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Entrepreneurship and Innovation in the Age of Sustainability

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Abstract

Nations grow through a process of development that harnesses the socio-economic resources of countries, through a sequence of discoveries & innovations, tested and trialled into usable goods and services, produced to satisfy human wants and desires, through the vehicle of entrepreneurship. Originally measured in GDP or GNP, the index of national growth was factored to HDI (Human Development Index) to ensure that the wellbeing of the society is not subdued by extreme human greed for profit. Now, it's time, the GDP needs to be factored with environmental or ecological wellbeing to ensure that the ecology no more degraded that would annihilate the whole planetary system on whose existence, the existence of the whole human society thrives. Review of research in the field, indicated lack of substantive research and if all, is of rare occurrence. Hence an attempt is made in this paper classify the whole arena of environmental sustainability and suggest measures to mitigate the environmental problems. The findings of the study have classified the entrepreneurial activities into three categories i.e. Macro-Entrepreneurial against Global Warming, Depletion of Ozone Layer, Climate Change, Biodiversity Loss, Nitrogen and Sulphur Cycles; Meso-Entrepreneurial against Water, Air, Land, and Oceanic Pollution, Deforestation, Desertification and Renewable Energy. Micro-Entrepreneurial for groups hard hit by calamities, like, Earth Quake, Land Slide, Water Scarcity, Soil Erosion and Social Evils like Inequality and Injustice. Waste management. It has also assessed innovations in green technologies, like biofuel and automation in IT that are in the pipeline. Once commercialised, will revolutionize the entire world with innovation, entrepreneurship and sustainability.

***Keywords*: Entrepreneurial Innovation, Sustainability, Green Entrepreneurship**

Introduction

The world today is facing a great challenge from environment, such as depletion of Ozone layer and emission of greenhouse gasses that causes climate change; air, water and land pollution, caused by emission of CO_2, particulate matters, solid and chemical waste due to growing industrialisation, unsustainable ways of production and consumption. Add to this, the burning of coal, oil and fossil fuel; running of transportation vehicles, desertification, deforestation and landslides caused by our unwarranted use of land; cutting of woods for fuel, furniture's and luxurious living. Our society is also infested with many other societal challenges, including rising income inequality and other forms of social injustice.

All these problems are due to the fact that either our business has failed to make their solutions a priority or did not make any prediction about the future state of affairs that would take place after 100 or thousand years ahead. As Albert Einstein said, "We can solve the worlds problem by using the same kind of thinking we used when we created them", but the laps will take too long to reconcile and the status of things will not remain the same, as it was when we started. Yet, it is not too late to correct the harm.

Nations grow through a process of development that harnesses the socio-economic resources of country through a sequence of discoveries & innovations, tested and trialled into usable goods and services, produced by means an industry and business, satisfying the needs of the society at large, through the vehicle of entrepreneurship. Originally measured in GDP or GNP, the index of national growth was factored to HDI (Human Development Index) to ensure that the wellbeing of the society is not subdued by extreme human greed for profit. Now, it's time, the GDP needs to be factored with environmental or ecological wellbeing to ensure that the ecology or environment are not degraded that would annihilate the whole planetary system on whose existence, the existence of the whole human society thrives.

Realization that the global economy is exhausting the world's natural resources and generating waste streams at an unprecedented scale, calls for the redesign of commercial activity that would stop the annihilating process and restructure a new economic model and implement business practices that would preserve the world's natural resources for today's communities and the economic, environmental, and social health and vitality of future generations. Sustainability in business is not about altruism and doing what is right for its own sake but, businesses with successful strategies that are profitable as well, because they integrate considerable amount of green and clean design and resource conservation throughout product life cycles and supply chains in ways that make economic sense. Sustainability innovation is about defining economic development as the creation of private and social wealth to ultimately eliminate harmful impacts on ecological systems, human health, and communities.

Methodology

Research Design: -
The research design will be **Explorative and Descriptive**.

Source of data: -
The sources of data will basically be secondary in nature, collected from the existing knowledge available in book, journals and periodicals, available manuscripts published or unpublished, reports and resolutions of UN conferences, World Bank, UNEP & UNDP, TEDx Talks, TV programmes on sustainability, epoch-making discoveries and innovations that are undergoing in the world at the moment.

Sampling Techniques: -
Since the research is not of primary nature, sampling is irrelevant, but in some issues like green consumerism, conscientious commerce and social & ecopreneur ship few social activists, marketers of eco-friendly products are interviewed.

Theoretical Framework

Sustainability Defined: A Bird's Eye View of The Semantics & Complexity of Sustainability

General Definition: - As a model of economic development, Sustainability can be defined as "meeting the needs of the present without compromising the ability of future generations to meet their needs". [i] According to this view, natural resources are part of "global commons "[1] and are considered as the property of the whole humanity irrespective of nationality and generations. No nation has an exclusive right to exploit or utilize it for its own nation or own generation. The upcoming future generations are the owners of this property in the same way as we are today. Hence, the present generation does not have an exclusive right to exhaust the whole of earth's resources for it own benefit and comfort.

Sustainability Defined by Engineers: -A sustainable product or process is one that constraints resource consumption and waste generation to an acceptable level, making a positive contribution to the satisfaction of human needs, and provides enduring economic value to the business enterprise[ii].

Sustainability Defined by Educators: - "Resource utilization should not deplete existing capital, that is, resources should not be used at a rate faster than the rate of replenishment, and waste generation should not exceed the carrying capacity of the surrounding ecosystem". [iii] A scientific, consensus-based articulation arrived by "The Natural Step", an educational foundation with global reach based in Stockholm, Sweden, says that "for sustainability to be achieved by society and for humans to prosper *and* coexist compatibly with natural systems, natural and man-made materials would not be extracted, distributed, and built up in the world at a rate exceeding the capacity of nature to absorb and regenerate those materials; habitat and ecological systems would be preserved; and actions that create poverty by undermining people's capacity to meet fundamental human needs (for subsistence, protection, identity, or freedom) would not be pursued. According to this philosophy, the concept of sustainability is composed of three pillars: economic, environmental, and social—also known, informally, as profits, planet, and people.[iv]

Sustainability Defined in Business Operations: - "Sustainability perspective may seem extreme in calling for waste-free businesses in which the nonproduct outputs become inputs for other products or services.[v] But sustainability's zero-waste goal offers a critical, underlying insight: health, environmental, and community social issues offer opportunities for businesses.[vi]

Sustainability Innovation

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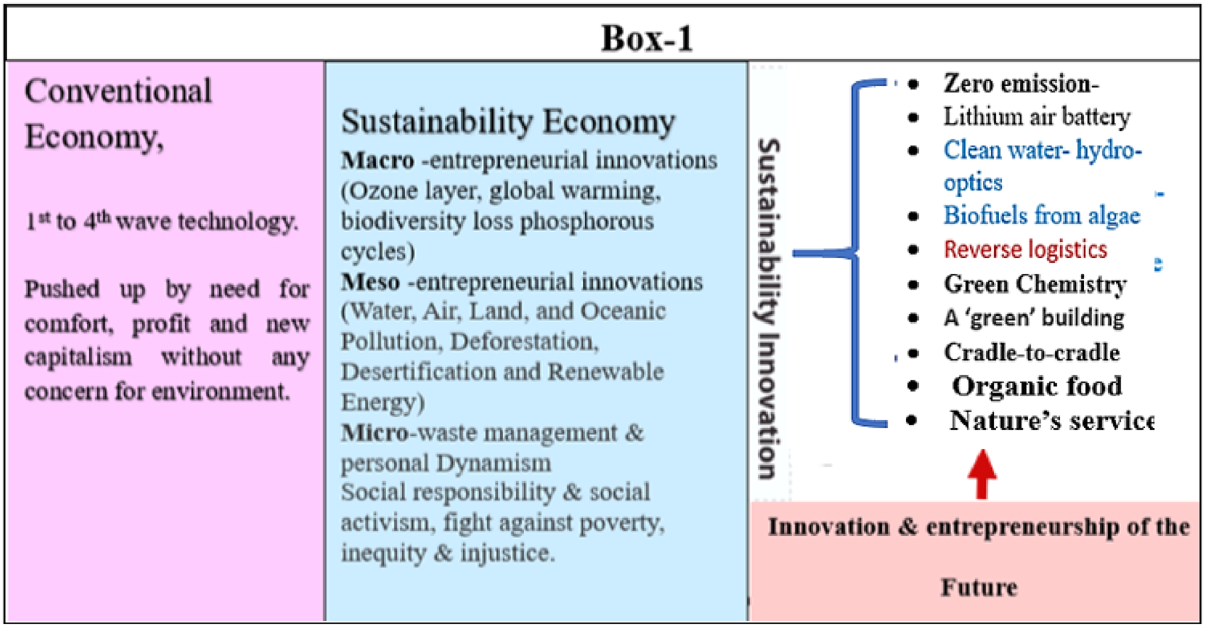
[1] **Global commons** is a term typically used to describe international, supranational, and global resource domains in which common-pool resources are found. Global commons include the earth's shared natural resources, such as the high oceans, the atmosphere and outer space and the Antarctic in particular. (http://www.unep.org/delc/GlobalCommons/tabid/54404/.) retrieved,6-10-2020.

The approach to **Sustainability Innovation** extends the premises of entrepreneurial innovation, a long-standing driver of social and economic change, to consider natural system viability and community health[vii]. Drawing on systems thinking, ecological and environmental health sciences, and the equitable availability of clean commerce, economic development opportunities, sustainability innovation offers a fast-growing market space within which entrepreneurial leaders are offering solutions and paths forward to address some of society's most critical challenges.

It is important **to recognize Sustainability Innovation** as a cross-disciplinary approach[viii]. Sustainability in business is about designing strategies for value creation through innovation using an interdisciplinary lens. Specialization and grounding in established disciplines provide requisite know-how, but sustainability innovation requires the ability to bridge disciplines and to rise above the narrow bounds and myopia of specialized training in conventional economic models to envision new possibilities. Sustainability innovation occurs when entrepreneurs and ventures stretch toward a better future to offer distinctly new products, technologies, and ways of conducting business. The empirical evidence suggests that while entrepreneurs who succeed typically bring their uniquely specialized know-how to the table, they also have a system view that welcomes and mixes diverse perspectives to create change.

Framework of Analysis

We will analyze sustainability innovations in 3 different perspective of technological developments i.e. 1. The conventional development during the whole period of waves of innovations starting from (1780 to1990) and its consequential deploration, 2. The modern technology addressing to the environmental and ecological concern and 3. The future of clean, green, zero waste technology and the nano-tech engineering.
The spectrum of analysis is given in box-1 below,



1. **The conventional economy and technological innovations**:
2.

We have under gone a train of successive innovations through which we have created new needs, new desires and a whole lot of products and services that has dramatically changed our way of living, our life style, our behaviour. Over a period of three decade we have come across five successive waves of innovations. In 1780's innovation in the field of iron, water power, mechanization, textile and commerce, in 1840's, steam power, rail road, steel and cotton, in 19thcentury, electricity, chemical, internal combustion machines, in 1950's, petrochemical, electronics, aviation and space, 1990's, digital network, biotechnology, soft ware & information technology and now it is time for sustainability, radical resource productivity, systems design, biomimicry, green chemistry , Industrial ecology, renewable energy, green nano technology[ix] , to name in a nutshell the 6th wave innovation and technology.

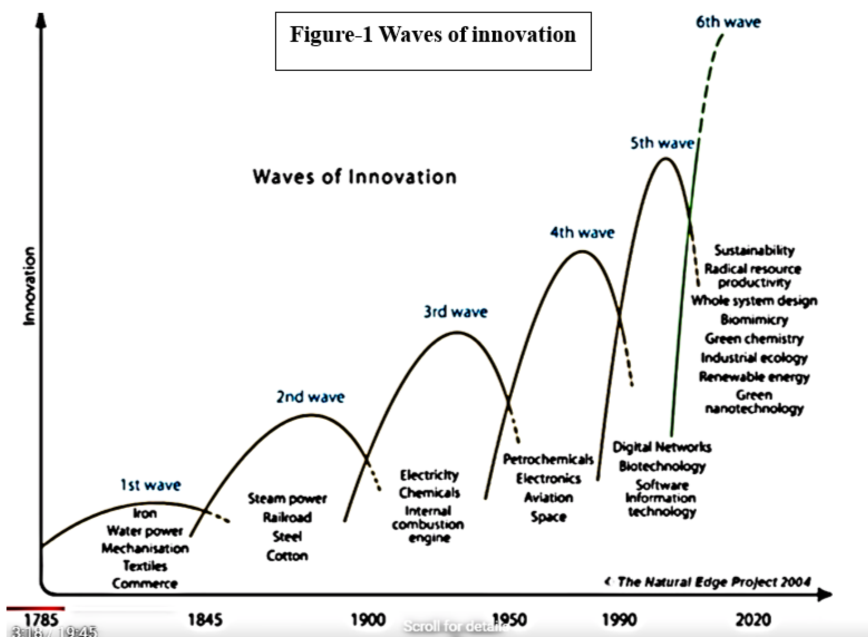


Figure-1 Waves of innovation

Consequences of conventional technology: -

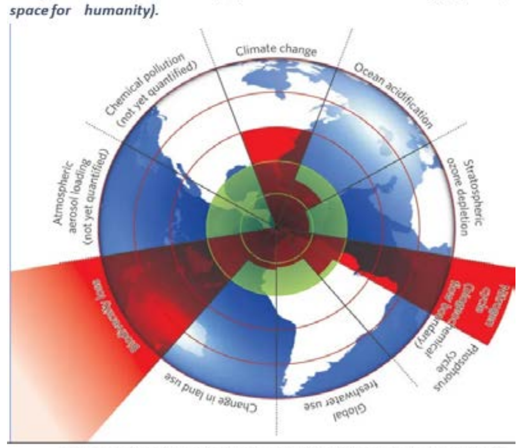
Let us revisit the doploration, we have caused in search of satisfying our grid for comfort, luxurious life syle and highly accelererated speed of material ahievements. Almost 200 years of development without concern for environment has led us to a state where our own existence has been challeneged. The state of anihillation that we have reached can be noted from the 4 picture sques shown below;

1. **Safe operating space for humanity (The planetary boundary of Environmental sustainability)**[x]**: -**

Although Earth has undergone many periods of significant environmental change, the planet's environment has been unusually stable for the past 10,000 years (Dansgaard, W. et al. 1993, Petit, J. R. et al. 1999, Rioual, P. et al.2001)[xi]. This period of stability — known to geologists as the Holocene — has seen human civilizations arise, develop and thrive. Such stability may now be under threat. Since the Industrial Revolution, a new era has arisen, the Anthropocene (Crutzen, P. J., 2002), in which human actions have become the main driver of global environmental change (Steffen, P. et al. 2007). This could see human activities push the Earth system outside the stable environmental state of the Holocene, with consequences that are detrimental or even catastrophic for large parts of the world. During the Holocene, environmental change occurred naturally and Earth's regulatory capacity maintained the conditions that enabled human development. Regular temperatures, freshwater availability and biogeochemical flows all stayed within a relatively narrow range. Now, largely because of a rapidly growing reliance on fossil fuels and industrialized forms of agriculture, human activities have reached a level that could damage the systems that keep Earth in the desirable Holocene state. The result could be irreversible and, in some cases, abrupt environmental change, leading to a state less conducive to human development (Steffen, W. et al. 2004). Without pressure from humans, the Holocene is expected to continue for at least several thousands of years (Berger, A. et al. 2002)

Planetary boundaries-To meet the challenge of maintaining the Holocene state, Rockstrom, J, Steffen, W. & Foley, J.A. in there work in 2009, propose a framework based on 'planetary boundaries'. These boundaries define the safe operating space for humanity with respect to the Earth system and are associated with the planet's biophysical subsystems or processes. Although Earth's complex systems sometimes respond smoothly to changing pressures, it seems that this will prove to be the exception rather than the rule. Many subsystems of Earth react in a nonlinear, often abrupt, way, and are particularly sensitive around threshold levels of certain key variables. If these thresholds are crossed, then important subsystems, such as a monsoon system, could shift into a new

Figure- 2 Planetary boundary of environmental sustainability (safe living space for humanity).



(The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable. The boundaries in three systems (rate of biodiversity loss, climate change and human interference with the nitrogen cycle), have already been exceeded.

state, often with deleterious or potentially even disastrous consequences for humans (Scheffer, M. et al. 2001, Lenton, T. M. et al. 2008).Most of these thresholds can be defined by a critical value for one or more control variables, such as carbon dioxide concentration.

Not all processes or subsystems on Earth have well-defined thresholds, although human actions that undermine the resilience of such processes or subsystems — for example, land and water degradation can increase the risk that thresholds will also be crossed in other processes, such as the climate system. They have tried to identify the Earth-system processes and associated thresholds which, if crossed, could generate unacceptable environmental change. They have found nine such processes for which they believed, it was necessary to define planetary boundaries: climate change; rate of biodiversity loss (terrestrial and marine); interference with the nitrogen and phosphorus cycles; stratospheric ozone depletion; ocean acidification; global freshwater use; change in land use; chemical pollution; and atmospheric aerosol loading (see Fig. 2 & Fig.3). In general, planetary boundaries are values for control variables that are either at a 'safe' distance from thresholds — for processes with evidence of threshold behaviour — or at dangerous levels — for processes without evidence of thresholds. Humanity may soon be approaching the boundaries for global freshwater use, change in land use, ocean acidification and interference with the global phosphorous cycle (see Fig. 2). **Accordingly, they found that three of the Earth-system processes — climate change, rate of biodiversity loss and interference with the nitrogen cycle —** have already transgressed their boundaries. For the latter two of these, the control variables are the rate of species loss and the rate at which N_2 is removed from the atmosphere and converted to reactive nitrogen for human use, respectively. These are rates of change that cannot continue without significantly eroding the resilience of major components of Earth-system functioning.

Figure- 3 Current value of environmental boundaries

PLANETARY BOUNDARIES

Earth-system process	Parameters	Proposed boundary	Current status	Pre-industrial value
Climate change	(i) Atmospheric carbon dioxide concentration (parts per million by volume)	350	387	280
	(ii) Change in radiative forcing (watts per metre squared)	1	1.5	0
Rate of biodiversity loss	Extinction rate (number of species per million species per year)	10	>100	0.1–1
Nitrogen cycle (part of a boundary with the phosphorus cycle)	Amount of N_2 removed from the atmosphere for human use (millions of tonnes per year)	35	121	0
Phosphorus cycle (part of a boundary with the nitrogen cycle)	Quantity of P flowing into the oceans (millions of tonnes per year)	11	8.5–9.5	-1
Stratospheric ozone depletion	Concentration of ozone (Dobson unit)	276	283	290
Ocean acidification	Global mean saturation state of aragonite in surface sea water	2.75	2.90	3.44
Global freshwater use	Consumption of freshwater by humans (km^3 per year)	4,000	2,600	415
Change in land use	Percentage of global land cover converted to cropland	15	11.7	Low
Atmospheric aerosol loading	Overall particulate concentration in the atmosphere, on a regional basis		To be determined	
Chemical pollution	For example, amount emitted to, or concentration of persistent organic pollutants, plastics, endocrine disrupters, heavy metals and nuclear waste in, the global environment, or the effects on ecosystem and functioning of Earth system thereof		To be determined	

Boundaries for processes in red have been crossed.

2. **Circles of Sustainability**[xii]:

Saint George IV developed the concept of circle of sustainability for the UN Global Compact Cities Programme in 2011 to measure four domains of sustainability - economics, ecology, politics and culture. This figure- 4, shows the sustainability of the metropolis of Melbourne across the four domains of sustainability). Indicating that out of 4 domains three domains are highly vibrant and good while only one domain i.e. domain of ecology is very poor and unsatisfactory (coloured res & yellow). A comparative study of 6 cities is shown in Figure-5 including India which indicates that none of the cities is vibrant or good in the domain of ecology i.e. ecology everywhere is the worst sufferer. However, politics is little better in all cities. This inces that the decision makers are callus about the environment.

Figure- 4 Circle of sustainability (Melbourne)

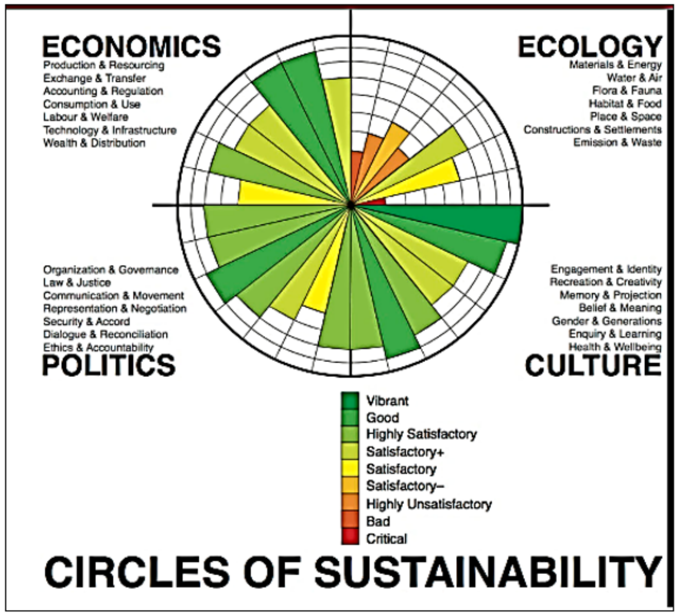
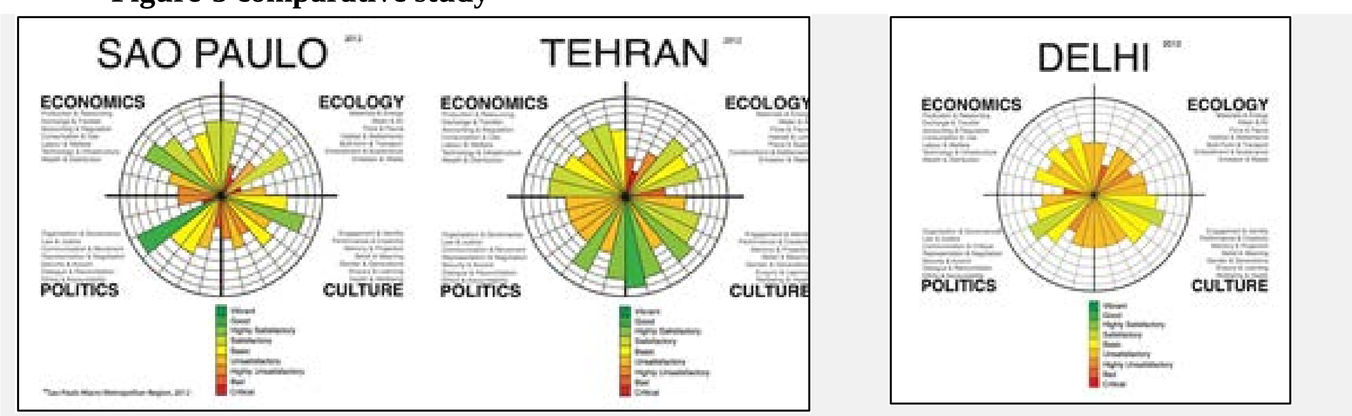
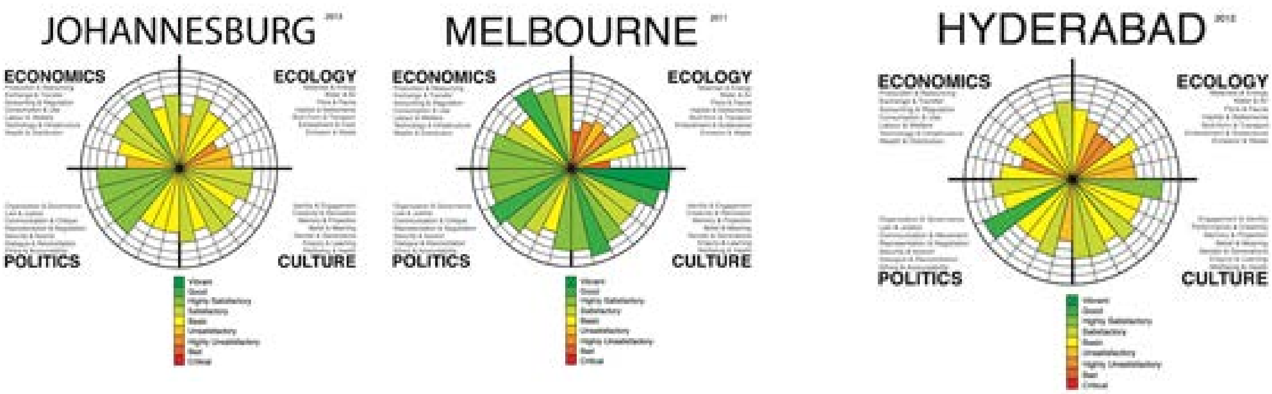


Figure-5 comparative study

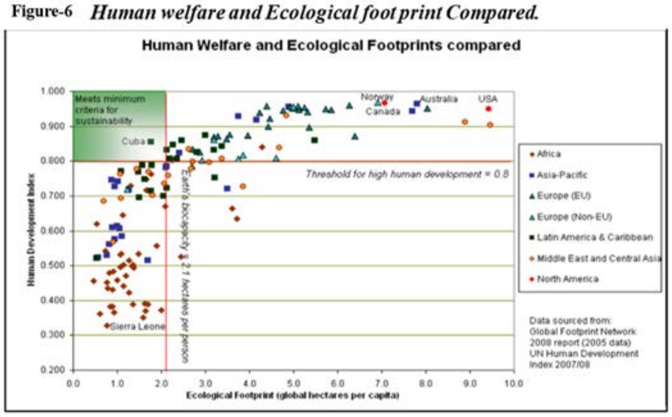




3. **Human welfare and Ecological foot print**[xiii]:

HDI is composite index that takes into consideration (1) health, (2) Education and (3) living standards, a comparison of human welfare and ecological foot print shows(see, Figure -6 below) that European Union, Latin America, Middle East & North America are the only Countries that Meet the Minimum Criteria For Sustainability (An HDI Of 0.8) Leaving Africa And Asia-Pacific Left Untouched i.e. Below Minimum Criteria[xiv]. India has moved from position .586 to in 2014 to 0.647 in 2018 in HDI. Falling by 2 points below the minimum criteria [xv].

Figure-6 *Human welfare and Ecological foot print Compared.*



4. **Climate change**

Anthropogenic climate change is now beyond dispute and, international discussions on targets for climate mitigation have intensified at UN. There is a growing convergence towards a '2 °C (Guardrail' approach), that is, containing the rise in global mean temperature to no more than 2 °C above the pre-industrial level.

The climate boundary is based on two critical thresholds: atmospheric concentration of carbon dioxide and radiative forcing (the rate of energy change per unit area of the globe as measured at the top of the atmosphere). Human changes to atmospheric CO_2 concentrations should not exceed 350 parts per million by volume (ppmv), and that radiative forcing should not exceed 1 watt per square metre (W/m^2) above pre-industrial levels. Transgressing these boundaries will increase the risk of irreversible climate change, such as the loss of major ice sheets, accelerated sea-level rise and abrupt shifts in forest and agricultural systems. Current CO_2 concentration stands at 387 p.p.m.v. and the change in radiative forcing is 1.5 W m^{-2} [xvi]. There are at least three reasons for climate boundary. First, current climate models may significantly underestimate the severity of long-term climate change for a given concentration of greenhouse gases (Hansen, J. et al., 2008). Most models[xvii] suggest that a doubling in atmospheric CO_2 concentration will lead to a global temperature rise of about 3 °C (with a probable uncertainty range of 2–4.5 °C) once the climate has regained equilibrium. But these models do not include long-term reinforcing feedback processes that further warm the climate, such as decreases in the surface area of ice cover or changes in the distribution of vegetation. If these slow feedbacks are included, doubling CO_2 levels gives an eventual temperature increase of 6 °C (with a probable uncertainty range of 4–8 °C). This would threaten the ecological life-support systems that have developed in the late Quaternary environment, and would severely challenge the viability of contemporary human societies.

The second consideration is the stability of the large polar ice sheets. Palaeo-climate data from the past 100 million years show that CO_2 concentrations were a major factor in the long-term cooling of the past 50 million years. Moreover, the planet was largely ice-free until CO_2 concentrations fell below 450 p.p.m.v. (±100 p.p.m.v.), suggesting that there is a critical threshold between 350 and 550 p.p.m.v. (Hansen, J. et al., 2008). A boundary of 350 p.p.m.v. aims to ensure the continued existence of the large polar ice sheets. Thirdly, the evidence that some of Earth's subsystems are already moving outside their stable Holocene state [2]. This includes the rapid retreat of the summer sea ice in the Arctic ocean(Johannessen, O. M. 2008), the retreat of mountain glaciers around the world(Solomon, S. et al. 2007), the loss of mass from the Greenland and West Antarctic ice sheets(Cazenove, A. 2006) and the accelerating rates of sea-level rise during the past 10–15 years(Cazenove, A. et al. 2006)[xviii].

5. **Rate of biodiversity loss: -**

Species extinction is a natural process, and would occur without human actions. However, biodiversity loss in the Anthropocene[3] has accelerated massively. Species are becoming extinct at a rate that has not

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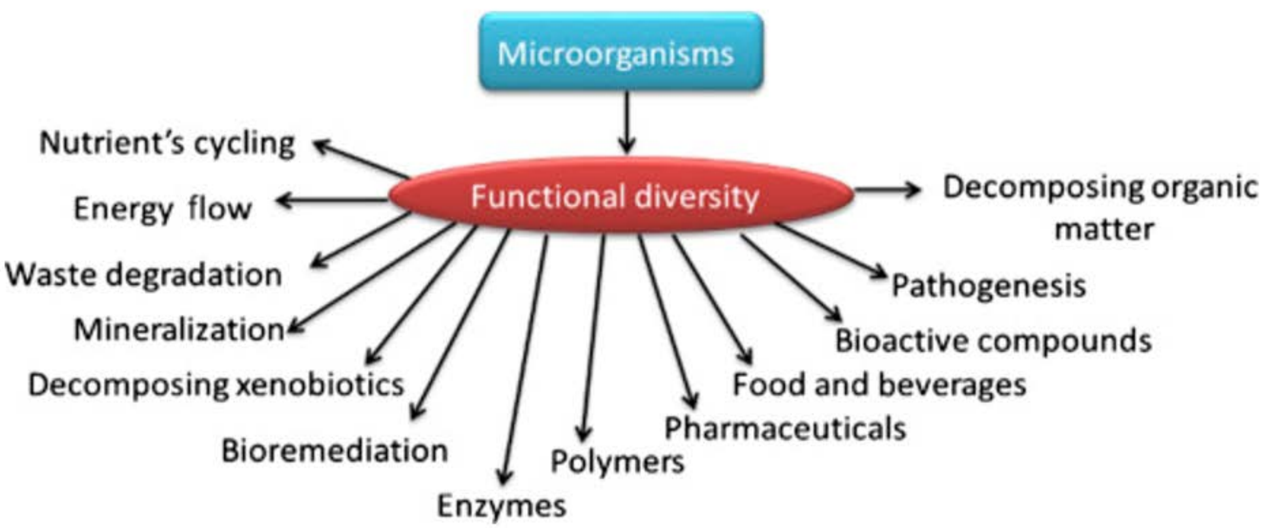
[2] The Holocene is the name given to the last 11,700 years* of the Earth's history — the time since the end of the last major glacial epoch, or "ice age." Since then, there have been small-scale climate shifts — notably the "Little Ice Age" between about 1200 and 1700 A.D. — but in general, the Holocene has been a relatively warm period in between ice ages.

[3] relating to or denoting the current geological age, viewed as the period during which human activity has been the dominant influence on climate and the environment.

been seen since the last global mass-extinction even (Mace, G. et al.2005). The fossil record shows that the background extinction rate for marine life is 0.1–1 extinction per million species per year; for mammals it is 0.2–0.5 extinctions per million species per year (Mace, G. et al.2005). Today, the rate of extinction of species is estimated to be 100 to 1,000 times more than what could be considered natural. As with climate change, human activities are the main cause of the acceleration. Changes in land use exert the most significant effect. These changes include the conversion of natural ecosystems into agriculture or into urban areas; changes in frequency, duration or magnitude of wildfires and similar disturbances; and the introduction of new species into land and freshwater environments (Sala, O. E. et al. 2000). The speed of climate change will become a more important driver of change in biodiversity this century, leading to an accelerating rate of species loss(Sahney, S. et al, 2008). Up to 30% of all mammal, bird and amphibian species will be threatened with extinction this century (Díaz, S. et al. 2005).

Biodiversity loss occurs at the local to regional level, but it can have pervasive effects on how the Earth system functions, and it interacts with several other planetary boundaries. For example, loss of biodiversity can increase the vulnerability of terrestrial and aquatic ecosystems to changes in climate and ocean acidity, thus reducing the safe boundary levels of these processes. There is growing understanding of the importance of functional biodiversity in preventing ecosystems from tipping into undesired states when they are disturbed (Folke, C. et al. 2004). This means that apparent redundancy is required to maintain an ecosystem's resilience. Ecosystems that depend on a few or single species for critical functions are vulnerable to disturbances, such as disease, and at a greater risk of tipping into undesired states (Scheffer, M. 2001, Chapin, F. S., III et al. 2000). Figure-7 shows the functional biodiversity objects and the process with the taxonomy of some microorganisms[xix].

Figure -7 objects and process of functional biodiversity



From an Earth-system perspective, setting a boundary for biodiversity is difficult. Although it is now accepted that a rich mix of species underpins the resilience of ecosystems, little is known quantitatively about how much and what kinds of biodiversity can be lost before this resilience is eroded(Purvis, A. et al. 2000). This is particularly true at the scale of Earth as a whole, or for major subsystems such as the Borneo rainforests or the Amazon Basin. Ideally, a planetary boundary should capture the role of biodiversity in regulating the resilience of systems on Earth. Because science cannot yet provide such information at an aggregate level, we propose extinction rate as an alternative (but weaker) indicator. As a result, our suggested planetary boundary for biodiversity of ten times the background rates of extinction is only a very preliminary estimate. More research is required to pin down this boundary with greater certainty. However, we can say with some confidence that Earth cannot sustain the current rate of loss without significant erosion of ecosystem resilience.

6. Nitrogen and phosphorus cycles

Modern agriculture is a major cause of environmental pollution, including large-scale nitrogen- and phosphorus-induced environmental change (Foley, J. A. et al. 2005). At the planetary scale, the additional amounts of nitrogen and phosphorus activated by humans are now so large that they significantly perturb the global cycles of these two important elements (Machenzie F. T. 2002) Human processes — primarily the manufacture of fertilizer for food production and the cultivation of leguminous crops — convert around 120 million tons of N_2 from the atmosphere per year into reactive forms — which is more than the combined effects from all Earth's terrestrial processes. Much of this new reactive nitrogen ends up in the environment, polluting waterways and the coastal zone, accumulating in land systems and adding a number of gases to the atmosphere. It slowly erodes the resilience of important Earth subsystems. Nitrous oxide, for example, is one of the most important non-CO_2 greenhouse gases and thus directly increases radiative forcing.

Unlike nitrogen, phosphorus is a fossil mineral that accumulates as a result of geological processes. It is mined from rock and its uses range from fertilizers to toothpaste. Some 20 million tons of phosphorus is mined every year and around 8.5 million–9.5 million tons of it finds its way into the oceans (Machenzie F. T. et al. 2002 & Bennett, E. M. et al. 2001). This is estimated to be approximately eight times the natural background rate of influx. Records of Earth history show that large-scale ocean anoxic events[4] occur when critical thresholds of phosphorus inflow to the oceans are crossed. This potentially explains past mass extinctions of marine life. Modelling (Handoh, I. C. 2008) suggests that a sustained increase of phosphorus flowing into the oceans exceeding 20% of the natural background weathering was enough

[4] **Anoxic events** (AE) occur when oceans become completely depleted of oxygen (O_2) below the surface levels.

to induce past ocean anoxic events.it is estimated that if there is a greater than tenfold increase in phosphorus flowing into the oceans (compared with pre-industrial levels), then anoxic ocean events become more likely within 1,000 years. Despite the large uncertainties involved, the state of current science and the present observations of abrupt phosphorus-induced regional anoxic events indicate that no more than 11 million tons of phosphorus per year should be allowed to flow into the oceans — ten times the natural background rate. We estimate that this boundary level will allow humanity to safely steer away from the risk of ocean anoxic events for more than 1,000 years, acknowledging that current levels already exceed critical thresholds for many estuaries and freshwater systems.

Although the planetary boundaries are described in terms of individual quantities and separate processes, the boundaries are tightly coupled. We do not have the luxury of concentrating our efforts on any one of them in isolation from the others. If one boundary is transgressed, then other boundaries are also under serious risk.

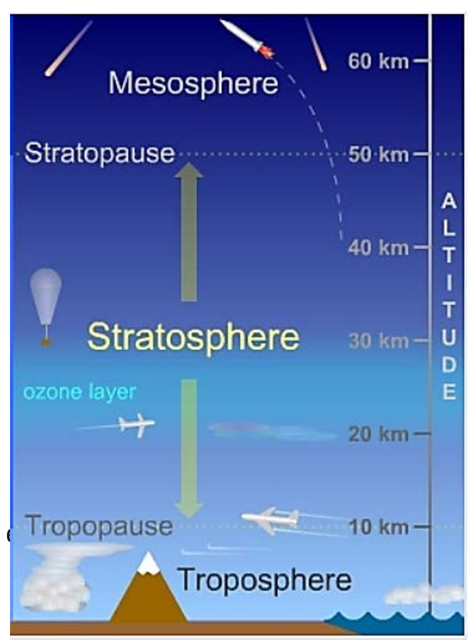
World Trends Towards Environmental Sustainability (Global Progress): -

In the words of professor Leyla Acaroglu, "sustainability is self-preservation, an understanding and managing to do more with less". If we have properly understood it, found the limit where to stop, we have protected our-self from the ensuing annihilation of the earth but also protected our future generation from their right to live in this planet. Since the time this consciousness came in 1987 when all countries signed the Montreal protocol, nations are busy finding ways out to take control of these environmental issues and shown considerable improvement in this direction.

SUSTAINABILITY ECONOMY.

1. **Macro- entrepreneurial innovation-**

1.1. Ozone Depletion[xx]:-



Gradual thinning of Earth's ozone layer in the upper atmosphere caused by the release of chemical compounds containing gaseous chlorine or bromine from industry and other human activities. The thinning is most pronounced in the polar regions, especially over Antarctica. Ozone depletion is a major environmental problem, because it increases the amount of ultraviolet (UV-B)[5] radiation that reaches Earth's surface,

[5] The initials **UVB stand for** the type B ultraviolet, the middle [illegible] A) and the intense germicidal UVC.

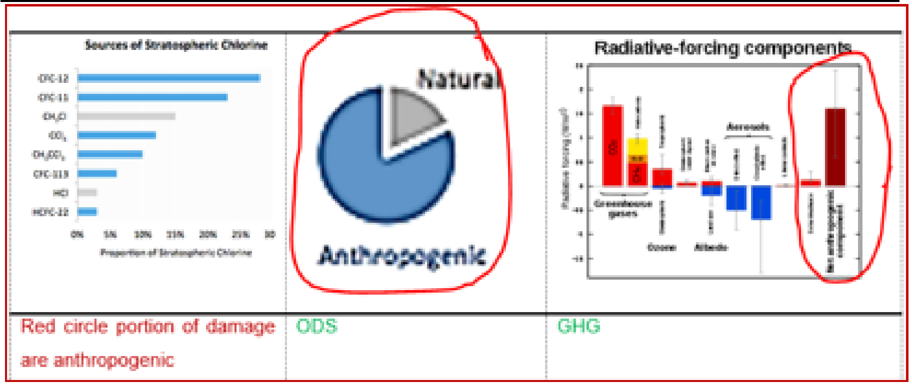
which increases the rate of skin cancer, eye cataracts, and genetic and immune system damage.(see, figure-1 effects of UV rays on humans). [xxi]

In 1974, American chemists Mario Molina and F. Sherwood Rowland of the University of California at Irvine recognized that human-produced chlorofluorocarbons (CFCs)—molecules containing only carbon, fluorine, and chlorine atoms—could be a major source of chlorine in the stratosphere. They also noted that chlorine could destroy extensive amounts of ozone after it was liberated from CFCs by UV radiation. Free chlorine atoms and chlorine-containing gases, such as chlorine monoxide (ClO), could then break ozone molecules apart by stripping away one of the three oxygen atoms. Later research revealed that bromine and certain bromine-containing compounds, such as bromine monoxide (BrO), were even more effective at destroying ozone than were chlorine and its reactive compounds. Subsequent laboratory measurements, atmospheric measurements, and atmospheric-modelling studies soon substantiated the importance of their findings. Crutzen, Molina, and Rowland received the Nobel Prize for Chemistry in 1995 for their efforts. These chemicals are called Ozone-depleting substances (ODS) are synthetic chemicals, which were used around the world in a wide range of industrial and consumer applications. The main uses of these substances were in refrigeration and air conditioning equipment and in fire extinguishers. Other important uses included aerosol propellants, solvents and blowing agents for insulation foams. Soon, **a global agreement to stop the use of ozone-depleting chemicals that damage the ozone layer was held.** The Montreal Protocol, ratified in 1987, was the first of several comprehensive international agreements enacted to halt the production and use of ozone-depleting chemicals, and in 2009, the Vienna Convention, the Montreal Protocol became the first treaties in the history of the United Nations to achieve universal ratification. Substances covered by the protocol are referred to as 'controlled substances' that include chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), halons, carbon tetrachloride, methyl chloroform and methyl bromide, which were banned as they are having high ozone depletion potential (ODP). In 1994, the United Nations General Assembly voted to designate September 16 as the International Day for the Preservation of the Ozone Layer, or "World Ozone Day", to commemorate the signing of the Montreal Protocol on that date in 1987.Ozone-depleting substances are also very potent greenhouse gases, reducing “global warming” which was the consequences of greenhouse gasses like carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Therefore, by reducing emissions of ozone-depleting substances, the Montreal Protocol has protected both the ozone layer and the climate change at the same time. Figure-8 shows how 85% of damage caused by ODS & GHG are anthropogenic.

Thus, under the Montreal Protocol succeeded in reducing GHG 5-6times the Kyoto Protocol for 2008.

Innovation averted the Ozone crisis:

Figure 8- 85% GHG is due to anthropogenic



The reduction of ODS emissions initially mitigated the ozone crisis by inventing products like hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) called the (F-gasses) as an alternative to CFC or HCFC, cooling agents used in refrigeration and air conditioning applications and spray production industries. But, soon these F-gases were found to be greenhouse gases, having even higher GH effect than carbon dioxide (CO_2) up to 23 000 times more powerful than the same amount of carbon dioxide, though the quantum of F-gases emissions was smaller than CO_2. Activism again took its term and production of f-gas stopped and, Innovation as its usual course came with large number of alternatives in two forms i.e. **Natural refrigerants , HFCs with lower GWP, such as R32, Hydro-fluoro-olefins (HFO_5), HFC-HFO blends and** R717 (Ammonia), R744 (Carbon dioxide), R170 (Ethane), R290 (CARE 40) Propane, R600a (CARE 10) Isobutane, R1150 (Ethylene), R1270 (CARE 45) Propylene. Since these products are inflammable, each alternative used in refrigeration and air conditioning (RAC) equipment, has to be measured in terms of global warming potential (**GWP**)toxicity and inflammability. Standards are given in figure-9. Figure-10,shows an example of product laveling.

Figure 9- Standards of safety group specified as follows:

* A2L and B2L are lower flammability refrigerants with a maximum burning velocity of ≤ 10 cm/s

	Lower toxicity	**Higher toxicity**
No flame propagation	A1	B1
Lower flammability	A2	B2
	A2L*	B2L*
Higher flammability	A3	B3

Figure-10. Shows an example of the product specifications

Figure-10. Example of specification

Chiller

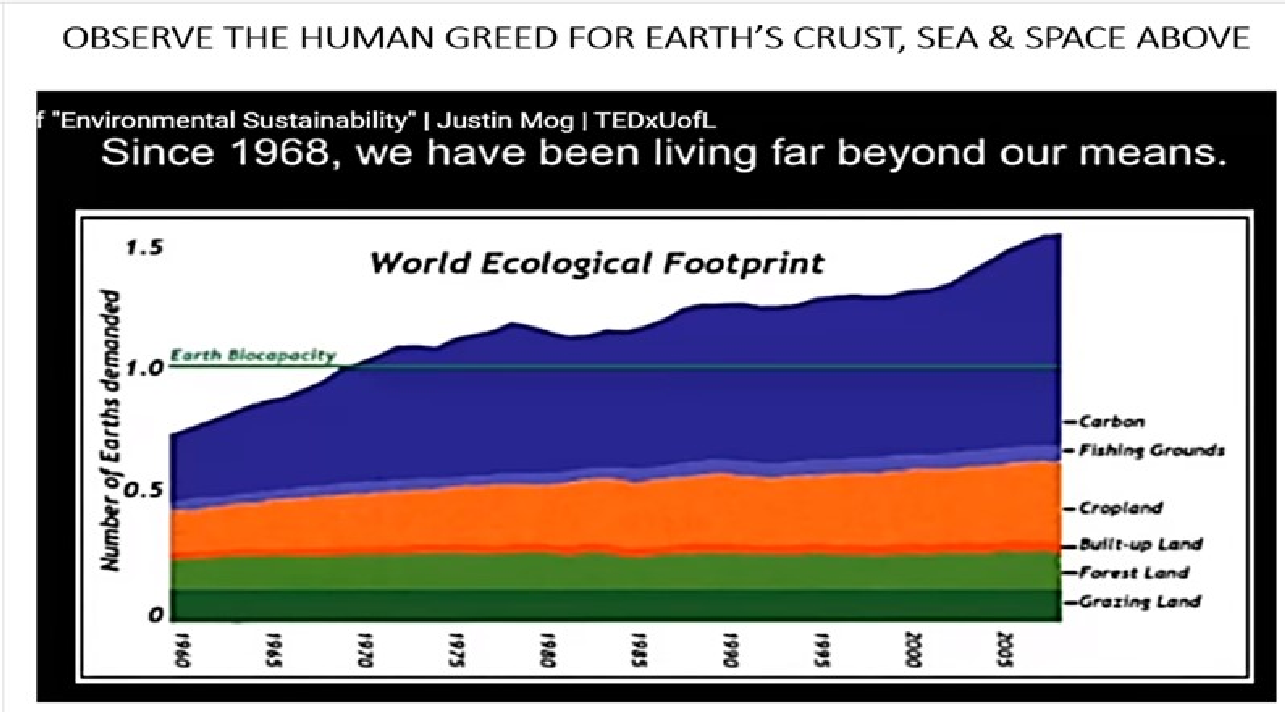
	Substance	**GWP**	**Composition**	**Safety group**	**Replacement for**
Natural refrigerants	R290 (propane) R717 (ammonia) R718(H_20) R744 (CO_2) R1270 (propene)	3 - - 1 2	- - - - -	A3 2BL A1 A1 A3	R134a, R407A, R410A R134a, R407A, R410A R134a, R407A, R410A R134a, R407A, R410A R134a, R404A, R407A

By now, science, has also indicated that CO_2 is a natural refrigerant and can be used in cooling large transport vehicles and public transport in future.

1.2. Global warming: - Global warming and depletion of ozone layer are supplementary and complementary to each other. On the one hand depletion of ozone layer causing huge amount hot and UV rays into earth's atmosphere which increases temperature of the earth which while deflating into the air gets absorbed in atmosphere by greenhouse gasses causing earth's temperature to shoot up. On the other hand, Industrialization and industrial production of luxury items, release huge quantum of greenhouse gasses like CO_2, CFCs, methane and nitrous-oxides which not only absorbs deflating rays from earth but also react with the ozone layer depleting it and causing holes in **ozone layer**. Both of them intertwiningly toxify atmosphere and destroy human life, flora and fauna with harmful diseases like cancer, skin diseases and gene mutation leading to defective life births, physical & mental disorders.

The challenge lies in containing the huge CO_2 emission caused by industrial production, efflux of chemical industries, burning of fossil fuels, natural respiratory system. The **World Economic Foot**

figure - 11 World ecological footprint



print[xxii] **(**figure-11) below shows how the carbon foot print covers 50% of the total ecological foot print and at this rate human society needs 1.7 earths to exist under the present level of pollution.

2. **Meso- entrepreneurial innovation-**The best possibility of overcoming the deploration

2.1 Ocean fertilization-

This is done effectively by Ocean fertilization by using nitrogen & phosphorous (macro nutrients), iron and zinc(micro nutrient) for sea weds and Phyto plankton, which via chlorophyl action absorbs co2 from air over ocean surface. This, according to "Ocean Nourishment Corporation" of Australia, can remove approximately 5–8 million tons of CO2 from the atmosphere for each year of operation, equivalent to offsetting annual emissions from a typical 1200 MW coal-fired power station or the short-term sequestration from one million hectares of new growth forest. In addition, these planktons being food to sea fish "Solomon" and many other fish species can avert the shortage of the sea food industry. Although, the process is controversial at UNO level, on grounds creating ecology of marine life, yet the process is effectively used by many countries under mutual agreement.

2.2 Reducing use of like fossil fuel that is the main source of CO_2

a) Using non-conventional and renewable energy to create electricity without using fossil fuels

The first round of scientific innovation goes in favour of -Solar energy, wind energy, tidal and geothermal energy for creating electricity. Since these are mostly costly and can't be created according to individual need, only community-based technology is in vogue. In UK tidal & wind energy have been in community use while in US they are integrated to the power grid though storable large batteries.

Now tidal power is changing tides-A more predictable power source than intermittent renewables like wind and solar, tidal power isn't new, however its growth and development has typically been restrained by high costs and limited availability. That's changing. Last year saw the launch of the first of 269 1.5 MW (megawatt) underwater turbines, part of world's first large scale tidal energy farm in Scotland. Around the world there are existing tidal power stations – such as the Sihwa Lake Tidal Power Station in South Korea, which has a capacity of 254MW – but the MeyGen array in Scotland will be able to take the potential of the technology further. It's hoped that when fully operational it will generate 398MW, or enough to power 175,000 homes. We might not know exactly how the electricity of tomorrow will be generated, but it's likely some or all of these technologies will play a part. What is clear is that our energy is changing

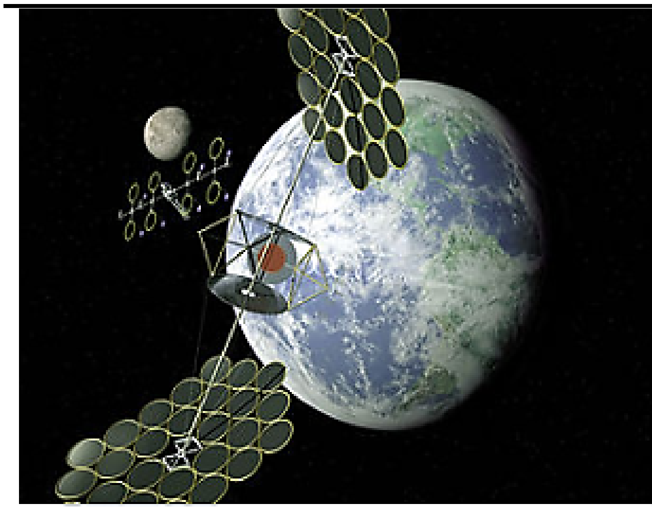
b) Cell technology is continuously improving through use of better mediums like moving from cadmium to lithium cells, making it more efficient, light weight that is convenient for use in cars to aeroplains.

c) Solar energy is taking up a new scale through space based solar power (SBSP)[xxiii]-

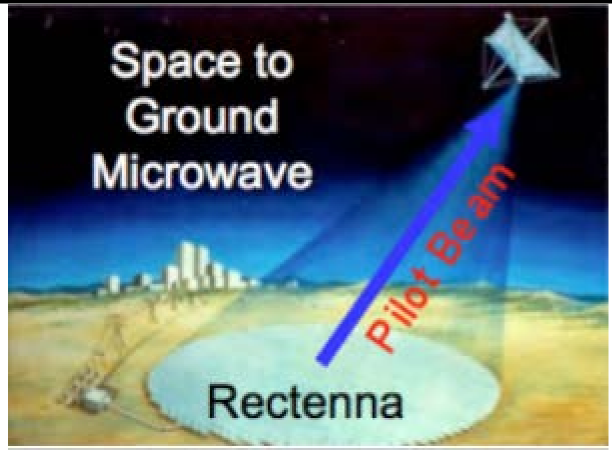
Space-based solar power (**SBSP**) is the concept of collecting solar power in outer space and distributing it to Earth. Potential advantages of collecting solar energy in space include a higher collection rate and a longer collection period due to the lack of a diffusing atmosphere, and the possibility of placing a solar collector in an orbiting location where there is no night. A considerable fraction of incoming solar energy (55–60%) is lost on its way through the Earth's atmosphere by the effects of reflection and absorption. Space-based solar power systems convert sunlight to microwaves outside the atmosphere, avoiding these losses and the downtime due to the Earth's rotation, but at great cost due to the expense of launching material into orbit. SBSP is considered a form of sustainable or green energy, renewable energy, and is occasionally considered among climate engineering proposals. It is attractive to those seeking large-scale solutions to anthropogenic climate change or fossil fuel depletion (such as peak oil). The new research in SBSP essentially consists of three elements[xxiv]. This is futures only source of huge power need after closure of fossil fuel thermal stations. (see figure- 12)

1. collecting solar energy in space with reflectors or inflatable mirrors onto solar cells or heaters for thermal systems
2. wireless power transmission to Earth via microwave or laser
3. receiving power on Earth via a rectenna, a microwave antenna

Figure-12 SBSP



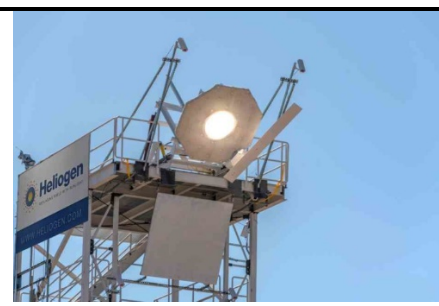
NASA Integrated Symmetrical Concentrator SPS concept



A laser pilot beam guides the microwave power transmission to a rectenna

Recently, Heliogen: The Bill Gates backed startup hoping to use mirrors to power heavy industry, such as cement, steel or aluminum manufacture by concentrating solar energy to achieve a temperature of over 1000°C, on a commercial scale, for the first time. Heliogen founder and chief executive officer Bill Gross said that by "commercial" he meant that the temperature was combined with sufficient power – between 250 and 400kW – for industrial purposes. The company is aiming to increase this figure to between 1MW and 10 MW[xxv].

Figure-13 the space based solar mirroring of Heliogen



Now a days, floating tidal & windmill are used for production of electricity in off shore oil drilling plants without using on-shore electricity.

2.3 Decarbonization-

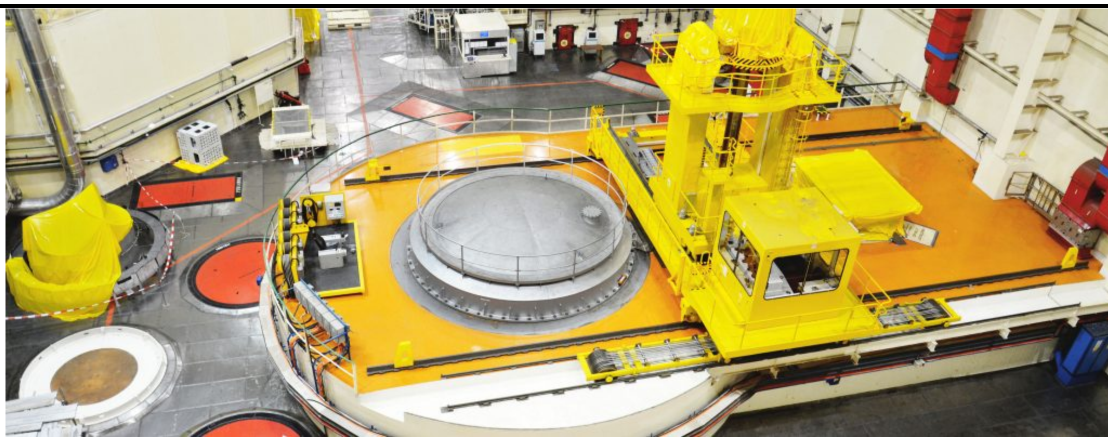
'Decarbonization' tends to refer to the process of reducing 'carbon intensity', lowering the amount of greenhouse gas emissions produced by the burning of fossil fuels. Generally, this involves decreasing CO2 output per unit of electricity generated. Reducing the amount of carbon dioxide occurring as a result of transport and power generation is essential to meet global temperature standards set by the Paris Agreement and UK government.

a) Bio-gas and biomass are the newest methods of getting electricity from animal, human waste, home wastes, agriculture waste (post fermentation) by aerobic (in the presence of oxygen) and anaerobic digestion (in the absence of oxygen)[xxvi] under high pressure to create fuel that can replace use of fossil fuel in transport vehicles and cars.

b) Microbial Fuel Cells – Harnessing the Power of Bacteria[xxvii]-Bacteria are all around us. Some are harmful, some are beneficial, but all of them 'breathe'. When they breathe oxidation occurs, which is when something combines with oxygen at a chemical level, and when bacteria do this, electrons are released. By connecting breathing microbes to a cathode and an anode (the positive and negative rods of a battery), the flow of these released electrons can be harnessed to generate power. This is what's known as a microbial fuel cell (MFC). MFCs are used largely to generate electricity from waste water, but are expanding into more exotic uses, like powering miniature aquatic robots.New developments are constantly expanding the power and applications of MFCs. Researchers at Binghamton University, New York found that combining phototropic (light-consuming) and heterotrophic (matter-consuming) bacteria in microbial fuel reactions generates currents 70 times more powerful than in conventional setups.

e. The photovoltaic cell technology has also undergone a considerable change[xxviii]- Rather than collecting photons like normal solar does (and which transparent materials by definition can't do) **photovoltaic glass** uses salts to absorb energy from non-visible wavelengths and deflects these to conventional solar cells embedded at the edge of each panel. Or there's solar PV paint, which contains tiny light sensitive particles coated with conductive materials. When layered over electrodes you've got a spray-on power generator. (see figure-14).

Figure-14 photovoltaic glass technology



3. **Micro- entrepreneurial innovation-**The managing the waste

3.1 The plastic pollution-

If we look at the figure- 15 each year 1.7 million barrels of oil, equivalent 340 million gallons of gassoline is used to produce bottled water. Only one in 5 bottles are recycled and the rest 4 bottles are put into landfills each year. In US 91.63 billions bottles are used every day (Globally its 563 billions) and the time taken for platic bottles to decompose is 1000 years. Alluminium cans take 600 years to decompose. Every minute, every day, more than 120,000 aluminum cans are recycled only in America. But, at the same time, every three-month, enough aluminum cans are thrown away in America that can rebuild the entire American commercial air fleet. **Glass waste**- Simply breaking down glasses and melting those broken glasses we can produce new glass. But the shocking fact is that if glasses are thrown away in landfills it will take one million years to decompose. **Dispoable Diapers -** Just in the United States alone, every year more than 18 billion disposable diapers are thrown away. These disposable diapers take approximately 550 years to decompose in landfills. This is what is underscoring the efforts of programs offering diaper and absorbent hygiene product recycling. A list of the pollutants added to land fills can be measured from the table-1 given below.

figure - 15 plastic bottles

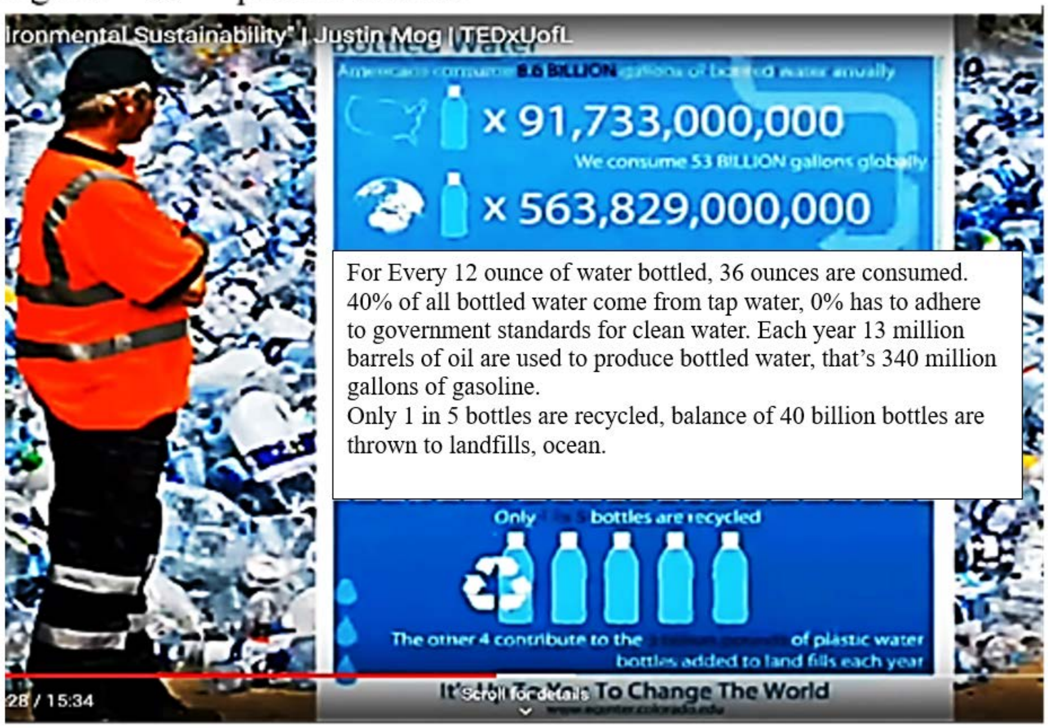


Table-1 How Long Does It Take Garbage to Decompose?[xxix]

.l. no.	Items thrown to land fills	Time taken to dicompose	2	Painted board	13 years
	Plastic bottles	1000 years	3	Cigarette Butts	10-12 years

	Disposable Diapers	550 years	4	Milk Cartons	5 years
	aluminium cans	200 years	5	Plywood -	1-3 years
	Glass	One million years	6	Styrofoam-	It does not biodegrade
	Monofilament Fishing Line -	600 years	7	Ropes -	3-14 months
	Rubber-Boot Sole -	50-80 years	8	Cotton Glove -	3 months
	Foamed Plastic Cups	50 years	9	Cardboard -	2 months
	Tin can-	50 years	0	Paper waste	2-6 week
	Leather shoes -	25-40 years;	1	Food waste	Depend on type o food
0	Nylon Fabric-	30-40 years;	2	i) an orange peel	6 months
1	Plastic bags	10-20 years	3	ii) an apple core or a banana peel	one month

3.2 Electricity from plastic waste[xxx]-

Students at Northeastern University have developed a device that converts plastic to electricity. The waste combustor processes non-recyclable plastic within two tanks. The top tank converts the plastic to gas through pyrolysis. The gas then travels to a lower tank, where it is burned to generate heat and steam. The steam powers a turbine to produce electricity.

3.3 Betavoltaics – Nothing Wasted from Nuclear Waste-

Nuclear material is constantly decaying and, in the process, emits radioactive particles. This is why extremely radioactive material is so dangerous and why properly storing nuclear waste is so important and so expensive. But this waste can actually be put to good use. Beta voltaic devices use the waste particles produced by low-level radioactive materials to capture electrons and generate electricity. The output from these devices can be fairly low and decreases over long periods of time, but because of the consistent output of nuclear decay they can be extremely long-lasting. For example, one beta voltaic battery could provide one watt of power continuously **for 30 years**. And while they aren't currently fit to work on a large scale, their longevity (and very compact size) makes them ideal power sources for devices such as sensors installed on equipment that needs to be operational for long periods.

4. Innovation &Change in Life Style

4.1 **Sift over from polluting vehicle to non-polluting Transport System: -**

In USA public transport has increased by 11+%, in Europ it 30+%, in Asia its 20+% and in Australia public transport has increase by 11+% (see, Figure-16).

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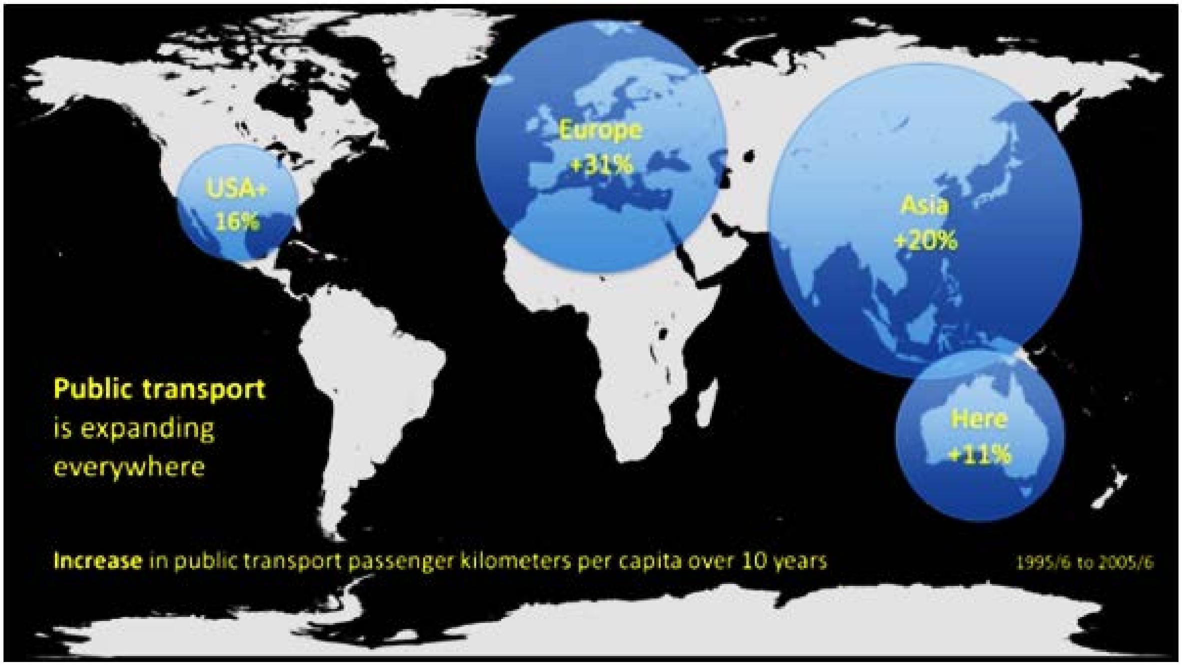
Figure- 1 word public Transport growth



Use of public transport has incresed in almost all continents, reducing CO2 emission between 1996 to 2006 a ten years period.

In China there is a tremenous increase in metro rail, the most energy efficient and non polluting public transport system from 0 in 1997 to 86 in 2011 covering a length 3500 kms (see, Figure-17). If you see Beijing Transport modal split (Figure-18), you will observe that starting from

Figure- 17 Metro Rail in china

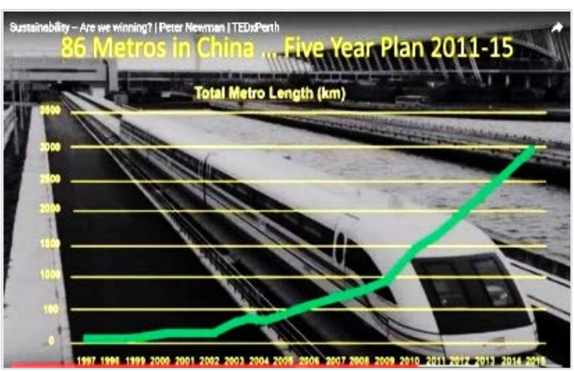
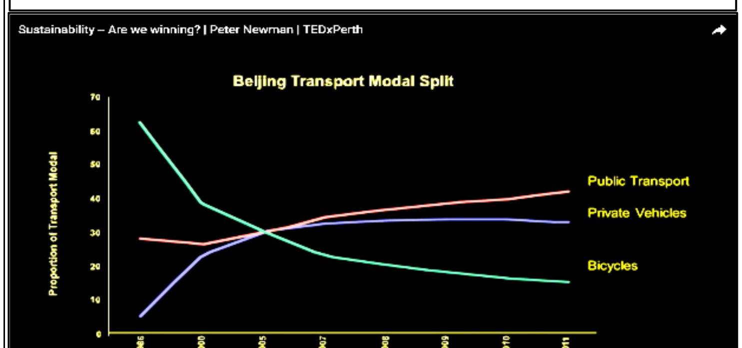


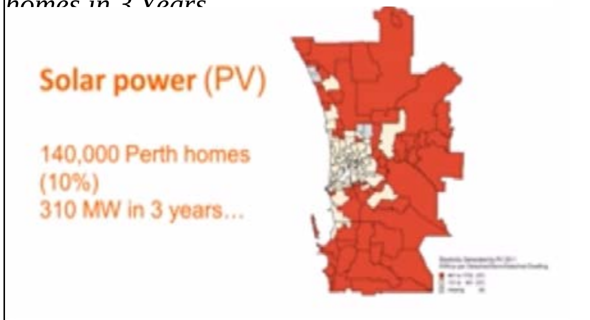
Figure- 18 Beijing Transport Modal split



2005 where proportion of both pulic transpot and private transport were the same level (at 30%) the proportion of public transpot has increased to 40% in 2011 and has crossed passed above the private transport which has stagnated at same 30% as it was in 2005. In Japan almost 250 million people are using e- cycles or e-scooters, zero emission vehicles giving the same service that a car or motor cycle could have given(see, Figure-19). Use of solar energy started in 10% of house hold in Perth in 3 years (see,figure-20) .

Figure- 19 E-Bikes & E-scooters in Japan

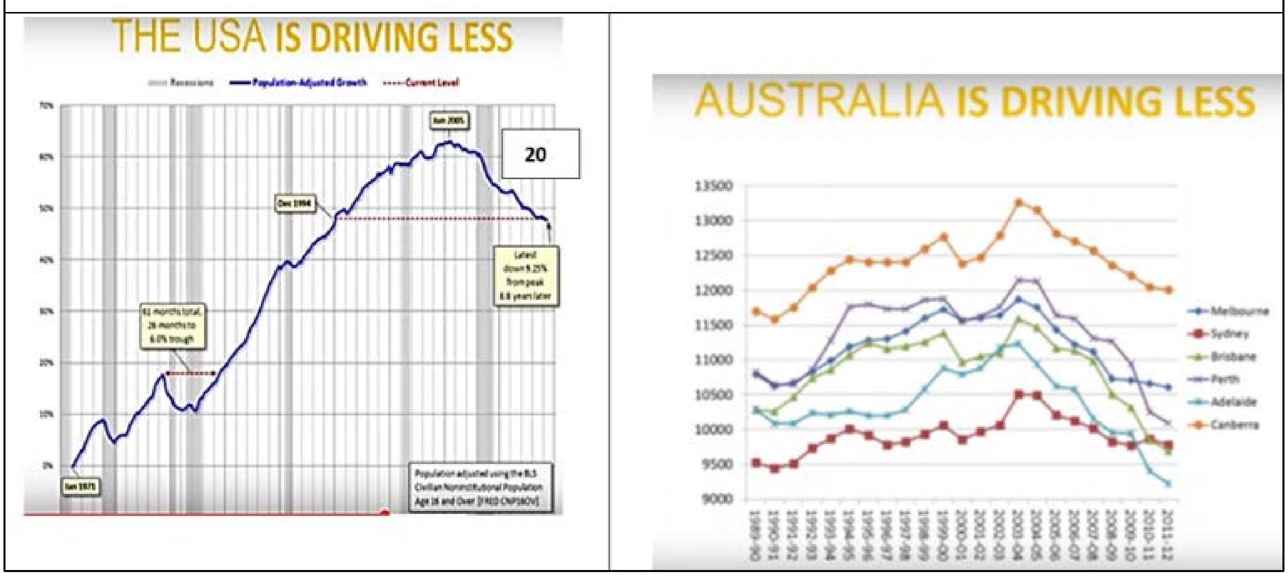
figure – 20 solar power(pv) 140000 Perth homes in 3 Years



4.2 Sift over from private vehicle to Public Transport System:

Look at figure-12 USA shows a considerable fall in driving cars from 60% in 2005 to 50% 2015, almost 10% reduction in driving. In Australia in almost all big cities i.e. Melbourn, Sydney, Brisben, Perth, Adelaide, Canbra. Private car used have tremendousy reduced (the highest fall - during 2006 to 2012. Melbourn has the lowest car use in 2012 (see, Figure 21, below).

Figure-21 driving less



4.3 **Home economics and waste dosposal-**

Innovation in CFL and Led lighting, elctronic cars, not only consumtion but also reducytion in CO2 emmision. Organic firming, where bio-mass, animal and human waste are used as fertilisaer has reduced the effect of air, water and soil pollution. Use of separate & coloured dustbins for waste dispoasl and use od dual split dustbins for disposal of home garbage have enhanced the efficiency of production of biogas and biomass.(see figure-22)

Figure-22 Home economics and waste dosposal

4.4. Individuals effort in finding innovative way to living style can add to the process of sustainability is paramount. The effort of a botanist doing research on sea weeds and algae has borought out a model of car where the algae is put on the roof of the car and the co2 emission from the car (see, figure-23)

Figure-23 A car eating co2- coutresy-CNN

4.5 social responsibility and activism-

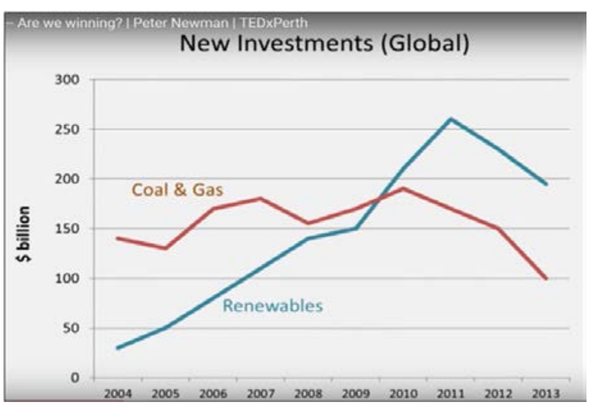
social responsibility and soial activism are no less innovative than innovation it self as it brings total transfometion of the society. Examples like making a movement like chipko movement [xxxi], Eath firstmovement[xxxii].see figure-24.

Figure-24 environmental protection movement

	EARTH FIRST! No Compromise in the Defense of Mother Earth!
The Chipko movement was a non-violent agitation in 1973 that was aimed at protection and conservation of trees, but, perhaps, it is best remembered for the collective mobilisation of women for the cause of preserving forests, which also brought about a change in attitude regarding their own status in society. The uprising against the felling of trees and maintaining the ecological balance originated in Uttar Pradesh's Chamoli district (now Uttarakhand) in 1973 and in no time spilled onto other states in north India. The name of the movement 'chipko' comes from the word 'embrace', as the villagers hugged the trees and encircled them to prevent being hacked.	EARTH FIRST! radical environmental group focused on the protection of wilderness and wildlife. Earth First! was formed in 1980 as an alternative to mainstream environmental organizations such as the Sierra Club and the Wilderness Society. Those groups were seen as too moderate and too willing to sacrifice the protection of some wild areas in order to make deals with politicians. In contrast, Earth First! adopted the slogan, "No compromise in defense of Mother Earth."

Investment in renewable energy:- The present the Global investment on-coventional energy has toppled the growth of investment in convetional in 2013. Global investment in renewable energy has started plumating from 2009- 2013 while investment in conventional energy like coal and oil has gone down(See, figure-26) given above.

Figure-25 Investment changing direction towards sustainability



1. **Decoupling wealth and fossil Fuel (Decarbonisation of environment): -**

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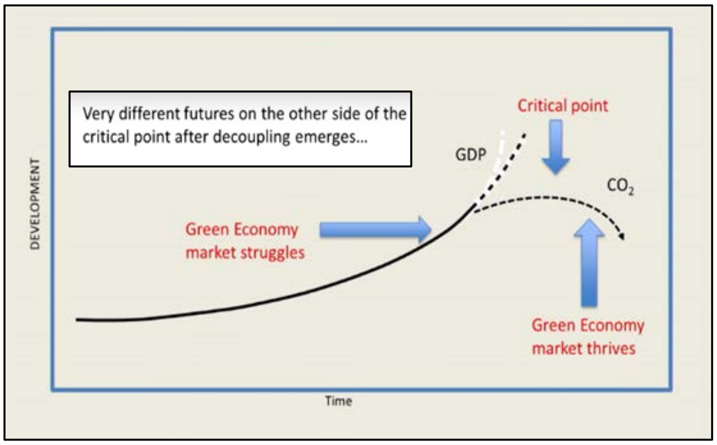
Figure- 26 Decoupling wealth& Fossil Fuel



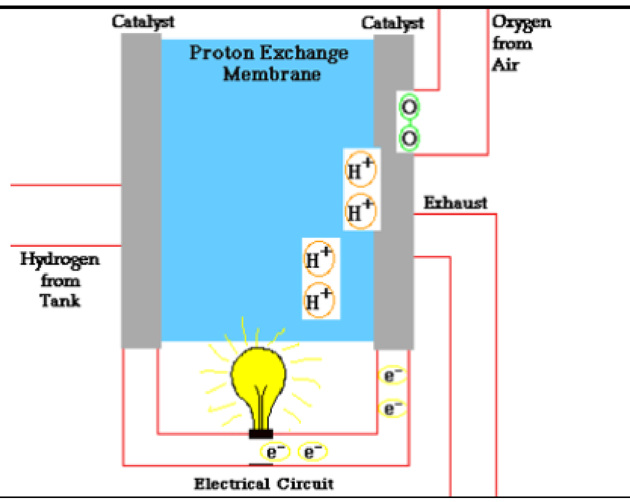
Movement towards wealth creation or industrialsation by utilisation of fossil fuel (coal, oil and gas) has now been decoupled from growth of GDP of nations and has taken a reverse gear, taking to renewable energy there by leaving fossil fuels way behind. This has created a new model of Sustainable Economic development which breakes the traditional economic theory that relied on conventional energy to non-conventional energy resources to increase productivity/ GDP.(see, Figure-26).

INNOVATIONS OF THE FUTURE AND SUSTAINABILITY ENTREPRENEURSHIP:

1. **Zero emission-Fuel cell technology**:

   a). zero power=decarbonisation+ electricity+H2 fuel cell rechcharge of cars which used hydrogen cylynder and oxigen from air when passed througha proton exchange membrane created electricity and water, both were used in apollo space satellite[xxxiii], water was used for drinking be astronaughts and electicty was used for supplying power to satelite, is a miraculous innovation that needed no power to create elctricity. Now on earth such fuel cells are being used to recharge electriccars of the modern age (See Figure-27).

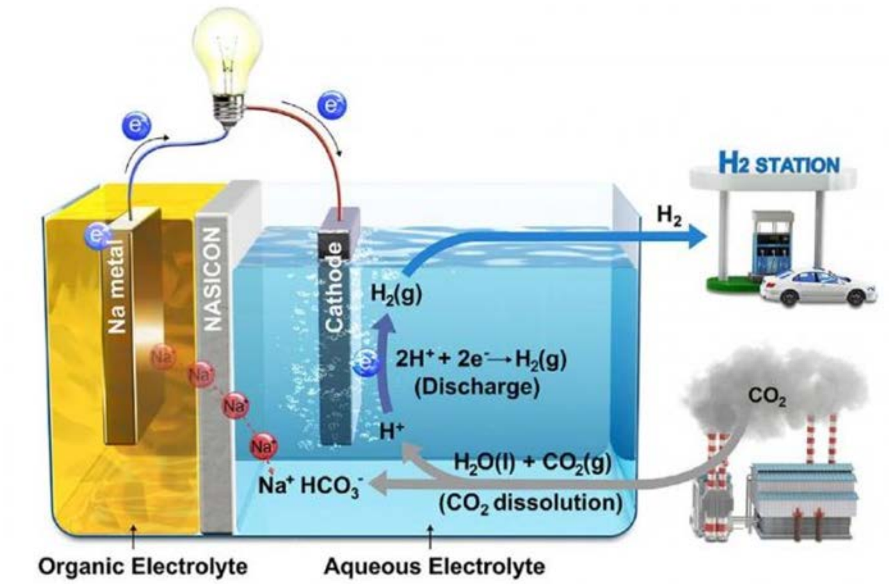
Figure-27fuel cell used in apollo satelite



Zero power= decarbonisation+elecricity+H_2 for fuel cell recharge of electronic car

b). Now that **Korean and US engineers**[xxxiv] **devised hybrid sodium-carbon dioxide fuel cell that eliminates carbon dioxide from air and produces electricity and hydrogen. The hydrogen efflux of this cell will work as input to the fuel cell tank for recharging the electric cars. See figure** The technology, developed by Prof Guntae Kim at Ulsan National Institute of Science and Technology (UNIST) in collaboration with material scientists and engineers at the Georgia Institute of Technology, depends on a well-understood phenomenon: the dissolution of carbon dioxide into water to produce an acidic solution, which occurs in nature when carbon dioxide dissolves in the oceans.

Figure-28 Schematic illustration of Hybrid Na-CO2 System and its reaction mechanism. *Image: UNIST*



Prof Kim and the team realized that this could be used to induce an electrochemical reaction. The creation of an acidic solution increases the number of protons in the water, each of which can attract an electron, and this implies that a battery system can be created. “Carbon capture, utilization, and sequestration (CCUS) technologies have recently received a great deal of attention for providing a pathway in dealing with global climate change,” says Prof Kim. “The key to that technology is the easy conversion of chemically stable CO_2 molecules to other materials.” He adds, “Our new system has solved this problem with CO_2 dissolution mechanism.”

The fuel cell system consists of a sodium metal anode submerged in an organic electrolyte, a separation membrane consisting of a sodium super ionic conductor (NASICON) ceramic, and a catalytic cathode (the researchers used platinum) in an aqueous electrolyte, which could be distilled water, seawater or a sodium hydroxide solution. The researchers explain in *iScience* how injecting carbon monoxide into the water triggers a reaction, with gaseous hydrogen liberated at the cathode – which can then be used in conventional fuel cells – and current flowing in an external circuit. Sodium ions are liberated from the anode, pass through the membrane and recombine with the hydrogen carbonate ions formed by the dissolution of carbon dioxide. In the system’s current form, the conversion efficiency of CO_2 is 50 per cent. The “hybrid Na-CO_2 cell” continues to produce electricity and hydrogen and does not regenerate carbon dioxide during charging, the team says. The system has been tested over more than a thousand hours with no damage to the electrodes. “This hybrid Na- CO_2cell, which adopts efficient CCUS technologies, not only utilizes CO_2 as the resource for generating electrical energy but also produces the clean energy source, hydrogen," said Jeongwon Kim, electrical engineer at Unist and co-first author for the research.

2. **Lithium air battery** (invariably using nano-technology) to store energy from renewable

Lithium-air batteries, which run on ambient oxygen, may be a sustainable and environment-friendly way to store energy and power electric vehicles, houses, and industries of the future, scientists say[xxxv]. Current lithium ion battery technology (first discovered in 1970) will probably not be able to handle the coming decades' huge demand for energy. It is estimated that by 2050, electricity will make up 50 per cent of the world's energy mix. Today, that rate is 18 per cent. However, installed capacity for renewable energy production is expected to increase fourfold. Keeping this in view research has made high energy density lithium-air batteries applying nano-technology that can fulfil the renewable energy battery requirement of the future.

3. **Clean water- hydro-optics-laser-crude-oil**[xxxvi]**-**

A laser system to detect minute traces of toxic substances in wastewater is being developed in the hydroptics project by a consortium of European scientists. Now, researchers from st-blaise, Switzerland-based alpes lasers have teamed up with a group of oil industry partners and academic institutes to create an ultrafast sensor that will make toxic wastewater harmless by detecting the tiniest concentrations of oil and suspended solids in water. Improving its detection rate using AI and machine learning, this new laser system will continuously monitor water in a live setting without the need for sampling or preparation. The team said the sensor will use hyperspectral imaging to detect microscopic pathogens that are indistinguishable to the human eye or conventional imaging methods. The process – which is claimed to be relatively simple – doesn't require the addition of chemicals or severe operational conditions, and does not produce additional waste streams, added Soares.

Figure- 29 Water before and after electrochemical treatment.

Image: Julia Ciarlini Jungers Soares, University of Sydney

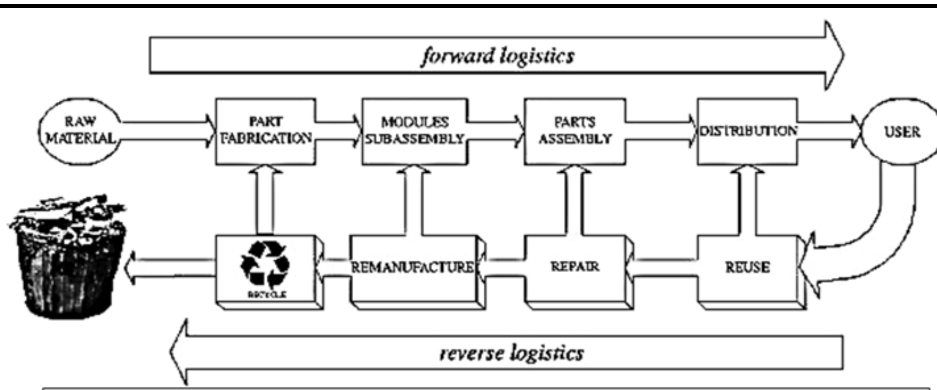
4. **Biofuels from algae for sustainable development**[xxxvii]

Microalgae are photosynthetic microorganisms that can produce lipids, proteins and carbohydrates in large amounts over short periods of time. These products can be processed into both biofuels and useful chemicals. Two algae samples (*Cladophora fracta* and *Chlorella protothecoid*) were studied for biofuel production. Microalgae appear to be the only source of renewable biodiesel that is capable of meeting the global demand for transport fuels. Microalgae can be converted to biodiesel, bioethanol, bio-oil, biohydrogen and biomethane via thermochemical and biochemical methods. Industrial reactors for algal culture are open ponds, photobioreactors and closed systems. Algae can be grown almost anywhere, even on sewage or salt water, and does not require fertile land or food crops, and processing requires less energy than the algae provides. Microalgae have much faster growth-rates than terrestrial crops. the per unit area yield of oil from algae is estimated to be from 20,000 to 80,000 liters per acre, per year; this is 7–31 times greater than the next best crop, palm oil. Algal oil can be used to make biodiesel for cars, trucks, and airplanes

5. Reverse logistics[xxxviii]:

Reverse logistics is the set of activities that is conducted after the sale of a product to recapture value and end the product's lifecycle. It typically involves returning a product to the manufacturer or distributor or forwarding it on for servicing, refurbishment or recycling. Reverse logistics is sometimes called aftermarket supply chain, aftermarket logistics or retro-logistics. Reverse logistics can be made more efficient and profitable with better planning, management and execution, and is a key component of service lifecycle management (SLM). Reverse logistics can have a significant impact on a company's bottom line, in good and bad ways. For example, generous return policies can encourage distributors and retailers to order more stock than they expect to sell, which can increase inventory costs for manufacturers. Proper disposal of products can minimize penalties from noncompliance with environmental regulations. e-commerce technologies involved in moving products to consumers (known as forward logistics) are used in reverse logistics, including barcodes and scanners used to track returns, materials handling systems in warehouses and Electronic Data Interchange (EDI) for transmitting documents between supply chain providers. SCM and ERP software vendors were initially slow to support reverse logistics, according to some experts, but most sellers now include some reverse logistics features in their suites. A number of niche vendors specialize in it. Third-party logistics providers (3PLs) also offer reverse logistics services.

Figure-30 reverse logistics



6. Green Chemistry:

Green chemistry, also called **sustainable chemistry**, is an area of chemistry and chemical engineering focused on the design of products and processes that minimize or eliminate the use and generation of hazardous substances.[xxxix]

While environmental chemistry focuses on the effects of polluting chemicals on nature, green chemistry focuses on the environmental impact of chemistry, including reducing consumption of non-renewable resources and technological approaches for preventing pollution.[xl] In the United States, the Environmental Protection Agency played a significant early role in fostering green chemistry through its pollution prevention programs, funding, and professional coordination. At the same time in the United Kingdom, researchers at the University of York contributed to the establishment of the Green Chemistry Network within the Royal Society of Chemistry, and the launch of the journal *Green Chemistry*.[xli]

Examples

a). **Solvents**: -Solvents are consumed in large quantities in many chemical syntheses as well as for cleaning and de-greasing. Traditional solvents are often toxic or are chlorinated. Green solvents, on the other hand, are generally derived from renewable resources and biodegrade to innocuous, often a naturally occurring product.[xlii] *Green solvents* are environmentally friendly solvents, or bio solvents, which are derived from the processing of agricultural crops[xliii]. The use of petrochemical solvents is the key to the majority of chemical processes but not without severe implications on the environment. Green solvents were developed as a more environmentally friendly alternative to petrochemical solvents.

i). **Ethyl lactate,** for example, is a green solvent derived from processing corn. Ethyl lactate is the ester of lactic acid.

ii). **Lactate ester** solvents are commonly used solvents in the paints and coatings industry and have numerous attractive advantages including being 100% biodegradable, easy to recycle, noncorrosive, noncarcinogenic, and nonozone-depleting

b). Synthetic techniques: A Novel or enhanced synthetic techniques can often provide improved environmental performance or enable better adherence to the principles of green chemistry. For example, the 2005 Nobel Prize for Chemistry was awarded, to Yves Chauvin, Robert H. Grubbs and Richard R. Schrock, for the development of the metathesis method in organic synthesis, with explicit reference to its contribution to green chemistry and "smarter production."

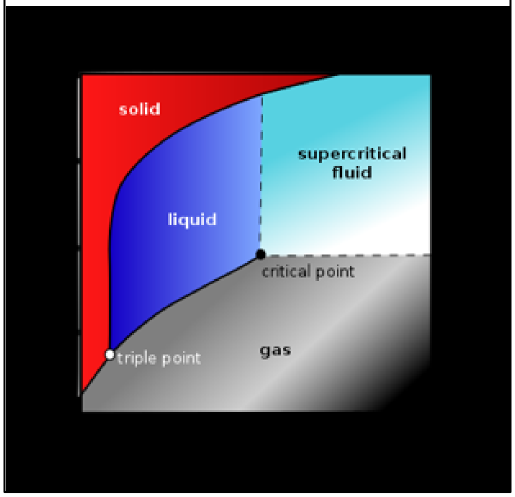
A 2005 review identified three key developments in green chemistry in the field of organic synthesis:

1. use of supercritical carbon dioxide as green solvent,
2. aqueous hydrogen peroxide for clean oxidations (e.g. redox action in electricals/galvanic cell) and
3. the use of hydrogen in asymmetric synthesis (e.g. Enantio-selective synthesis can be achieved by using a chiral feature that favors the formation of one(desired) enantiomer over another (Undesired) through interactions at the transition state)[6].

[6] Many of the building blocks of biological systems such as sugars and amino acids are produced exclusively as one enantiomer. As a result, living systems possess a high degree of chemical chirality(assimetry) and will often react differently with the various enantiomers of a given compound. Examples of this selectivity include:

Supercritical carbon dioxide (sCO_2)

Figure-30 Supercritical CO_2



Supercritical carbon dioxide (sCO_2) is a fluid state of carbon dioxide where it is held at or above its critical temperature and critical pressure.

Carbon dioxide usually behaves as a gas in air at standard temperature and pressure (STP), or as a solid called dry ice when cooled and/or pressurised sufficiently. If the temperature and pressure are both increased from STP to be at or above the critical point for carbon dioxide, it can adopt properties midway between a gas and a liquid. More specifically, it behaves as a supercritical fluid above its critical temperature (304.13 K, 31.0 °C, 87.8 °F) and critical pressure (7.3773 MPa, 72.8 atm, 1,070 psi, 73.8 bar),[1] expanding to fill its container like a gas but with a density like that of a liquid.

Supercritical CO_2 is becoming an important commercial and industrial solvent due to its role in chemical extraction in addition to its low toxicity and environmental impact. The relatively low temperature of the process and the stability of CO_2 also allows most compounds to be extracted with little damage or denaturing. In addition, the solubility of many extracted compounds in CO_2 varies with pressure, permitting selective extractions.

- Carbon dioxide is gaining popularity among coffee manufacturers looking to move away from classic decaffeinating solvents, because of real or perceived dangers related to their use in food preparation. CO is forced through the green coffee beans which are then sprayed with water at high pressure to remove the caffeine. The caffeine can then be isolated for resale (e.g. to the pharmaceutical or beverage manufacturers) by passing the water through activated-charcoal filters or dry distillation, crystallization or reverse osmosis.
- Supercritical carbon dioxide is used to remove organochloride pesticides and metals from agricultural crops without adulterating the desired constituents from the plant matter in the herbal supplement industry.

- **Flavour:** the artificial sweetener aspartame has two enantiomers. L-aspartame tastes sweet whereas D-aspartame is tasteless.
- **Odor:** *R*-(–)-carvone smells like spearmint whereas *S*-(+)-carvone smells like caraway.
- **Drug effectiveness:** the antidepressant drug Citalopram is sold as a racemic mixture. However, studies have shown that only the (*S*)-(+) enantiomer is responsible for the drug's beneficial effects.
- **Drug safety:** D-penicillamine*5 is used in chelation therapy *6 and for the treatment of rheumatoid arthritis whereas L-penicillamine is toxic as it inhibits the action of pyridoxine, an essential B vitamin*7

- Supercritical carbon dioxide can be used as a more environmentally friendly solvent for dry cleaning over traditional solvents such as hydrocarbons, including perchloroethylene.
- Supercritical carbon dioxide is used as the extraction solvent for creation of essential oils and other herbal distillates. Its main advantages over solvents such as hexane and acetone in this process are that it is non-toxic and non-flammable. Furthermore, separation of the reaction components from the starting material is much simpler than with traditional organic solvents. The CO can evaporate into the air or be recycled by condensation into a cold recovery vessel. Its advantage over steam distillation is that it operates at a lower temperature, which can separate the plant waxes from the oils.
- In laboratories, sCO_2 is used as an extraction solvent, for example for determining total recoverable hydrocarbons from soils, sediments, fly-ash and other media, and determination of polycyclic aromatic hydrocarbons in soil and solid wastes. Supercritical fluid extraction has been used in determining hydrocarbon components in water.

- Processes that use sCO_2 to produce micro and nano scale particles, often for pharmaceutical uses, are under development.

c. Bio-succinic acid

In 2011, the Outstanding Green Chemistry Accomplishments by a Small Business Award went to BioAmber Inc. for integrated production and downstream applications of bio-based succinic acid. Succinic acid is a platform chemical that is an important starting material in the formulations of everyday products.
Succinic acid (E363) is listed in Commission Regulation (EU) No 231/2012 as an authorized food additive and categorized in “Additives other than colours and sweeteners”.
Approved uses
The following food may contain E363 with the maximum uses range from 3000-6000mg/kg:

- Flavored fermented milk
- Soups and broths
- Flavored drinks in powder form for home preparation of drinks

Traditionally, succinic acid is produced from petroleum-based feedstocks. BioAmber has developed process and technology that produces succinic acid from the fermentation of renewable feedstocks at a lower cost and lower energy expenditure than the petroleum equivalent while sequestering CO_2 rather than emitting it. However, lower prices of oil precipitated the company into bankruptcy and bio-sourced succinic acid is now barely made.

7. ‘Green’ building is a building design:

A ‘green’ building is a building that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environment. Green buildings preserve precious natural resources and improve our quality of life.

There are a number of features which can make a building ‘green’. These include:

- Efficient use of energy, water and other resources
- Use of renewable energy, such as solar energy
- Pollution and waste reduction measures, and the enabling of re-use and recycling
- Good indoor environmental air quality
- Use of materials that are non-toxic, ethical and sustainable
- Consideration of the environment in design, construction and operation
- Consideration of the quality of life of occupants in design, construction and operation
- A design that enables adaptation to a changing environment

Any building can be a green building, whether it's a home, an office, a school, a hospital, a community centre, or any other type of structure, provided it includes features listed above.

However, it is worth noting that not all green buildings are – and need to be - the same. Different countries and regions have a variety of characteristics such as distinctive climatic conditions, unique cultures and traditions, diverse building types and ages, or wide-ranging environmental, economic and social priorities – all of which shape their approach to green building. This is why World GBC supports its member Green Building Councils and their member companies in individual countries and across regions, to pursue green buildings that are best suited to their own markets. US LEED certification norms or scale is shown in figure-31[7].

8. **Cradle-to-cradle design** (also referred to as **2CC2**, **C2C**, **cradle 2 cradle**, or regenerative design)

It is a biomimetic approach to the design of products and systems that models human industry on nature's processes, where materials are viewed as nutrients circulating in healthy, safe metabolisms. The term itself is a play on the popular corporate phrase "cradle to grave", implying that the C2C model is sustainable and considerate of life and future generations—from the birth, or "cradle", of one generation to the next generation, versus from birth to death, or "grave", within the same generation.

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[7] **Leadership in Energy and Environmental Design** (**LEED**) is a green building certification program used worldwide.[9] Developed by the non-profit U.S. Green Building Council (USGBC) it includes a set of rating systems for the design, construction, operation, and maintenance of green buildings, homes, and neighborhoods which aims to help building owners and operators be environmentally responsible and use resources efficiently.

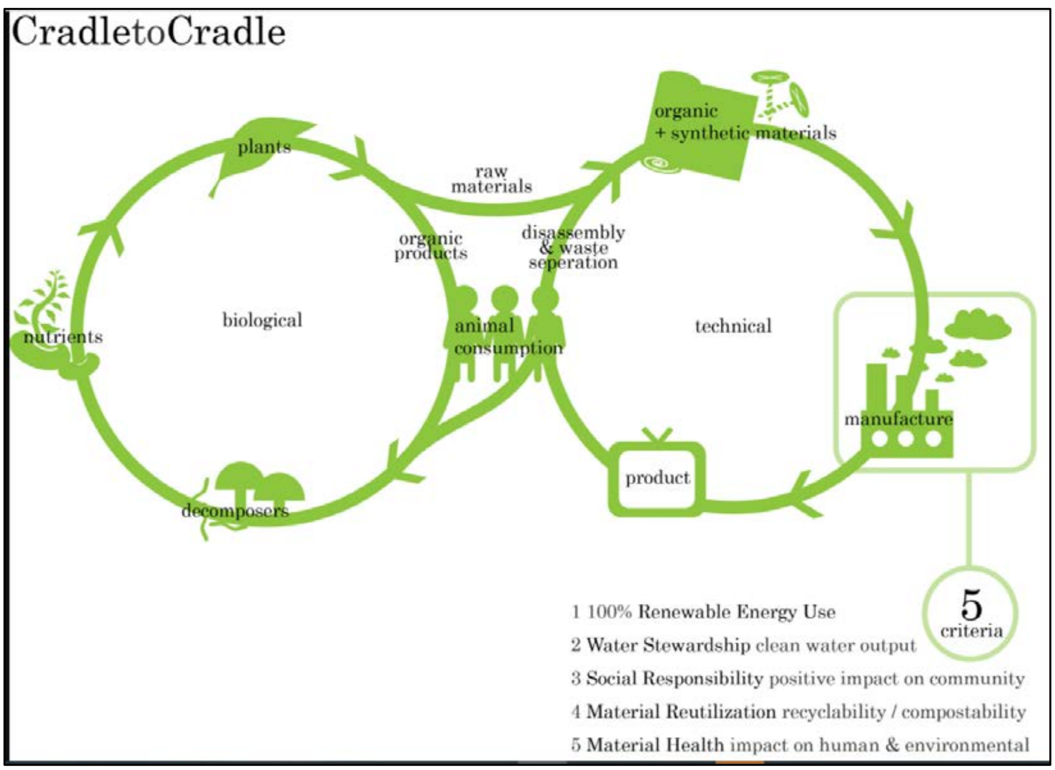
Figure-31 LEED V4.1 health certificate grading scale

LEED v4.1 BD+C: Healthcare
Project Checklist

Project Name:
Date:

Y	?	N			
Y			Prereq	Integrative Project Planning and Design	Required
			Credit	Integrative Process	1
0	0	0		**Location and Transportation**	**9**
			Credit	LEED for Neighborhood Development Location	9
			Credit	Sensitive Land Protection	1
			Credit	High Priority Site	2
			Credit	Surrounding Density and Diverse Uses	1
			Credit	Access to Quality Transit	2
			Credit	Bicycle Facilities	1
			Credit	Reduced Parking Footprint	1
			Credit	Electric Vehicles	1
0	0	0		**Sustainable Sites**	**9**
Y			Prereq	Construction Activity Pollution Prevention	Required
Y			Prereq	Environmental Site Assessment	Required
			Credit	Site Assessment	1
			Credit	Protect or Restore Habitat	1
			Credit	Open Space	1
			Credit	Rainwater Management	2
			Credit	Heat Island Reduction	1
			Credit	Light Pollution Reduction	1
			Credit	Places of Respite	1
			Credit	Direct Exterior Access	1
0	0	0		**Water Efficiency**	**11**
Y			Prereq	Outdoor Water Use Reduction	Required
Y			Prereq	Indoor Water Use Reduction	Required
Y			Prereq	Building-Level Water Metering	Required
			Credit	Outdoor Water Use Reduction	1
			Credit	Indoor Water Use Reduction	7
			Credit	Cooling Tower Water Use	2
			Credit	Water Metering	1
0	0	0		**Energy and Atmosphere**	**35**
Y			Prereq	Fundamental Commissioning and Verification	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
			Credit	Enhanced Commissioning	6
			Credit	Optimize Energy Performance	20
			Credit	Advanced Energy Metering	1
			Credit	Grid Harmonization	2
			Credit	Renewable Energy	5
			Credit	Enhanced Refrigerant Management	1
0	0	0		**Materials and Resources**	**19**
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Management Planning	Required
Y			Prereq	PBT Source Reduction- Mercury	Required
			Credit	Building Life-Cycle Impact Reduction	5
			Credit	Building Product Disclosure and Optimization - Environmental Product Declarations	2
			Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materia	2
			Credit	Building Product Disclosure and Optimization - Material Ingredients	2
			Credit	PBT Source Reduction- Mercury	1
			Credit	PBT Source Reduction- Lead, Cadmium, and Copper	2
			Credit	Furniture and Medical Furnishings	2
			Credit	Design for Flexibility	1
			Credit	Construction and Demolition Waste Management	2
0	0	0		**Indoor Environmental Quality**	**16**
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
			Credit	Enhanced Indoor Air Quality Strategies	2
			Credit	Low-Emitting Materials	3
			Credit	Construction Indoor Air Quality Management Plan	1
			Credit	Indoor Air Quality Assessment	2
			Credit	Thermal Comfort	1
			Credit	Interior Lighting	1
			Credit	Daylight	2
			Credit	Quality Views	2
			Credit	Acoustic Performance	2
0	0	0		**Innovation**	**6**
			Credit	Innovation	5
			Credit	LEED Accredited Professional	1
0	0	0		**Regional Priority**	**4**
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
0	0	0		**TOTALS** Possible Points:	**110**

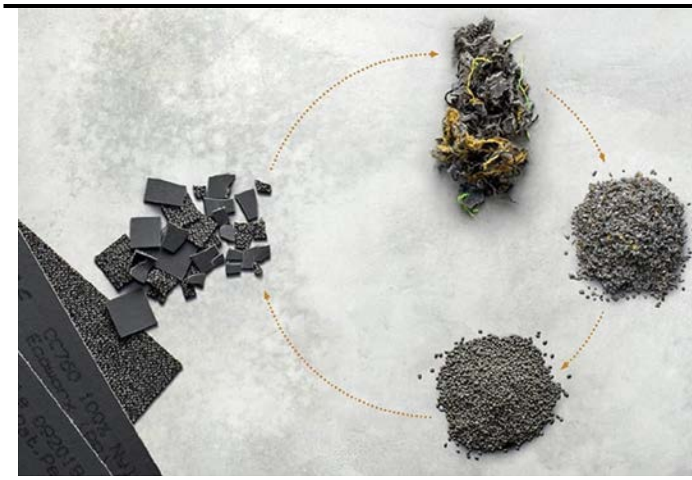
Certified: 40 to 49 points, Silver: 50 to 59 points, Gold: 60 to 79 points, Platinum: 80 to 110



In the cradle-to-cradle model, all materials used in industrial or commercial processes—such as metals, fibers, dyes—fall into one of two categories: "technical" or "biological" nutrients.

1. *Technical nutrients* are strictly limited to non-toxic, non-harmful synthetic materials that have no negative effects on the natural environment; they can be used in continuous cycles as the same product without losing their integrity or quality. In this manner these materials can be used over and over again instead of being "downcycled" into lesser products, ultimately becoming waste.
2. *Biological nutrients* are organic materials that, once used, can be disposed of in any natural environment and decompose into the soil, providing food for small life forms without affecting the natural environment. This is dependent on the ecology of the region; for example, organic material from one country or landmass may be harmful to the ecology of another country or landmass.[1]

The two types of materials each follow their own cycle in the regenerative economy envisioned by Keunen and Huizing



- EcoWorx provides ingredient transparency through Cradle to Cradle Certification™ at the Silver Level.
- Uses 40% less energy in production than traditional carpet tile.
- Weighs 40% less than traditional carpet tile – creating carbon reductions in transport and increasing efficiency in installation.
- Low VOCs – meeting the requirements for Green Label Plus certification. Contributes to LEED 2009 and v4.
- High performance sustainability – at no additional cost

When the product wares out it is not thrown but returned to the manufacturer who re uses it to reproduce new product, causing no waste, no polution.

C2C suggests that industry must protect and enrich ecosystems and nature's biological metabolism while also maintaining a safe, productive technical metabolism for the high-quality use and circulation of organic and technical nutrients. the model in its broadest sense is not limited to industrial design and manufacturing; it can be applied to many aspects of human civilization such as urban environments, buildings, economics and social systems.

The term "Cradle to Cradle" is a registered trademark of McDonough Baumgart Design Chemistry (MBDC) consultants. The Cradle to Cradle Certified Products Program began as a proprietary system; however, in 2012 MBDC turned the certification over to an independent non-profit called the Cradle to Cradle Products Innovation Institute. Independence, openness, and transparency are the Institute's first objectives for the certification protocols. Certificate is given on following standards.

A product receives an achievement level in each category — Basic, Bronze, Silver, Gold, or Platinum — with the lowest achievement level representing the product's overall mark. The chart above is an example of a product scorecard:

The certification process recognizes transition and human intention as part of any successful protocol for continuous product improvement. The program also recognizes that any manufacturer's knowledge may vary widely regarding the chemicals used in a product, the extent to which the materials in a product can be reused in biological or technical cycles, and the energy and water used to produce a product. The goal of continuous improvement is not "zero" or simply reducing the human and environmental impact of a product, but instead combines the progressive reduction of "bad" with the increase in "good."

Every manufacturer receiving the certification mark for their product is required to make a good faith effort toward optimization.

9. Organic food

Organic food is food produced by methods complying with the standards of organic farming. Standards vary worldwide, but organic farming features practices that cycle resources, promote ecological balance, and conserve biodiversity. Organizations regulating organic products may restrict the use of certain pesticides and fertilizers in the farming methods used to produce such products. Organic foods typically are not processed using irradiation, industrial solvents, or synthetic food additives. In the 21st century, the European Union, the United States, Canada, Mexico, Japan, and many other countries require producers to obtain special certification to market their food as organic. Although the produce of kitchen gardens may actually be organic, selling food with an organic label is regulated by governmental food safety authorities, such as the National Organic Program of the US Department of Agriculture (USDA) or European Commission (EC). From an environmental perspective, fertilizing, overproduction, and the use of pesticides in conventional farming may negatively affect ecosystems, biodiversity, groundwater, and drinking water supplies. These environmental and health issues are intended to be minimized or avoided in organic farming.

10. Nature's service-

Nature's services are conditions and processes through the natural ecosystems i.e. the species that make them up, sustain and fulfil human life. They maintain bio diversity and production of ecosystem goods such as sea food, forage, timber, biomass fuel, natural fiber and many pharmaceutical industrial products and their precursors. The harvest and trade of these goods represent an essential and inevitable part of human economy. In addition to the production of the goods, ecosystem services sustain the actual life support functions, such as cleaning, recycling, renewal and conferring many intangible aesthetic and cultural benefits as well. They are generated by a complex of natural cycles, driven by solar energy, that constitute the biosphere-the thin layer near earth's surface and oceanic or marine system that contain all millions and trillions of lives known or unknown to us. The cycle operates on very different scales. Biochemical cycles, such as the movement of the element carbon through the living and physical environment are truly global and reach from the top of the atmosphere to deep into soils and ocean bottom sediments. Life cycles of bacteria, in contrast, may be completed in a much smaller period, yet have tremendous impact on human and animal life. The cycle also operates at a very different rate. The biochemical cycling of carbon for instance occurs at orders of magnitude faster than that of may be orders of magnitude faster than phosphorous and nitrogen, just as the life cycle of micro-organisms may be orders of magnitude faster than those of trees.

All of these cycles, the micro and macro level organisms are products of billions of years of evolution. They are absolutely pervasive and unnoticed. But for the miracle of science, it could have been impossible for us to imagine their existence and even their role in carbon sequestration cycle that connects all of us, the plant and animal kingdom through a small garden of beautiful flower or falling leaves of trees in the forest or the decomposed body of an animal in a deserted land or forest soil.

For millennia, humans have drawn benefits from these cycles, without causing disruption. Yet, today human influence can be discerned in the most remote reaches of the biosphere, deep below earth's surface, far out in the sea in a tiny tropical island, and up in the cold thin air high above Antarctica. Virtually no place remains untouched, chemically, physical, biologically, by the curious hand of humanity. Interestingly, the nature and value of earths life support system have become conspicuous primarily through their disruption and loss. Thus, for instance, deforestation has revealed, critical role in the hydrological cycle, in particular, mitigating flood, draught, forces of wind and rain causing erosion. Thinning of the stratospheric ozone layer sharpened the awareness of the value of its service in screening out the harmful ultra violate radiation.

Conclusion

Nature's service and ecosystem have gained recognition and precipitation through efforts to substitute technology for them. Earlier, we used technology to explore and exploit natural resources to

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meet our greed for wealth and comfort, economic growth and development without concern for ecology and earths support system. The consequences are now forcing us to rethink our priorities and goals in returning the nature what she has lost. At the same time, it demands achieving a sustainable life more qualitative than before, no less reach than what we have achieved over years, yet creating a resilient society, where no poverty strikes, no inequity or injustice exists, no diversity is lost, no animal endangered, no calamity exist, no biological cycle is interrupted and make our future generation feel that their predecessors were not selfish or misers.

The solution lies in innovation and technology. The torch bearers are the entrepreneurs who pour their capital and investment in green, clean, zero waste, zero emission, cradle to cradle technology and technology that eats out carbons and puffs out oxygen. It demands entrepreneurs who make the process of manufacturing, distribution and consumption life sustaining, ecofriendly, nature protecting and without creating any distortion in the ecological balance and biological cycles of the earth.

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