is quite enough if not more than is sustainable – Humans must develop a new worldview where the planet is finite and resources are finite – Humans must understand that they are a part of interdependent web of life that in turn is totally dependent on the harvesting the energy from the Sun – Life is chemistry running backwards driven by an external supply of energy. We are all part of the same family. When we destroy members of our family we become weaker – and at some point the hole in the web

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<sup>9</sup> "Every form of life on Earth depends on plants ability to capture the Sun's energy and transform it into food..."  
<http://www.youtube.com/watch?v=CRkGb7inQ5I>

## Mis-measuring Our Lives (Reframed)

that allows the flow of energy from the sun to reach our mouths becomes so large, the web is broken – the network is compromised and we are isolated from this flow of energy – guess what we big brained mammals die.

We of course will take out and cause the extinction of massive amounts of other species – just as we apparently did on Easter Island and even North America as early homo sapiens or predecessors eliminated the ready food source known as woolly mammoths, giant sloths, etc. driving them into extinction.

We must replace the generalized concept of ‘development’ with ‘sustainable mutual benefit’ The EIS is a start – but it doesn’t go far enough. The EPA is a start but it needs more teeth and more strength and more outreach to explain its importance to sustainable living – it must be used as a means of moderating unsustainable behavior until our self-centered anthropocentric illness is purged from our thinking and from the human created systems that allow it to propagate. We as individuals must use peer pressure to call out the hoarders and point out their mental illness and even demand that they seek help in overcoming their dis-ease and propensity to hoard – to be maliciously self-centered

As Stiglitz, et. al. indicate, there is no single indicator or measuring stick available that accurately tells us who is and who is not living sustainably. Certainly economic indicators such as the GDP are meaningless for this purpose.

Before continuing to evaluate Chapter Three, and the quest to develop a new method of measuring sustainability, let’s be sure we first agree on what we trying to measure.

At this point in the evolution of Life on planet earth, the “natural” path of evolution of single species has been inundated with human constructs – human creations. Our ancestors, pre homo sapiens, started with the simple manipulation of basic earth resources some 2 million years ago by shaping rocks into slightly modified forms that further extended their human capability. The fashioning of a rock into a sharp edged implement that can assist in carving / cutting game into smaller edible pieces (the human evolved teeth and jaws are not the best for ripping and tearing meat into bit size pieces that can be easily chewed and swallowed. Today we observe other primates as well as crows utilize sticks of wood as extensions of themselves to assist in procuring food. Often a stick can be inserted into a small hole or crack harboring ants or termites- the stick is then extracted with a load of edibles still clinging defensively to this ingenious hunting tool.

Humans are now able to fashion most elements found in the periodic table into new shapes and forms and combinations that in turn can be shaped into components needed to construct a larger tool (system) from swords to plows to planes to spacecraft to wind turbines to solar panels to electric cars.

## Reframing Development

In its seemingly endless pursuit of “development” certain homo sapiens, hell bent on personal gain continue to alter, destroy, burn, eliminate niches – living space for other living species – this anthropocentric perspective pretends that there is little or no value in respecting the habitat of other members of our living family – it naively and falsely assumes that humans are the most important and perhaps only species of any consideration – greed and arrogance run rampant and are dominating the behavior of these insensitive (and to be truthful, ignorant self-serving mentally ill people who are in fact suicidal – no problem – suicide may be an appropriate behavior in some circumstances – but their behavior is worse – it is ecocidal as well – and that where the human race – all homo sapiens – and all 1.9 million species should step in and say NO MORE. Humans must



## Mis-measuring Our Lives (Reframed)

stop increasing in number – 7 billion is quite enough if not more than is sustainable – Humans must develop a new worldview where the planet is finite and resources are finite – Humans must understand that they are a part of interdependent web of life that in turn is totally dependent on the harvesting the energy from the Sun – Life is chemistry running backwards driven by an external supply of energy. We are all part of the same family. When we destroy members of our family we become weaker – and at some point the hole in the web that allows the flow of energy from the sun to reach our mouths becomes so large, the web is broken – the network is compromised and we are isolated from this flow of energy – guess what we big brained mammals die.

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**See the reframing of the Blue Diamond Development project**

### Reframing Environment

The concept of “Environment” has become a term that is often used in a pejorative manner by the professional anthropocentric developer. To the developer, life is a war with the tree hugging environmentalists who chain themselves to the very equipment needed to make a profit.

However, in the Real World, to paraphrase POGO, “We have met the Environment and it is us.”

The Universe Story clearly tells us that in the ‘Real World’ we humans are an integral part of the interdependent web of life embedded within the living system we call Earth’s ecosystem. Although our eyes can differentiate our body outline and we can create a ‘real world’ where the ‘environment’ begins beyond our body outline, in the ‘Real World’ there is no such distinction.

Radioactive isotopes can be found floating in the atmosphere, deposited in the soil, in the water we drink, within a medical diagnostic machine, carried around by another being or lodged within one of our own cells. The unstable atom does not recognize the difference between the inside and the outside of our body. The isotope will spontaneously decay and emit ionizing radiation wherever it is. If you are nearby, and the high energy photon bullet is absorbed by your body, you are wounded. Some molecule (e.g. DNA) within one of your cells has been altered. We are what we are exposed to – the environment.

Every breath you take brings a new batch of molecules from the atmosphere around you. Because of the natural circulation of the atmosphere, Brownian motion and the observed Second Law of Thermodynamics (Entropy tends to increase), high concentrations of a given chemical species (e.g. a

toxic material such as benzene vapor<sup>10</sup>) will disperse and eventually become distributed around the planet. This is a good thing because it tends to dissipate deadly concentrations of specific species such as carbon monoxide generated by incomplete burning of hydrocarbons coming from the exhaust pipe of a gasoline burning car for example. We humans must breath air (oxygen) to live; plant must “breath” air (CO<sub>2</sub>) to live – that’s the environment.

All the food we eat potentially contains toxic materials introduced by contaminated soil or by spraying with pesticides/herbicides or by improper preparation or by packing in toxic bearing packaging. Animals that ingest heavy metals or other toxic substances will often store these materials in their bodies so that when they are introduced into the food chain, the recipient of this food energy also receives a concentrated dose of the toxic material. As a result of human behavior that can and must be changed, eating tuna more than one a week is now considered dangerous to one’s health because of the high levels of mercury contained within these fish. Mercury has been and still is being introduced into the oceans by humans - for example by burning coal containing mercury (and other heavy metals), then dumping the exhaust products into the atmosphere to be scattered around the planet. Mercury is particularly onerous because it is known to compromise the neurological development of infants – we humans certainly don’t need to lose any more of our mental capacity than we already have. Just the simple process of eating introduces the “environment” into our bodies and then into every one of our cells – we are what we eat – the environment.

The Universe Story reminds us we are an integral part of the interdependent web of life – there is little distinction between us and the environment. Filling the environment with human-created waste materials that are not good for life must stop. We are poisoning ourselves and our children and their children. Our current human behavior is not sustainable. These materials continue to build up around us faster than our living cousins (who are obviously lower on the food chain) can collect them and serve them up to us.

The developer living in the human-created “real world” views the environment as the non-living infinite supply of air, water and soil we need for our existence - the stuff that is just always there that we don’t have to even think about. The environment is the convenient place we can dump the stuff we don’t want because nature will take care of it for us – it will detoxify the lethal chemicals we don’t want, it will eat the oil we spill and dump and leak, it will cover up the radioactive materials we create with our weapons, our reactors, our medical tools, ... In the human-created ‘real world’ the developer wonders “why do these weirdo environmentalists spend so much time and money (tax dollars) worrying about stuff like the environment? It is out there and will always be out there for as long as I live? Don’t even tell me that I need to think about the fact that this stuff is finite – there is plenty for me and my family.”

The Universe Story suggests that when we see the word “environment” we should reframe it to mean “ourselves, our family, all humans, all Life (all 1.9 million living species) and everything in the life support system of

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<sup>10</sup> Benzene is widely used in the United States . It ranks in the top 20 chemicals for production volume. A major source of benzene exposure is tobacco smoke. Indoor air generally contains levels of benzene higher than those in outdoor air. The benzene in indoor air comes from products that contain benzene such as glues, paints, furniture wax, and detergents. <http://www.bt.cdc.gov/agent/benzene/basics/facts.asp> For a more complete list see: <http://www.schmidtandclark.com/benzene-products-list>

spaceship Earth” - everything on Earth that touches Life. The environment is not something outside us – it is within us and extends to everything we are connected to.

Hopefully when we use the phrase, “Protect the Environment,” we mean preserve, conserve and respect everything that supports and promotes Life – as well as Life itself. This obviously implies that our human behavior does not contaminate, destroy, foul, pollute, consume or make the environment unlivable for future generations.

Every breath we take draws more of the environment into our lungs, and blood stream and into each and every cell in our body. Each sip of water and the Each bit of food Each thing we touch – just being present exposes us to radioactive ionizing radiation

## Introduction

The first two chapters have dealt extensively with the measurement of current well-being, either along dimensions that can be summed up in monetary units (chapter 1), or along dimensions that are less amenable to conversion into monetary units (chapter 2).

The sustainability issue that is raised by this last chapter is of a different nature. Sustainability poses the challenge of determining whether we can hope to see the current level of well-being at least maintained for future periods or future generations, or whether the most likely scenario is that it will decline, **OR the most likely scenario is that our well-being will continue to evolve/increase as we homo sapiens re-learn how to channel our free will into more and more cooperative efforts.** If the rate of evolving consciousness can outpace and overtake our population growth, we will voluntarily stop growing in a physical sense. Then there is a chance our species will not only survive but go on to become of mutual benefit to the whole of Life on Planet Earth – in which case the ecosystem will thrive – thoughtfully navigated by our collective consciousness and mutual respect. The creative possibilities for a cooperative ecosystem are boundless and limited only by the time the Earth remains habitable. It is no longer a question of measuring the present, but of **predicting the future and adapting our behavior to be in right relations with the interdependent web of Life – that will assure sustainable creative evolution**, and this prospective dimension multiplies the difficulties already encountered in the first two chapters.

Let’s pause for a moment, look around, and reflect on Life around us.

Our ability to predict the future is dependent on our understanding the past and perceiving patterns.

To our credit, we homo sapiens excel at meticulously observing the Universe. To our credit, we are also endowed with enormous curiosity – with an inherent desire to formulate the abstract concept of a question. As a result, we ask the question Why? We ask the question How? In fact our minds seemed to fill with more questions that we can ever answer. For the child and the child-like, the ‘question’ becomes the chocolate dessert of Life.

As a result of asking questions, we find answers and the Universe Story is being updated, amended, and extended at such a rapid pace today it is hard to keep up with and comprehend the amazing richness of this emerging story. Nevertheless, we will attempt to transfer a few items from the Universe Story into this discussion of our human-created economic system. As we review Stiglitz’ Chapter on measuring Sustainable Development and ask “Why doesn’t the

GDP adequately measure what is of true value to our lives?” we hope to identify potential changes/updates to our system that reflect our current understanding of the Universe.

So before attempting to look forward, let’s look back for a moment.

Life on planet Earth can be traced back 3.5 billion years. Homo Habilis (upright handybeings who used tools extensively) seemed to emerge around 2-3 million years ago. Their descendants, us Homo sapiens, emerged from eastern Africa around 150,000 years ago – about 6000 human generations ago.

What is Life? Is discussed further in Appendix Q. To physical scientists, Life seemed to be an anomaly. An example of where the Universe was not adhering to its second law of thermodynamics – a Life form, a being is a place in time and space where the Universe is creating order from randomness – everywhere else the Universe tends toward disorder – but not within the boundaries of a living being. The living being extracts specific building block materials in a specific sequence from the mother Earth and assembles them sequentially into a new order, replicating cell by cell until an adult member of that living species has finally emerged. It appears that within the boundary we call this meticulously ordered living being, entropy has decreased. We note however that this life form could not exist without an incoming source of energy (and raw materials) – without energy and materials crossing the border. As we trace the source of that energy we are lead back to its origin – the Sun. When we draw the boundary to include the Sun, we then capture the hydrogen fusion process that is the source of the electromagnetic energy / sunlight. We then find that the entropy of this larger system is indeed increasing and is consistent with the general principle of the second law of thermodynamics. Life is a subprocess associated with the flow of energy from a solar system. Life on Earth harvests energy (sunlight) from its source, the Sun, and transforms it into other forms (chemical energy, mechanical energy, thermal energy) along the path to waste heat / disorder (thermal energy, infrared electromagnetic radiation).

We then observe that after a period of time, the order begins to change and eventually death occurs and the building blocks become disordered again – returned to dust / star stuff. Although Schroedinger proposed a concept called negative entropy to “explain” the process of Life, but that hasn’t yet been found to be too helpful.

Pross describes life as a system of systems (of subsystems) that are in non-equilibrium – i.e. energy is flowing/transitioning through the system – just as the rain flows down the hillside into the stream that flows into the river that flows into the ocean and evaporates to be transported back to rain onto the hillside. This process is “driven” by energy from the Sun. So too is Life driven by the energy from the Sun. When the energy stops flowing through a living being, we say death has occurred, life has ended.

Life evolved sustainably on the planet until quite recently. The importance of the Sun – the energy from the sun is “intuitive” to the plants that turn to face the sun, to the turtle that basks in the sun, to all the animals that sleep at night and awaken each morning to forage/hunt for their daily food while avoiding the ‘dangers’ of being in the middle of the food chain. Even early homo sapiens seemed to sense that the energy of the Sun was essential for their very life. As we look back at the remaining fragments of past cultures, we say our ancestors even worshiped the Sun as an immortal being – as a god – as a singular God.

As we refocus on the more immediate landscape of history, we see significant changes in how we view the Real World.

The Great Burning (of ancient hydrocarbon) began with the discovery of oil 70 feet below the surface in the Drake Well near Titusville, PA around 6 generations ago (CE 1859).

**Future generations.** With that perspective, now let's turn around and look forward. Based on the past, what can we project for the future – more of the same? Within 3 more generations (75 years), all the proven and known oil reserves on the planet will be depleted, (assuming our current rate of consumption). Within three additional generations, we will deplete all the remaining coal, natural gas, tar sands oil, shale oil resources. So 6 generations from now (150 years), the Great Burning of one-time-only ancient hydrocarbon resources will cease forever -

As we look further ahead into the future, we see the Sun has enough hydrogen and helium fuel to continue the fusion process for several more billion years before it transitions into a red giant, expands and engulfs Mercury, Venus and Earth. We look ahead and see that the expected natural changes of the Earth as its core cools and the tectonic plates continue their migratory paths colliding into one another and the general chemistry of the planet continues to follow the Law of the Universe we call the Second Law of Thermodynamics, the ever trend toward increasing entropy – toward disorder and randomness – we see there is at least 500 million years during which the Earth should remain habitable for life as we know it – that assuming that we are not visited by an intruding asteroid that creates yet another mass extinction. So assuming we have at least 500 million years to go, that translates to about 20,000,000 (20 million) future human generations that could inhabit our planet Earth. Future generations? Think 20 million. Impossible? Absolutely not – the current array of living species have lived sustainably, using the energy from the sun and recycling material resources for the past 3,500 million (3.5 billion) – seems possible to continue another 500 million (that's 15% more).

If we attempt to strip away the toys humans have created and leave only the “tools” created to extend our human capabilities, to see, to hear, to feel, to travel, to carry, to assemble, to recycle, harvest sunlight and other renewable sources of energy, one cannot help but be impressed with the exponential increase in human extended capabilities – prosthesis to extend our vision, our hearing, our ability to lift and carry Earth's resources, to extract (dig, drill) and travel.

So to recap, when we think about sustainable living in the new with respect to the next 20 million generations that could inhabit this planet, we need to begin thinking about how non-humans learned how to utilize Earth's resources sustainably – recycling every atom so it is available for the next generation and the next – for the past 3,500 million years.

As brilliant and conscious as we are, with as much individual freedom that we have here in America, it is time to use that brilliance, that consciousness responsibly – to freely and willingly take on the responsibility for living in a manner that respects all life and protects the resources for future generations – so that every atom of Earth's basic building blocks is available for those who will follow, from whom we are borrowing.

Despite these difficulties, many proposals have been made for measuring sustainability in quantitative terms, stemming from seminal work such as Nordhaus and Tobin's "sustainable measure of economic welfare" in the 1970s, or following the strong impulse given by the Brundtland Report in 1987 and the Rio Summit at the turn

of the 1990s. The present chapter will start with a short review of these proposals. We shall see that many of them fail to distinguish clearly between the measurement of current well-being and the assessment of its sustainability. To put it very simply, many proposals try to cover all three dimensions examined by the three subgroups of the Commission, and sometimes try to sum them up in a single number. This is not the way the Commission has structured its approach, and with good reason. We firmly believe that sustainability deserves separate measurement, and we shall focus in this chapter on the sustainability issue *stricto sensu*.

Such a restriction allows focusing on what the literature calls a "wealth" or "stock-based" approach to sustainability. The idea is the following: the well-being of future generations compared to ours will depend on what resources<sup>11</sup> and wisdom<sup>12</sup> we pass on to them. Many different forms of resources are involved here. Future well-being will depend upon the magnitude of the stocks of exhaustible resources<sup>13</sup> that we leave to the next generations.<sup>14</sup> It will depend also on how well we maintain the quantity and quality of all the other renewable natural resources that are necessary for life. From a more economic point of view, it will also depend upon how much physical capital- machines and buildings-we pass on, and how much we devote to the 'constitution of the human capital' of future generations, essentially through expenditure on education and research. And it also depends upon the quality of the institutions (such as the economic /political /legal /educational systems ) that we transmit to them, which is still another form of "capital" that is crucial for maintaining a properly functioning human society. And it will also depend on how we used the easy-to-access one-time-only ancient sunlight (petroleum, coal, natural gas, tar sands oil, shale oil) as the seed to convert our high energy use life style to one that can continue by using only renewable energy sources. And perhaps most important of all, it will depend on the worldview we pass along to future generations – without a worldview that embeds homo sapiens into right relations with all other forms of Life on our common finite planet, we will be handing over an unsustainable legacy that is sure to end in the self-induced extinction of our species as well as many others. A truly tragic legacy.

How can we measure whether enough of these assets' will be left or accumulated for future generations? In other words, when can we say that we are currently living above our means? In particular, is there any

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<sup>11</sup> "Resources" is intended to include everything available to Life on the planet – this includes the raw materials, the incoming energy from the Sun, the gravitation pull of the Sun, Moon, planets, etc. and the interdependent energy web of Life upon which we humans are totally dependent for our well being. The flow of energy from the sun to autotrophs to heterotrophs. The river of energy that flows from the ocean to the land – from the sun to all the forms of Life on Earth

<sup>12</sup> In this instance, wisdom is meant to indicate "lessons learned," lasting truths, laws of the Universe, etc. gleaned from all previous generations. The term 'wisdom' is meant to capture the importance of collective learning. How homo sapiens like every other living species on our planet uses DNA to transfer information from one generation to the next – the information needed to assembly the basic body form and to assembly the organs that result in a mature living system with innate abilities and capabilities to be a 'conscious' being. A living being with enhanced consciousness - the ability to sense and respond to a stimulus. An atom has the most primitive form of consciousness and responds to certain quanta of electromagnetic energy – certain wavelengths or frequencies that correspond to quantum of energy required to excite higher states of electron field surround the atoms nucleus. We assume that just as our awareness of the Universe has increased almost exponentially in the past century, so too consciousness will continue to evolve – assuming we can prevent our self-destruction as a species – assuming we are successful in measuring our behavior against a sustainability scale.

<sup>13</sup> "Exhaustible resources" needs to be defined. All the star stuff on the planet used to assembly living systems is relatively stable and does not wear out – its half life certainly exceeds the 500 million years we expect the Earth to be inhabitable by life as we currently know it. This star stuff is not exhaustible EXCEPT when humans lose it.

<sup>14</sup> Future well being also depends on our progress toward eliminating war (and all forms of violence), it depends on whether we can acquire a profound understanding of our interdependence to all Life, it depends on whether we can adopt a new ethic – e.g. Ecomorality and become less anthropocentric

reasonable hope of being able to characterize this with one simple number that could play the role for sustainability that GDP has long played for the measurement of economic performance? One reason for such a quest would be to avoid the multiplication of competing numbers. However, if we want to accomplish this, we need to convert all the stocks of resources passed on to future generations into a common metric, be it monetary or not.<sup>15</sup>

We shall discuss in some detail why such a goal seems overly ambitious. The aggregation of heterogeneous items seems possible up to a point for physical and human capital or some natural resources that are traded on markets. But the task appears much more complicated for most natural assets, due to the lack of relevant market prices and to the many uncertainties concerning the way these natural assets will interact with other dimensions of sustainability in the future. This will lead us to suggest a pragmatic approach that combines a monetary indicator, which could send us reasonable signals about economic sustainability, and a set of physical indicators devoted to environmental issues. We provide some examples of such physical indicators, yet, in the end, the choice of the most relevant ones must be left to specialists from other fields, before submission to the public debate.

We will also discuss, explore the use of some slightly different metrics for the natural non-living resources available to humans for making 'tools.' We know that all of these basic building block, atoms, elements contained in the periodic table of elements, are finite in quantity here on our planet.

We know it is not currently possible / feasible to travel to the next planet or the next solar system and bring back a meaningful amount of new material resources – the physics of the process currently requires so much energy it is neither practical nor even feasible in the near future. 'Mine-ing' the Moon or Mars is truly fiction in the foreseeable future.

As a result, we will explore a parameter that makes us aware of how well we are Borrowing / Returning the raw materials present on planet Earth. Our current "Mine-ing" and haphazard unaccountable "Recycling" approach in use today is clearly unsustainable.

Example: Everyone is familiar with the element known as Au<sup>79</sup> (Gold). Let's use it to construct a parameter that compares the amount of Gold that is being "Mine-ed" to the amount of Gold that is being returned to the global commons each year. For a sustainable planet, 100% of the amount of Gold Extracted from the commons must be Returned to the commons over at least a typical human lifetime – say 50-100 years. Another metric that can be constructed is how much of the given resource still remains in situ – that has yet to be extracted from the Earth and put into circulation. In the case of Gold, estimates indicate that 75 % of the Gold that exists on the planet has already been found and that within about 20 years the remainder will be extracted and mining operations will cease.

Gold is an interesting example because it serves humans in several ways. Gold does not appear to have any significant value to non-humans (because it does not enter into chemical reactions and participate in the photosynthesis or metabolic processes nor is it a source of energy to power human "tools").

**Gold used to create new 'Tools.'** Humans have found its amazing physical/ chemical characteristics make it an ideal material for making certain 'tools.' For example, it does not chemically react with O<sub>2</sub>

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<sup>15</sup> Percent of materials that are recycled / returned for future generations

(oxidize) or many other normally reactive materials. It is therefore an excellent material to use in highly corrosive environments – including the human mouth where it is commonly used to construct crowns. Gold has useful  $\alpha/\epsilon$  properties (absorptivity divided by emissivity) for electromagnetic radiation (heat, light) purposes so it is used for thermal control applications on spacecraft.

**Gold used for adornment.** Gold is commonly used to create beautiful pieces of jewelry to adorn the human body. It's a social custom perhaps based on a desire to display one's wealth – or when worn discretely perhaps there is another rationale – not sure – as a male I don't wear such adornments.

**Gold used as currency.** Gold has also been used to mint coins and even as a basis for currency.

**Gold used to store wealth.** Humans have also created a world where Gold is hoarded as an indication of wealth. Supposedly there are tons of gold bars in Fort Knox.

Within another generation, humans will find that that the extraction of trace amounts of gold atoms remaining in the Earth and in the oceans is extremely difficult, energy intensive, and time consuming – essentially the extraction of Gold will become an unsustainable human activity. We will then be faced with some interesting issues.

First of all there can no longer be further 'consumption' of Gold – beginning today. 'Mine-ing' Gold (or any resource) must stop. The extraction process must undergo a fundamental change. Unaccountable "Mine-ing" must be replaced with accountable "Our Owe-ing" as the resource is transferred into the commons for human borrowing/returning.

**The concept of the split-estate must be re-examined.** **Split Estate** - The concept of Split Estate dates back to English law, which reserved the mineral rights of all land, public and private to the king. Over time, Split Estate has come to be defined as a situation in which a property owner is not the same party who owns the rights to extract minerals from underneath the property. In fact, especially in the Western states, surface owners rarely own their mineral rights, and the party who does own them, is entitled to extract them, even if the surface owner doesn't want them to.

The U.S. Mine-ing Act of 1872 is sorely outdated – as are the subsequent attempts to update it. We humans, particularly us Americans would do well to consider a new paradigm. 'Mine-ing' is both a process and an attitude. The process of mining first requires a 'permit' process to acquire the 'minerals rights' for extracting this common resource/material from Earth and considering it as personal 'property.' To consider it "Mine" and be able to do whatever I want with this resource – although it is a foregone conclusion that once 'mine' I intend to make a profit. This transfer of Earth's finite resources from the commons to the unaccountable (and hence irresponsible) private stewardship must end. There is no issue with sustainably extracting this resource from the Earth for responsible use to make human tools – the Universe seems to applaud sustainable creativity. But 'Mine-ing' must be replaced by the paradigm of 'Our Owe-ing/Return-ing' Raw materials on planet Earth are by definition in the commons and belong to no single person while in situ. If someone chooses to extract that material from Earth sustainably, using renewable energy and accounting for every atom extracted, and placing that material into the commons then we say,"go for it." Basically the extractor is acknowledging that the material was and is 'ours' and that by extracting it, they then take the responsibility of 'owe-ing' the planet for said materials. They of course can transfer that "owe-ing" responsibility to someone else who wants to make a piece of jewelry, (or multilayer



thermal insulation for a spacecraft or a micro switch for a normally corrosive environment, or.... ). The jeweler then fashions the Gold into a ring and sells it thereby transferring responsibly for the “owe-ing” to the ring bearer.

As someone who wore a gold band until it became so thin it became unsafe to wear, I in effect was behaving unsustainably. During the many years of use, atoms of Gold that made up the ring were being worn off and lost (consumed). This gold that was entrusted in me was being scattered around North America (that’s as far as I ranged). The well worn ring now sits abandoned (being hoarded for sentimental reasons) in a small jewelry box where it is not available to others who might have a use for this resource. Future generations are now deprived of the amount of the Gold atoms that were worn off my ring. As I stand in the sandbox of sustainability, I now observe my behavior as irresponsible. Reflecting on what a sustainable world might like, I’m sure there are other ways to display one’s commitment to a long term relationship with another human being than scattering precious gold dust to the winds. In retrospect, without being conscious of my actions, when I purchased the ring, I took on the privilege of using this precious resource along with the responsibility for returning every atom to the commons on or before my death. Because a gold atom does not wear out, had I returned all the gold it would have remained available for future generations –but losing even a single atom of Gold is theoretically unsustainable.

In a sustainable world, I would be expected to pay the replacement cost for the effort required to extract the lost amount of Gold from previously abandoned mines or from the ocean. In our unsustainable ‘real world’ it is acceptable behavior to buy the privilege of wearing the ring of Gold without taking on the responsibility for ever returning it to the commons. In a sustainable world, it must be returned to the commons with a reasonable time frame – just like we learned to check out our library books.

There will of course be measures in place in a sustainable world that acknowledge that to err is human. The extractor (and subsequent “owe-ers’ must safeguard this precious material (all materials are precious) and act responsibly so as not to ‘lose’ any of this finite star stuff for future generations to create their new ‘tools.’

Is this meticulous ‘stewardship’ of Earth’s finite materials an impossibility or is it simply an inconvenience? Is it inconvenient to return a library book? Of course! Do we understand why Borrowing / Returning is a good concept? Of course! So let’s give this concept of Borrow /Return a chance to be applied to all of Earth’s finite resources and begin brainstorming possible, practical ways we use these resources during our lifetime, and then be assured these resources as returned to the commons for all future generations.

## Taking Stock

Providing a brief summary of the very abundant literature that has been devoted to the measurement of sustainability or durable development is not an easy task. We will use an imperfect but simple typology that distinguishes (1) large and eclectic dashboards, (2) composite indices, (3) indices that consist of correcting GDP in a more or less extensive way and (4) indices that essentially focus on measuring how far we currently “overconsume” our resources. This last category is itself heterogeneous, since we shall include in it indices as different as the ecological footprint and adjusted net savings, which, as we shall see, convey very different messages. We would also like to add a fifth category (5) indices starting to emerge that attempt to reflect a new Ecomorality: The Ethics of Deep Sustainability (millions of years).

Many of these emerging ethical principles are the result of acknowledging that our planet is finite and its resources and dynamic systems are finite, that there is a finite amount of sustainable life-supporting energy arriving each day via sunlight.

We can augment our daily supply of sunlight by tapping into the power associated with the water cycle that is driven by the incoming solar power.<sup>16</sup>

*The Universe Story teaches us that:* the Thermal energy generally derived from the absorption of sunlight is used to overcome the heat of vaporization and cause a water molecule to evaporate from a liquid surface. The molecule is still H<sub>2</sub>O but by breaking the bond with other like molecules it is now free to migrate into the atmosphere and be carried away by the wind.

(importance of thinking like a molecule, like a plant, like a cell, like a animal) – it is not likely that a rock can think like a human but it is possible for a human to think like a rock – we have people who spend their lives as geologist, materials engineers, chemists

We can augment our daily supply of energy by harvesting the power associated with the wind cycle that is driven by the incoming solar power.<sup>17</sup>

We can augment this supply of energy by tapping into the thermal energy emerging from our molten mantle.

We can augment this supply of energy by utilizing the pull of gravity.

Note: At this point in human consciousness, nuclear reactors based on fission are **not** sustainable for several reasons mentioned in Appendix C. Why our Presidents continue to appoint nuclear scientists to head up the U.S. Department of Energy are incongruous to a sustainable national energy policy (which doesn't exist except in the minds of the oil and gas companies whose mantra is "Transition to renewable energy slowly. Keep 'all of the above' options in play – especially clean coal, and clean natural gas and clean gasoline. Why not tar sands oil and shale oil? Of course we have to continue digging and drilling and extracting these resources because they are part of 'all of the above.'")

## Dashboards or Sets of Indicators

Dashboards or sets of indicators are one widespread approach to the general question of sustainable development. This approach involves gathering and ordering a series of indicators that bear a direct or indirect relationship to socio-economic progress and its durability. In the last couple of decades, international organizations have played a major role in the emergence of sustainability dashboards, with the United Nations playing a prominent role. In particular, the 1992 Rio Summit adopted Agenda 21, whose 40th chapter invites the signatory countries to develop quantitative information about their actions and accomplishments.

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<sup>16</sup> Western cultures were using water wheels around 3<sup>rd</sup> century BC. See Water Wheels: [http://en.wikipedia.org/wiki/Water\\_wheel](http://en.wikipedia.org/wiki/Water_wheel)

<sup>17</sup> Wind sails on boats and ships have been harvesting wind power for at least 5,000 years. Harvesting wind to provide mechanical power for an irrigation project is attributed to Babylonian emperor Hammurabi in the 17th century BC.<sup>[2]</sup> [http://en.wikipedia.org/wiki/History\\_of\\_wind\\_power](http://en.wikipedia.org/wiki/History_of_wind_power)

Other international initiatives to build sustainable development dashboards have been taken by the OECD and Eurostat, following the European Council's adoption of its own Sustainable Development Strategy in 2001. The current version of this dashboard includes 11 (or 9) indicators for level 1 (Table 3.1), 33 indicators for level 2 and 78 indicators for level 3, with the level 2 and 3 indicators covering 29 sub-themes. Similar national initiatives have accompanied this general movement, albeit in a somewhat scattered way. Local initiatives have also mushroomed over the last decade, some based on the initial impetus from Agenda 21.

**Table 3.1. Reviewed List of European Sustainable Development Indicators (level 1)**

<i>Theme</i>	<i>Level 1 indicators</i>
1.Socio-economic development	Growth rate of GDP per inhabitant
2.Sustainable consumption and production	Resource productivity
3.Social inclusion	At-risk-of-poverty rate after social transfers
4.Demographic changes	Employment rate of older workers
5.Public health	Healthy life years and life expectancy at birth
6.Sustainable development	Total greenhouse gas emissions Consumption of renewables
7.Sustainable transport	Energy consumption of transport
8.Natural resources	Common bird index Fish catches outside safe biological limits
9.Global partnership	Official Development Assistance (ODA)

*Source:* Eurostat, 2007 ( [http://epp.eurostat.ec.europa.eu/cache/ITY\\_OFFPUB/KS-77-07-115/EN/KS-77-07-115-EN.PDF](http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-77-07-115/EN/KS-77-07-115-EN.PDF) )

For the user, the most striking feature of this very abundant literature is the extreme variety of the indicators proposed. Some are very comprehensive-GDP growth retains its place, and is even the first indicator in the European Dashboard-while others are much more specific, such as the percentage of smokers in the population. Some pertain to outcomes, others to instruments. Some can easily be related both to development *and* to sustainability-literacy performance matters for both current well-being and future growth- but others pertain only either to current development or to long-run sustainability. There are even some items whose link with both dimensions is questionable or at least of indeterminate sign: is a high fertility rate a good thing for sustainability? **'NO!** Maybe yes for the sustainability of pensions, but maybe not for environmental sustainability. And is it always a signal of good economic performance? This probably depends on what we consider "high" or "low" in terms of fertility.

These dashboards are useful in at least two respects. First, they are an initial step in any analysis of sustainability, which by its nature is highly complex and therefore necessitates an effort at establishing a list of relevant variables and encouraging national and international statistical offices to improve the measurement of these indicators. The second one is related to the distinction between "weak" and "strong" sustainability. The "weak" approach to sustainability considers that good performance in some dimensions can compensate for low performance in others. This allows a global assessment of sustainability using mono-dimensional indices. The "strong" approach argues that sustainability requires separately maintaining

the quantity or quality of many different environmental items. Following this up therefore requires large sets of separate statistics, each pertaining to one particular subdomain of global sustainability.

Dashboards nevertheless suffer because of their heterogeneity, at least in the case of very large and eclectic ones, and most lack indications about causal links, their relationship to sustainability and/or hierarchies among the indicators used. Further, as communications instruments, one frequent criticism is that they lack what has made GDP a success: the powerful attraction of a single headline figure allowing simple comparisons of socioeconomic performance over time or across countries.

### Composite Indices

Composite indices are one way to circumvent the problem raised by the richness of dashboards and to synthesize the abundant and purportedly relevant information into a single number. The technical report reviews a few of these.

For example, Osberg and Sharpe's Index of Economic Well-Being is a composite indicator that simultaneously covers current prosperity (based on measures of consumption), sustainable accumulation and social topics (reduction in inequalities and protection against "social" risks). Environmental issues are addressed by considering the costs of CO<sub>2</sub> emissions per capita. Consumption flows and wealth accumulation (defined broadly to include R&D stocks, a proxy for human capital and the costs of CO<sub>2</sub> emissions) are evaluated according to national accounts methodology.

Each dimension is normalized through linear scaling (nine OECD countries) and aggregation relies on equal weighting. But at this stage the "green" dimension of this index is still secondary.

Other examples focus more specifically on the green dimension, such as the "Environmental Sustainability Index" (ESI) and the "Environmental Performance Index" (EPI). The ESI covers 5 domains: environmental systems (their global health status), environmental stress (anthropogenic pressure on the environmental systems), human vulnerability (exposure of inhabitants to environmental disturbances), social and institutional capacity (their capacity to foster effective responses to environmental challenges) and global stewardship (cooperation with other countries in the management of common environmental problems). It uses 76 variables to cover these 5 domains. There are, for instance, standard indicators for air and water quality (e.g., SO<sub>2</sub> and NO<sub>x</sub>)' health parameters (e.g., infant death rate from respiratory diseases), environmental governance (e.g., local Agenda 21 initiatives per million people), etc. The EPI is a reduced form of the ESI, based on 16 indicators (outcomes), and is more policy-oriented.

The messages derived from this kind of index are ambiguous. The global ranking of countries has some sense, but it is often considered to present an overly optimistic view of developed countries' contributions to environmental problems. Problems also arise between developed countries. For instance, the index shows a very narrow gap between the United States and France, despite strong differences in terms of their CO<sub>2</sub> emissions. In fact, the index essentially informs us about a mix of current environmental quality, of pressure on resources and of the intensity of environmental policy, but not about whether a country is actually on a sustainable path: no threshold value can be defined on either side of which we would be able to say that a country is or is not on a sustainable path.

On the whole, these composite indicators are better regarded as invitations to look more closely at the various components that underlie them. This kind of function of composite indicators has often been put forward as one of their main *raison d'être*. But this is not reason enough to retain them as measures of sustainability *stricto sensu* which could secure the same standing as GDP or other accounting concepts. There

are two reasons for this. First, as with large dashboards, there is the lack of a well-defined notion of what sustainability means. The second is a general criticism that is frequently addressed at composite indicators, i.e., the arbitrary character of the procedures used to weight their various components. These aggregation procedures are sometimes presented as superior to the monetary aggregations that are used to build most economic indices, because they are not linked to any form of market valuation. Indeed, and we shall come back to this point several times, there are many reasons why market values cannot be trusted when addressing sustainability issues, and more specifically their environmental component. But monetary or not, an aggregation

procedure always means putting relative values on the items that are introduced in the index. In the case of composite sustainability indicators, we have little understanding of the arguments for putting one relative value or another on all the different variables that matter for sustainability. The problem is not that these weighting procedures are hidden, non-transparent or non-replicable—they are often very explicitly presented by the authors of the indices, and this is one of the strengths of this literature. The problem is rather that their normative implications are seldom made explicit or justified.

### Adjusted GDPs

Other candidates for the measurement of sustainability are those that restart from the conventional notion of GDP but try to systematically augment or correct it using elements that standard GDP does not take into account and that matter for sustainability, Nordhaus and Tobin's sustainable measure of economic welfare (SMEW) may be regarded as the common ancestor to this strand. They provided two indicators. The first was a measure of economic welfare (MEW) obtained by subtracting from total private consumption a number of components that do not contribute positively to welfare (such as commuting and legal services) and by adding monetary estimates of activities that do contribute positively to welfare (such as leisure and work at home). The second step consisted in converting the MEW into the SMEW by taking into account changes in total wealth. The SMEW measures the level of MEW that is compatible with preserving the capital stock. To convert the MEW into the SMEW, Nordhaus and Tobin used an estimate of total public and private wealth, including reproducible capital, non-reproducible capital (limited to land and net foreign assets), educational capital (based on the cumulated cost of years spent in education by people belonging to the labor force) and health capital, based on a permanent inventory method with a depreciation rate of 20% per year. But they did not in the end include estimates of environmental damage or natural resource depletion.

Two strands have developed from this seminal contribution. The first has tried to enrich Nordhaus and Tobin's approach, sometimes deviating increasingly from the criterion of accounting consistency. Examples include the Index of Sustainable Economic Welfare (ISEW) and the Genuine Progress Indicator (GPI). These indicators deduct some evaluations of the costs of water, air and noise pollution from consumption and also try to account for the loss of wetlands, farmland and primary forests, and for other natural resource depletion, and for CO<sub>2</sub> damage and ozone depletion. Natural resources depletion is valued by measuring the investment necessary to generate a perpetual equivalent stream of renewable substitutes.

In all countries for which both ISEW and GPI are available, their values are very similar and at some point in time start diverging from GDP. This has led some authors to put forward a so-called "threshold" hypothesis, according to which GDP and welfare move in the same direction up to a certain point, beyond which the continuation of GDP growth does not allow any further improvement in well-being. In other words, according to such indicators, sustainability is already far behind us, and we have already entered a phase of decline.

The other strand is more firmly integrated into the realm of national accounting. It is based on the so-called System of Environmental Economic Accounting (SEEA), a satellite account of the Standard National Accounts

(SNA). The SEEA brings together economic and environmental information in a common framework to measure the contribution of the environment to the economy and the impact of the economy on the environment. The UN Committee of Experts on Environmental-Economic Accounting (UNCEEA), created in 2005, is now looking to mainstream environmental economic accounting, to elevate the SEEA to an international statistical standard by 2010 and to advance SEEA implementation in countries.

The SEE A comprises four categories of accounts. The first considers purely physical data related to flows of materials (materials drawn into the economy and residuals produced as waste) and energy and marshals them as far as possible according to the SNA accounting structure. The second category of accounts takes those elements of the existing SNA that are relevant to the good management of the environment and makes the environment-related transactions more explicit. The third category of accounts comprises accounts for environmental assets measured in physical and monetary terms (timber stock accounts, for instance).

These first three categories of the SEEA are vital building blocks for any form of sustainability indicator. But what is at stake here is the fourth and last category of SEEA accounts, which deals with how the existing SNA might be adjusted to account (exclusively in monetary terms) for the impact of the economy on the environment. Three sorts of adjustments are considered: those relating to resource depletion, those concerning so-called defensive expenditures (protection expenditures being the most emblematic ones) and those relating to environmental degradation.

It is these environmental adjustments to existing SNA aggregates that are better known under the rather loose expression of "Green GDP," which is an extension of the concept of net domestic product. Indeed, just as GDP (Gross) is turned into NDP (Net) by accounting for the consumption of fixed capital (depreciation of produced capital), the idea is that it would be meaningful to compute an "ea-NDP" (environmentally-adjusted) that takes into account the consumption of natural capital. The latter would comprise resource depletion (the overuse of environmental assets as inputs to the production process) and environmental degradation (the value of the decline in the quality of a resource, roughly speaking).

Green GDP and ea-NDP remain, however, the most controversial outcomes of the SEEA, and as such are less implemented by statistical offices, because of the many problems that are raised by these two concepts. Valuing environmental inputs into the economic system is the (relatively) easier step. Since these inputs are incorporated into products that are sold in the marketplace, it is possible (in principle) to use direct means to assign a value for them based on market principles. In contrast, as pollution emissions are outputs; there is no direct way to assign a value to them. All the indirect methods of valuation will depend to some extent on "what if" scenarios. Thus, translating valuations of degradation into adjustments to macro-economic aggregates takes us beyond the realm of *ex-post accounting* into a much more hypothetical situation. The very speculative nature of this sort of accounting explains the great discomfort and strong resistance among many accountants to this practice.

But there is a more fundamental problem with Green GDP, which also applies to Nordhaus and Tobin's SMEW and to the ISEW/GNI indices. None of these measures characterize sustainability *per se*. Green GDP just charges GDP for the depletion or damage to environmental resources. This is only one part of the answer to the question of sustainability. What we ultimately need is an assessment of how far we are from these sustainable targets.

In other words, what we need are measures of *overconsumption* or, to put in dual terms, of *underinvestment*. This is precisely what our last category of indicators purports to do.

### Indicators Focusing on ~~Over~~Consumption<sup>18</sup> or Underinvestment

Under this heading, we group all kinds of indicators that address the issue of sustainability in terms of ~~over~~consumption, underinvestment or excessive pressure on resources. Though such indicators tend to be presented in flow terms, they are built upon the assumption that some stocks that are relevant for sustainability correspond to the measured flows, i.e., stocks that are being transmitted to future generations and determine their opportunity sets. As with GDP and other aggregates, trying to perform this task with a single number requires the choice of a metric and an explicit aggregation procedure for these stocks and their variations.

#### Adjusted Net Savings (ANS)

Adjusted net savings (also known as genuine savings or genuine investment) is a sustainability indicator that builds on the concepts of green national accounts but reformulates these concepts in terms of stock or wealth rather than flows of income or consumption. The theoretical background is the idea that sustainability requires the maintenance of a constant stock of "extended wealth," which is not limited to natural resources but also includes physical, productive capital, as measured in traditional national accounts, and human capital. Net adjusted savings is taken to be the change in this total wealth over a given time period, such as a year **or a generation or 10 generations or projected over a 1000 generations**. Such a concept clearly appears to be the relevant economic counterpart of the notion of sustainability, in that it includes not only natural resources but also (in principle at least) those other ingredients necessary to provide future generations an opportunity set that is at least as large as what is currently available to living generations. **This is a good thing.**

Empirically, adjusted net savings (**for a given period of time**) are derived from standard national accounting measures of gross national savings by making four types of adjustment.

**First**, estimates of the capital consumption of produced assets are deducted to obtain net national savings.

**Second**, current expenditures on education are added to net domestic savings as an appropriate value for investment in human capital (in standard national accounting these expenditures are treated as consumption). **Since education is such a broad concept we will later differentiate between education that 'advances consciousness' versus education that simply is intended to brainwash, diminish, suppress, marginalize, indoctrinate, manipulate, create fear or otherwise limit individual and collective growth in awareness / consciousness.** Education that is violent is subtracted from the net domestic savings.

**Third**, estimates of the depletion of a variety of natural resources are deducted to reflect the decline in asset values associated with their extraction and harvest. **Here again 'natural resources' is a broad term and it is appropriate to differentiate between 'natural resources' that are organic/renewable and those that are finite.**

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<sup>18</sup> We must replace Overconsumption with a different term because Sustainable Living demands ZERO consumption. ANY consumption is Overconsumption – so the two are synonymous.

**Organic/Renewable.** The depletion of trees in an acre of forested land can occur in a number of different ways – some more negative than others.

- 1) **Case # 1.** An irresponsible for-profit corporation focused on maximizing their profit clear cuts the land and extracts \_\_\_\_\_ board feet of lumber.
  - a. That portion of the planet is no longer harvesting current sunlight and storing it as energy in biomass (with other useful purposes than for its burning value) – valuable energy coming to our planet is being wasted.

**Subtract the value of that lost energy harvesting opportunity cost.**
  - b. The beneficial functions of the forest (and there are many – sequestering of CO<sub>2</sub>, production of O<sub>2</sub>, habitat for many other forms of life, soil retention, water cycle management, etc.) has been terminated by this human action.

**Subtract the replacement value for each of these terminated functions**

There is nothing left but tree stumps, and trimmed branches that over time will decompose (be used as food by microorganisms). The lumber company did not pre-plant an adjacent comparable forested area that could become the new niche for those species who used the forested area as their home, their niche as the forest was being clearcut. So it will years before the forest functions return if ever.
  - c. If the intent of extracting the trees was to shred them into pulp for paper products with a one-time (non-recycled ) use (e.g. tissue, toilet paper, ...) that ends up as sludge in sewage treatment plants or is burned or is dumped in a landfill, this depletion would be a deduction from the Planet's Savings.
  - d. If some of the trees were to be converted into lumber for buildings, furniture, etc, then that portion could be added back in as a Savings.
- 2) **Case # 2.** Only the mature, or dying trees are harvested to transition their accumulated wealth / biomass into forms useful to humans and ideally forms that can be recycled/reused for an extended period of time.

My grandfather, a farmer, maintained a 40 acre 'woods.' The wooded area served as pasture for domesticated animals – including a small herd of milk cows. Well water was available – automatically pumped into a large galvanized steel stock tank by a lone windmill. During the summer, he observed the wooded area noting trees that were in the winter of their lives and marked them for harvest the coming fall / winter. The harvested trees were carefully felled in a direction that caused the least amount of damage to nearby trees, then trimmed and the main trunk was cut into 10-20 foot long logs to be transported to the saw mill and transitioned into green lumber for buildings, fences, shelves, and even some simple furniture. The green lumber was stacked and stored for months to dry before using. Large limbs were trimmed and piled to dry before being buzz sawed into circle wood as fuel for wood burning cook stoves, pot bellied parlor stoves and furnaces to heat the home.

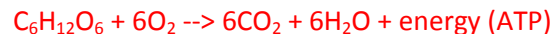


When a larger tree matured, reach its end of life and was harvested, canopy overhead opened up a bit allowing a bit more sunlight to reach the ground etc. A new seedling appears. This natural progression of this renewable resource would be neither a deduction or an addition to the forest's savings account– it would maintain a more or less uniform average Savings account but since at least a portion of the tree is used for lumber, buildings, furniture, etc. that portion could be considered as a net Savings for the planet.

### Inorganic / Non-renewable resources.

It is very difficult to wear out an atom of the stable isotopes of non-radioactive matter listed in the Periodic Table. For example the two Hydrogen atoms that combine with an Oxygen atom to form the water (H<sub>2</sub>O) that makes up 60% of our human body is about 13.4 billion years old. The Oxygen atom is a bit younger, but at least 4.56 billion years old. A molecule of water (a particular set of hydrogen and oxygen atoms) can be as old as 4.56 billion years or have been born a moment ago in your body when a glucose molecule combined with 6 oxygen molecules to form 6 molecules of CO<sub>2</sub>, 6 of water and some useable energy in the form of Adenine Triphosphate(ATP).

Glucose + oxygen --> carbon dioxide + water + energy (ATP which stands for adenine triphosphate)



However humans do 'lose' these basic elements. On a finite planet there is a finite amount of every element. We address an example using the element AU (Gold) in another section of this reframing discussion. Within about 25 years, we will have "mined" essentially the known gold reserves on the planet. From that point on, for the next 20 million generations, we would have to assume that the loss or hoarding of any atom of gold is a loss of the element to the commons and it is no longer available for future generations.

Estimates of resource depletion are based on the calculation of resource rents. An economic rent represents the "excess" return to a given factor of production. Rents are derived by taking the difference between world prices and the average unit extraction or harvest cost (including a "normal" return on capital).

If this is like "No more mine-ing – just "Our owe-ing /Returning" then great. The percent of these resources that are recycled vs lost or tossed into the ocean/landfill, etc should be recorded somehow.

**Finally**, global pollution damages from carbon dioxide emissions (and other GHGs such as methane) are deducted. This in effect attempts to account for the amount of 'burning' that is conducted – any burning of ancient hydrocarbons is definitely forbidden and a deduction of the planets net savings. The burning of biomass is not the same thing. So there are acceptable and unacceptable CO<sub>2</sub> emissions.

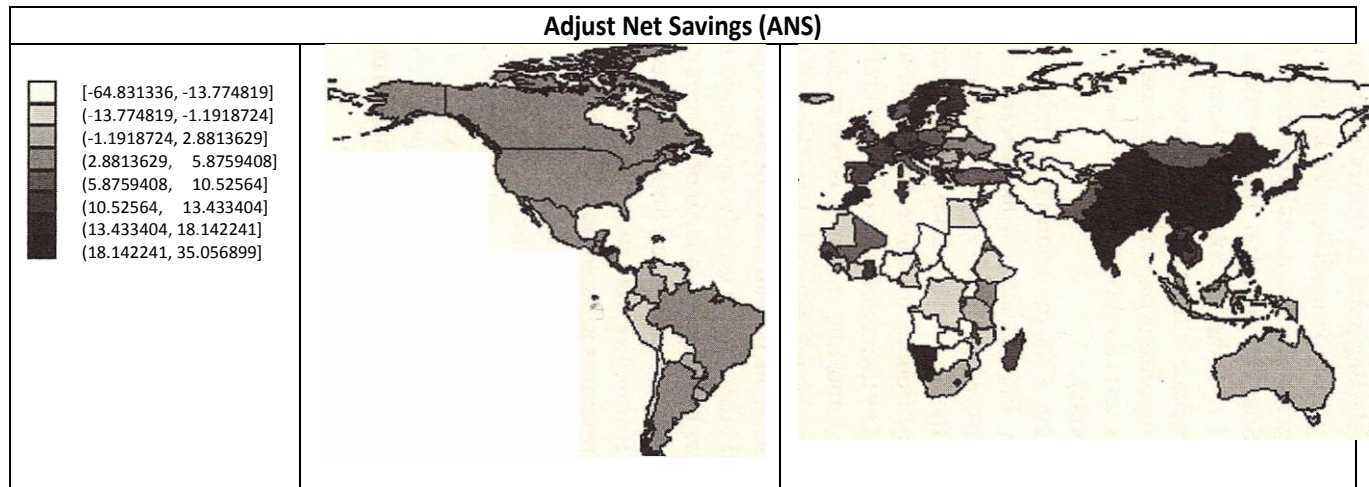
Negative adjusted net savings rates imply that "extended wealth" is in decline, and as such provide a warning of non -sustainability.

How does this indicator compare with standard measures of saving and investment in national accounts? World Bank computed ANS for developed countries such as France and the United States shows that changes

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over time are almost exclusively driven by gross savings, while the gap in levels between ANS and gross savings is due mostly to capital consumption and human capital accumulation whereas, according to the index, natural capital changes play only a relatively marginal role. Moreover, **the ANS figures show that most developed countries are on a sustainable path, while many emerging or developing countries are not. This result illustrates how absurd the ANS is as an indicator of sustainability.**

In particular, according to this measure most natural resource-exporting countries are on a non-sustainable path (Figure 3.1).



**Figure 3.1.** Geographical distribution for adjusted net savings

Source: World Bank, data for 2006.

*Reading:* Countries are ranked from the most unsustainable (in white) to the most sustainable (in dark). Non-sustainability can be due either to the over extraction of exhaustible resources or to low investment in human and physical capital. The frontiers of countries with missing values are not represented.

This kind of approach appeals to many economists, as it is grounded on an explicit theoretical framework. However, the current methodology underlying empirical calculations has well-known shortcomings: the relevance of the ANS approach crucially depends on **what** is counted (the different forms of capital passed on to future generations), namely, what is included in "extended wealth," and on the **price** used to count and aggregate in a context of imperfect or indeed non-existent valuation by markets—the problem that we already mentioned when discussing the implicit prices used by composite indicators. **Indeed the price assigned to these resources / forms of capital can completely reverse the resulting outcome – how convenient the ANS calculations are for the so called ‘developed’ countries!**

Indeed, a major shortcoming of ANS estimates is that the adjustment for environmental degradation is only limited to a restricted set of pollutants, the most significant one being carbon dioxide emissions. **The authors acknowledge that the calculations do not include other important sources of environmental degradation, such as underground water depletion, unsustainable fisheries, soil degradation and a fortiori biodiversity loss. This is a major omission.**

For those natural assets that are taken into account, **pricing techniques remain the major issue.** For exhaustible resources, the World Bank's estimates of ANS rely on current prices **that do not in any way represent their true value – the price of petroleum for example has nothing to do with actual costs because of so many externalities.** When the Real World reparation and replacement costs are added to the ancient hydrocarbon extraction /burning industry, the ANS will show a dramatic reversal – ‘developed nations will be

the most UNSustainable. In theory, the use of market prices to evaluate flows and stocks is warranted only in a context of perfect markets, which is clearly not the case in reality, and especially not for natural resources, where externalities and uncertainties are paramount. Exactly. Further, market prices for fossil energy sources and other minerals have tended, in recent years, to fluctuate widely, causing significant swings in measures of ANS based on current market prices and this has very strongly reduced the practical relevance of the ANS for concerned countries. My previous point exactly.

1.

As for pricing environmental degradation, things turn out to be even trickier because of the absence of any market valuation that could be used as a starting point: in theory, we must evaluate so-called "accounting prices" by modeling the long-term consequences of given changes in environmental capital and how they impact future well-being. But practical implementation raises considerable problems. Under the current state of the art, the prices used to value carbon emissions in existing estimates of ANS are not able to give it any significant role in the global assessment of sustainability, **and this casts doubts on the usefulness of the indicator as a guide for policy. (Emphasis is mine)** If we were to address the externalities and tack on a carbon burning fee – a Pigouvain tax based on the combination of the reparation costs to re-sequester the carbon dioxide emissions released during the extraction/refining / transportation/ final burning process AND add in the replacement costs for returning like amounts of energy to the planet that is being extracted – energy derived from renewable sources and conveniently saved in a formed equally as safe and durable and compact as the ancient hydrocarbon, then the price of consuming ancient hydrocarbons would be better represented and it turned the ANS over on its head.

Finally, by computing ANS per country we miss the global nature of sustainability. Indeed, one may feel uneasy when faced with the message conveyed by ANS about resource-exporting countries (e.g., oil). In these countries, from the ANS perspective, non-sustainability stems from an insufficient rate of reinvestment of the income generated by the exploitation of the natural resource: "overconsumption" by importing countries is not an issue at all. Developed countries, which are generally less endowed with natural resources but richer in human and physical capital than developing ones, would then appear unduly sustainable. As a consequence, some authors have argued in favor of imputing the consumption of exhaustible resources to their final consumers, i.e., the importing countries. Exactly. If scarcities were fully reflected in the prices at which exhaustible resources are sold on international markets, it is true that there would be no reason for making such a correction. However, when prices are non-competitive, the importing country pays less for its imports than would be required; it will have a responsibility in global non-sustainability that is not captured by the money-value of its imports. Low prices allow such countries to overconsume and to transfer the long-term costs of this overconsumption to the exporting countries. **Good discussion that to me totally negates the current use of ANS as a useful indicator of sustainable living.**

### Footprints

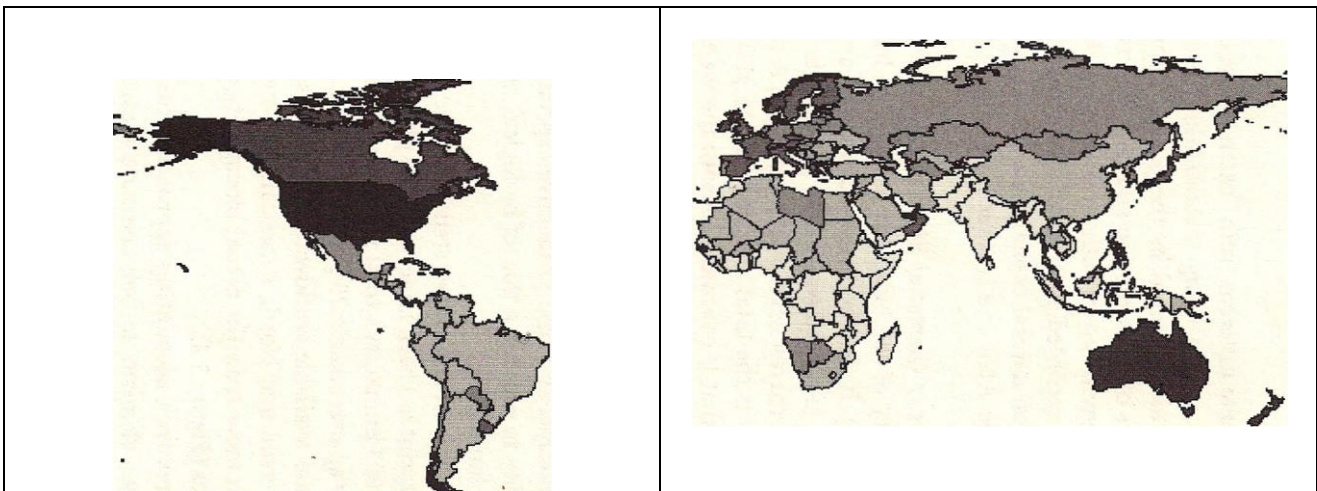
Although apparently quite different from "extended wealth" notions, various attempts at measuring sustainability through the use of "footprints" are also inspired by the general approach of comparing current flows of consumption and their effects on certain dimensions of the environment with an existing stock. In this sense, they may also be regarded as "wealth" measures. However, the focus is exclusively on natural capital, and the valuation convention differs from the ANS one in that no market prices are explicitly used.

The Ecological Footprint (hereafter EF) measures how much of the regenerative capacity of the biosphere is used up by human activities (consumption). It does so by calculating the amount of biologically productive land and water area required to support a given population at its current level of consumption. A country's

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footprint (demand side) is the total area required to produce the food; fiber and timber that it consumes, absorb the waste that it generates and provide space for its infrastructure (built-up areas).

On the supply side, biocapacity is the productive capacity of the biosphere and its ability to provide a flux of biological resources and services useful to humankind. The results are well-known and rather striking: since the mid- 1980s, humanity's footprint has been larger than the planet's carrying capacity, and in 2003 humanity's total footprint exceeded the Earth's biocapacity by approximately 25 percent. While 1.8 global hectares per person are available worldwide, Europeans use 4.9 global hectares per person and North Americans use twice that amount, that is, much more than the actual biocapacity of those two geographical zones (Figure 3.2).



**Figure 3.2. Ecological Footprint by country**

Source: Global Footprint Network, data for year 2005.

Reading: Dark areas correspond to countries with the highest values for the Ecological Footprint, i.e., with the highest contributions to worldwide unsustainability. Countries with missing values are not represented.

This indicator shares with accounting approaches the idea of reducing heterogeneous elements to one common measurement unit (the global hectare, e.g., one hectare with productivity equal to the average productivity of the 11.2 billion bioproductive hectares on Earth). It assumes that different forms of natural capital are substitutable and that different natural capital goods are additive in terms of land area, but strongly stands against weak sustainability assumptions. In fact, this indicator gives no role to savings and capital accumulation: any positive ecological surplus (biocapacity that exceeds the EF) does not entail an increase in some natural capital stock, and hence an improvement in future productive capacity. *A fortiori*, saving and accumulating manufactured or human capital does not help sustainability. **On the other hand, one must observe that the indicator ignores the threat to sustainability resulting from the depletion of non-renewable resources (e.g., oil):** the consequences for sustainability are treated only from the waste assimilation (implied CO<sub>2</sub> emissions) point of view rather than from an analysis based on depletion dynamics.

**This is a major shortcoming – fatal in fact – for the ‘footprint’ measuring stick. The measuring stick must be unrelenting severe for any culture that burns ancient hydrocarbons to be a valid indicator. Also the footprint does not appear to adequately deal with materials that 100% recycled – nor does it seem to award those cultures that harvest their energy from renewable sources. Will have to study this more. More energy use is not a bad thing if the user harvests all that energy themselves.**

The results are also problematic for measuring a country's own sustainability, because of the substantial anti-trade bias inherent in the EF methodology. The fact that densely populated (low biocapacity) countries like the Netherlands have ecological deficits, whilst sparsely populated (high biocapacity) countries like Finland enjoy surpluses can be seen as part of a normal situation where trade is mutually beneficial, rather than an indicator of non-sustainability. Indeed, recent research has tended to move away from comparing a country's EF with its *own* biocapacity, and to propose instead to divide all countries' EFs by *global* biocapacity. By doing this, one is acknowledging that EFs are not measures of a country's own sustainability but of its contribution to global non-sustainability.

Overall, this means that the EF could at best be an indicator of instantaneous non-sustainability *at the worldwide level*. EFs for countries should be used as indicators of inequality in the exploitation of natural resources and interdependencies between geographical areas. Moreover, even the worldwide ecological deficit emphasized by the EF may not convey the message it is said to. Indeed, one can show that the worldwide imbalance is mostly driven by CO<sub>2</sub> emissions, expressed in hectares of forest needed for storage. By definition, the worldwide demand placed on cropland, built-up land and pasture cannot exceed world biocapacity.

As a result, less-encompassing but more-rigorously-defined footprints, such as the Carbon Footprint (CF), would seem better suited, insofar as they are more clearly physical measures of stocks that do not rely on specific assumptions about productivity or an equivalence factor. As far as communications is concerned, such an indicator is just as capable of sending strong messages in terms of the overutilization of the planet's capacity for absorption. The CF also has the interesting feature of being computable at any level of disaggregation. This makes it a powerful instrument for monitoring the behavior of individual actors. **Good discussion – this reviewer needs to spend more time analysing the way the footprint is calculated.**

## Quantifying Sustainability in a Consensual Way: What Are the Main Stumbling Blocks?

Let's summarize the main messages so far. The previous section has shown the large number of existing attempts to quantify sustainability. This abundance of measures is a serious drawback insofar as different synthetic indicators convey widely divergent messages. This leads to a great deal of confusion among statisticians and policymakers. It urges a return to the fundamental questions: What do we want to measure exactly? What are the real obstacles to doing so with a single headline measure?

### What Do We Want to Measure?

Since the Brundtland Report, the notion of sustainable development has expanded to become an all-encompassing concept that absorbs every dimension of present and future economic, social and environmental well-being. Such an ambition is justified, but it covers all the domains considered by the three subgroups of the Commission. The mandate of our environment/sustainability subgroup was narrower than that: it concentrated on the "sustainable" component of "sustainable development." This question of durability can be expressed in the following terms: assuming we have been able to assess what is the current level of well-being, the question is whether the continuation of present trends does or does not allow it to be maintained.

It seems reasonable to separate the two notions of current well-being and of its sustainability, because the two questions are interesting in themselves. This provides a first guide for sorting out the many different approaches reviewed in the first half of this chapter.

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- The extensive dashboards of sustainable development effectively conflate the measurement of current well-being and the measurement of its sustainability. This is not to say that dashboards are of no use. Quite the contrary: our final conclusion will be that a unidimensional view of sustainability certainly remains out of reach. But we do want to end up with a limited number of indicators—a “micro” dashboard—and one that is specifically dedicated to the sustainability issue, based on a clear notion of what sustainability means.
- Composite indicators raise similar problems, with the additional complication that the way in which various items are weighted is **currently arbitrary with our existing economic system**, with consequences that are seldom made explicit.
- Measures of a *sustainable standard of living*, such as the Green GDP (**yet to be defined**), are also insufficient for assessing sustainability. The proximity that such a sustainability indicator would necessarily have with standard GDP could be a source of confusion. If there are two GDP indicators, which one should we use in which context? The only acceptable one is the one rooted in the Real World – not indicators that are rooted in the human created “real world.” What conclusion would we draw from the fact that a given country's Green GDP is x% or y% of its GDP defined in standard terms? Does this necessarily imply that this country is on an unsustainable path? **Depends on what the Green GDP actually is – still hasn't been defined so this is a rhetorical question.**

In fact, Green GDP focuses on only one side of the problem, i.e., the measurement of what can be consumed every year without environmental impoverishment. **Let's stop and discuss this a bit.**

### **What can be consumed without environmental impoverishment?**

As an individual, I look around and observe – what is it I can see – touch –

What we can interact with is star stuff - children of the Light – the world of hadrons - small and large – simple and complex. But apparently there is much more – the Dark Matter – the Dark Energy. That we are saving for future generations to ponder, explore, discover. Of what we can see, there is another significant division –

1) the stuff that – atoms and groups of atoms we call molecules that have transitioned to a lower free energy state –gave up some energy to form their relationships – we call inorganic e.g. CO<sub>2</sub>, water, minerals and

2) the stuff that took some energy to arrange into their current state – organic

3) the stuff that took energy to arrange and is required to keep them arranged in a living state that allows energy to flow thru this system to do work – to respond to stimulus – to be conscious – the stuff that can grow or be grown.

Systems that can do mechanical work – move material – is the wind alive? – that can replicate – that can add order take in energy and increase order

Let's first differentiate the “what” and divide it into three categories.

- 1) Basic elements found in the periodic table that are considered abundant on the crust of planet Earth – The Earth's molten core is 86 % iron and 4% nickel and the remaining 10% is thought to be Oxygen (or sulfur). But these materials really are not considered reachable at the moment. So let's

## Mis-measuring Our Lives (Reframed)

become a little more practical and examine the solid crust we walk upon and dig into daily looking for precious elements, ancient hydrocarbons, and ancient water.

There is the physical and the virtual – the stuff made from star stuff that allows use to create the virtual stuff that is also vital to future generations – the evolving consciousness, the wisdom, the lessons learned, the mental tools, the knowledge about the universe and its ways – the laws of the universe – actions to take to be sustainable – without environmental impoverishment? What is environmental? Everything including us is part of environmental – all life – all the complex systems we are currently aware of Gaia – the carbon cycle the energy cycle the water cycle the ocean conveyor – the wind – the rain the food chain the mycelium -

## Mis-measuring Our Lives (Reframed)

Ninety-eight percent (98%) of the Earth's crust (by mass) is comprised of the 8 most common elements:

% by mass	Name (Symbol)
46.6%	Oxygen ( <sup>8</sup> O)
27.7%	Silicon ( <sup>14</sup> Si)
8.1%	Aluminum ( <sup>13</sup> Al)
5.0%	Iron ( <sup>26</sup> Fe)
3.6%	Calcium ( <sup>20</sup> Ca)
2.8%	Sodium ( <sup>11</sup> Na)
2.6%	Potassium ( <sup>19</sup> K)
2.1%	Magnesium ( <sup>12</sup> Mg)
1.5%	OTHER

- 2) Basic elements less abundant
- 3) Structures of Atoms – Molecules – energy related – food related – hydrocarbons – autotrophs that are human edible – non toxic
- 4) Human creations – products that are produced sustainably – lets assume that humans created a ring out of gold. That gold is then returned at the end of the humans life to the commons and reshaped into something else using renewable energy – this production can go on forever because the gold atoms do not wear out – to produce the ring sustainable, we of course must not lose even one atom of gold in the process. The person who borrows the gold must not lose one atom or they will have to pay for the extraction of more to replace what was not returned. When we borrow a precious resource, we may have to put aside a 'deposit' equal to the replacement cost or a percent thereof. In the event the gold is stolen, then the borrower is still responsible – this responsibility will diminish the desire to hoard gold because it carries so much responsibility – gold is just an example of any precious element of which there is a known limited supply for all generations.

If the "what" is one of the As we stated earlier, every physical element that we extract from the Earth is a potential building block for us and the 20 million generations that hopefully will follow ours. If we truly consume (meaning lose, misplace, bury in places unknown, dump into the ocean, scatter to the winds) even 1% of a finite resource – <sup>29</sup>Cu (copper) each year, after 4 generations there is no more copper available for the 5<sup>th</sup> generation.

There are 117 know elements, 22 of which were created by humans. Elements below atomic number 84 are generally stable – non-radioactive (with the exception of a rare element [Technetium](#) <sup>43</sup>Tc )

This does not tell us whether we are on a sustainable path. If we want to measure sustainability, what is required is a *comparison* between this concept of genuine production and current consumption. All this makes the appropriate sustainability index more akin to a concept of net investment or disinvestment, and this is precisely the route that extended wealth or ANS exemplifies, but which is also implicitly followed by foot-print indicators that are more specifically focused on the renewal or depletion of environmental assets.



The argument goes as follows: the capacity of future generations to have standards of well-being at least equal to ours depends upon our passing them sufficient amounts of all the assets that matter for well-being. If we denote by "W" the "extended wealth" index used to quantify this stock of resources, measuring sustainability amounts to testing whether this global stock or some of its components evolve positively or negatively, i.e., computing its or their current rates of change,  $dW$  or  $dW_i$ . If negative, this means that downward adjustments in consumption or well-being will be required sooner or later. This is exactly what one should understand by "non-sustainability."

In our view, such a formulation of the sustainability issue has the potential to provide the common language necessary for constructive debates between people from very different perspectives. To take just one example, it fully answers one of the longstanding objections made to GDP by environmentalists, i.e., the fact that ecological catastrophes can increase GDP through their implied impact on economic activity. In an extended wealth approach, an ecological catastrophe is registered as a destruction of capital. This accounts for the fact that it deteriorates sustainability by decreasing the resources available for generating future well-being. This outcome can be avoided only if some action is taken to repair the damage, with these actions being counted as positive investment.

### Summarizing Sustainability in One Number: Is It Realistic?

Now, we have seen that both ANS and footprint evaluations are subject to many objections and can be considered, at best, as proxies of what would be genuine indices of changes in extended wealth or its components. Returning to fundamentals means asking precisely what would be required to measure the above-mentioned  $dW$  indices in a satisfactory way. Assuming away the measurement problems at first, we have to be more specific about several concepts: What is to be sustained? How do the various assets that will be passed on to future generations affect this measure of well-being? And how should they be weighted against each other?

It is clearly this last question that is more problematic and tends to crystallize opposition between the proponents of monetary indicators and physical indicators. Is there actually some reasonable prospect of evaluating everything in money units, or should we accept that this is possible only up to a certain point?

If all assets were traded on perfect markets by perfectly forward-looking agents fully taking into account the welfare of future generations, one could argue that their current prices reflect the discounted streams of their future contributions to future well-being. But many assets are not traded at all, and even for those that are it is unlikely that current prices fully reflect this future-oriented dimension, due to market imperfections, myopia and uncertainty. This implies that a true measure of sustainability requires a  $dW$  index in which assets are valued not at market prices, but rather "using imputed "accounting prices" based on some objective physical or economic modeling of how future damage to the environment will affect well-being, just as it requires an exact evaluation of how current additions to the stock of human or physical capital are likely to improve or help maintain well-being in the future.

Recent research has clarified the requisites of such an exercise. One is a full set of economic and physical projection of how initial conditions determine the future joint path of economic, social and environmental variables. Another is the *a priori* definition of how this path translates in terms of well-being at all future dates, i.e., the knowledge of the social utility function, generally formalized as a discounted sum of well-being over all future periods.

Equipped with such instruments, it should be possible to derive sustainability indices that have the properties that one would expect, i.e., a capacity to anticipate future declines in well-being below its current level. Some simulations proposed in the technical report illustrate certain aspects of this capacity. First of all, this sustainability index is the best suited for sending correct forewarnings to countries that are on unsustainable paths because of an insufficient rate of accumulation or of renewal of their produced capital, be it human or physical. And this is of course an important property: even if environmental issues are of considerable importance, we cannot ignore these other dimensions of sustainability.

Second, such an indicator is inconsistent with the "strong" view of non-sustainability (i.e., problems arising from the depreciation of environmental assets that are essential to human well-being or even survival) only when it relies on fixed price levels for natural and non-natural assets. But if we were able to derive this index from a physical-economic model predicting future interactions between the economy and the environment in a reliable way, then this index would send us correct forewarnings of non-sustainability, through strong increases in the relative accounting or "imputed" prices of these critical natural assets.

But the problem is with those "ifs." This construction remains fully theoretical. It shows us at best the direction in which index builders could try to go. It can also be used as a tool for emphasizing the many obstacles to the building of a comprehensive index and the need for more pragmatic second-best solutions.

### Technological Uncertainties Argue in Favor of a More Hybrid Approach

Measuring sustainability with a single dW index can work only under two strong assumptions: one is that future eco-environmental developments can be predicted perfectly, and the second is that there is perfect knowledge about how these developments are going to affect well-being. These two assumptions are clearly at odds with our real-world situation. Debates on eco-environmental perspectives are dominated by ignorance and uncertainty about future interactions between the two spheres, and by a lack of consensus about the very definition of the objective function.

Let's briefly develop the first point. The future is fundamentally uncertain. Uncertainty takes many forms, some of them amenable to probability computation, while many others are much more radical. This affects not only the parameters of any models that one may try to use to project eco-environmental interactions, but also the structure of the models themselves, the measurement of current stocks and even the list of the natural assets for which current and future stocks need to be taken into account. Most of the debate concerning long-term environmental change reflects different beliefs about future eco-environmental scenarios. There is no reason why sustainability measurement should escape such difficulties.

Some solutions might be considered for this problem. One is to do what all prospectivists do when they want to emphasize the uncertain nature of future trends, i.e., work with scenarios or provide confidence intervals. One could also consider submitting indices to some form of "stress test," i.e., recompute them under assumptions of external shocks on asset values. This could include sudden upward adjustments in the value of environmental assets, but also drastic reductions in the value of some other items—such as produced capital and human capital. Such modes of presentation could be explored and eventually adopted.

But this could still be insufficient or difficult to present in a convenient way. Questions such as climate change require a specific consideration which drives us back to the distinction between weak and strong sustainability. The point is not that aggregate indices are by nature unable to account for situations of strong non-sustainability. The point is that we would be able to do so only by adopting extreme valuations of critical environmental assets, and that we are not that well equipped to quantify precisely what these extreme

valuations should be. In such cases, and *a fortiori* for items for which we do not even have a single guestimate of a monetary value, a separate physical accounting is unavoidable.

The problem then is to present such an index in a compelling way. Monetary indices have the advantage of using units that speak to everyone. In addition, they can be related to other monetary quantities: this is what we do when we compute extended savings rates, and the orders of magnitude of such savings rates can be understood easily. On the other hand, a tonnage of CO<sub>2</sub> emissions is not a very informative number if we do not have some reference for how many tons can be emitted each year without severe consequences for the climate. Other physical indicators have been advocated by climate specialists, including "CO<sub>2</sub> radiative forcing:" measuring the effect of CO<sub>2</sub> on the Earth's energy imbalance and measuring the regression of permanent ice. But it is difficult for non-experts to take such indicators on board. It is essential to find more suggestive ways to highlight such figures if we want the indicator to have an impact on the debate. One of the major successes of the EF has been its ability to express pressure on the environment in an easily understandable unit. The EF indicator has limits that make it problematic to many observers. But, given the objective of limiting climate change, the general idea of using the footprint as a generic unit for the different forms of pressure that mankind exerts on

Earth's regenerative capacity is an option. A metric like this is used, for instance, with the more focused concept of the Carbon Footprint or the kindred concept of the CO<sub>2</sub> budget.

### Uncertainty Is Also Normative

In addition to raising technological issues, measuring sustainability with a single index number would confront us with severe normative questions. The point is that there can be as many indices of sustainability as there are normative definitions, of *what* we want to sustain. In standard national accounting practice, the normative issue of defining preferences is generally avoided through the assumption that observed prices reveal the true preferences of people. No explicit normative choice is therefore to be made by the statistician. But as soon as we recognize that market prices cannot be trusted, alternative imputed prices must be computed, whose values will strongly depend upon normative choices,

Can we solve this normative problem? One could attempt to solve it empirically by trying to infer the definition of well-being from current observations of how people value environmental factors compared to economic ones, using contingent valuations or direct measures of the impact of environmental amenities on indices of subjective well-being. But can the contingent evaluations and subjective measures established today in our specific eco-environmental setting be used to predict the valuations of future generations in eco-environmental settings that may have become very different? It could be argued that our descendants may become very sensitive to the relative scarcity of some environmental goods to which we pay little attention today because they are still relatively abundant, and that this requires that we immediately place a high value on these items just because we think that our descendants may wish to do so.

Another example of these normative issues is the question of determining how sustainability indices should aggregate individual preferences. This depends on how distributional considerations are taken into account in our measures of current well-being. For instance, if we consider that the headline indicator of current well-being must be the total disposable income of the bottom 80% of the population, or of the bottom 50%, rather than global disposable income, then sustainability indicators should be adapted to such an objective function. This would be in line with one of the other aspects of the Brundtland definition of sustainability that is often overlooked, i.e., its concern for the distribution of resources *within* as well as *between* generations. In a world where inequalities within countries naturally tend to increase, messages concerning sustainability will differ depending on the goal that we set ourselves. Specific attention to distributional issues may even

suggest enlarging the list of capital goods that matter for sustainability: the "sustainability" of well-being for the bottom  $x\%$  of the population may imply some specific investment in institutions that offer efficient help in protecting this population from poverty. In principle, the theoretical framework based on extended wealth tells us how we could ideally put some value on this kind of "institutional" investment. But, needless to say, the prospect of actually being able to do this is still more remote than for other assets.

### An Additional Source of Complexity: The Global Dimension

A global context poses additional problems for sustainability indicators. Advocates of the ANS argue that sustainability problems generally concentrate in poor resource-exporting countries even if it is in developed countries that the resources are ultimately consumed. The argument is that, if markets work properly, the pressure that developed countries exert on other countries' resources is already reflected in the prices that they pay for importing these resources. If, despite the cost of their imports, the developed countries can still maintain a positive ANS, this means that they invest enough to compensate for their consumption of natural resources. It is then the responsibility of exporting countries to reinvest the income from their exports in sufficient quantities if they also want to be on a sustainable path.

Yet this logic holds true only under the assumption of efficient markets. If markets are not efficient and if the natural resource is underpriced, then importing countries benefit from an implicit subsidy while the exporting ones are effectively taxed. This means that the actual sustainability of developed countries is overestimated, while that of the developing countries is underestimated. And this problem will be all the more crucial when there are no markets at all, or in the presence of strong externalities.

To illustrate this issue, let's imagine a very simple two-country setting, where both countries produce and consume with external effects on the stock of a natural resource that is a global public good with free access. Country 2 uses a clean technology that has no impact on the natural resource, while country 1 uses a "dirty" one that leads to a depreciation of the resource. Let's push the asymmetry further by assuming that it is only country 2 that is affected by the degradation of the environmental good. Country 1 is completely indifferent to the level of degradation of this environmental good, for instance because its geographical characteristics fully protect it from the consequences.

In such a setting, it is natural to redefine countries 1 and 2 as being respectively "the polluter" and "the polluted." In this setting, there are two ways to consider sustainability. One is to compute changes in extended wealth for each country using country-specific accounting prices for the natural resource. The idea is that the environmental good is a common asset, but valued differently by each country, because they are not concerned in the same way by its degradation. In this example, the accounting price for the polluter will be zero, because we have assumed that it is not impacted at all by environmental changes, which implies that it attributes no value at all to the environmental asset. On the other hand, the polluted country will attribute a positive value to the asset. The message conveyed using this extended wealth concept is that the polluter is on a sustainable path, while the polluted is not.

From a certain point of view, it is correct to say that the polluter is not confronted by the prospect of a decline in well-being, in contrast to the polluted. But from another viewpoint, the message is clearly misleading. There is nothing the polluted can do to restore its sustainability. It is only a change in the polluter's technology that could help restore the polluted country's sustainability. We are in need of indices that would convey such a message. The popularity of foot-print indicators stems precisely from the fact that, whatever their other limitations, they are able to send such messages to policy-makers and public opinion. This is one more argument in favor of an eclectic approach that mixes points of views. An approach centered

on national sustainabilities may be relevant for some dimensions of sustainability, but not for others. Global warming is a typical example of the latter case, as the prospective consequences of climate change are distributed very unevenly, without necessarily correlating with a country's CO<sub>2</sub> emissions.

## Conclusion

To sum up, what have we learned, and what can we conclude? This trip through the world of sustainability indicators has been a bit lengthy, and we have not been able to avoid technicalities completely. A wide variety of indicators are already available and we have analyzed the reasons why a comprehensive assessment of sustainability is difficult to establish in a fully consensual way. Assessing sustainability requires many assumptions and normative choices, and it is further complicated by the existence of interactions between the socio-economic and environmental models followed by the different nations. The issue is indeed complex, more complex than the already complicated issue of measuring current well-being or performance. But we shall nevertheless try to articulate a limited set of recommendations, which we shall also try to keep as pragmatic as possible.

### **Recommendation 1: Sustainability assessment requires a well-identified sub-dashboard of the global dashboard to be recommended by the Commission.**

The question of sustainability is complementary to the question of current well-being or economic performance, and must be examined separately. This recommendation to separate the two issues might look trivial. Yet it deserves emphasis, because some approaches fail to adopt this principle, leading to confusing messages. The confusion reaches a peak when one tries to combine these two dimensions into a single indicator. This criticism applies not only to composite indices, but also to the notion of Green GDP. To take an analogy, when driving a car, a meter that weighed up in one single value the current speed of the vehicle and the remaining level of gasoline would not be of any help to the driver. Both pieces of information are critical and need to be displayed in distinct, clearly visible areas of the dashboard.

### **Recommendation 2: The distinctive feature of all components of this sub-dashboard should be to inform about variations of those "stocks" that underpin human well-being.**

In order to measure sustainability, what we need are indicators that tell us the sign of the change in the quantities of the different factors that matter for future well-being. Putting the sustainability issue in these terms compels recognition that sustainability requires the simultaneous preservation or increase in several "stocks": quantities and qualities not only of natural resources but also of human, social and physical capital. Any approach that focuses on only a part of these items does not offer a comprehensive view of sustainability.

Speaking in such terms also avoids many of the misconceptions about the messages sent by traditional national accounts indicators. For instance, a frequent criticism of GDP is that it classifies ecological catastrophes as blessings for the economy, because of the additional economic activity generated by repairs. The stock approach to sustainability clearly avoids this ambiguity. Catastrophes will be recorded as a form of depreciation of natural or physical capital. Any resulting increase in economic activity would have a positive value only insofar as it helps to restore the initial level of the capital stock.

**Recommendation 3: A monetary index of sustainability has its place in such a dashboard, but under the current state of the art, it should remain essentially focused on economic aspects of sustainability.**

The stock approach to sustainability can in turn be broken down into two versions. One version would just look at variations in each stock separately with a view to doing whatever is necessary to keep it from declining or at least to keep it above some critical threshold beyond which further reductions would be highly detrimental to future well-being. Or one could attempt to summarize all stock variations in synthetic figures.

This second track is the one followed by so-called extended wealth or adjusted savings approaches, which share the idea of converting all these assets into a monetary equivalent. We have discussed the potential of such an approach, but also its limitations. In certain conditions, it allows us to anticipate many forms of non-sustainability, but the requirements for such a capacity are extremely high. This is because the aggregation required by this approach cannot be based on market values: market prices are non-existent for quite a large number of the assets that matter for future well-being. Even when they are available, there is no guarantee that they adequately reflect how these different assets will matter for future well-being. In the absence of such price messages, we have to turn to imputations, which raises both normative and informational difficulties.

All this suggests staying with a more modest approach, i.e., focusing the monetary aggregation on items for which reasonable valuation techniques exist, such as physical capital, human capital and natural resources that are traded in markets. This more or less corresponds to the hard part of "adjusted net savings" as computed by the World Bank and further developed by several authors. "Greening" this index more intensively is of course a relevant objective, and we can keep it on the agenda but we know that the analytical apparatus for doing so is a complex one: large-scale projection models of interactions between the environment and the economy, projecting changes in the relative scarcities of corresponding assets and their impact on relative accounting prices, and allowing also a proper treatment of uncertainties or potential irreversibilities that affect these interactions. Meanwhile, we must focus this indicator essentially on what it does relatively well, i.e., the assessment of the "economic" component of sustainability, that is, the assessment of whether or not countries overconsume their economic wealth.

**Recommendation 4: The environmental aspects of sustainability deserve a separate follow-up based on a well-chosen set of physical indicators.**

As far as environmental sustainability is concerned, the limitations of monetary approaches do not mean that efforts to monetize damages to the environment are no longer needed: it is well known that fully opposing any kind of monetization often leads to policies that act as if environmental goods had no value at all. The point is that we are far from being able to construct monetary values for environmental goods that at the macro level can be reasonably compared to market prices of other capital assets. Given our state of ignorance, the precautionary principle legitimates a separate follow-up of these environmental goods.

Another reason for a separate treatment is that these environmental issues often pertain to global public goods, such as the case of the climate. In such cases, the problem with the standard extended wealth approach is that it essentially focuses on country-specific sustainabilities. With global public goods, what is involved is more the contributions by the different countries to global unsustainabilities.

The EF could have been an option for this kind of follow-up. In particular, in contrast to net adjusted savings, it essentially focuses on contributions to global non-sustainability, with the message that the main

responsibility lies with the developed countries. Yet the group has taken note of its limitations, and in particular that it is far from being a pure physical indicator of pressure on the environment: it retains some aggregation rules that may be problematic. In fact, much of the information that it conveys about national contributions to non-sustainability is imbedded in a simpler indicator, the Carbon Footprint, which is therefore one good candidate for monitoring humanity's pressure on the climate, among many indicators proposed by climatologists that are shortly reviewed in the technical report.

For other aspects of environmental sustainability, such as air quality, water quality, biodiversity and so on, one can again borrow from these large eclectic dashboards. Just to note a few of the indicators already incorporated in such dashboards, we could mention smog-forming pollutant emissions, nutrient loading to water bodies, the abundance of key specified natural species, rates of conversion of natural habitats to other uses, the proportion of fish catches beyond safe biological limits and many others. Today, at this stage of the debate, economists do not have any particular qualification for suggesting what the right choices are. This is why we will not propose any closed list of these indicators here.

In short, our pragmatic compromise is to suggest a small dash-board, firmly rooted in the logic of the "stock" approach to sustainability, which would combine:

- An indicator more or less derived from the extended wealth approach, "greened" as far as possible on the basis of currently available knowledge, but whose main function, however, would be to send warning messages concerning "economic" nonsustainability. This economic non-sustainability could be due to low savings or low investment in education, or to insufficient reinvestment of income generated by the extraction of fossil resources (for countries that strongly rely on this source of income).
- A set of well-chosen *physical* indicators, which would focus on dimensions of environmental sustainability that are either already important or could become so in the future, and that remain difficult to capture in monetary terms.

This scenario has several points of convergence with conclusions reached by other reports recently devoted to the topic, such as the recent *OECD /Eurostat/UNECE* report on sustainability measurement, whose conclusions were released in 2008, or the more recent report by the French Economic, Social and Environmental Council released in 2009. The first one, in particular, strongly advocates the stock-based approach to sustainability and proposes a small dashboard clearly separating assets that can be monetarized in a reasonable way and other assets for which separate physical measures are necessary. The second one warns against limits of the EF and, as far as climatic change is concerned, argues in favor of the Carbon Footprint index. Such points of convergence are reassuring: they suggest that from a relatively confused situation we are steadily moving towards a more consensual framework for the understanding of sustainability issues (see the box below)."

## Physical and Other Non-Monetary Indicators: Which Ones to Choose?

The Commission's general position has been to avoid formulating definitive turnkey proposals on any of the different issues it has raised: All proposals, rather, intend to stimulate further debate. This is all the more

## Mis-measuring Our Lives (Reframed)

true in the domain of physical sustainability indicators where the expertise of specialists from other disciplines is crucial and was only indirectly represented in the Commission's composition.

Some suggestions can however be made, in connection with conclusions of some recent related reports.

In 2008, a OECD/UNECE/Eurostat working group produced a report on measuring sustainable development whose messages have several points in common with ours. It strongly advocates the stock-based approach to sustainability as the relevant way of structuring a .micro dashboard of sustainability indicators gathering both stock and flow variables. It also suggests a line of demarcation between determinants of "economic well-being ,(those that are the most directly amenable to monetary evaluation and the determinants of "foundational" well-being, among which four couples of stock/flow environmental indicators devoted respectively to global warming, other forms of atmospheric pollution, quality of water and biodiversity. The details and positions of these indicators in the dashboard can be visualized in the following table.

<b>Small set of sustainable development indicators proposed by the UNECE/OECD/Eurostat working Group on sustainability measurement</b>		
Indicator domain	Stock indicator	Flow indicator
Foundational well-being	Health-adjusted life expectancy	Index of changes in age-specific mortality and morbidity
	Percentage of population with post-secondary education	Enrollment in post-secondary education
	Temperature deviations from normals	Greenhouse gas emissions
	Ground level ozone and fine particulate concentrations	Smog-forming pollutant emissions
Economic well-being	Quality-adjusted water availability	Nutrient loadings to water bodies
	Fragmentation of natural habitats	Conversion of natural habitats to their uses
	Real per-capita net foreign financial asset holdings	Real per-capita investment in foreign financial assets
	Real per-capita produced capital	Real per-capita net investment in produced capital
	Real per-capita human capital	Real per-capita net investment in human capital
	Real per-capita natural capital	Real per-capita net depletion of natural capital
	Reserves of energy resources	Depletion of energy resources
	Reserves of mineral resources	Depletion of mineral resources
	Timber resource stocks	Depletion of timber resources
	Marine resource stocks	Depletion of marine resources
Source: UNESCO/OECD/Eurostat (2008)		

More recently, the French Economic, Social and Environmental Council (CESE) has produced a report whose initial aim was the assessment of the Ecological Footprint but that has more widely explored the different tracks available for quantifying sustainability. It has the same messages as the current report concerning the limits of this EF index, and the fact that most of the relevant information that it conveys is more directly



and more neatly reflected in one of its subcomponents, the Carbon Footprint. As a consequence, it strongly advocates in favor of this index. Compared to Global GHG emissions suggested in the OECD /UNECE /Eurostat Dashboard presented above, the Carbon Footprint has the advantage of being expressed in this unit that is intuitively so appealing and that has made the success of the EF. In addition to this, this CESE report has suggested emphasizing the other physical indicators already present in large International dashboards such as the one elaborated for the European Union Strategy for ' Sustainable Development. Some of them are those already quoted in the OECD/UNECE/Eurostat dashboard.

As far as climate change is concerned, some other indicators can be considered. Direct observation of mean temperature is one possibility but not the best suited, because it has a tendency to run behind the main components of climate change and because there can always be disagreements about the causes of temperature rises, hence about their permanent or transient character. Consequently, climatologists prefer to make use of a thermodynamic concept, the CO<sub>2</sub> radiative forcing, that measures the earth energy imbalance created by the action of CO<sub>2</sub> as a greenhouse gas.

Alternatively, it is possible to directly use a notion of a CO<sub>2</sub> remaining budget: according to climatologists, there is an upper limit of 0.75 trillion tonnes of carbon that might be discharged in the atmosphere if the risk of temperatures exceeding 2° Celsius above pre-industrial levels is limited to one-in-four, this upper bound at 2°C being largely accepted among climate experts as a "tipping point" opening the door to unstoppable feedback effects (methane from melting permafrost, CO<sub>2</sub> and methane from decaying tropical forests, all sorts of green-house gases released by saturated warming oceans, etc..). Of this 0.75 total budget, emissions to 2008 have already consumed circa 0.5. Hence the importance of monitoring this remaining CO<sub>2</sub> budget. The attractiveness of this indicator is to be strongly consistent with the stock-based approach to sustainability. It can be also rephrased in the very expressive terms of a countdown index, i.e., the time that remains until exhaustion of this stock, under the assumption of emissions remaining on their current trend. This kind of representation is often used for other forms of exhaustible resources.

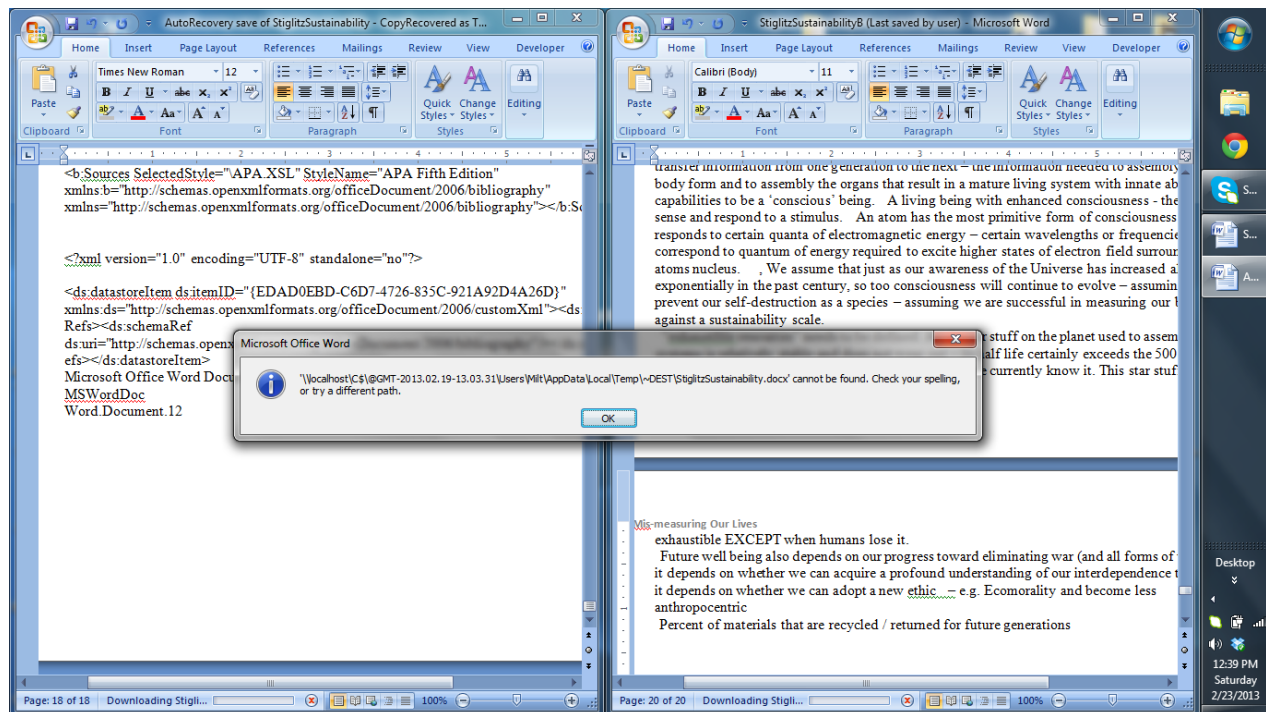
Still other indirect indicators of global warming are the regression of permanent ice or the oceanic pH. The regression of permanent ice has the advantage of being an advanced one and to be directly related to manifest effects. The oceanic pH increases with the amount of CO<sub>2</sub> that is naturally pumped into the oceans. A consequence of this increase is a decrease in the quantity of phytoplankton, which is itself a carbon sink no less important than the forests. One may therefore say that the physical sink (sea water dissolving atmospheric CO<sub>2</sub>) destroys the biological one. This is the reason why the oceanic pH appears to be another good tentative indicator of climate change, pointing to one of the most vicious feedback effects. Among criteria for choosing between all the indicators, two are of particular importance. One is their appropriability by the public; the other is the capacity of declining them at national or even subnational levels: in this respect, the Carbon Foot-print has quite a lot of advantages.

As far as biodiversity is concerned, the issue is currently under review by the TEEB ("the economics of the environment and biodiversity") group working at the initiative of the European Union and it has been also recently addressed by a report by the French *Conseil d'Analyse Strategique*, in this case with the idea of pushing as far as possible the monetization of this dimension. The reason for this search of monetary equivalent is essentially that it may foster incorporation of this dimension in investment choices: many public decisions such as building a new motorway imply, some potential biodiversity loss through fragmentation of natural habitats. But the report also provides a very detailed and technical review of available physical measures of biodiversity, to which the reader is referred for information.

## Mis-measuring Our Lives (Reframed)

At last, moving away from environmental preoccupations, but still on the “non-monetary” side, one important issue is the social capital and “institutional assets” that we transmit to future generations. One will have noticed the UNECE// OECD/Eurostat Dashboard presented above did not propose any indicator of this kind, not because the question is not relevant, but mainly because of lack of consensus about the way to measure it. Subgroup 3 was not in a position to explore this question further, but efforts along this direction remain undoubtedly necessary.

A subsidiary question concerns a user's guide to such a dash board. A warning should be given that no limited set of figures can pretend to forecast the sustainable or unsustainable character of highly complex system with certainty. The purpose is, rather, to have a set of indicators that give an "alert" to situations that pose a high risk of non-sustainability. Whatever we do, however, dashboards and indices are only one part of the story. Most of the efforts involved in assessing sustainability focus on increasing our knowledge about how the economy and the environment interact now and are likely to interact in the future.



## Appendix A Gross Domestic Product

## Appendix B Universe Story

## Appendix C Extras

Stuff that goes somewhere – but where?

Step # 1 Begin by Questioning The Title of the Work - Sustainable Development and Environment?"

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The “Real World” includes the attraction force we call gravity. The “real world” contains the human-created attraction force we call greed.

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As we reframe Chapter 3 of “Mis-measuring our Lives: Why GDP Doesn’t Add Up,” we question whether what we observe in our Real World as ‘sustainable’ and what we observe in our human-created world called ‘development’ can be combined into a single concept **OR** if their union is simply an oxymoron.

The following discussion (red text) “reframes” the original work (black text) of Stiglitz, et. al. by using some of the “lessons learned” from our emerging Universe Story, aka Everybody’s Story.

Hence the need to re-examine the measuring stick used to

The Universe Story reminds us that we homo sapiens are but one of over 1.9 million documented living species on this planet – species that are interconnected and affected by one another – species that depend on one another as an extended family for their very existence – (we are taught this at an early age in the context of a “food chain.”) More on that later. If we were able to take a broader poll, most of the 1.9 million species in our extended family would also perceive themselves as being worse off – and they too would be right.

The good news: There does not appear to be any fundamental physical law we can observe in the Universe that precludes Life from continuing to thrive and evolve on planet Earth – at least for the next 500 million years or so.<sup>19</sup>

The bad news: What is now and will continue to be an ever increasing threat to our lives (and to the further evolution of all Life and consciousness) is the collective effect of unsustainable human behavior – particularly those humans captivated by concept of physical development. At our present level of consciousness, framed in an anthropocentric paradigm, we are concerned first and foremost about humankind – that’s a good thing, but not at the exclusion of all that surrounds us, that supports us, that we depend on for our very existence.

A measure of our well being, our lives at this point in our evolving consciousness might be better to measure our critical deficiencies rather than or in addition to our amazing accomplishments. (When we are sick, we focus on our symptoms in the hope of diagnosing and correcting our dis-ease.)

% of energy use that is non-renewable energy – Goal is 0% - all other life lives off 100% renewable

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<sup>19</sup> There is some probability that the Earth may be impacted by more asteroids in the next half billion years – although the average size of these objects has generally been decreasing over the past 4.5 billion years.

## Mis-measuring Our Lives (Reframed)

% of material resources that are recycled – Goal is 100% - all other life recycles 100%

% of creations that are cradle to cradle – goal 100% - all other life is 100%

**Energy.** Without question, the most important requirement for Life on the planet is Energy. In his book, “What is Life? How Chemistry Becomes Biology” Addy Pross attempts to describe a living organism to us lay people as a complex integration of complex dynamic non-equilibrium systems driven by an external source of energy. Life is the flow of energy through a complex arrangement of Earth’s basic /elemental resources. When the flow of energy stops, Life ceases and the complex arrangement returns to basic star stuff – to dust. You can have water, C, H, O, N and all the 22 other basic elements in the Periodic Table required to assembly a human being, you can even have each of these basic building blocks properly assembled into complex proteins, DNA, hormones, cells, organelles, organs and even a complete human being, but without a source of energy the arrangement cannot ‘live’ and will eventually return to dust. Life forms that currently thrive on our planet are dependent on energy from the sun – a high quality form of energy, a spectrum of electromagnetic radiation we simply call sunlight.<sup>20</sup> Autotrophs look to the Sun for the energy to grow and mature – in the process, a portion of the solar energy absorbed by the autotroph is converted into chemical energy stored in the form of biomass – the various elements of the plant. Heterotrophs in turn look to the autotrophs (and other heterotrophs) as their source of energy.

In this discussion of “Sustainable Development and Environment,” we borrow the perspective of deep time from the Universe Story and use it to project into the future to reframe our concept of ‘future generations.’

and we are trying to live within its “real world” boundaries then obviously something is wrong. and use our God-given powers of observation, reason and logic, intuition, and change the system – as scary as change is, it beats continuing on the path of self-destruction.

For homo sapiens, these human-created systems form a new reality. In general, individuals and groups of individuals are motivated to moderate their free will and make choices to be consistent with this human-created reality and consider it to be the “real world.”

Motivation is broad: life experiences from conception, socialization, education, advertizing, brain washing, fear, pleasure, idealism, futurism, religious beliefs, customs, laws, punishment, reward, greed, hunger, safety, wanting to belong, follow the herd, go with the trend,

Systems include: economics, education, political, religious, ethical, moral,

We draw on the recent knowledge that our Milky Way galaxy family is but one of 100 billion galaxies each with 100 billion smaller families like our solar system consisting of a central gravitational center, a star /sun with other bodies planets) orbiting we call stars/solar systems – some apparently similar to ours add in the importance of energy as the basis of Life on planet Earth.

We add in the observation that all Life forms harvest current (or recent) sunlight (directly or indirectly) to live sustainably. Modern day Homo sapiens are the only exception among the 1.9 million documented living species – since the 1800s we humans have been living off ancient reserves of one-time-only hydrocarbons we

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<sup>20</sup> The average power arriving at the outer regions of the Earth’s atmosphere is around 1366 W/m<sup>2</sup>  
[http://science.nasa.gov/science-news/science-at-nasa/2003/17jan\\_solcon/](http://science.nasa.gov/science-news/science-at-nasa/2003/17jan_solcon/)

extract from Earth - with no intention of ever paying it back so that it is available for future generations - a withdrawal from a finite account on a finite planet that is expected to host Life for the next 500 million years.

The Universe Story allows us to look back 3.5 billion years and then follow a sequential evolution of Life on our planet up to the present day. Throughout the 13.7 billion year history of our expanding Universe, paradoxically, we see a coming together. We observe a persistent direction that is often described as complexification<sup>21</sup> or emergence.<sup>22</sup>

Emergence is defined by Ursula Goodenough as the creation of something more from nothing but as a result of new relationships. We can expand on that definition somewhat – emergence is the creation of ‘something more’ (ordered) from ‘nothing but’ (something that already exists in a state of less order) as a result of doing some work (e.g. adding some energy) to form new relationships (between the ‘nothing but’s’).

As we turn the pages of the Universe Story, we are struck by the emergence of Life and its diversity. We are struck by the phylogenetic tree of life that illustrates how all Life on the planet is related. We are in awe of the ever evolving consciousness of living beings. And we cheer when we see evidence that the consciousness of homo sapiens evolved so they could record life experiences, and then recall/remember these experiences as abstractions, then convey / communicate these abstract concepts to fellow homo sapiens as cave art in prehistoric Europe. We are thrilled when we observe that self-reflection by our ancestors acknowledged that our species had evolved to possess enormous capabilities that resulted in diverse range of behaviors – and coined a new phrase to describe this observation: free will. – we are impressed to find that our ancestors understood that this wonderful gift of free-will and individual freedom so worshiped in America had to be accompanied by individual responsibility that placed civil boundaries on our free will – that actually limited our individual freedom for our mutual benefit – at some point in human evolution it became clear to the majority of people that indiscriminate killing of one another was not a good behavior - social contracts / laws emerged that created something more from nothing but a series of observations - were no longer a - that we in turn continue this pattern and insist on creating even more non-physical entities – social systems, etc. So here we are today, reflecting on how we got here and whether our current population and behavior is having a debilitating influence on the trajectory of Life on planet Earth.

– and attempt to extract the principles that work sustainably. We suggest additional considerations for measuring the sustainability of a social order. We focus on the most fundamental element of Life – our source of energy. Without a continuous flow of energy, there is no sustainable Life. We focus on Biomimicry from which we derive the sustainable concept of ‘Cradle to Cradle’ - the fundamental basis for 100 % recycling of all Earth’s resources (anything less than 100% is not sustainable).

And as a result, we suggest some extensions (based on the Universe Story) to the work of Stiglitz, et. al. – extensions intended to stimulate further discussion for those interested in updating a broken/obsolete economic system.

---

<sup>21</sup> Addy Pross

<sup>22</sup> Ursula Goodenough

-----

Add Socrates: He contended that we already know the answers-we just have to remember –and he proceeds to lead his student toward the answer to the students question using the students past knowledge – this seems to work in many cases; however there are emerging facts inserted into the Universe Story every day that even Socrates didn't know or couldn't be expected to extract from his prior knowledge.

-----

[https://www.youtube.com/watch?feature=player\\_embedded&v=l7AWnfFRc7g](https://www.youtube.com/watch?feature=player_embedded&v=l7AWnfFRc7g) empathy

Bestselling author, political adviser and social and ethical prophet Jeremy Rifkin investigates the evolution of empathy and the profound ways that it has shaped our development and our...

[http://www.youtube.com/watch?feature=player\\_embedded&v=anXE46utpo8](http://www.youtube.com/watch?feature=player_embedded&v=anXE46utpo8) 350.org

Thought you might enjoy seeing what Gail send into the Las Vegas Sun recently.

Harry Ried's speech to the NV Legislation that Gail refers to can be found at:

<http://www.lvrj.com/news/text-of-reid-s-speed-to-nevada-legislature-192157441.html>

– as an producer (employer), as an employee (member of the producing team), and as a ‘consumer’ (a user of the goods or services produced).

Unfortunately as the number of humans on our finite planet continues to stupefyingly increase now exceed 7 billion, using this system,

-----

## ENVIRONMENT

Everything

Natural, native, not only,

valor, vigilant, valued, variable, variant, variety, vary, vegetable, vehicle, vein, venerable, veracious, verdant, verify, vernacular, versatile, vertebrate, vested, viable, vibrant, vicarious, vigilant, vintage, virtual, virtuous, visible, visionary, vital, vivid, voice, voluminous, vulnerable

Mis-measuring Our Lives (Reframed)

inanimate, invisible,

r

o

n

m

e

n

t

-----

What is Life?

Importance of Energy

-----

Insert personal recollection of horses

As we humans extended our capabilities and grew in numbers, we began having more and more impact on the interdependent web of Life. The integrated effect of our behavior – a large injustice by one person pales by comparison to a small injustice by 7 billion people. Or 300,000,000 people.

-----

**Appendix D Why Nuclear Reactors are not Sustainable.**

**Appendix E “The Universe Within” Neil Shubin**

## Mis-measuring Our Lives (Reframed)

https://www.youtube.com/user/theRSAorg?feature=watch

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13.8 BYA BIG BANG  
FORMATION OF THE EARTH  
FORMATION OF THE MOON 4.6 BYA  
2 BYA RISE OF OXYGEN IN THE ATMOSPHERE  
640 MYA FIRST ANIMALS  
200 MYA OPENING OF THE ATLANTIC OCEAN  
HUMANS

08:31 / 19:13

The Universe Within  
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midnight  
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Boredom & kidneys suppressed  
Highest alcohol tolerance

10:15 / 19:13

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[http://www.youtube.com/watch?feature=player\\_profilepage&v=vfp4Ci1b0TI](http://www.youtube.com/watch?feature=player_profilepage&v=vfp4Ci1b0TI)

## Appendix F Water Made in Humans

[http://wiki.answers.com/Q/What is the balanced equation of respiration](http://wiki.answers.com/Q/What_is_the_balanced_equation_of_respiration)

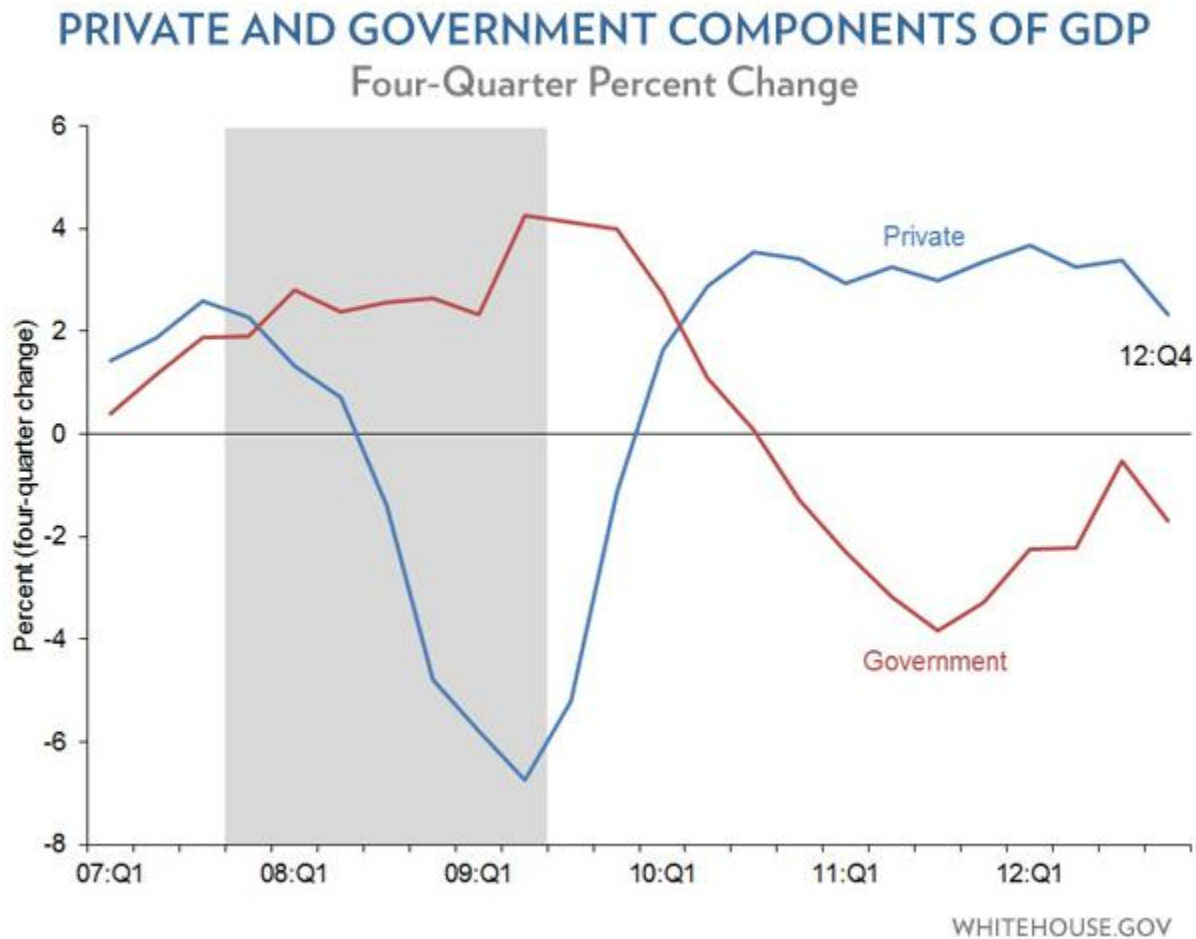


## Appendix G U.S. Economy

### The U.S. economy in one chart

Posted by [Neil Irwin](#) on January 30, 2013 at 10:27 am

In his [latest post](#) analyzing fourth quarter gross domestic product data, White House chief economist Alan Krueger offers a chart that tells you most of what you need to know about the U.S. economy circa 2013.



Source: White House

Through 2008 and 2009, it shows, the private sector in the United States was contracting on a huge scale. Consumer spending, business investment and residential investment all were plummeting. At that time, government spending soared, both from the fiscal stimulus package enacted at the start of 2009 and automatic increases in social welfare programs that kick in when the economy is weak, like unemployment insurance benefits.

Since then, the private sector has been expanding. But the public sector has been simultaneously pulling back. That includes state and local governments slashing spending to balance their budgets, the expiration of federal stimulus, and starting in 2011 deficit-reduction policies arrived at as part of a deal to raise the federal debt ceiling.

The question now is which will be more powerful in 2013: The underlying strength of the private sector, or the contractionary effects of further fiscal austerity.

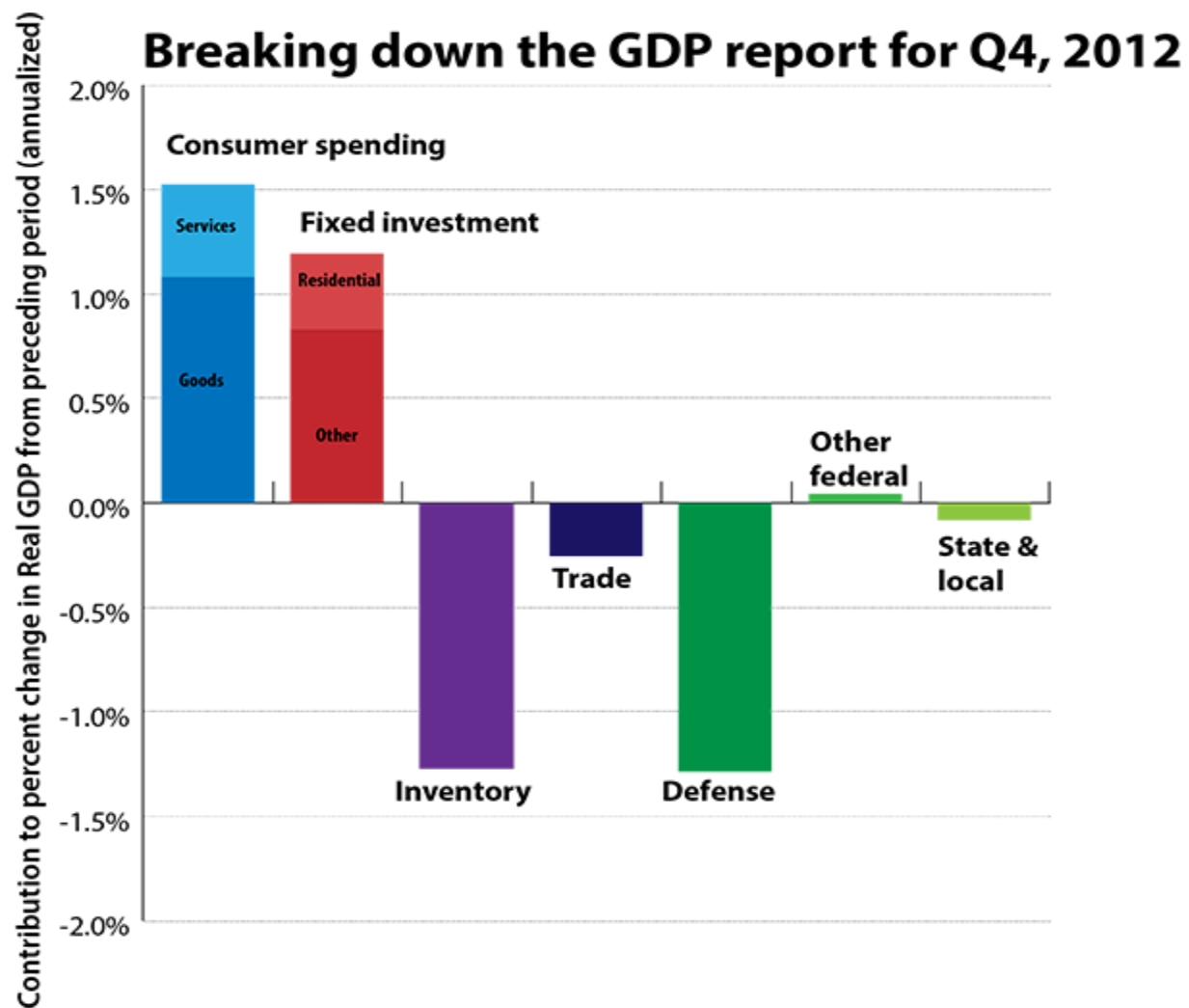
<http://www.washingtonpost.com/blogs/wonkblog/wp/2013/01/30/think-the-u-s-needs-austerity-look-at-this-chart-first/>

### The only chart you need on the GDP report

Posted by [Dylan Matthews](#) on January 30, 2013 at 10:31 am

The [GDP report](#) for the fourth quarter of 2012 is, on its face, disappointing. The economy shrunk, at an 0.1 percent annual rate, the first such contraction since the recession's nadir in 2009. But commentators are surprisingly upbeat about it. Spending and investment are still looking good, but sharp contractions in business inventory and [federal defense spendings](#) sunk the overall number. Paul Ashworth at Capital Economics [called it](#) "The best-looking contraction in U.S. GDP you'll ever see."

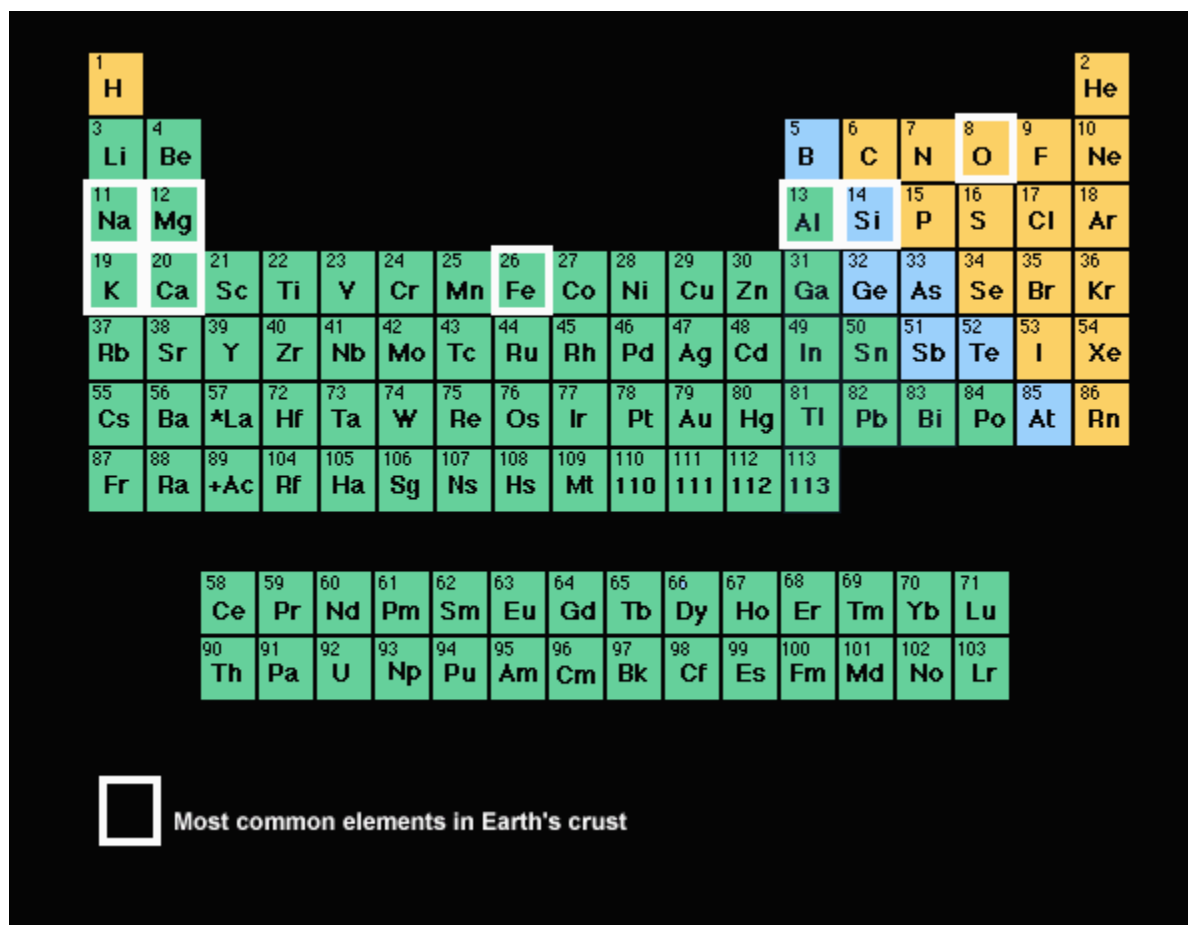
Judge for yourself. Here's what the report looks like, if you break it down by its components.



<http://www.washingtonpost.com/blogs/wonkblog/wp/2013/01/30/the-only-chart-you-need-on-the-gdp-report/>

## Appendix H Elements in the Earth's Crust

L.Gardiner/Windows to the Universe



Even though there are 92 [elements](#) that are naturally found, only eight of them are common in the rocks that make up the Earth's outer layer, the [crust](#). Together, these 8 elements make up more than 98% of the crust.

The 8 most common elements in Earth's crust (by mass):

- 46.6% Oxygen (O)
- 27.7% Silicon (Si)
- 8.1% Aluminum (Al)
- 5.0% Iron (Fe)
- 3.6% Calcium (Ca)
- 2.8% Sodium (Na)
- 2.6% Potassium (K)
- 2.1% Magnesium (Mg)

## Mis-measuring Our Lives (Reframed)

The picture on the left shows where these [elements](#) are located within the [periodic table](#). Together, the elements oxygen and silicon make up most 74.3% of the Earth's crust including [silicate minerals](#) such as [quartz](#) and [feldspar](#).

[http://www.windows2universe.org/earth/geology/crust\\_elements.html](http://www.windows2universe.org/earth/geology/crust_elements.html)

Related links:

[Plate Tectonics](#)

[What's a molecule?](#)

[Newly-Found Rock May Prove Antarctica and North America Were Connected](#)

Last modified November 13, 2007 by [Lisa Gardiner](#).

1	H																	2	He																										
3	Li	4	Be												5	B	6	C	7	N	8	O	9	F	10	Ne																			
11	Na	12	Mg																	13	Al	14	Si	15	P	16	S	17	Cl	18	Ar														
19	K	20	Ca	21	Sc	22	Ti	23	V	24	Cr	25	Mn	26	Fe	27	Co	28	Ni	29	Cu	30	Zn	31	Ga	32	Ge	33	As	34	Se	35	Br	36	Kr										
37	Rb	38	Sr	39	Y	40	Zr	41	Nb	42	Mo	43	Tc	44	Ru	45	Rh	46	Pd	47	Ag	48	Cd	49	In	50	Sn	51	Sb	52	Te	53	I	54	Xe										
55	Cs	56	Ba	*La	Hf	72	Ta	73	W	74	Re	75	Os	76	Ir	77	Pt	78	Au	79	Hg	80	Tl	81	Pb	82	Bi	83	Po	84	At	85	Rn												
87	Fr	88	Ra	+Ac	Rf	104	Ha	105	Sg	106	Ns	107	Hs	108	Mt	109	110	111	112	113																									
																		58	Ce	59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb	66	Dy	67	Ho	68	Er	69	Tm	70	Yb	71	Lu
																		90	Th	91	Pa	92	U	93	Np	94	Pu	95	Am	96	Cm	97	Bk	98	Cf	99	Es	100	Fm	101	Md	102	No	103	Lr

This chart is called the Periodic Table of the elements. It is used by chemists to organize the different elements by grouping together elements with similar chemical properties.

Click on image for full size

L.Gardiner/Windows to the Universe

Related links:

[The Periodic Table of the Elements](#)

[Atoms](#)

[Isotopes](#)

An element (also called a "chemical element") is a substance made up entirely of [atoms](#) having the same [atomic number](#); that is, all of the atoms have the same number of [protons](#). Hydrogen, helium, [oxygen](#), [nitrogen](#), carbon, gold, silver, lead, and uranium are well-known examples of elements.

Chemists use a special type of chart, called the "[periodic table](#)", to organize the elements into groups based on similar chemical properties. There are 94 different elements that we know of which occur in nature on [Earth](#). All of them, plus one other (californium) have been detected in space. Humans have been able to make many other new elements that don't occur in nature, usually by crashing atomic nuclei together at super high speeds in [particle accelerators](#). As of 2007, there were 117 known elements, 22 of which were created by people.

Most elements come in more than one variety. An atom of an element might have different numbers of [neutrons](#) in its [nucleus](#). Such atoms are called "[isotopes](#)" of the element. For example, normal hydrogen has just one proton and no neutrons in its nucleus. An isotope of hydrogen called "deuterium" has one proton **plus** one neutron in its nucleus. A [radioactive](#) isotope of carbon is often used to figure out how old things are using a technique called "[carbon dating](#)". Most natural carbon is carbon-12 (or  $^{12}\text{C}$ ); it has 6 protons and 6 neutrons. Radioactive [carbon-14](#) ( $^{14}\text{C}$ ) has 6 protons plus 8 neutrons. Scientists measure the ratio of  $^{12}\text{C}$  to  $^{14}\text{C}$  in objects to tell how old they are.

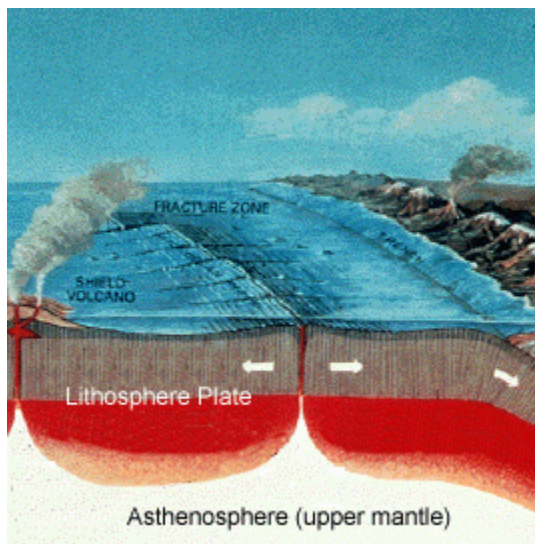
Hydrogen is the most common element in the [Universe](#), followed by helium. Both formed soon after the [Big Bang](#) that gave birth to the Universe. Pretty much all of the other elements, including much of the stuff that makes up your body, were created in [supernova explosions](#) of [dying stars](#). You are truly a "child of the Universe"! [Oxygen](#) and carbon are the third and fourth most abundant elements in the Universe. Oxygen is also the most abundant element by mass in Earth's crust, and the second most abundant gas (after nitrogen) in our planet's atmosphere.

## Mis-measuring Our Lives (Reframed)

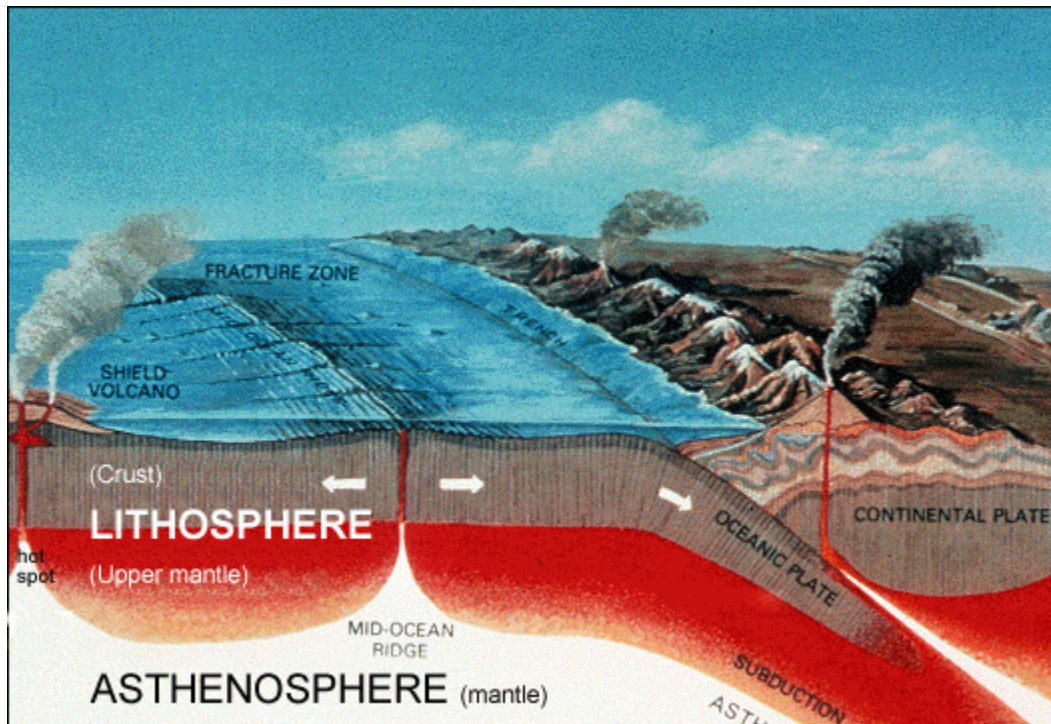
Many common substances are made of [molecules](#) that consist of two or more different types of atoms. Since they have more than one type of atom, these substances are **NOT** elements; they are called compounds. [Water](#) (H<sub>2</sub>O) is probably the best-known compound; it has two different types of atoms (elements) in it, hydrogen (H) and oxygen (O). Glucose, a simple sugar, is another example of a compound. Glucose molecules (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>) have atoms of the elements carbon, hydrogen, and oxygen in them.

All of the elements have one- or two-letter abbreviations. Some are obvious, like hydrogen (H), oxygen (O), carbon (C), uranium (U), helium (He), or calcium (Ca). Some seem to make no sense at all, like lead (Pb), silver (Ag), and gold (Au). In the case of the seemingly nonsense symbols, the letters are derived from the name of the element in a language that has been used for scientific terminology throughout the ages, typically Greek or Latin. In Latin, lead (Pb) is "**plumbum**", silver (Ag) is "**argentum**", and gold (Au) is "**aurum**".

## Appendix I The Earth's Crust, Lithosphere and Asthenosphere



This drawing shows the Earth's lithosphere (crust and upper mantle) on top of the asthenosphere.



**Crust**, the upper [layer](#) of the Earth, is not always the same. Crust under the oceans is only about 5 km thick while continental crust can be up to 65 km thick. Also, ocean crust is made of denser minerals than continental crust.

The tectonic plates are made up of Earth's crust and the upper part of the mantle layer underneath. Together the crust and upper mantle are called the **lithosphere** and they extend about 80 km deep. The lithosphere is broken into giant plates that fit around the globe like puzzle pieces. These puzzle pieces [move](#) a little bit each year as they slide on top of a somewhat fluid part of the mantle called the asthenosphere. All this moving rock can cause [earthquakes](#).

The **asthenosphere** is ductile and can be pushed and deformed like silly putty in response to the warmth of the Earth. These rocks actually flow, moving in response to the stresses placed upon them by the churning motions of the deep interior of the Earth. The flowing asthenosphere carries the lithosphere of the Earth, including the continents, on its back.

The crust is broken into many large plates that move slowly relative to each other. Mountain ranges form when two plates collide and their edges are forced up. In addition, many other [surface features](#) are the result of the [moving plates](#). The plates move about one inch per year, so millions of years ago the continents and the oceans were in different positions. About [250 million years ago](#), most of the land was connected together, and over time has separated into seven continents.

[http://www.windowsuniverse.org/earth/interior/earths\\_crust.html](http://www.windowsuniverse.org/earth/interior/earths_crust.html)

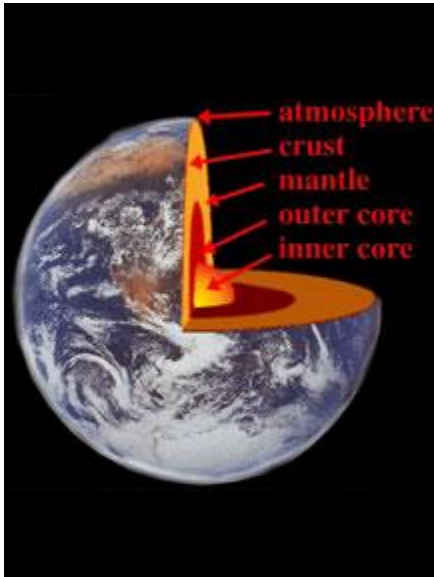
Related links:

[Return to Plate Tectonics](#)

[Return to Earth's Surface & Interior](#)

[Making Earthquakes... Indoors](#)

## Appendix J Structure of the Interior of Earth



This diagram shows the different layers found inside the Earth.

Click on image for full size

*Windows Original.*

Earth has a diameter of about 12,756 km (7,972 mi). The Earth's interior consists of rock and metal. It is made up of four main layers:

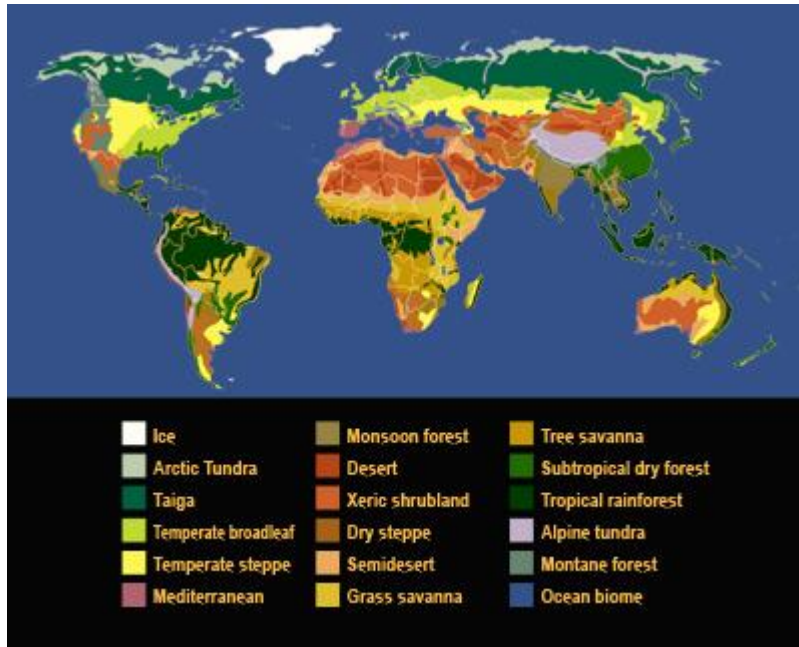
- 1) the inner core: a solid metal core made up of nickel and iron (2440 km diameter)
- 2) the outer core: a liquid molten core of nickel and iron
- 3) the mantle: dense and mostly solid silicate rock
- 4) the crust: thin silicate rock material

The temperature in the core is hotter than the Sun's surface. This intense heat from the inner core causes material in the outer core and mantle to move around.

The movement of material deep within the Earth may cause large [plates](#) made of the crust and upper mantle to move slowly over the Earth's [surface](#). It is also possible that the movements generate the Earth's magnetic field, called the [magnetosphere](#).

[http://www.windows2universe.org/earth/Interior\\_Structure/interior.html](http://www.windows2universe.org/earth/Interior_Structure/interior.html)

## Appendix K Biomes and Ecosystems



Earth's biomes are areas with similar climate, geography, and other conditions as well as similar plants, animals, and other living things. Click on image for full size  
*Windows to the Universe*

- Related links:  
[Ocean biome](#)  
[Tundra biome](#)  
[Tropical rainforest biome](#)  
[Arctic tundra](#)  
[Temperate forest biome](#)  
[Grassland biome](#)  
[Desert biome](#)

**Biomes** are large regions of the world with similar [plants](#), [animals](#), and other [living things](#) that are adapted to the climate and other conditions. Explore the links below to learn more about different biomes.

- [Tundra](#)
- [Taiga](#)
- [Temperate forest](#)
- [Tropical rainforest](#)
- [Desert](#)
- [Grassland](#)
- [Ocean biome](#)

A biome is made of many similar ecosystems. An ecosystem is often much smaller than a biome, although the size varies.

**Ecosystems** are the interactions between the living things and the nonliving things in a place. In an ecosystem, the [plants](#), [animals](#), and other organisms rely on each other and on the physical environment – the soil, water, and nutrients, for example.

Even though they are living in the same place, each species in an ecosystem has its own role to play. This role is called a niche. The niche for one species might be to climb trees and eat their fruit, while the niche for another species might be to hunt for small rodents. For a tree, a niche might be to grow tall and make food with the Sun's energy through the process of [photosynthesis](#). If the niche of two species is very similar, they might compete for food or other resources.

Sometimes ecosystems get out of balance. If, for example, it rains a lot and a type of bird that thrives with extra water increases in numbers, other species in the ecosystem might be crowded out. The birds might take food or space or other resources from other species. They might eat all the food. Sometimes an ecosystem naturally gets back into balance. Other



## Mis-measuring Our Lives (Reframed)

times an ecosystem will become more and more out of balance. Today, human actions are having an impact on ecosystems all over the world. Making buildings and roads, fishing and farming all have an impact on ecosystems. Pollution on land, [air pollution](#), and [water pollution](#) is sending many ecosystems out of balance too.

Last modified October 28, 2008 by [Lisa Gardiner](#).

<http://www.windows2universe.org/earth/ecosystems.html>

## Appendix L Mine-ing

"IF IT CAN'T BE GROWN, IT MUST BE ~~MINED~~ **OUR-OWED (BORROWED/RETURNED)**"

**Natural resources are the foundation for our lives and lifestyles.**



What would our lives be like without mining? Imagine a world without transportation such as jet planes or railroads, without communications such as cell phones or radar, without decorative items such as art or jewelry, without buildings such as skyscrapers or parking garages, without defense systems items such as missiles or submarines, without medical care items such as X-rays or surgical tools. We wouldn't have any of these things without mining and minerals.

<http://www.mineralseducationcoalition.org/elements/technetium>

Add discussion of how to transition from the 1872 concept of “mine-ing” to “our owe-ing” – sustainable extraction – based on sustainable end use – based on responsible our owe-ing.

Then there is the issue of the “spilt estate” and energy bill of 2005

## Appendix M Greek Tragedy

**Tragedy: the Basics** ([Links](#)) [See also](#)

**Origins:** Tragedy's origins are obscure, but it apparently started with the singing of a choral lyric (called the *dithyramb*) in honor of Dionysus. It was performed in a circular dancing-place (*orchestra*) by a group of men who may have impersonated satyrs by wearing masks and dressing in goat-skins. (The Greek word *tragoedia* means "goat-song.") Eventually, the content of the *dithyramb* was widened to any mythological or heroic story, and an actor was introduced to answer questions posed by the choral group. (The Greek word for actor is *hypokrites*, which literally means "answerer." It is the source for our English word "hypocrite.") Tragedy was recognized as an official state cult in Athens in 534 BC. According to tradition, the playwright Aeschylus added a second actor and Sophocles added a third.

**Performance:** Greek tragedies were performed in late March/early April at an annual state religious festival in honor of Dionysus. The presentation took the form of a contest between three playwrights, who presented their works on three successive days. Each playwright would prepare a trilogy of three tragedies, plus an unrelated concluding comic piece called a *satyr* play. Often, the three plays featured linked stories, but later writers like Euripides may have presented three unrelated plays. Only one complete trilogy has survived, the *Oresteia* of Aeschylus. The Greek theatre was in the open air, on the side of a hill, and performances of a trilogy and satyr play probably lasted most of the day. Performances were apparently open to all citizens, including women, but evidence is scanty. [The theatre of Dionysus at Athens](#) probably held around 12,000 people (Ley 33-34).

## Mis-measuring Our Lives (Reframed)

The presentation of the plays probably resembled modern opera more than what we think of as a "play." All of the choral parts were sung (to flute accompaniment) and some of the actors' answers to the chorus were sung as well. The play as a whole was composed in various verse meters. All actors were male and wore masks, which may have had some amplifying capabilities. A Greek chorus danced as well as sang. (The Greek word *choros* means "a dance in a ring.") No one knows exactly what sorts of steps the chorus performed as it sang. But choral songs in tragedy are often divided into three sections: *strophe* ("turning, circling"), *antistrophe* ("counter-turning, counter-circling") and *epode* ("after-song"). So perhaps the chorus would dance one way around the *orchestra* ("dancing-floor") while singing the *strophe*, turn another way during the *antistrophe*, and then stand still during the *epode*.

**Definition:** Tragedy depicts the downfall of a noble hero or heroine, usually through some combination of *hubris*, fate, and the will of the gods. The tragic hero's powerful wish to achieve some goal inevitably encounters limits, usually those of human frailty (flaws in reason, *hubris*, society), the gods (through oracles, prophets, fate), or nature. Aristotle says that the tragic hero should have a flaw and/or make some mistake (*hamartia*). The hero need not die at the end, but he / she must undergo a change in fortune. In addition, the tragic hero may achieve some revelation or recognition (*anagnorisis*--"knowing again" or "knowing back" or "knowing throughout" ) about human fate, destiny, and the will of the gods. Aristotle quite nicely terms this sort of recognition "a change from ignorance to awareness of a bond of love or hate."

### LINKS:

- [Dr. J's Illustrated Greek Drama](#) (explains origins of Greek drama) (Broken link)
- [Dr. J's Illustrated Greek Theater](#) (explains staging of Greek drama--great photos)
- [Robin Mitchell-Boyask's Greek Drama and Culture course page](#)
- [South Slope of the Acropolis](#) images from "The Ancient City of Athens" site (with many views of the [Theatre of Dionysus](#))
- More Photos of the Theatre at Epidauros: <http://harpy.uccs.edu/greek/epidauros.html>
- View of the Theatre of Dionysus at Delphi: <http://harpy.uccs.edu/greek/arch/delphi3.jpg>

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### Aristotle on Tragedy

(From the *Poetics* of Aristotle [384-322 BC])

#### I. Definition of Tragedy

"Tragedy, then, is a process of imitating an action which has serious implications, is complete, and possesses magnitude; by means of language which has been made sensuously attractive, with each of its varieties found separately in the parts; enacted by the persons themselves and not presented through narrative; through a course of pity and fear completing the purification (*catharsis* [\*]), sometimes translated "purgation") of such emotions."

a) "imitation" (*mimesis* [\*]): Contrary to Plato, Aristotle asserts that the artist does not just *copy* the shifting appearances of the world, but rather imitates or *represents* Reality itself, and gives form and meaning to that Reality. In so doing, the artist gives shape to the *universal*, not the *accidental*. Poetry, Aristotle says, is "a more philosophical and serious business than history; for poetry speaks more of universals, history of particulars."

b) "an action with serious implications": *serious* in the sense that it best raises and purifies pity and fear; serious in a moral, psychological, and social sense.

## Mis-measuring Our Lives (Reframed)

c) "complete and possesses magnitude": not just a series of episodes, but a whole with a beginning, a middle, and an end. The idea of *imitation* is important here; the artist does not just slavishly *copy* everything related to an action, but *selects* (represents) only those aspects which give form to universal truths.

d) "language sensuously attractive...in the parts": language must be appropriate for each part of the play: choruses are in a different meter and rhythm and more melodious than spoken parts.

e) tragedy (as opposed to epic) relies on an enactment (dramatic performance) not on "narrative" (the author telling a story).

f) "purification" (*catharsis*)[\*]: tragedy first raises (it does not create) the emotions of pity and fear, then purifies or purges them. Whether Aristotle means to say that this purification takes place only within the action of the play, or whether he thinks that the audience *also* undergoes a cathartic experience, is still hotly debated. One scholar, Gerald Else, says that tragedy purifies "whatever is 'filthy' or 'polluted' in the *pathos*, the tragic act" (98). Others say that the play arouses emotions of pity and fear in the *spectator* and then purifies them (reduces them to beneficent order and proportion) or purges them (expels them from his/her emotional system).

## II. The Tragic Hero

The tragic hero is "a [great] man who is neither a paragon of virtue and justice nor undergoes the change to misfortune through any real badness or wickedness but because of some mistake."

a) a great man: "one of those who stand in great repute and prosperity, like Oedipus and Thyestes: conspicuous men from families of that kind." The hero is neither a villain nor a model of perfection but is basically good and decent.

b) "mistake" (*hamartia*)[\*]: This Greek word, which Aristotle uses only once in the *Poetics*, has also been translated as "flaw" or as "error." The great man falls through--though not entirely because of--some weakness of character, some moral blindness, or error. We should note that the gods *also* are in some sense responsible for the hero's fall.

## III. Plot

Aristotle distinguished six elements of tragedy: "plot, characters, verbal expression, thought, visual adornment, and song-composition." Of these, PLOT is the most important. The best tragic plot is single and complex, rather than double ("with opposite endings for good and bad"--a characteristic of comedy in which the good are rewarded and the wicked punished). All plots have some *pathos* [\*] (suffering), but a complex plot includes reversal and recognition.

a) "reversal" (*peripeteia*)[\*]: occurs when a situation seems to be developing in one direction, then suddenly "reverses" to another. For example, when Oedipus first hears of the death of Polybus (his supposed father), the news at first seems good, but then is revealed to be disastrous.

b) "recognition" (*anagnorisis* or "knowing again" or "knowing back" or "knowing throughout" )[\*]: a change from ignorance to awareness of a bond of love or hate. For example, Oedipus kills his father in ignorance and then learns of his true relationship to the King of Thebes. Recognition scenes in tragedy are of some horrible event or secret, while those in comedy usually reunite long-lost relatives or friends. A plot with tragic reversals and recognitions best arouses pity and fear.

c) "suffering" (*pathos*)[\*]: Also translated as "a calamity," the third element of plot is "a destructive or painful act." The English words "sympathy," "empathy," and "apathy" (literally, absence of suffering) all stem from

this Greek word.

**NOTE**

\*(You are responsible for these terms, both in English and in Greek.)

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## Appendix N Natural Events – Human-Created Disasters

### Real World

1 Avalanches

2 Earthquakes

3 Volcanic eruptions

Gases

Thermoplaste

Rock, Ash

Atmospheric Particles

Lava

4 Hydrological disasters

4.1 Floods

4.2 Limnic eruptions

4.3 Tsunami

5 Meteorological disasters

5.1 Blizzards

5.2 Cyclonic storms

5.3 Droughts

5.4 Hailstorms

5.5 Heat waves

5.6 Tornadoes

6 Wildfires

7 Health disasters

7.1 Epidemics

8 Space disasters

8.1 Impact events – Meteoroids, Comets,

8.2 Solar flares

### 8.3 Gamma ray burst

9 Wild Animals

10 Poisonous Species

## Human-Created “real world” Violence

Overpopulation – starvation

Wars

Weapons of Mass Destruction

Separation of Wealth – Hoarding

Poisoning – human created chemicals / radioactive materials

Interpersonal Crime / Violence

Earthquakes

Curious humans have compared the energy released by natural earthquakes to the energy released by humans-created explosions.

Natural disasters<sup>23</sup>

The **Mercalli intensity scale** is a [seismic scale](#) used for measuring the intensity of an [earthquake](#). It measures the *effects* of an earthquake, and is distinct from the [moment magnitude](#)  $M_w$  usually reported for an earthquake (sometimes described as the obsolete [Richter magnitude](#)), which is a measure of the *energy* released. The intensity of an earthquake is not totally determined by its magnitude.

The scale quantifies the effects of an earthquake on the Earth's surface, humans, objects of nature, and man-made structures on a scale from I (not felt) to XII (total destruction).<sup>[1][2]</sup> Values depend upon the distance to the earthquake, with the highest intensities being around the [epicentral](#) area. [http://en.wikipedia.org/wiki/Mercalli\\_intensity\\_scale](http://en.wikipedia.org/wiki/Mercalli_intensity_scale)

## Appendix O Reframing Examples

Before attempting to reframe elements of a complex system such as the American Free Enterprise economic system, let's look at a few simple examples and compare the “Real World” and the ‘real world’ to illustrate the “reframing” process.

**Example #1:** *On March 11, 2011, a powerful, magnitude 9.0 quake hit northeastern Japan, triggering a tsunami that in turn resulted in the second worst nuclear disaster in human history.*

[http://en.wikipedia.org/wiki/2011\\_T%C5%8Dhoku\\_earthquake\\_and\\_tsunami](http://en.wikipedia.org/wiki/2011_T%C5%8Dhoku_earthquake_and_tsunami)

**Background.** On the left side of the desk we place the Universe Story that begins some 13.7 billion years ago. In the beginning, some call the Big Bang, energy and matter were completely interchangeable. The four fundamental forces of nature emerged: the gravitational force, the strong and weak nuclear forces and the electromagnetic force. Within the first several seconds of the life of the expanding Universe, matter began to emerge in the form of electrons, protons, and neutrons. Within 300,000 years the original energy (photons) had expanded, cooled and become transformed into atom hydrogen (76%) and helium (24%) allowing the residual light to escape as the cosmic background radiation (CMBR) we can see today with the WMAP satellite. Of particular interest is the Chapter that begins 4.5 billion years ago that tells us about the

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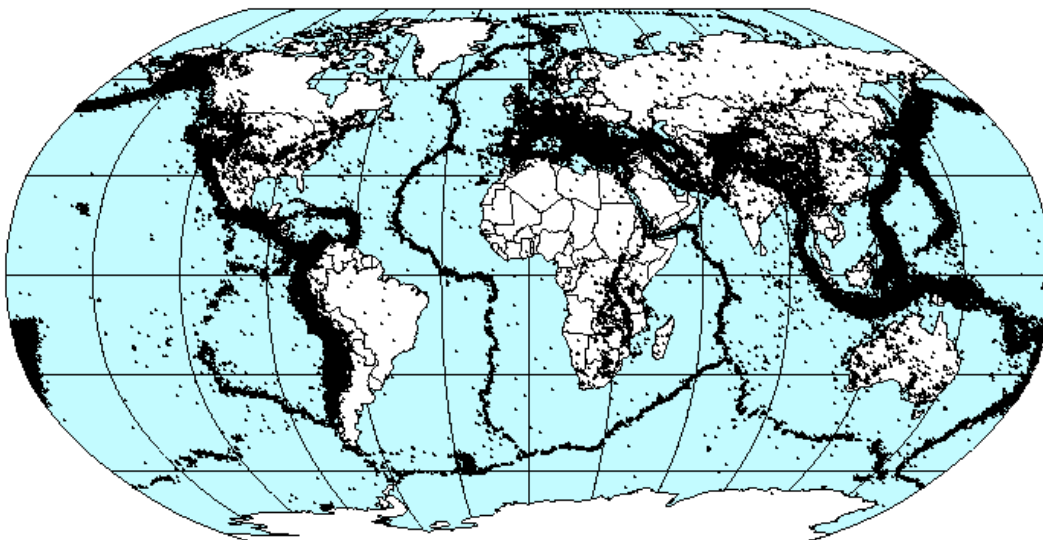
<sup>23</sup> See Appendix N

## Mis-measuring Our Lives (Reframed)

birth of our solar system, the accretion disc of star stuff that once swirled around our gravitational center, the Sun, the coalesce of the disc into smaller gravitational centers we call planets – one of which became Earth. The Story tells us about the dramatic birth of our planet and its early collision with another large solar body that then formed our Earth – Moon pair. The Story tells us about the Earth’s molten core of iron and nickel and about the outer cool layer we walk on and call the crust. The Story goes on to tell us about the tectonic plates that float atop the molten mantle and are in constant (albeit slow) motion (several cm / year). Grinding and pushing each other where they met. The Story tells us that this motion of the continental plates is a natural phenomenon that shapes our mountains, our valleys, our oceans, and forms our volcanoes.

Currently 70% of the Earth’s surface is covered by water. It can be argued that without this ongoing collision of the tectonic plates and the slow but continuous formation of new mountains, wind and water erosion would level the land mass, carry it into the ocean and the entire planet would be covered by water – just as we see on Jupiter’s moon Europa – a solar body covered entirely by ocean (in Europa’s case an ice covered ocean). Without the continuous motion of the tectonic plates, we land creatures would have little if any dry land to stand on today.

The Universe Story tells us about our current knowledge of these tectonic plates, their boundaries where they interact with each other– boundaries define locations around the planet where the epicenters of earthquakes tend to be concentrated (as shown by the coalescing black dots in the figure below).



### Earthquake Epicenters: 358,214 events between 1963-1998

Reference: <http://denali.gsfc.nasa.gov/dtam/seismic/>

The Universe Story goes on to tells us about the compression and tension that results when the tectonic plates push against each other, the stresses (and potential energy) that build up until the rocky crust fractures and moves abruptly (converting potential energy into kinetic energy and then into thermal energy) to relieve these stresses – a momentary event we call an Earthquake.

Earthquake events have been occurring for billions of years and will continue for several billion more. The Story tells us about the structural properties of the rock in these fault areas and the energy involved in abrupt shifts in the Earth’s crust. Creative humans have learned how to measure this energy (using a [seismometer](#))

**Mis-measuring Our Lives (Reframed)**

on a logarithmic scale (formerly the Richter scale now the MMS or  $M_w$  scale<sup>24</sup>) to ranges from a value of 2 that is barely perceptible by a human to the largest yet recorded, 9.5 ( $M_w$ ), an earthquake that occurred beneath Chile in 1960.<sup>25</sup> Earthquakes are an integral part of the Real World that has emerged from the expanding Universe.

On the other side of our desk we will open a recent story of a human-created “real world” disaster – a new story that is as old as an ancient Greek tragedy. We can then compare the two worldviews and note the human influence – each of us can decide if the human-created “real world” is consistent with the Real World.

Universe-created ‘Real World’ Perspective	Human-created ‘real world’ Perspective
<b>“Real World” Earthquake</b>	<b>‘real world’ Tōhoku Disaster</b>
In the ‘Real World’ we would describe this event as a naturally occurring Earthquake.	In the human-created “real world” we would describe the same event as a human disaster – a failure of homo sapiens to adapt sustainably to the natural environment of the bioregion.
<p>The earthquake can be described in various ways.</p> <p>It was the most powerful known <a href="#">earthquake ever to have hit Japan</a>, and the fifth <a href="#">most powerful earthquake in the world</a> since modern record-keeping began in 1900.<sup>[12][14][15]</sup></p> <p>The earthquake moved <a href="#">Honshu</a> (the main island of Japan) 2.4 m (8 ft) east</p>	<p>The disaster can be described in various ways.</p> <p>There were nearly 20,000 human lives lost – over 90% by drowning from the ensuing tsunami that followed the actual earthquake.</p> <p>127 million people Over 300,000 people were displaced by the tsunami.</p>
<p>The 9.0 <a href="#">magnitude (<math>M_w</math>) undersea megathrust earthquake</a> occurred on 11 March 2011 at 14:46 <a href="#">JST</a> (05:46 UTC) in the north-western Pacific Ocean at a relatively shallow depth of 32 km (19.9 mi),<sup>[36]</sup> with its <a href="#">epicenter</a> approximately 72 km (45 mi) east of the <a href="#">Oshika Peninsula</a> of <a href="#">Tōhoku</a>, Japan, lasting approximately six minutes.<sup>[1][2]</sup> The earthquake was reported as 9.0 <math>M_w</math>.<sup>[3][38]</sup> by the USGS</p> <p>The earthquake triggered powerful <a href="#">tsunami</a> waves that reached heights of up to 40.5 metres (133 ft) in <a href="#">Miyako</a> in Tōhoku's <a href="#">Iwate Prefecture</a>,<sup>[16][17]</sup> and which, in the <a href="#">Sendai</a> area, travelled up to 10 km (6 mi) inland.<sup>[18]</sup></p>	<p>The tsunami caused <a href="#">nuclear accidents</a>, primarily the <a href="#">level 7 meltdowns</a> at three reactors in the <a href="#">Fukushima Daiichi Nuclear Power Plant</a> complex, and the associated evacuation zones affecting 200,000.<sup>[29][30]</sup></p> <p>the U.S. recommended that Japanese citizens evacuate up to 80 km (50 mi) of the plant.<sup>[31]</sup></p> <p>Property loss is estimated to be Early estimates placed insured losses from the earthquake alone at US\$14.5 to \$34.6 billion.<sup>[32]</sup> Including the tsunami and nuclear ‘accidents’ the <a href="#">World Bank</a>’s estimated economic cost was US\$235 billion, making it the costliest natural disaster in world history.<sup>[34][35]</sup></p>
This earthquake occurred where the Pacific Plate is subducting under the plate beneath northern Honshu. The Pacific plate, which moves at a rate of 8 to 9 cm (3.1 to 3.5 in) per year, dips under Honshu's underlying plate releasing large amounts of energy. This motion pulls the upper plate down until the stress	

<sup>24</sup> MMS -Moment Magnitude Scale , Earthquake Facts, <http://earthquake.usgs.gov/learn/facts.php>

<sup>25</sup> The largest recorded earthquake in the world was a magnitude 9.5 ( $M_w$ ) in Chile on May 22, 1960.

Mis-measuring Our Lives (Reframed)

<p>builds up enough to cause a seismic event. The break caused the sea floor to rise by several meters.<sup>[47]</sup></p> <p>The <a href="#">Japanese Meteorological Agency</a> said that the earthquake may have ruptured the fault zone from Iwate to Ibaraki with a length of 500 km (310 mi) and a width of 200 km (120 mi).<sup>[50][51]</sup></p> <p>The earthquake may have had a mechanism similar to that of <a href="#">another large earthquake in 869</a> with an estimated <a href="#">surface wave magnitude (<math>M_s</math>)</a> of 8.6, which also created a large tsunami.<sup>[53]</sup></p> <p>Other major earthquakes with tsunamis struck the <a href="#">Sanriku Coast</a> region <a href="#">in 1896</a> and <a href="#">in 1933</a>.</p>	
<p>Energy</p> <p>This earthquake released a <a href="#">surface energy</a> (<math>M_e</math>) of <math>1.9 \pm 0.5 \times 10^{17}</math> <a href="#">joules</a>,<sup>[58]</sup> dissipated as shaking and tsunamic energy, which is nearly double that of the 9.1-magnitude <a href="#">2004 Indian Ocean earthquake and tsunami</a> that killed 230,000 people.</p> <p>If harnessed, the surface energy from this earthquake would power a city the size of Los Angeles for an entire year.<sup>[42]</sup></p> <p>The total energy released, also known as the <a href="#">seismic moment</a> (<math>M_0</math>), was more than 200,000 times the surface energy and was calculated by the USGS at <math>3.9 \times 10^{22}</math> joules,<sup>[59]</sup> slightly less than the 2004 Indian Ocean quake.</p> <p>This is equivalent to 9,320 <a href="#">gigatons of TNT</a>, or approximately 600 million times the energy of the <a href="#">Little Boy bomb</a>.</p>	<p>Although Japan has invested the equivalent of billions of dollars on anti-tsunami seawalls which line at least 40% of its 34,751 km (21,593 mi) coastline and stand up to 12 m (39 ft) high, the tsunami simply washed over the top of some seawalls, collapsing some in the process.<sup>[199]</sup></p>
	<p>We first observe the bioregion of Japan and observe that the Japanese people are very aware of the natural phenomenon involving moving tectonic plates and earthquakes. They continue to conduct research into a better understanding of such events in an effort to someday be able to predict their occurrence and provide warning to those who might be affected. The Japanese had already incorporated their knowledge of earthquakes into the design of new buildings and other infrastructure – as a result the loss of life and property from the direct ground movement of the latest earthquake of magnitude 9.0 was lessened– it was the ensuing tsunami that caught them unprepared and became the major disaster – especially the secondary effects the tsunami had on the human-created Fukushima<sup>26</sup> nuclear power plants that were not designed to accommodate</p>

<sup>26</sup> [Fukushima](#)



Mis-measuring Our Lives (Reframed)

	<p>simultaneous flooding and a major power outage to the plants. As a result, a natural event in the Real World was transformed into a major disaster for all Life on the planet as a result of human behavior. The General Electric nuclear engineers who designed the Mark 1 reactors that were sold to the Japanese to generate electrical power did not consider this series of events. As a result, after the tsunami, three reactors lost power, lost the ability to cool their Uranium fuel rods, overheated, exploded, and spewed radioactive materials into our common atmosphere and common ocean and across the nearby countryside. The same atmosphere, the same ocean that 7 billion humans share. The same atmosphere and ocean that all Life on the planet shares – all of the individual beings that make the 1.9 million living species here on planet Earth. If human eyes were as sensitive as a Geiger counter, we would now see an ongoing major fireworks display surrounding the Fukushima reactors for miles around – unstable isotopes exploding and sending out bullets of ionizing radiation in all directions – bullets that pierce the living cells of plants and animals – tearing their molecules apart – destroying complex molecules from proteins to DNA - causing mutations in that beings genetic code. If the damaged cell dies, that may actually be a good thing. If the damaged DNA is able to replicate, it may produce new cells that are foreign to its host system yet able to thrive indiscriminately - if these mutated cells are not destroyed by the host system immune system they become a cancer – and without appropriate external intervention become fatal to that living being.</p>

Human-created 'real world' Perspective	Universe-created 'Real World' Perspective
<p><b>Example #2</b>  <b>Anthropocentric viewpoint:</b> Humans are so amazing. They can even defy gravity and travel to the moon.</p>	<p><b>Eco-centric Viewpoint Within the Real World:</b> Humans are amazing. They were able to travel to the moon and back – not by defying gravity or any other law of the Universe – but just the opposite, by carefully adhering to all the laws of nature encountered along the journey.</p> <p>As a result of meticulous observation of the behavior of the expanding Universe and its many 'laws,' humans learned how to</p>

	<p>precisely apply these laws of the Real World and shape Earth’s resources into a ‘tool’<sup>27</sup> that allowed them to make their journey to the moon, walk on its surface, collect surface samples and return safely.</p> <p>The Universe is a sandbox of infinite possibilities and creative opportunities albeit constrained within invariant boundaries (rules/laws).</p> <p><b>Economics Vs. Real World – a Story about Human Arrogance:</b> Humans, unfortunately attempted to ‘defy’ one of the laws of the Universe during the early phases of the Apollo Program.</p> <p>In a human initiated effort to reduce the “weight / cost ” of the Apollo Crew Module, a design decision was made to use a pure oxygen Life Support System for the spacecraft rather than mimic the Earth’s atmosphere that includes 78% Nitrogen and 21% Oxygen. Since the Astronauts really don’t need Nitrogen for respiration, just Oxygen, why carry that additional ‘inert’ weight of the Nitrogen all the way to the Moon and back? The economic system indicates it would be a lot cheaper (and the Apollo modules would be much lighter in weight) spacecraft woullighter in weight) – we don’t need it for respiration? True. However, humans attempted to ignore the known propensity of a pure oxygen environment to react with (burn/combust) about everything if there is an ignition source – such as a small spark.</p> <p>The first Apollo capsule was designed and built to use a lighter weight 100% O<sub>2</sub> environment. Unfortunately, but predictably, the Real World trumped the human-created “real world” of wishful thinking. Humankind lost three American Astronauts in a fire that was initiated within their closed Apollo capsule during a training exercise. The Life Support System was redesigned to include both nitrogen and oxygen. No further lives were lost during this decade long program.</p> <p>From an eco-centric perspective, we have not developed a sustainable method of traveling to the moon and back. The Apollo Project consumed large amounts of ancient hydrocarbons to produce the materials and rocket fuel required to make that journey. A significant amount of Earth’s resources are now on the surface of the moon, or dispersed in our Earth’s atmosphere during launch and re-entry – these resources are no longer available to future generations.</p>
<p>Example #2 The world has unlimited resources.</p>	

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<sup>27</sup> This ‘tool’ is often described as the Apollo Saturn V launch vehicle (rocket), and the Apollo Crew Module, Service Module and Lunar Module.

## Appendix P “Real World” versus “real world”

We will occasionally slip into the mode of calling what we observe in the expanding Universe as the “Real World” as we currently understand it. As we look around we can also see the human-created “real world.” The “Real World” includes the Earth’s ecosystem. The “real world” includes the human-created American economic system.

By definition there is nothing wrong with the Real World – it consistently is what it is and Life on Earth has evolved to accommodate and exist sustainably within the Real World – within the frame/boundaries/laws of the Real World. Unfortunately, the ‘real world’ created by humans is not also in concert with the ‘Real World’ – and guess what? The Real World will always trump the real world. Sorry, that’s a given. We will cite more examples of this as we go along.

## Appendix Q Earth’s Resources

Let’s discuss Earth’s resources. Two basic types. Materials – elements in the periodic table – and then there is energy.

Including: sunlight, particles, solar wind deflected

Gravitation energy – sun, moon, planets, to a lesser degree every atom in the Universe

Wind,

Kinetic

Atomic

Chemical

thermal

Energy is conserved – light to mass to elements to molecules

Core 86 % iron, 4 % Ni, 10% Oxygen or sulfur

Crust – show the table

Atmosphere N<sub>2</sub>, O<sub>2</sub>

Water 98% salt 2% fresh

Minerals

What’s the earth worth

Resources with energy

Wind

## Mis-measuring Our Lives (Reframed)

Geothermal

Ancient hydrocarbons

Recent hydrocarbons – bio mass

## Appendix R Energy – Sustainable Use

Energy is the essence of Life – without an ongoing source of energy, Life would be reduced to inorganic chemistry and Earth would look like Venus or Mars or mercury but Mars has sun? just not the other ingredients for life. A lab of solutions – complex but not self replicating

What we call life would be reduced to star stuff – to dust

But with the addition of energy and the instructions of how to assemble this star stuff in self replicating manner – an extremely complicated system is non-equilibrium chemical systems – each of which involves the flow of energy from a high quality to a lower quality – there would be no life – from

If the Earth were left to its own – it would be covered by natural plant and animal life – no roads except those traveled by animals, no highways, no houses except those constructed by animals,

No toxic materials created by humans – primarily – if something creates a toxic material that kills all the microorganisms that help the life form extract materials from the soil, then it is not sustainable.

Web of invisible underground fungi, bacteria, required to support plant life. Dead /sterile soil – can't grow anything until the soil comes alive –

[Play video](#)

00:10:40

Added on 5/06/10

2,038,036 views

Americans consume 96 billion boe only 9.2 is renewable

The GDP is \$3T for this annual consumption that should be subtracted from the 39,000 x 300,000,000 GDP. The national energy debt should go up by \$3T each year – the Real Wealth of the planet has been reduced by that amount because the energy has been consumed

As we speak, the wealth of the planet

Mark.

## Mis-measuring Our Lives (Reframed)

Over the next hour the planet will receive \_\_\_\_\_ kWh of energy.

The good news is that the Earth as an interdependent ecosystem will harvest a certain amount of this ongoing gift from the Sun - Natural plants and cyanobacteria Plants autotrophs will harvest 5% - human planted plants will harvest \_\_\_\_\_

\_\_\_\_% will be used for food – the remainder will be used for biofuel

Humans will capture \_\_\_\_\_ with wind \_\_\_\_\_ with solar

Humans will expend/burn \_\_\_\_\_ in this coming hour – \_\_\_\_% for food and \_\_\_\_% for tools and toys

A tool is an extension of human for the purpose of evolving consciousness, collective learning, and sustainable further extension of human capabilities.

Are unsustainable activities condoned – some might be. Suppose we assemble Earth's resources to build the Hubble telescope that extends our outward vision to see back into the past 13 billion years – but those resources used to construct the telescope are now lost to the planet for 1,000,000 years until the orbiting spacecraft eventually decays and it comes back into the atmosphere – the basic elements will be literally scattered to the wind – burned during the re-entry

The SGDP would be a negative value.